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Research Article

Nutrition quotient for preschoolers and key impacting factors in Korea: a cross-sectional study on food literacy, social support, and the food environment of primary caregivers

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Objectives: This study evaluated the nutrition quotient for preschoolers (NQ-P) and analyzed the impact of key factors, such as caregivers' food literacy, social support, and food environment, on the eating habits of preschool children in Korea. This study also sought to provide foundational data for developing tailored nutrition education programs by identifying the nutrition education needs of caregivers.

Methods: This study was conducted among caregivers of preschool children (aged 0–6 years) using an online self-administered survey conducted from August 22 to August 28, 2023. A total of 1,116 survey responses were analyzed. This study assessed children's NQ-P score, caregivers' food literacy, social support, food environment, and nutritional education needs. Data were analyzed using SPSS 29.0 (IBM Co.).

Results: The average NQ-P score for preschool children was 52, showing a tendency for the balance score to decrease and the moderation score to increase with age. Children from rural and low-income areas exhibited significantly lower NQ-P scores. Caregivers' food literacy was higher in urban and higher-income groups. Multiple regression analysis revealed that social support, food literacy, income, and food environment significantly affected children's NQ-P scores. The effectiveness of nutrition education varied based on the income level, with nutrition education on healthy eating being the most preferred topic for preschool children.

Conclusion: This study confirmed that caregivers' food literacy and social support significantly affected preschool children's nutritional status. This suggests a need for tailored nutritional education and dietary support policies, particularly for low-income and rural populations.

Keywords: food literacy; nutrition quotient for preschoolers; child, preschool; social support

INTRODUCTION

The preschool years represent a critical period of continuous physical, cognitive, and social development during which dietary preferences and eating behaviors

are established that often persist into adulthood. Thus, ensuring appropriate nutritional intake and fostering healthy eating habits during this stage is essential [1-4]. In Korea, various dietary issues have been identified among preschoolers, including nutritional imbalances, selective eating, skipping breakfast, and increased consumption of processed foods. These factors contribute to health problems, such as obesity, underweight, and childhood diabetes [5]. According to the 2023 National Health Statistics, 2.9% of children aged 1–2 years and 7.3% of children aged 3–5 years exhibited nutritional deficiencies, while excessive nutrient intake was observed in 4.1% and 3.5%, respectively, potentially impacting their physical development. Additionally, breakfast skipping rates were 6.6% among children aged 1–2 years and 7.1% of children aged 3–5 years, 24.9% of children aged 1–2 years, and 40.4% of children aged 3–5 years consumed at least one out-of-home meal per day [6].

The COVID-19 pandemic has further influenced dietary patterns, leading to a decline in dining out, increased food delivery, and greater reliance on dietary supplements [7]. Restrictions on outdoor activities also resulted in increased screen time and decreased physical activity, significantly altering preschoolers' daily routines [8]. However, research on the dietary habits of preschoolers, including infants aged 0–1 year, in Korea is limited. Notably, no studies have employed the revised 2021 nutrition quotient for preschoolers (NQ-P). Thus, a precise assessment of dietary habits is needed to evaluate nutritional status and eating behaviors in this population group, along with the development of targeted dietary management strategies and nutrition education programs to support healthy growth and formation of proper eating habits [9].

Primary caregivers play a pivotal role in shaping preschoolers' dietary patterns. Their food choices and home food environments significantly affect the children's future eating habits and overall health [10]. Parental influence on their children operates both directly (through parenting behaviors and interactions) and indirectly (through socioeconomic status, occupational status, and living environment, all of which affect parenting attitudes and roles) [11]. Moreover, caregivers' nutritional knowledge and attitudes have a profound impact on preschoolers' dietary intake and the formation of appropriate eating habits. Assessing caregivers' nutritional awareness and knowledge is essential for predicting children's future health behaviors. Caregivers with higher nutritional awareness are more likely to apply their knowledge to foster proper eating habits among their children [12].

Several factors influence preschoolers' dietary habits, including socioeconomic status, food literacy, and food environment. As preschoolers' eating habits are strongly influenced by their primary caregivers, examining factors such as caregivers' food literacy, social support, and food environment is important. However, studies on these factors are limited. The preschool age is crucial for establishing eating habits that persist into adulthood. This period is not only critical for physical growth and emotional development, but also for nutritional well-being, underscoring the importance of systematic nutrition education in this group and those associated with them [13]. With the growing need for nutrition education programs, studies have examined caregivers' requirements for such programs. However, most of this research has focused on school-aged children, such as elementary and middle school students, whereas studies on preschoolers' nutritional education needs have been limited to specific regions or qualitative focus group interviews [14-18].

This study aimed to provide a comprehensive understanding of the dietary environment and nutritional status of preschoolers by conducting a multifaceted analysis of the NQ-P and food literacy, social support, and food environment of their primary caregivers. Furthermore, this study aimed to generate evidence-based policy recommendations for improving nutritional support for preschoolers. Additionally, to facilitate the promotion of healthy eating habits, this study examined the nutritional education needs of primary caregivers, providing a basis for the development of effective evidence-based nutritional education programs.

METHODS

Ethics statement

The study was approved by the institutional review board of Hallym University (IRB No. HIRB-2023-018).

1. Study design

This cross-sectional study was designed in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (https://www.strobe-statement.org/).

2. Study participants and data collection period

This study made use of Data Spring (https://www.d8aspring.com), a professional survey agency that targets primary caregivers of preschoolers across Korea. Participants were selected based on their voluntary agreement to participate in the survey, and their status as primary caregivers was verified using preliminary screening questions. A combination of convenience and regional quota sampling was used, with urban and rural areas accounting for 90% and 10% of the respondents, respectively. The survey was conducted over 7 days (August 22 to 28, 2023). Among the 1,262 voluntary respondents, 146 were excluded because of ineligibility, resulting in a final sample of 1,116 valid responses (response rate: 88.4%).

3. Study measures

1) General characteristics

The survey collected demographic data on the primary caregivers, including their sex, age, relationship with the child(ren) in their care, residential area, and monthly household income. For the preschoolers, information on sex, age, height (cm), and weight (kg) was collected. The body mass index (BMI; kg/m^2) was calculated to assess weight status. Following Kim *et al.* [19] classification criteria, preschoolers were categorized based on age-specific BMI percentiles as follows: underweight (< 5th percentile), normal weight (5th–85th percentile), overweight (85th–95th percentile), and obese (≥ 95th percentile). For ages 0–2 years, overweight was defined as a weight-for-length ≥ 95th percentile on growth charts.

2) Nutrition quotient for preschoolers

The NQ-P is a validated tool used to assess the nutritional status and dietary quality of preschoolers [20, 21]. The NQ-P comprises three domains: balance, moderation, and practice. Each domain comprises 15 items. A weighted scoring system is used to derive the final NQ-P score. Cronbach's α for the NQ-P in this study was 0.626, confirming its reliability.

3) Primary caregivers' food literacy, social support, and food environment

Food literacy was assessed using a life-cycle-specific Food Literacy Scale [22-24]. The adult version of this tool consists of 25 items across five domains (total score: 100 points): production (7 items), selection (5 items), preparation and cooking (7 items), intake (3 items), and disposal (3 items). The domain scores were calculated by applying item-specific weights, summing the weighted scores within each domain, and then applying additional domain-specific weights to obtain a total score. Cronbach's α for the Food Literacy Scale in this study was 0.927, indicating high reliability. To assess social support for dietary practices, previously validated measurement tools were adapted to fit the caregiving context [25]. Participants responded to four items using a 5-point Likert scale regarding the availability of fresh food at home, parental involvement in meal preparation, and snack guidance over the past 3 months. The items included questions regarding the availability of fresh fruits and vegetables at home, availability of fresh milk and dairy products, frequency of meal preparation for preschoolers, and encouragement of healthy snacking (e.g., fruits, vegetables, milk, and yogurt). The Social Support Scale demonstrated a Cronbach's α value of 0.716, confirming its internal consistency. The food environment was assessed using a 5-item scale developed by Yang and Kim [26]. The five domains of the Food Environment Scale included availability, physical accessibility, affordability, acceptability, and accommodation. Each domain was rated on a 5-point Likert scale, ranging from "strongly disagree" (1 point) to "strongly agree" (5 points). The Food Environment Scale exhibited high reliability, with Cronbach's alpha = 0.869.

4) Nutrition education needs

Nutritional education needs were assessed based on prior research [17, 18, 27]. The survey included three key items: perceived effectiveness of nutrition education (rated on a 5-point Likert scale from "strongly disagree" to "strongly agree"), participation in nutrition education

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within the past 3 months (response options: yes/no/unsure), and preferred nutrition education topics (multiple responses allowed).

4. Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics 29.0 (IBM Co.), with statistical significance accepted at $P < 0.05$. Descriptive statistics were calculated for all the variables. Continuous variables were presented as mean ± standard deviation. Categorical variables are expressed as frequencies (n) and percentages (%). For comparisons of the NQ-P, food literacy, social support, food environment, and nutrition education needs according to the preschoolers' and caregivers' characteristics were compared by using independent t-tests and one-way analysis of variance. Chi-square and Duncan's multiple comparison tests were used for analysis of categorical variables. A stepwise multiple linear regression analysis was conducted to evaluate the impact of primary caregivers' food literacy, social support, food environment, monthly income, residential area, and the perceived effectiveness of nutritional education on preschoolers' NQ-P scores. Multiple response frequency analysis was used to identify the caregivers' preferred nutrition education topics.

RESULTS

1. General characteristics of study participants

Table 1 presents the general characteristics of the participants. Among primary caregivers, females were predominant. Almost two-thirds of participants were in their 30s, followed by those in their 40s, 20s, and 50s. In terms of relationship with the child, 40.9% of the caregivers were fathers and 58.5% were mothers. Regarding the regional distribution, the vast majority of the participants resided in urban areas, whereas only about 10% lived in rural areas. Monthly household income was distributed as follows: most (about one-third) had an income of 400–599 million KRW, followed by those with incomes of 200–399 million KRW, 600–799 million KRW, 800 million KRW, and 200 million KRW, in descending order. Among the preschoolers, just more than half were boys. Each age group (0–1 years, 2–4 years, and 5–6 years) accounted for roughly one-third of the children. Just more than two-thirds of the children were classified as normal weight, while the rest were classified as underweight, overweight, or obese.

2. NQ-P and domain scores

Table 2 presents the total and domain scores of the NQ-P according to sex, age, region, and household income.

Table 1. Characteristics of the study subjects

Variable	Category	Value
Main caregiver (n = 1,116)		
Sex	Male	460 (41.2)
	Female	656 (58.8)
Age (year)	20–29	58 (5.2)
	30–39	701 (62.8)
	40–49	346 (31.0)
	50–59	11 (1.0)
Relationship	Father	457 (40.9)
	Mather	653 (58.5)
	Grandparents	4 (0.4)
	Other	2 (0.2)
Region	Urban	997 (89.3)
	Rural	119 (10.7)
Education level	High school	116 (10.4)
	University	878 (78.7)
	Graduate	122 (10.9)
Occupation	Office worker	537 (48.1)
	Sale or service	73 (6.6)
	Professional	115 (10.3)
	Self-employed business	54 (4.8)
	Housewives	310 (27.8)
	Others	27 (2.4)
Family income (million KRW/month)	< 200	43 (3.9)
	200–399	297 (26.6)
	400–599	420 (37.6)
	600–799	214 (19.2)
	≥ 800	142 (12.7)
Children (n = 1,116)		
Sex	Male	577 (51.7)
	Female	539 (48.3)
Age (year)	0–1	369 (33.1)
	2–4	374 (33.5)
	5–6	373 (33.4)
Weight status	Underweight	133 (11.9)
	Normal weight	762 (68.3)
	Overweight	124 (11.1)
	Obesity	97 (8.7)

n (%).

Table 2. Scores of NQ-P and its factors by sex, age, region and household income

Variable	Total (n = 1,116)	Sex			Age (year)				Region			Household income			
		Male (n = 577)	Female (n = 539)	*P*-value[1]	0–1 (n = 369)	2–4 (n = 374)	5–6 (n = 373)	*P*-value[2]	Urban (n = 997)	Rural (n = 119)	*P*-value[1]	Upper (n = 356)	Middle (n = 420)	Low (n = 340)	*P*-value[2]
NQ-P[3]	52.3 ± 11.8	52.4 ± 11.9	52.2 ± 11.7	0.788	51.0 ± 12.4[a]	52.9 ± 11.7[b]	53.0 ± 11.2b	0.037	52.6 ± 11.7	49.7 ± 12.6	0.013	54.6 ± 11.7[c]	52.5 ± 10.7[b]	49.5 ± 12.5[a]	< 0.001
Balance	48.6 ± 13.7	48.5 ± 13.4	48.7 ± 14.1	0.788	50.0 ± 15.1[b]	49.0 ± 12.8[b]	46.7 ± 13.1[a]	0.003	49.0 ± 13.6	44.8 ± 14.5	0.001	52.2 ± 13.9[c]	48.1 ± 12.9[b]	45.4 ± 13.8[a]	< 0.001
Moderation	40.4 ± 19.9	41.6 ± 20.3	39.1 ± 19.5	0.039	29.4 ± 23.3[a]	45.2 ± 16.2[b]	46.4 ± 14.5[b]	< 0.001	40.3 ± 19.9	40.9 ± 20.8	0.757	39.6 ± 20.1	41.8 ± 19.0	39.5 ± 20.8	0.197
Practice	59.5 ± 18.8	59.4 ± 19.2	59.6 ± 18.5	0.857	59.0 ± 18.6	58.8 ± 19.5	60.7 ± 18.4	0.346	59.8 ± 18.6	57.1 ± 20.3	0.144	61.8 ± 18.3[b]	60.1 ± 18.1[b]	56.5 ± 20.0[a]	0.001

Mean ± SD.
NQ-P, nutrition quotient for preschoolers.
[1]*P*-value was determined by t-test.
[2]*P*-value was determined by ANOVA.
[3]This score encompasses the balance, moderation, practice dimensions of NQ-P.
[a,b,c]Values with different superscripts within each row are significantly different at $P < 0.05$, as determined by Duncan's multiple comparison test.

Significant sex differences were observed in the moderation domain, with boys scoring higher than girls ($P < 0.05$). Age-related differences were also noted in the total NQ-P score ($P < 0.05$), balance domain ($P < 0.01$), and moderation domain ($P < 0.001$), whereas no significant differences were observed in the practice domain. Balance scores declined with increasing age ($P < 0.01$), whereas moderation scores increased with age ($P < 0.001$). Regional analysis revealed that preschoolers in rural areas had significantly lower total NQ-P scores ($P < 0.05$) and balance domain scores ($P < 0.01$) than did their urban counterparts. Additionally, household income correlated positively with the total NQ-P scores ($P < 0.001$), balance scores ($P < 0.001$), and practice scores ($P < 0.05$), whereas no significant differences were observed in the moderation domain.

3. Primary caregivers' food literacy, social support, and food environment scores

Table 3 presents the total scores for primary caregivers' food literacy, social support, and food environment by urban/rural area and monthly household income. Regarding food literacy, urban caregivers had significantly higher total ($P < 0.01$), production ($P < 0.05$), intake ($P < 0.01$), and disposal ($P < 0.05$) domain scores. Income-based analysis revealed significantly higher food literacy scores in the higher-income groups across all domains, including total score ($P < 0.001$), production ($P < 0.001$), selection ($P < 0.001$), preparation and cooking ($P < 0.001$), intake ($P < 0.001$), and disposal ($P < 0.01$). Although social support scores showed no significant regional differences, they varied significantly according to income level ($P < 0.01$), with high-income groups scoring the highest, followed by middle-income, and low-income groups. Food environment analysis showed significantly higher scores in urban versus rural areas ($P < 0.001$), which increased with higher household income levels ($P < 0.001$).

4. Impact of primary caregivers' characteristics on preschoolers' NQ-P scores

Table 4 presents the correlations between primary caregivers' characteristics and preschoolers' NQ-P scores. Significant positive correlations were found between preschoolers' NQ-P scores and caregivers' food literacy,

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social support, food environment, and the perceived effectiveness of nutrition education (all $P < 0.001$). A stepwise multiple linear regression analysis (Table 5) revealed that caregivers' social support ($P < 0.001$), food literacy ($P < 0.001$), monthly income ($P < 0.01$), and food environment ($P < 0.05$) were significant predictors of preschoolers' NQ-P scores (adjusted $R^2 = 0.188$, $P < 0.001$). Social support, food literacy, and food environment were positively associated and lower income was negatively associated with preschoolers' NQ-P scores.

Table 3. Scores of food literacy, social support and food environment by region and household income

Variable	Total (n = 1,116)	Region		*P*-value[1)]	Household income			*P*-value[2)]
		Urban (n = 997)	Rural (n = 119)		Upper (n = 356)	Middle (n = 420)	Low (n = 340)	
Food literacy[3)]	62.3 ± 13.8	62.7 ± 13.7	59.2 ± 14.4	0.008	65.6 ± 13.8[c]	62.6 ± 13.3[b]	58.7 ± 13.5[a]	< 0.001
Production	54.0 ± 21.3	54.5 ± 21.1	49.4 ± 23.1	0.013	57.7 ± 22.1[c]	54.6 ± 20.9[b]	49.3 ± 20.2[a]	< 0.001
Selection	59.0 ± 17.1	59.2 ± 16.9	57.3 ± 19.1	0.259	60.9 ± 18.0[b]	59.8 ± 16.8[b]	55.9 ± 16.2[a]	< 0.001
Preparation and cooking	69.0 ± 15.2	69.2 ± 15.2	67.3 ± 15.0	0.197	72.5 ± 14.8[c]	68.5 ± 14.7[b]	66.0 ± 15.6[a]	< 0.001
Intake	62.6 ± 17.1	63.2 ± 16.8	58.0 ± 18.7	0.002	66.8 ± 16.1[c]	62.9 ± 16.1[b]	57.9 ± 18.2[a]	< 0.001
Disposal	68.6 ± 16.6	69.0 ± 16.4	65.8 ± 17.2	0.044	71.1 ± 16.0[b]	68.4 ± 16.1[a]	66.4 ± 17.3[a]	0.001
Social support[4)]	4.0 ± 0.7	4.0 ± 0.7	3.9 ± 0.7	0.053	4.1 ± 0.6[b]	4.0 ± 0.7[a]	3.9 ± 0.6[a]	0.005
Food environment[5)]	3.7 ± 0.7	3.7 ± 0.7	3.4 ± 0.8	< 0.001	3.8 ± 0.7[c]	3.7 ± 0.7[b]	3.5 ± 0.8[a]	< 0.001

Mean ± SD.
[1)]*P*-value was determined by t-test.
[2)]*P*-value was determined by ANOVA.
[3)]This score encompasses the balance, moderation, practice dimensions of NQ-P.
[4)]Measured using a 5-point Likert scale (never = 1, always = 5).
[5)]Measured using a 5-point Likert scale (strongly disagree= 1, strongly agree = 5).
[a,b,c]Values with different superscripts within each row are significantly different at $P < 0.05$, as determined by Duncan's multiple comparison test.

Table 4. Correlation analysis of NQ-P, food literacy, social support, food environment and nutrition education effectiveness

	NQ-P	Food literacy	Social support	Food environment	Nutrition education effectiveness
NQ-P	1				
Food literacy	0.361***	1			
Social support	0.368***	0.502***	1		
Food environment	0.255***	0.372***	0.399***	1	
Nutrition education effectiveness	0.162***	0.323***	0.262***	0.225***	1

NQ-P, nutrition quotient for preschoolers.
***P*-value was determined by correlation analysis.

Table 5. Linear multiple regression analysis to explore factors related to the NQ-P in each domain (stepwise)

Variable	B	SE	β	t	*P*-value[1)]	TOL	VIF
(Constant)	21.198	2.255			< 0.001		
Social support	1.039	0.146	0.231	7.139	< 0.001	0.695	1.440
Food literacy	0.172	0.028	0.201	6.227	< 0.001	0.699	1.430
Household income (low)[2)]	−2.371	0.705	−0.093	−3.361	0.001	0.960	1.042
Food environment	0.238	0.097	0.074	2.451	0.014	0.794	1.260
$F = 65.577$; $P < 0.001$; $R^2 = 0.191$; adj. $R^2 = 0.188$							

NQ-P, nutrition quotient for preschoolers; SE, standard error; TOL, tolerance; VIF, variance inflation factor.
[1)]*P*-value was determined by linear multiple regression analysis.
[2)]Reference group: household income (upper).

5. Nutrition education needs assessment

Table 6 presents primary caregivers' perceptions of nutrition education effectiveness and recent participation in nutrition education programs. The mean effectiveness score of nutrition education was 3.9, with no significant urban–rural differences. However, income-related differences were observed, with lower-income caregivers rating nutrition education effectiveness lower than did middle- and high-income caregivers ($P < 0.01$). Regarding participation in nutrition education programs within the past 3 months: about one-quarter reported participation, more than half stated that they had not participated, and the remainder were unsure. Significant urban-rural differences were noted ($P < 0.01$), whereas no significant differences were observed across income levels.

Table 7 presents caregivers' preferred nutrition education topics, which included the following, in descending order of preference: healthy eating education, sensory education using food ingredients, food hygiene education, unbalanced diet education, sustainable dietary education, cooking education, traditional food culture education, and other.

DISCUSSION

The preschool years represent a crucial period for establishing lifelong dietary habits, and preschoolers' eating

Table 6. Scores of nutrition education effectiveness and nutrition education experience by region and household income

Variable	Total (n = 1,116)	Region		*P*-value	Household income			*P*-value
		Urban (n = 997)	Rural (n = 119)		Upper (n = 356)	Middle (n = 420)	Low (n = 340)	
Nutrition education effectiveness	3.9 ± 0.9	3.9 ± 0.9	3.8 ± 0.9	0.495[1)]	3.9 ± 0.9[b]	3.9 ± 0.8[b]	3.7 ± 0.9[a]	0.003[2)]
Nutritional education experience within 3 months				0.004[3)]				0.144[3)]
Yes	296 (26.5)	265 (26.6)	31 (26.0)		93 (26.1)	122 (29.1)	81 (23.8)	
No	635 (56.9)	579 (58.1)	56 (47.1)		201 (56.5)	242 (57.6)	192 (56.5)	
Not sure	185 (16.6)	153 (15.3)	32 (26.9)		62 (17.4)	56 (13.3)	67 (19.7)	

Mean ± SD.
[1)]*P*-value was determined by t-test.
[2)]*P*-value was determined by ANOVA.
[3)]*P*-value was determined by Chi-square test.
[a,b]Values with different superscripts within each row are significantly different at $P < 0.05$, as determined by Duncan's multiple comparison test.

Table 7. Desired nutrition education topics for preschool children

Variable	Total (n = 1,116)	Region		Household income		
		Urban (n = 997)	Rural (n = 119)	Upper (n = 356)	Middle (n = 420)	Low (n = 340)
Nutrition education on healthy eating[1)]	654 (20.8)	587 (21.0)	67 (19.2)	213 (21.0)	253 (21.5)	188 (19.7)
Sensory education	606 (19.3)	544 (19.4)	62 (17.8)	186 (18.3)	211 (18.0)	209 (21.9)
Food hygiene	581 (18.5)	516 (18.4)	65 (18.7)	202 (19.9)	219 (18.6)	160 (16.7)
Unbalanced diet	499 (15.9)	449 (16.1)	50 (14.4)	164 (16.2)	184 (15.7)	151 (15.8)
Sustainable diet	330 (10.5)	290 (10.4)	40 (11.5)	103 (10.2)	129 (11.0)	98 (10.2)
Cooking	252 (8.0)	222 (7.9)	30 (8.6)	76 (7.5)	97 (8.2)	79 (8.3)
Traditional food culture	209 (6.6)	178 (6.4)	31 (8.9)	67 (6.6)	75 (6.4)	67 (7.0)
Others	14 (0.4)	11 (0.4)	3 (0.9)	3 (0.3)	7 (0.6)	4 (0.4)
Total	3,145 (100)	2,797 (100)	348 (100)	1,014 (100)	1,175 (100)	956 (100)

n (%).
[1)]Multiple response.

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behaviors are strongly influenced by their primary caregivers. This study thus examined preschoolers' NQ-P scores and the association thereof with caregivers' food literacy, social support, food environment, and nutrition education needs.

The findings indicate that the mean NQ-P score was 52.3, with scores for the balance domain of 48.6, moderation domain of 40.4, and practice domain of 59.5. Compared to previous nationwide studies [21], these scores were generally lower, likely due to the inclusion of preschoolers aged 0–1 year, who typically exhibit less independent dietary behaviors. Regional disparities were observed, as preschoolers in rural areas exhibited significantly lower total NQ-P scores ($P < 0.05$) and balance domain scores ($P < 0.01$) than did their urban counterparts. These differences may be attributed to limited access to diverse nutritious foods and disparities in the availability of nutrition education in rural settings. Additionally, higher household income was associated with significantly better dietary quality, as indicated by higher total NQ-P ($P < 0.001$), balance domain ($P < 0.001$), and practice domain ($P < 0.05$) scores, consistent with previous studies demonstrating the influence of socioeconomic factors on preschoolers' dietary behaviors [28, 29]. These findings highlight the need for targeted interventions to reduce disparities between nutrition education and food environments.

The mean food literacy score of the primary caregivers was 62.3, with domain scores of 54.0 for production, 59.0 for selection, 69.0 for preparation and cooking, 62.6 for intake, and 68.6 for disposal. Urban caregivers had significantly higher food literacy scores than did rural caregivers ($P < 0.01$), and high-income groups exhibited significantly higher food literacy scores than did middle- and low-income groups ($P < 0.001$), which was consistent with the findings of previous research [30, 31] on the importance of parental food literacy in preschoolers' nutritional status. The mean social support score was 4.0, with higher scores observed in high-income groups ($P < 0.01$), consistent with prior findings that low-income households tend to have lower social support and inadequate food environments at home [32]. Given the critical role of the home food environment in child development, government intervention for economically disadvantaged households is necessary. Food environment analysis revealed significant differences across urban–rural locations and across income levels. Urban caregivers reported significantly higher food environment scores across all domains ($P < 0.001$), while a higher monthly income was significantly associated with greater food environment scores ($P < 0.001$). These findings align with those of previous studies [33, 34] that reported challenges in accessing fresh food and food desert phenomena in low-income and rural areas.

Analysis of the factors influencing preschoolers' nutritional status showed that primary caregivers' social support ($P < 0.001$), food literacy ($P < 0.001$), income status ($P < 0.01$), and food environment ($P < 0.05$) significantly affected preschoolers' NQ-P scores (adjusted $R^2 = 0.188$, $P < 0.001$). Primary caregivers play a pivotal role in preschoolers' dietary habits and meal patterns as caregivers' food choices and home food environments directly influence their nutritional status [10, 17]. Differences in access to nutritional information, the ability to purchase healthy food, and opportunities to participate in health programs appear to be particularly prominent in high-income households and urban areas. Therefore, nutrition education programs should be tailored to caregivers' characteristics, and regional and economic circumstances. Specifically, policy support and expanded nutrition education programs are essential for low-income and rural populations, along with concrete measures to enhance fresh food purchasing conditions and to improve access to nutritional information. Previous studies have demonstrated that government-led nutrition support programs, such as the Nutrition Plus program, effectively improve the nutritional status of preschoolers and caregivers [35-37]. Sustained policies and support are needed, including increased financial support and the expansion of nutrition assistance programs, such as Nutrition Plus, food banks, and food vouchers.

Additionally, the development and continuous operation of nutrition education programs involving collaboration among childcare centers, home environments, and children's food service management support centers should be ensured. For rural areas, policy interventions, such as mobile markets and fresh food delivery services, should be considered to enhance fresh food purchasing environments.

Regarding preferred nutrition education topics, primary caregivers prioritized healthy eating education (20.8%), sensory education using food ingredients (19.3%), food hygiene education (18.5%), and picky eating management (15.9%). These preferences align with previous research [17, 18] and reflect an increased awareness of food hygiene owing to the COVID-19 pandemic. These findings underscore the importance of identifying the nutrition education needs of primary caregivers and developing well-structured, sustainable nutrition education programs.

Limitations

This cross-sectional study based on proxy reporting by primary caregivers and self-administered online surveys using convenience sampling has limitations in establishing clear causal relationships. Additionally, as the existing NQ-P was developed for preschoolers aged 3–5 years, the NQ-P criteria may not be applicable to children aged 0–2 years. Furthermore, the survey's reliance on primary caregivers' subjective assessments may not accurately reflect preschoolers' dietary habits and nutritional status. To address this, objective data collection methods (e.g., meal observations and food intake frequency surveys) should be incorporated. Finally, given that both NQ-P scores and diet-related factors (food literacy, social support, and food environment) showed differences according to monthly household income and residential areas, further research is needed to develop strategies to reduce socioeconomic disparities. Despite these limitations, this study provides valuable baseline data for a comprehensive understanding of preschoolers' dietary environments and nutritional status, as well as for policy development and support.

Conclusion

This study examined the associations of primary caregivers' food literacy, social support, and food environment with preschoolers' NQ-P. These findings indicate that caregivers' nutritional knowledge, social environment, and access to healthy foods significantly affect preschoolers' dietary behaviors, underscoring the importance of caregiver-focused nutrition education interventions.

CONFLICT OF INTEREST

There are no financial or other issues that might lead to conflict of interest.

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DATA AVAILABILITY

Research data is available from the corresponding author upon request.

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