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Healthy diets positively associated with health-related quality of life in children and adolescents from low socioeconomic areas: Findings from the Greek Food Aid Program, DIATROFI

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ABSTRACT

Objectives: To assess the relationship of diet with health-related quality of life (HRQoL) in vulnerable children and adolescents.
Methods: Data included 6583 children and adolescents (aged 3–18 years old) from the Greek Food-Aid DIATROFI Program in the 2015 to 2016 and 2017 to 2018 school years. HRQoL was measured with the Pediatric Quality of Life Inventory questionnaire and diet with food frequency questionnaires. The healthy plant-based diet index (hPDI), animal score, and dietary patterns were investigated.
Results: The hPDI and animal score were associated with good HRQoL (odds ratio [OR] [95% confidence interval], 10-unit increase: OR_{hPDI} = 1.28 [1.05, 1.57], OR_{animal} = 1.51 [1.14, 2.00]) and physical (OR_{animal} = 1.62 [1.23, 2.13]), emotional (OR_{hPDI} = 1.30 [1.07, 1.58], OR_{animal} = 1.41 [1.08, 1.85]) and school function (OR_{hPDI} = 1.32 [1.09, 1.59], OR_{animal} = 1.46 [1.12, 1.89]). Dietary patterns of fruits, raw vegetables, and cheese were associated with good HRQoL (OR of 1-unit increase: 1.22 [1.13, 1.32]), and physical OR = 1.18 [1.09, 1.27]) and emotional function (OR = 1.09 [1.02, 1.18]). Starchy foods and sweetened beverages were associated with poor HRQoL (OR = 0.75 [0.63, 0.90]), and emotional (OR = 0.80 [0.68, 0.95]) and school function (OR = 0.72 [0.61, 0.85]).
Conclusion: Healthy diets and dietary patterns were positively associated with the HRQoL of vulnerable children and adolescents, which may offer opportunities for prevention.

Introduction

Childhood and adolescence are important life stages during which it is crucial to investigate the relations of health-related determinants with short- and long-term health. Health-related quality of life (HRQoL) provides a measure of overall physical and psychosocial well-being, and thus can be an indicator for disease [1,2]. Poor physical function is a risk factor for chronic diseases [3], and poor emotional, social and school function are risk factors for poor mental and physical health, and social development [4,5]. Additionally, children and adolescents who struggle with mental well-being are at higher risks of having mental disorders and comorbidities in adulthood [6]. Thus, monitoring HRQoL and designing interventions to improve HRQoL during childhood and adolescence could be essential to promoting positive health outcomes throughout the life course.

Several factors are associated with the HRQoL of children and adolescents. Low socio-economic status (SES), child mental health problems and lack of social support have been associated with poor child and adolescent HRQoL [7,8]. In contrast, higher parental education, parental work status and family wealth have been positively associated with HRQoL [9]. Healthy diets and dietary behaviors have also been positively associated with HRQoL in children and adolescents of the general population [10]. Additionally, healthy diets have generally been associated with improved mental health and academic performance in children and adolescents [11,12]. Healthy, balanced diets supply

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children and adolescents with the necessary energy and nutrients needed to promote physical and psychosocial health, and growth and development [10,13]. While it may be challenging to improve the social and demographic factors that contribute to poor HRQoL and health outcomes in children and adolescents, dietary interventions may provide a more accessible means by which their HRQoL could be improved.

While these relations have been investigated in children and adolescents with chronic diseases and those from the general population, few studies have investigated the associations of diet with the HRQoL of vulnerable children and adolescents, such as those from low SES and immigrant backgrounds. This is vital since children and adolescents from these communities are exposed to additional HRQoL risk factors, including limited access to healthcare and recreational activities, financial difficulties, family stress, language barriers and discrimination [8,14,15]. Children and adolescents from low SES or immigrant backgrounds are at higher risk of poor physical and mental health, poor cognitive development, and school performance, and social exclusion [15,16]. In addition, nutritional education and consumption of nutrient-dense foods, due to food insecurity, are poorer in these communities [17,18].

To address these issues, school-based food aid and nutritional education programs, such as the DIATROFI program in Greece, have been established to improve the health outcomes of children and adolescents from vulnerable communities [8,19,20]. Recent studies by the DIATROFI program have shown that improvement in adherence to a Mediterranean diet (as defined by the KIDMED score [21]) was associated with improved health-related quality of life (HRQoL), and emotional and social function [20]. Given these relations and the fact that KIDMED scores provide only a predefined proxy of diet quality, we aimed to assess the relationship of diet quality and dietary patterns (derived from food frequency questionnaires) with HRQoL in 6583 children and adolescents of the DIATROFI program.

Methods

Participants and procedures

This study used baseline data on 6583 students (aged 3–18 years old) participating in the Greek DIATROFI program for the first time during the 2015 to 2016 (*n* = 5058) and 2017 to 2018 (*n* = 1525) study years (http://diatrofi.prolepsis.gr/en/). These study years were selected based on the criteria that they were the most recent study years with the largest sample sizes prior to the COVID-19 pandemic (as factors related to COVID-19 could not be adjusted for and can contribute to HRQoL). The DIATROFI program was implemented in 2012 with the support of the Greek Ministry of Education and Religious Affairs to provide food aid for children and adolescents attending schools in areas of low SES in Greece. Details of the DIATROFI program have been previously described [8,19]. Briefly, along with providing food aid, and nutrition education activities, a detailed questionnaire, including questions on socio-demographics, nutrition, well-being, and others, was completed by parents/guardians. Questionnaires were returned to school principals, and thereafter provided to the research team to ensure anonymity. Prior to participating in the program, all parents and school personnel were presented with a comprehensive information letter outlining the program's objectives, implementation, and methodology. Informed consent was obtained from parents prior to their participation. The DIATROFI Program received ethical approval from the National and Kapodistrian University of Athens' Bioethics Committee and the Ethical Committee of Prolepsis Institute (13416-10/2021). The program is conducted in compliance with the Declaration of Helsinki and adheres to all relevant institutional regulations concerning the ethical use of human subjects and volunteers.

Measures

HRQoL

The dependent variables of this study included several HRQoL measurements in children and adolescents. These measurements were evaluated using the Pediatric Quality of Life Inventory questionnaire (PedsQL), which has been validated for the Greek population [22], according to the authors' scoring instructions (https://www.pedsql.org/score.html; see Supplementary Methods for more details). The PedsQL includes physical, emotional, social and school function domains, and a total HRQoL score, comprising all domains. Due to the lack of national thresholds and the left skewness of the domains and total scores, these scores were dichotomized as "poor-to-average scores" and "good scores," based on the 15th percentile, and were additionally investigated as continuous variables by transforming the scores to percentiles.

Dietary features

Two dietary indexes and five dietary patterns were the independent variables of this study. These dietary features were derived from a modified semi-quantitative food frequency questionnaire (FFQ; [23], where 75 FFQ items were assessed on a scale starting from "never/less than once a month" to "more than twice a day." Food item frequencies were converted to (weighted) calculation values, with the assumption that 1 month included 28 d, and specific criteria were applied to remove biased reporting of the FFQ (Supplementary Methods). The diet quality indexes included the previously described healthy plant-based diet index (hPDI; [24] and an animal score [25] Table S1). The five dietary patterns representing students' eating habits were derived by factor analysis (FA; see Factor Analysis below the heading "Data handling").

Socio-demographic and anthropometric characteristics

Socio-demographic and anthropometric characteristics were acquired from the questionnaire and included age, students' sex, parents and students' country of birth, students' immigration status, students' screen time duration, family SES, school region, and students' BMI. *Students' immigration status* was defined as "non-immigrant," "first-generation immigrant," and "second-generation immigrant" according to the reported parents' and student's country of birth, as previously described [8]. Non-immigrants included students who were born in Greece and whose parents (both) were also born in Greece. First-generation immigrants included students born abroad, with at least one parent born abroad, and second-generation immigrants included students who were born in Greece with at least one parent born abroad. *Family SES* was defined using the Family Affluence Scale (FAS; [26], which considers the number of cars and computers a family owns, how often they travel, and if the student has their own room. By summing the values of these variables, a composite FAS score was derived, which was further categorized into a three-point ordinal scale of low- (0–2), moderate- (3–5), and (6–9) high-affluence corresponding to low, moderate and high family SES. *BMI standard deviation scores* (SDS) were generated with the Growth Analyzer Research Calculation Tool (version 4.1) using the 0 to 19-year-old World Health Organization (WHO) World 2007 (Brazil, Ghana, Indian, Oman, Norway, and United States of America) reference [27,28]. BMI SDS were categorized based on WHO standards as "severe thinness" (-3 standard deviations [SDs]), "thinness" (-2 SDs), "normal" (0–5 y: -2>+2 SDs, 6–18 y: -2>+1 SDs), "overweight" (0–5 y: +2 SDs, 6–18 y: +1 SDs) and "obese" (0–5 y: -+3 SDs, 6–18 y: +2 SDs; [29].

Data handling and analysis

Factor analysis (FA) for data handling

To investigate students' dietary habits, dietary patterns were first derived by FA using the extraction method of principal components on all weighted FFQ items, using the regression method. Suitability for conducting FA was confirmed by Bartlett's test of sphericity and the Kaiser-Mayer-Olkin (KMO) test, where KMO values for all items were >0.8. To determine the number of dietary patterns to retain, eigenvalues ≥ 2.0 were considered relevant and the "elbow" of the scree plot was investigated. This was followed by orthogonally rotating (Varimax rotation method) the components. For each component, food items with loadings $|\geq 0.4|$ were considered to contribute significantly to the pattern (Table S2). Component scores were calculated with the regression method [30] 2009. Bartlett's test of sphericity and the KMO test were conducted using the *psych* package, version 2.2.9, in R, and FA was implemented using the *factanal* function of the stats package, version 4.2.1, in R.

Statistical analysis

Continuous variables were presented as mean values (standard deviation) for normally distributed variables and median values (interquartile range) for non-normally distributed variables. Descriptive statistics were investigated by the Wilcoxon and Kruskal-Wallis rank-sum tests for groups of 2, or 3 or more levels, respectively, due to the non-normal distribution of HRQoL scores (tested through histogram, Q-Q plot, and Kolmogorov-Smirnoff test). To investigate the relationship between students' dietary indexes and dietary patterns with students' HRQoL measurements, we used multiadjusted logistic regression (for dichotomized HRQoL measurements) and linear regression (for HRQoL measurements transformed into percentiles). For the logistic models, dietary indexes were reduced 10 times to investigate the relationship between a 10-unit increase of the dietary indexes on the HRQoL outcomes. Models were first adjusted for determinants (e.g., age, sex, family SES, and immigrant status) based on literature, and then further adjusted for determinants identified as having a higher predictive value for HRQoL than the dietary features (see Data-Driven Determinants of HRQoL in Supplementary Methods and Fig. S1). Results were reported as odds ratios (OR) and their corresponding 95% confidence intervals (95%CI) for logistic regression, and as β coefficients and standard errors (SE) for linear regression. For linear regressions, Benjamini-Hochberg correction was used to adjust for multiple testing and a false discovery rate (FDR) below 5% was considered statistically significant, while *P*-values <0.05 were considered nominally significant. For the data analysis, base R (v 4.3.2) was used, along with the *foreach* (v 1.5.2) and *basecamp* (v 1.1.2) packages. All corresponding scripts are available at: https://github.com/snbrushett/dietary_patterns_HRQoL_DIATROFI_study.

Results

Background characteristics

First, the baseline measurements of 6583 DIATROFI program students from the 2015 to 2016 (*n* = 5058) and 2017 to 2018 (*n* = 1525) were assessed (Table 1). Students from the 2015 to 2016 school year, female students, students of normal weight, non-immigrant students, and students from families with middle and high SES had significantly higher HRQoL scores ($P < 0.001$).

Relationships of students' HRQoL with dietary features

Next, to investigate the relations of students' HRQoL with diet we first generated dietary patterns, which were representative of students' habitual diets. Using FA, we identified five dietary patterns, which explained 33.9% of the total variation in dietary intake (Fig. S2, Table S2). The dietary patterns were, 1) meat, seafood, and prepared meals, 2) cooked vegetables, grains, and legumes, 3) fruits, raw vegetables, and cheese, 4) confectioneries and pizza, and 5) starchy foods and sweetened beverages.

Table 1
Students' school and sociodemographic characteristics according to students' health-related quality of life (HRQoL) scores in the 2015 to 2016 and 2017 to2018 baseline measurement of the DIATROFI Program in Greece.

	Total sample	HRQoL, score (Range [0, 100])	*P*-value
Total Sample	*n*=6583	88.04 (17.39)	-
School characteristics			
School year, n (%)			
2015–2016	5058 (76.8)	89.1 (16.3)	<0.001
2017–2018	1525 (23.2)	85.9 (21.7)	
School region, n (%)			
Attica and Central Greece	4152 (64. 6)	88.0 (18.2)	0.041
Central Macedonia	1887 (29.4)	88.6 (17.4)	
Eastern Macedonia and Thrace	159 (6.0)	89.1 (15.2)	
Student characteristics			
Age, years (SD)	9 (4)	-	-
Sex, n (%)			
boys	3377 (52.8)	87.5 (18.1)	<0.001
girls	3022 (47.2)	89.1 (16.3)	
BMI, n (%)			
severe thinness	51 (1.0)	84.8 (22.8)	<0.001
thinness	131 (2.6)	88.0 (16.1)	
normal	2934 (58.0)	89.8 (15.2)	
overweight	1205 (23.8)	88.6 (17.4)	
obese	735 (14.5)	87.0 (19.6)	
Immigrant status, n (%)			
non-immigrant	4137 (66.1)	89.1 (16.3)	<0.001
first-generation	312 (5.0)	88.0 (21.7)	
second-generation	1805 (28.9)	86.3 (18.5)	
Screen time, hours per week (IQR)	5 (5)	-	-
Family characteristics			
Family socio-economic level, n (%)			
low	2005 (31.7)	86.4 (19.6)	<0.001
middle	3326 (52.6)	89.1 (17.4)	
high	989 (15.6)	89.1 (15.2)	

Missing data (n): HRQoL (102), sex (184), BMI (1527), immigrant status (329), screen time (313) and family socio-economic level (263).
HRQoL, Health-Related Quality of Life score; BMI, Body Mass Index.

We then investigated the relationship of students' dietary indexes and dietary patterns with HRQoL measurements using multivariable logistic regression analysis (Tables 2 and 3). We first used a conventional approach to adjust for covariates identified by literature (Models 2), and thereafter, used a data-driven approach to adjust for covariates that had a higher predictive value for HRQoL than the dietary features (Model 3, Fig. S1).

In the unadjusted and adjusted models, a 10-unit increase in the hPDI was significantly and positively associated with total HRQoL, and emotional and school function. Similarly, a 10-unit increase in the animal score was positively associated with total HRQoL and all domain scores, except for social function. For the hPDI, the odds of having good HRQoL, and emotional and school function increased by 1.28 (odds ratio [95% confidence interval]): OR = 1.28 [1.05, 1.57]), 1.30 (OR = 1.30, [1.07, 1.58]) and 1.32 times (OR = 1.32, [1.09, 1.59]), respectively. For the animal score, the odds of having good HRQoL, and physical, emotional, and school function increased by 1.51 (OR = 1.51 [1.14, 2.00]), 1.62 (OR = 1.62 [1.23, 2.13]), 1.41 (OR = 1.41 [1.08, 1.85]) and 1.46 times (1.46 [1.12, 1.89]), respectively.

With regards to dietary patterns, after adjustment, students who had more frequent intakes of fruits, raw vegetables and cheese (dietary pattern 3) were 1.22 times (OR = 1.22 [1.13, 1.32]), 1.18 times (OR = 1.18, [1.09, 1.27]) and 1.09 times (OR = 1.09, [1.02, 1.18]) more likely to have good HRQoL, and physical and emotional function, respectively. In contrast, the odds of having a good HRQoL, emotional function, and school function decreased by 25%, (OR = 0.75 [0.63, 0.90]), 20% (OR = 0.80 [0.68, 0.95]) and 28% (OR = 0.72 [0.61, 0.85]), respectively, if students consumed starchy foods and sweetened beverages (dietary pattern 5) more frequently. Similar findings were also observed when investigating students' HRQoL transformed to continuous percentiles (Table S2).

Discussion

In this study, we aimed to investigate the relationship of diet with HRQoL in vulnerable children and adolescents of the DIATROFI program in Greece. We showed that after adjustment of all determinants with higher predictive value for HRQoL than the dietary features, healthy plant (hPDI) and animal-based (animal score) diets were still positively associated with HRQoL, and emotional and school function. A healthy animal-based diet was also positively associated with physical function. To the best of our knowledge, associations of the hPDI and animal score on HRQoL have not been previously performed [31].

With regards to the dietary patterns derived from FFQ items, we observed that frequent intakes of fruits, raw vegetables and cheese (dietary pattern 3) were positively associated with HRQoL, physical function and emotional function, whereas frequent intakes of starchy foods and sweetened beverages (dietary pattern 5) were negatively associated with HRQoL, physical function, and school function. Previous studies assessing the relationship of dietary patterns with HRQoL and its domains, across age and disease groups (and including healthy participants), demonstrated that an increase in healthier food patterns, such as the intake of fruits and vegetables, and the reduced intake of "Western" type dietary patterns (defined as "increased intake of saturated fat and refined foods along with low intake of vegetable and fruits") were positively associated with HRQoL and one or more of its domains [32]. Few studies of this kind have been performed in children and adolescents. To our knowledge, only one study on Iranian adolescents of the general population showed that adolescents belonging to

Table 2
The relationship of a 10-unit increase in students' dietary indexes with students' health-related quality of life (HRQoL) measurements (dichotomized based on the 15th percentile) in the 2015 to 2016 and 2017 to 2018 Greek DIATROFI Program baseline assessments.

	Poor-to-average vs. good HRQoL	Poor-to-average vs. good physical function	Poor-to-average vs. good emotional function	Poor-to-average vs. good social function	Poor-to-average vs. good school function
Crude model 1	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
hPDI	1.23 (1.05, 1.44)**	1.15 (0.98, 1.34)	1.22 (1.05, 1.43)*	1.12 (0.96, 1.31)	1.36 (1.18, 1.58)***
Animal score	2.00 (1.62, 2.48)***	1.92 (1.55, 2.38)***	1.59 (1.29, 1.97)***	1.47 (1.19, 1.82)***	1.64 (1.34, 2.00)***
Adjusted model 2					
hPDI	1.25 (1.06, 1.48)**	1.14 (0.96, 1.34)	1.30 (1.10, 1.54)**	1.13 (0.96, 1.33)	1.44 (1.23, 1.69)***
Animal score	1.61 (1.27, 2.03)***	1.62 (1.28, 2.04)***	1.41 (1.12, 1.78)**	1.21 (0.96, 1.53)	1.32 (1.06, 1.65)*
Adjusted model 3					
hPDI	1.28 (1.05, 1.57)*	1.16 (0.95, 1.42)	1.30 (1.07, 1.58)**	1.13 (0.92, 1.39)	1.32 (1.09, 1.59)**
Animal score	1.51 (1.14, 2.00)**	1.62 (1.23, 2.13)**	1.41 (1.08, 1.85)*	1.07 (0.81, 1.42)	1.46 (1.12, 1.89)**

OR, odds ratio; 95%CI, 95% confidence interval; hPDI, healthy plant-based diet index; SES, socio-economic status; BMI-SDS, Body Mass Index standard deviation score. All models were additionally adjusted for margarine intake (see **Dietary quality indexes** in Supplementary Methods for more details).
Logistic regression was applied. Adjusted model 2: model 1 adjusted for age, sex, family socio-economic status and immigrant status. Adjusted model 3: model 2 adjusted for school region, screen time (hrs), school year and BMI-SDS.
***$P < 0.001$.
**$P < 0.01$.
*$P < 0.05$.

the top tertile of a Mediterranean dietary pattern (defined as "high intakes of vegetables, fruits, olives, potatoes, eggs, nuts and legumes, pickles, low-fat dairy, fish, poultry, and vegetable oils") were less likely to have impaired HRQoL than adolescents of the bottom tertile [33]. Overall, our findings are consistent with previous studies on the general and chronic diseases child and adolescent populations [31] and coincide with the current 2020 to 2025 Dietary Guidelines for Americans [13], though studies on vulnerable children and adolescents are limited. Irrespective, the available literature combined with our findings demonstrate the possible generalizability of these relations across different children and adolescent populations (general, diseases and vulnerable) and countries [10,13].

Healthy diets and the increased consumption of nutrient-dense foods, such as fruits and vegetables, supply children and adolescents with the energy levels and nutrients required for optimal physiological functions and physical activity, and to meet cognitive demands, which are all factors that contribute to HRQoL [10,13]. It is interesting to note that to maintain these processes, around 20% of the body's total energy is utilized by the brain, where most of this energy is derived from the metabolism of glucose in the diet [34]. A recent DIATROFI study showed that one year after a food-aid intervention, an increase in children and adolescents' adherence to a Mediterranean diet (which was measured using KIDMED scores) was associated with increased odds of having improved HRQoL, and emotional and social function [20]. Notably, while the

Table 3
The relationship of students' dietary patterns with students' health-related quality of life (HRQoL) measurements (dichotomized based on the 15th percentile) in the 2015 to 2016 and 2017 to 2018 Greek DIATROFI Program baseline assessments.

	Poor-to-average vs. good HRQoL	Poor-to-average vs. good physical function	Poor-to-average vs. good emotional function	Poor-to-average vs. good social function	Poor-to-average vs. good school function
Crude Model 1	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Component 1: meat, seafood and prepared meals	0.92 (0.79, 1.06)	1.00 (0.87, 1.16)	1.04 (0.90, 1.19)	0.94 (0.81, 1.09)	0.95 (0.83, 1.08)
Component 2: cooked vegetables, grains and legumes	0.98 (0.88, 1.08)	0.95 (0.85, 1.05)	1.02 (0.92, 1.13)	0.99 (0.89, 1.10)	1.01 (0.91, 1.11)
Component 3: fruits, raw vegetables and cheese	1.22 (1.16, 1.29)***	1.18 (1.12, 1.25)***	1.10 (1.04, 1.16)***	1.12 (1.07, 1.18)***	1.16 (1.10, 1.21)***
Component 4: confectioneries and pizza	1.16 (0.97, 1.39)	0.97 (0.81, 1.17)	0.96 (0.81, 1.15)	1.17 (0.97, 1.41)	1.27 (1.07, 1.52)**
Component 5: starchy foods and sweetened beverages	0.74 (0.65, 0.84)***	0.83 (0.73, 0.95)**	0.78 (0.68, 0.89)***	0.79 (0.69, 0.91)**	0.65 (0.57, 0.73)***
Adjusted Model 2					
Component 1: meat, seafood and prepared meals	1.00 (0.85, 1.18)	1.06 (0.90, 1.26)	1.09 (0.92, 1.28)	1.03 (0.87, 1.22)	0.99 (0.85, 1.16)
Component 2: cooked vegetables, grains and legumes	0.98 (0.87, 1.10)	0.96 (0.85, 1.08)	1.06 (0.94, 1.19)	0.99 (0.88, 1.12)	1.05 (0.94, 1.18)
Component 3: fruits, raw vegetables and cheese	1.18 (1.11, 1.26)***	1.15 (1.09, 1.23)***	1.07 (1.01, 1.13)*	1.08 (1.02, 1.15)*	1.10 (1.04, 1.17)**
Component 4: confectioneries and pizza	1.08 (0.88, 1.31)	0.92 (0.76, 1.12)	0.92 (0.76, 1.12)	1.07 (0.87, 1.32)	1.17 (0.97, 1.42)
Component 5: starchy foods and sweetened beverages	0.74 (0.64, 0.86)***	0.84 (0.73, 0.98)*	0.78 (0.67, 0.91)**	0.82 (0.70, 0.96)*	0.68 (0.59, 0.78)***
Adjusted Model 3					
Component 1: meat, seafood and prepared meals	1.06 (0.87, 1.29)	1.14 (0.93, 1.40)	1.19 (0.98, 1.45)	1.19 (0.96, 1.48)	0.95 (0.80, 1.14)
Component 2: cooked vegetables, grains and legumes	0.93 (0.80, 1.07)	0.90 (0.78, 1.04)	1.00 (0.87, 1.15)	0.93 (0.80, 1.08)	1.05 (0.92, 1.20)
Component 3: fruits, raw vegetables and cheese	1.22 (1.13, 1.32)***	1.18 (1.09, 1.27)***	1.09 (1.02, 1.18)*	1.09 (1.01, 1.18)*	1.08 (1.01, 1.16)*
Component 4: confectioneries and pizza	1.02 (0.80, 1.28)	0.86 (0.68, 1.09)	0.81 (0.65, 1.02)	0.95 (0.73, 1.23)	1.22 (0.97, 1.53)
Component 5: starchy foods and sweetened beverages	0.75 (0.63, 0.90)**	0.86 (0.73, 1.03)	0.80 (0.68, 0.95)*	0.83 (0.69, 1.01)	0.72 (0.61, 0.85)***

OR, odds ratio; 95%CI, 95% confidence interval; hPDI, healthy plant-based diet index; SES, socio-economic status; BMI-SDS, Body Mass Index standard deviation score.
Logistic regression was applied. Adjusted model 2: model 1 adjusted for age, sex, family socio-economic status and immigrant status. Adjusted model 3: model 2 adjusted for school region, screen time (hrs), school year, and BMI-SDS.
***$P < 0.001$.
**$P < 0.01$.
*$P < 0.05$.

KIDMED scores provided an indication of adherence to a Mediterranean diet [21], FFQs and the dietary patterns derived from the FFQs provide a better representation of the dietary habits and intakes of children and adolescents [13]. Thus, these results, together with the findings of our current study, suggest that an overall improvement in the quality of the diet, with increased intakes of fruits, vegetables and cheese, and a reduction in starchy foods and sweetened beverages, is associated with an improved total HRQoL and its domains.

Overall, our findings suggest that an increase in nutrient-dense foods, such as fruits and vegetables, and a decrease in energy-dense foods, such as starchy foods and sweetened beverages, might not only be associated with improvement in the quality of vulnerable children and adolescent diets, but may also be associated with improving their HRQoL. Given that HRQoL can act as an indicator for several early and later life disease risks, these findings suggest that dietary interventions which improve HRQoL outcomes could also ultimately promote overall positive health outcomes along the life course. Importantly, these findings propose that these relations hold true for children and adolescents from vulnerable communities, which have been understudied. Given that children and adolescents from these communities are most at risk for poor health outcomes throughout the life course, these findings suggest an accessible means, that is, diet, by which their health outcomes could be improved. Notably, in addition to improving HRQoL, a healthy and balanced diet also promotes healthy body weight and reduces chronic disease risks (for example, obesity and diabetes) [13]. Studies have shown that school-based food-aid programs, such as the DIATROFI program in Greece and those implemented by the Healthy, Hunger-Free Kids Act of the US, improved the quality of students' diets and reduced the odds of obesity, especially in children and adolescents in poverty [17,35].

Strength, limitations, and future directions

A strength of this study was the large sample size (n = 6583) that was used to investigate the relationship of diet and HRQoL in children and adolescents from low SES regions of Greece. This enabled us to conduct a data-driven approach to identify and adjust for determinants that could potentially explain the HRQoL in children and adolescents more effectively than diet. Of the determinants that were adjusted for, family SES and immigrant status were among them, which is often not the case. In this study, diet quality and dietary patterns were derived from FFQ items, which provided a representation of the dietary habits of the children and adolescents in our study. It should be noted, however, that a limitation of using FFQ items in this study was that only weighted frequencies of food items were available, and thus we could not account for total caloric intake (kcal/d). Since there are no established national thresholds, another limitation of this study was the categorization of HRQoL measurements into binary groups, which may not precisely capture the experiences of students with poor-to-average HRQoL. However, it served as a proxy that allowed us to explore the HRQoL in children and adolescents, and we were able to show similar findings when dichotomizing HRQoL measurements or transforming them as percentiles. Additionally, physical activity was not adjusted for in our analyses. This could have somewhat confounded our findings given its associations with diet and HRQoL, and should be accounted for in future studies. It is also important to note that this is a cross-sectional study and thus causality cannot be inferred. Lastly, this study only investigated the baseline (before the dietary intervention) relationships of diet with HRQoL in children and adolescents. Future research investigating the long-term impact of dietary interventions on the HRQoL of children and adolescents will provide further evidence whether diet improves their overall HRQoL and health outcomes, irrespective of SES or immigrant background.

Conclusions and public health implications

In this study, we showed that healthy diets and dietary patterns in children and adolescents from vulnerable groups were associated with good HRQoL outcomes. Given that limited studies of these relations exist, these results suggest that in addition to reducing chronic disease risks, healthy diets and dietary patterns may also contribute to the HRQoL of all children and adolescents, independently of SES or immigrant status. This might imply that for vulnerable children and adolescents at high risk of poor HRQoL and health outcomes, dietary interventions could be a relatively accessible approach to improve their HRQoL and health outcomes, which could also potentially increase their odds for positive health outcomes into adulthood.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

S. Brushett: Conceptualization, Formal analysis, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – original draft. **M.L.A. de Kroon:** Data curation, Supervision, Writing – original draft, Writing – review & editing. **K. Katsas:** Formal analysis, Investigation, Methodology, Resources, Software, Writing – original draft, Writing – review & editing. **O. Engel:** Formal analysis, Investigation, Methodology, Resources, Software, Writing – original draft, Writing – review & editing. **S.A. Reijneveld:** Supervision, Writing – original draft, Writing – review & editing. **A. Linos:** Funding acquisition, Project administration, Supervision, Writing – original draft, Writing – review & editing.

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Supplementary materials

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References

[1] Ravens-Sieberer U, Karow A, Barthel D, Klasen F. How to assess quality of life in child and adolescent psychiatry. Dialogues Clin Neurosci 2014;16:147–58.

[2] OECD. Measuring what matters for child well-being and policies. Paris: OECD Publishing; 2021. https://doi.org/10.1787/e82fded1-en.

[3] Booth FW, Roberts CK, Laye MJ. Lack of exercise is a major cause of chronic diseases. Compr Physiol 2012;2:1143–211. https://doi.org/10.1002/cphy.c110025.

[4] Tempelaar WM, de Vos N, Plevier CM, van Gastel WA, Termorshuizen F, MacCabe JH, et al. Educational level, underachievement, and general mental health problems in 10,866 adolescents. Acad Pediatr 2017;17:642–8. https://doi.org/10.1016/j.acap.2017.04.016.

[5] Segrin C. Indirect effects of social skills on health through stress and loneliness. Health Commun. 2019;34:118–24. https://doi.org/10.1080/10410236.2017.1384434.

[6] Otto C, Reiss F, Voss C, Wüstner A, Meyrose A-K, Hölling H, et al. Mental health and well-being from childhood to adulthood: design, methods and results of the 11-year follow-up of the BELLA study. Eur Child Adolesc Psychiatry 2021;30:1559–77. https://doi.org/10.1007/s00787-020-01630-4.

[7] Ravens-Sieberer U, Erhart M, Gosch A, Wille N, Group TEK. Mental health of children and adolescents in 12 European countries—results from the European KIDSCREEN study. Clin Psychol Psychother. 2008;15:154–63. https://doi.org/10.1002/cpp.574.

[8] Diamantis DV, Stavropoulou I, Katsas K, Mugford L, Linos A, Kouvari M. Assessing quality of life in first- and second-generation immigrant children and adolescents; highlights from the DIATROFI food aid and healthy nutrition promotion program. Int J Environ Res Publ Health 2023;20:2471. https://doi.org/10.3390/ijerph20032471.

[9] von Rueden U, Gosch A, Rajmil L, Bisegger C, Ravens-Sieberer U. Socioeconomic determinants of health related quality of life in childhood and adolescence: results from a European study. J Epidemiol Community Health 2006;60:130–5. https://doi.org/10.1136/jech.2005.039792.

[10] Wu XY, Zhuang LH, Li W, Guo HW, Zhang JH, Zhao YK, et al. The influence of diet quality and dietary behavior on health-related quality of life in the general population of children and adolescents: a systematic review and meta-analysis. Qual Life Res 2019;28:1989–2015. https://doi.org/10.1007/s11136-019-02162-4.

[11] Rampersaud GC, Pereira MA, Girard BL, Adams J, Metzl JD. Breakfast habits, nutritional status, body weight, and academic performance in children and adolescents. J Am Dietet Assoc 2005;105:743–60. https://doi.org/10.1016/j.jada.2005.02.007.

[12] Kim SY, Sim S, Park B, Kong IG, Kim J-H, Choi HG. Dietary habits are associated with school performance in adolescents. Medicine (Baltimore) 2016;95:e3096. https://doi.org/10.1097/MD.0000000000003096.

[13] U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2020-2025. 9th Edition Washington D.C.: The U.S. Government; 2020. Available at: https://www.dietaryguidelines.gov/.

[14] Chaudry A, Wimer C. Poverty is not just an indicator: the relationship between income, poverty, and child well-being. Acad Pediatr 2016;16:S23–9. https://doi.org/10.1016/j.acap.2015.12.010.

[15] Toppelberg CO, Collins BA. Language, culture, and adaptation in immigrant children. Child Adolesc Psychiatr Clin N Am 2010;19:697–717. https://doi.org/10.1016/j.chc.2010.07.003.

[16] Chang R, Li C, Qi H, Zhang Y, Zhang J. Birth and health outcomes of children migrating with parents: a systematic review and meta-analysis. Front Pediatr 2022;10:810150. https://doi.org/10.3389/fped.2022.810150.

[17] Zota D, Dalma A, Petralias A, Lykou A, Kastorini C-M, Yannakoulia M, et al. Promotion of healthy nutrition among students participating in a school food aid program: a randomized trial. Int J Public Health 2016;61:583–92. https://doi.org/10.1007/s00038-016-0813-0.

[18] Kastorini C-M, Markaki I, Tsiampalis T, Critselis E, Petralias A, Linos A, et al. Dietary patterns and food insecurity of students participating in a food aid programme: the Mediterranean perspective. Eur J Public Health 2021;31:143–50. https://doi.org/10.1093/eurpub/ckaa178.

[19] Yannakoulia M, Lykou A, Kastorini CM, Papasaranti ES, Petralias A, Veloudaki A, et al. Socio-economic and lifestyle parameters associated with diet quality of children and adolescents using classification and regression tree analysis: the DIATROFI study. Public Health Nutr 2016;19:339–47. https://doi.org/10.1017/S136898001500110X.

[20] Diamantis DV, Katsas K, Kalogiannis D, Kouvari M, Linos A. Health-related quality of life in childhood and adolescence: the interrelation with level of adherence to mediterranean diet and dietary trajectories: highlights from the DIATROFI program (2021−2022). Nutrients 2023;15:1829. https://doi.org/10.3390/nu15081829.

[21] Serra-Majem L, Ribas L, Ngo J, Ortega RM, García A, Pé