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Nutrition and sustainable development goal 10: reduced inequalities, 2nd edition

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Nutrition and sustainable development goal 10: reduced inequalities, 2nd edition

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Editorial: Nutrition and sustainable development goal 10: reduced inequalities

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KEYWORDS

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Editorial on the Research Topic
Nutrition and sustainable development goal 10: reduced inequalities

The United Nations Sustainable Development Goals (SDGs) are the cornerstone of the 2030 Agenda for Sustainable Development. Nutrition-related challenges occupy an important place within this agenda. Indeed, the increasing prevalence of cardiometabolic diseases in the last decades constitutes the main concern for public health worldwide and it can have a lasting impact on the development of urbanized societies (1). Moreover, the necessity to develop sustainable and resilient agro-food systems to protect the environment has become a priority in all international policies (2). Accordingly, in a globalized world experiencing an overall urban transition, the Nutrition and Sustainable Development Goal (SDG) 10: Reduced Inequalities, aims to provide new theoretical and empirical insights, on nutrition-related issues situated at the crossroads of health and environmental dimensions, to identify at-risk subgroups in different socio-ecological contexts and to suggest alternatives to improve both human and environmental health.

Through the articulation of 14 relevant contributions that include 10 original case studies conducted worldwide, 1 clinical trial, 2 literature reviews, and 1 brief research report, the SDG 10: Reduced Inequalities provided relevant outcomes along with critical analyses and interpretations to illustrate challenges and initiatives around nutrition-related health and environmental issues. Through contributions focusing on the determinants of nutritional health, but also on issues and orientations of agro-food systems at both the national and regional levels, the SDG 10: Reduced Inequalities provides an original overview of factors leading to at-risk dietary patterns and potential socio-political strategies to address such public health issues in a medium- or long-term perspective. This Research Topic has a specific focus on Low- and Middle-income Countries where the urbanization rates are highest (3), as the incidence of obesity-related cardiometabolic diseases (4), while the sustainability of agro-food systems becomes a social priority with increasing soil deterioration (5).

Hence, the first two contributions, by Shifera et al. and Mengstie et al., focused on the determinants of malnutrition in Ethiopia. These works showed that rural and socially excluded populations are more exposed to undernutrition, both for children and mothers. Such trends are in line with the literature, which highlights that countries in the early stages of urban transition present persistently high rates of stunting, wasting and underweight. In continuity with these works, two contributions in Iran, by Ebrahimi et al. and Roustaee et al., showed that along the urbanization process, the consumption of processed energy-dense foods increases in multiple age groups, with a higher risk of obesity-related cardiometabolic diseases. Such a comparative framework sheds light

on how countries in more advanced stages of urban transition, such as Iran, are more exposed to new forms of malnutrition like over nutrition, compared to countries that still maintain a pre-industrial lifestyle in some spaces, such as Ethiopia or Bangladesh where another relevant contribution was realized by Islam et al.. Then, Mhamad et al. showed that the prevalence of stunting among preschool children in Iraq is relatively low in some urban areas of the country. The SDG 10 also benefits from a scoping review conducted by John et al. in Nigeria, the largest economy in Africa, which highlights the evidence of an ongoing double burden of malnutrition among children under five years, between persisting undernutrition favoring wasting/stunting and increasing over nutrition favoring overweight/obesity. Meanwhile, in a high income country like China, Jiang et al. described how the social isolation of the elderly reduces health-related quality of life.

This Research Topic presents several contributions on socio-political strategies to improve nutritional health, especially in urbanized areas, with potential positive fallouts on environmental health. For example, in addition to the previous contribution from Nigeria by John et al., which recommends health policy interventions at all levels (individual, household, regional and national), Stadlmayr et al. conducted a scoping review in sub-Saharan Africa highlighting the necessity to improve the food environment to favor greater access to fruits and vegetables, through food safety, sustainable local production, lower prices and food diversity. Another contribution by Hudson et al. showed that school gardening, nutrition education, and cooking programs delivered to elementary children may positively influence the home food environment in the Austin area of Texas (USA). In the continuity of these works, Liu et al. discussed the positive role of self-efficacy in the relationship between age, social isolation and poorer nutritional literacy in rural China, which is associated with a higher number of chronic diseases. Then, in the suburban area of Berlin in Germany, a contribution by Darkhani underlined the positive role of women in the development of alternative food networks to favor environmentally sustainable modes of production, certified food quality, food safety consciousness, and health and nutrition concerns. In addition, Brukalo et al. highlighted how public procurement of fatty products for Polish educational units can be improved to promote children's health. Hence, standardized guidelines are required to promote healthier food choices, encourage sustainable diets, and ultimately improve the overall health and wellbeing of children. Finally, in the context of the current ecological crisis, specifically the increasing number of natural disasters in Indonesia, a clinical trial conducted by Fatmah demonstrated that *Api-api* mangrove, an abundant plant species in coastal areas of the country, consumed as sword bean snack bars constitutes a viable and efficient substitute for emergency food provisions, particularly in disaster-stricken communities.

Accordingly, based on these fruitful contributions, the SDG 10 provides new insights to identify at-risk subgroups for nutrition-related diseases along the global urban transition. Children under five years, older adults and socially excluded populations are all subgroups overexposed to stunting, wasting or overweight, depending on the current stage of urban transition in their respective countries. This Research Topic innovatively presents a clear overview of the ongoing nutritional transition associated with the globalized urbanization process. Moreover, the SDG 10 describes multiple local, national and regional alternatives worldwide to address the public health nutritional issues stemming from this urban transition. Alternative food networks, such as innovative agro-food systems where women can play a major role in Germany; school gardening and nutrition education in Texas (USA); or multilevel food intervention programs based on sustainable local production, food safety and food diversity in Nigeria, constitute a small sample from this large landscape of adaptive strategies to allow healthy population and individual trajectories in growing urban areas worldwide.

Author contributions

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The association between personal social capital and health-related quality of life among Chinese older people: A cross-sectional study

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Background: Lower health-related quality of life (HRQoL) can result in adverse effects on the health of older people. This study aims to explore the relationship between personal social capital (PSC) and HRQoL among Chinese elderly people from rural-and-urban perspective.

Materials and methods: 4,802 samples were included from China's health-related quality of life Survey for Older Adults 2018 (CHRQLS-OA 2018). The PSC, including bonding and bridging social capital (BOC and BRC), was measured by the Chinese version of the Personal Social Capital Scale (PSCS-16). The HRQoL was evaluated by the European Five Dimensions Questionnaire (EQ-5D-3L). Linear and Tobit regression models were conducted to examine the relationship between PSC and HRQoL.

Results: The BOC and BRC of rural older people were significantly lower than those of urban older people. Pain/discomfort and anxiety/depression were the most significant health problems affecting the older samples. In the five dimensions, the proportion of rural older people with problems was higher than that of urban older people. Among rural older people, BOC was significantly related to self-rated health and EQ-5D utility index ($p < 0.05$); while BRC was insignificantly associated with self-rated health ($p > 0.05$) but related to EQ-5D utility index ($p < 0.05$). Both BOC and BRC were significantly correlated with self-rated health and EQ-5D utility index ($p < 0.05$) among urban older people.

Conclusion: Our study reveals older people's worrying PSC and HRQoL status. The relationship between PSC and HRQoL suggested that more social support and care of intimates should be encouraged to increase the PSC of older people, especially rural older people.

KEYWORDS

Chinese elderly people, personal social capital, health-related quality of life, urban-rural distribution, sociocultural aspects of health and wellbeing

Introduction

Aging has become a major global public health issue, with an estimated 1.5 billion people aged 60 and over worldwide by 2030 (1). As one low-and middle-income country with the largest population globally, the aging process in China is much faster than in many other countries worldwide in terms of growth rate and proportion (2). The Chinese population over 60 years old has been to 264.02 million, accounting for about 18.70% of the total population in 2020 (3). In contrast, the number of people over 60 years old in China is estimated to increase to 420 million by 2035 (4), indicating that China's aging situation is becoming increasingly severe. Besides, due to the deterioration of the physical functions of the older people with ages, most of them may suffer from certain kinds of diseases, especially chronic diseases (5–7), which will directly affect their health-related quality of life (HRQoL).

According to World Health Organization (WHO), HRQoL refers to that individuals' perception of their position in life in the context of the culture and value systems in which they live and concerning their goals, expectations, standards, and concerns (8). HRQoL reflects the multi-dimensions of health, including physiology, psychology, social function, subjective judgment, and life satisfaction (9). Developed countries first researched HRQoL and mainly focused on the population of children (10, 11), women (12, 13), and patients (14, 15). However, they pay more attention to the older people currently because aging has become one of the global public issues (16–18). Most researchers studied HRQoL of the older people on influencing factors, and have proven that demographic factors (e.g., gender, age, marital status, and living areas) (19–22), health-related behaviors (e.g., drinking, smoking) (23, 24), and chronic diseases (25) can affect the HRQoL of the older people. With the development of the economy and the change in social perception, researchers also found that socioeconomic factors such as income, educational levels, and employment were related to the HRQoL of older people (26). In addition, previous studies have also proved that social relationships (e.g., social capital) were associated with individual health (27–29).

Social capital is regarded as the sum of resources and values based on a network of personal and organizational relationships (30). It describes the characteristics of a society that can achieve common goals (31). Considering the difficulty of collecting collective social capital, most studies focus on personal social capital (PSC). PSC can be further distinguished into two dimensions: bonding social capital (BOC) and bridging social capital (BRC) (32). BOC refers to the trust and cooperation between similar members with some social demographic factors (such as age, social status, etc.), while BRC means connections between community residents whose status and power are different (30). Social capital, as a kind of actual or potential resource, many studies have proved that it plays a key role whether on a personal or collective level (33). To date, current studies have found that collective-level social capital was positive associated with HRQoL (34, 35), but limited research exists on the relationship between PSC and HRQoL of the older people. Due to the tremendous socioeconomic and health disparities between urban and rural areas in China, this study was conducted from the perspective of urban-rural differences. The hypothesis of this study is that the PSC (BOC and BRC) is related to HRQoL positively among rural and urban older people. Moreover, rare studies distinguish between BOC and BRC while elaborating on the association between PSC and HRQoL. Thus, this study aimed to explore the relationship between PSC (BOC and BRC) and HRQoL among Chinese older people. Considering the other developing countries with huge populations, such as India, Brazil, and so on, Chinese experience on the suggestions about the relationship between HRQoL and PSC among older people can offer certain reference.

Materials and methods

Design and participants

The date of this study was obtained from China's Health-Related Quality of Life Survey for Older Adults 2018 (CHRQLS-OA 2018) (36). This cross-sectional survey was conducted during the Spring Festival in 2018, and intended to explore the health status of the Chinese older people aged 60 years old and above. We used convenient sampling to collect data and the survey sites including Henan province, Hubei province, Fujian province, Jiangsu province, etc. According to the study design, volunteers met the following inclusion criteria were considered as our target population: (1) individuals aged 60 years old or above, (2) individuals who voluntarily participated in our survey. But not all participants were included. Therefore, the excluded criteria were (1) individuals who could not conduct normal conversation because of aphasia, deafness, or other critical body illnesses, (2) individuals who had severe mental disorders or had been diagnosed with cognitive impairment, (3) individuals who had lost their daily living abilities. The questionnaire included participants' sociodemographic characteristics, personal social capital, behaviors, lifestyles, mental health, HRQoL, coping styles, etc. Overall, we collected 5,638 questionnaires and 5,442 were valid after data quality control, of which 4,807 were offline samples with an effective rate of 85.26%.

Since the purpose of this study was to explore the relationship between the personal social capital of the elderly and HRQoL, respondents with missing values on personal social capital and EQ-5D were excluded. Finally, 4,802 samples of the older people aged 60 years and above were included in the study.

Measures

Assessment of personal social capital

The Chinese Version of the Personal Social Capital Scale (PSCS-16) was adopted to measure PSC (37). The PSCS-16 contains 16 questions, composed of two sub-scales: BOC and BRC, both are formed from four sub-items and each sub-item contains two questions. The BOC contains (a) the perceived social network size, (b) the number of trusted social network members, (c) the number of social network members with resources (such as professional work and social influence), and (d) the number of reciprocal social network members; similarly, the BRC contains (a) perceived group size, (b) whether the group represents an individual, (c) resources owned by these groups and (d) the likelihood of getting help from the group on request (38). These response options of 16 questions were assessed using a five points Likert scale (1 = all, 2 = most, 3 = some, 4 = a few, and 5 = none). The average of two related questions' score is the score for this sub-item, with an overall range of 8–40 points. To be consistent with the EQ-5D scores, the PSCS adopted reverse–code statistically. A higher score indicated that participants possessed more personal social capital.

The PSCS-16 has proven reliable and valid in China (19). In this study, Cronbach's alpha of PSCS-16 total scale, BOC and BRC were 0.965, 0.932, and 0.965, and Kaiser-Meyer-Olkin (KMO) were 0.855, 0.919, and 0.953, respectively.

Assessment of health-related quality of life

Health-related quality of life was measured using the European Five Dimensions Questionnaire (EQ-5D-3L), which consisted of the EQ-5D descriptive system, the European Five Dimensions Questionnaire Visual Analogue Scale (EQ-VAS) and the Utility Index. The EQ-5D descriptive system measured participants' health status in three levels of severity (no problems, moderate problems, and extreme problems) with five dimensions: Mobility (MO), Self-care (SC), Usual activities (UA), Pain/discomfort (PD), Anxiety/depression (AD) (39). The EQ-VAS score was recorded on a scale with anchor points 0 (worst health state) and 100 (best health state), which reflected their knowledge of health (40).

The EQ-5D utility index system refers to converting the combination of problems in the five dimensions of EQ-5D into a total utility score to evaluate the overall quality of life of the sample population. A higher EQ-5D utility index indicated higher levels of HRQoL (41). This study adopted the utility index system developed by Zhuo et al. (42), a model ranging from 0.1702 to 1.0000.

Previous studies have confirmed EQ-5D-3L's reliability and validity in China (25). The Cronbach's alpha of EQ-5D-3L was 0.786, and KMO was 0.788 in the study.

Basic demographic characteristics

The basic demographic information of this study included participants' sociodemographic characteristics (gender, age, marital status, residence), socioeconomic status (annual family income per capita, educational levels, employment), number of chronic diseases and healthy behaviors (smoking, drinking, exercise, number of chronic diseases).

Statistical analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 22.0 (SPSS Inc., Chicago, IL, USA) and Stata SE 16.0, with a 95% Confidence Interval (CI) and a statistical significance level of 0.05.

Categorical variables were represented by frequencies and proportions, while metric variables were expressed as mean and standard deviation. The chi-square test was used to test whether there was a difference in sociodemographic characteristics between urban and rural areas and univariate analysis of five dimensions in EQ-5D-3L. Differences in each dimension of personal social capital between rural and urban areas, single factor analysis of EQ-VAS and EQ-5D utility index score among samples with different demographic characteristics were carried out using *T*-test and Analysis of Variance (ANOVA). The association between personal social capital and five dimensions of EQ-5D was examined by multiple linear regression, which included one initial model and four adjusted models. Linear regression and Tobit regression were, respectively used to analyse the relationship between the social capital of the older people and EQ-VAS and EQ-5D utility scores.

Results

General sociodemographic characteristics of respondents

As shown in **Table 1**, this study consisted of 4,802 older adults; all samples were divided into two groups, among whom 59.45% (n = 2,855) were from rural areas and 40.54% (n = 1,893) were from urban areas.

Overall, of the participants, 49.64% were males and 50.36% were females. Nearly half of older people (44.78%) were under 70 years old, while 17.39% were over 80 years old. Most respondents (63.29%) were currently married. The annual family income per capita of less than 15,000 yuan accounted for the majority of the respondents (35.35%). Over half of the participants had received an education (68.13%), and 69.81% were reported without occupations. There were 52.29% of the samples suffered from chronic diseases, and the proportion of both non-smokers and non-drinkers was over 50% (68.15%, 56.70%, respectively). 74.89% of older people do regular exercise.

The following characteristics were found to be significant statistically differences across these two groups: age (χ^2 = 13.106, p = 0.011), marital status (χ^2 = 32.834,

TABLE 1 Sociodemographic characteristics of respondents.

Variable	Description	Total (4,802)		Rural (2,855)		Urban (1,893)		χ^2	*P*
		N	%	*N*	%	*N*	%		
Gender	Male	2,344	49.64	1,404	49.40	940	50.00	0.162	0.687
	Female	2,378	50.36	1,438	50.60	940	50.00		
Age (years)	60–64	1,033	21.83	659	23.15	374	19.83	13.106	0.001
	65–69	1,086	22.95	669	23.50	417	22.11		
	70–74	1,102	23.28	644	22.62	458	24.28		
	75–79	689	14.56	386	13.56	303	16.07		
	≥80	823	17.39	489	17.18	334	17.71		
Marital status	Married	2,995	63.29	1,707	60.02	1,288	68.22	32.834	<0.001
	Not married*	1,737	36.71	1,137	39.98	600	31.78		
Family annual income per capita (RMB)	<15,000	1,656	35.35	1,345	47.76	311	16.64	1015.495	<0.001
	15,000–30,000	1,185	25.29	854	30.33	331	17.71		
	30,000–45,000	896	19.12	400	14.20	496	26.54		
	>45,000	948	20.23	217	7.71	731	39.11		
Educational level	Illiterate	1,503	31.86	1,269	44.71	234	12.45	730.309	<0.001
	Elementary school	1,603	33.98	973	34.28	630	33.53		
	Junior high school or above	1,611	34.15	596	21.01	1,015	54.02		
Employment	Unemployed	3,297	69.81	1,760	61.80	1,537	81.97	218.360	<0.001
	Employed	1,426	30.19	1,088	38.20	338	18.03		
Number of chronic diseases	0	2,222	47.71	1,283	45.69	939	50.78	14.104	0.001
	1	1,260	27.06	770	27.42	490	26.50		
	≥2	1,175	25.23	755	26.89	420	22.72		
Smoking	Never smoke	3,216	68.15	1,834	64.58	1,382	73.55	80.573	<0.001
	Used to smoke	407	8.62	220	7.75	187	9.95		
	Smoking	1,096	23.23	786	27.68	310	16.50		
Drinking	Never drink	2,652	56.70	1,591	56.58	1,061	56.89	9.812	0.007
	Used to drink	390	8.34	208	7.40	182	9.76		
	Drinking	1,635	34.96	1,013	36.02	622	33.35		
Regular exercise	No	1,179	25.11	980	34.81	199	10.58	352.176	<0.001
	Yes	3,517	74.89	1,835	65.19	1,682	89.42		

*Not married includes divorce, separated, widowed, and never married; Sample sizes of the demographic characteristic variables may not sum to $n = 4802$ due to missing values. According to variables sorted in table, the missing data values are 69, 70, 117, 85, 85, 79, 145, 145, 83, 125, and 106, respectively.

$p < 0.001$), family annual income per capita ($\chi^2 = 1015.495$, $p < 0.001$), educational level ($\chi 2 = 730.309$, $p < 0.001$), employment ($\chi^2 = 218.360$, $p < 0.001$), number of chronic diseases ($\chi^2 = 14.104$, $p = 0.001$), smoking ($\chi^2 = 80.673$, $p < 0.001$), drinking ($\chi^2 = 9.812$, $p = 0.007$), and regular exercise ($\chi^2 = 352.176$, $p < 0.001$).

Scores of personal social capital of the elderly

Table 2 shows the scores of personal social capital among the participants. The respondents' total score of personal social capital was 21.06 ± 7.33, while the score of two dimensions of personal social capital (BOC and BRC) were 11.38 ± 3.62 and 9.67 ± 4.15, respectively. The scores of the BOC and BRC among older people in rural areas were significantly lower than those in urban areas ($p < 0.001$).

Health status distribution on the five dimensions of European Five Dimensions Questionnaire

In this study, pain/discomfort was the most common problem among the older people: 51.52% in rural areas compared with 40.67% in urban areas ($p < 0.001$). While self-care was the least frequently reported problem: 20.91% in rural areas compared with 13.63% in urban areas ($p < 0.001$). Five dimensions of EQ-5D-3L were all statistically significant between rural and urban areas ($p < 0.001$) (Table 3).

TABLE 2 Scores of personal social capital among older people (Mean ± SD).

Variable	Total	Rural areas	Urban areas	*t*	*p*
BOC	11.38 ± 3.62	10.48 ± 3.63	12.74 ± 3.17	−22.728	<0.001
BRC	9.67 ± 4.15	8.49 ± 3.84	11.46 ± 3.96	−25.854	<0.001
PSC	21.06 ± 7.33	18.96 ± 7.02	24.20 ± 6.63	−26.085	<0.001

BOC, bonding social capital; BRC, bridging social capital; and PSC, personal social capital.

TABLE 3 Health status distribution on the five dimensions of European Five Dimensions Questionnaire (EQ-5D-3L).

EQ-5D dimensions		Rural		Urban		χ^2	*p*
		N	%	*N*	%		
Mobility	No problem	2,087	73.10	1,529	80.77	38.496	<0.001
	Some problems	739	25.88	344	18.17		
	Confined to bed	29	1.02	20	1.06		
Self-care	No problems	2,258	79.09	1,635	86.37	40.879	<0.001
	Some problems	543	19.02	235	12.41		
	Unable to	54	1.89	23	1.22		
Usual activities	No problem	2,050	71.80	1,494	78.92	30.837	<0.001
	Some problems	739	25.88	362	19.12		
	Unable to	66	2.31	37	1.95		
Pain/discomfort	No problems	1,384	48.48	1,123	59.32	55.794	<0.001
	Some problems	1,393	48.79	740	39.09		
	Extreme problems	78	2.73	30	1.58		
Anxiety/depression	No problem	1,844	64.59	1,535	81.09	153.491	<0.001
	Some problems	960	33.63	331	17.49		
	Extreme problems	51	1.79	27	1.43		

Distribution of VAS scores and utility index among older people

Table 4 shows the scores of the samples' self-rated health and utility index. The following characteristics were significantly different among the rural participants in both VAS and utility index scores: gender, age, marital status, annual family income per capita, educational attainment, employment, number of chronic diseases, drinking, and regular exercise ($p < 0.05$). Significant differences were found in VAS scores in urban samples in age, marital status, annual family income per capita, educational level, employment, number of chronic diseases, smoking, drinking, and regular exercise ($p < 0.05$). While in utility index scores only age, marital status, annual family income per capita, employment, number of chronic diseases, and regular exercise were found to be significantly different among urban samples ($p < 0.05$).

The relationship between personal social capital and European Five Dimensions Questionnaire Visual Analogue Scale

As shown in Table 5, for the rural sample, in model 1, only BOC was positively correlated with the EQ-VAS score of the older people ($B = 0.977$, 95% CI = 0.75–1.21). After adjusting for sociodemographic characteristics, socioeconomic status, number of chronic diseases, and healthy behaviors, in model 5, BOC was still positively related to the EQ-VAS score of the older people ($B = 0.567$, 95% CI = 0.32–0.81), and BRC had nothing to do with the EQ-VAS score of the elderly ($p > 0.05$).

For the urban sample, in model 1, both the BOC ($B = 0.752$, 95% CI = 0.47–1.03) and the BRC ($B = 0.697$, 95% CI = 0.47–0.92) were related to the EQ-VAS score of the elderly positively. After adjusting for sociodemographic characteristics, socioeconomic status, number of chronic diseases, and healthy behaviors, in model 5, both the BOC ($B = 0.614$, 95% CI = 0.32–0.91) and the BRC ($B = 0.349$, 95% CI = 0.12–0.58) were still positively correlated with the EQ-VAS score of the participants.

The relationship between personal social capital and EQ-5D utility index

As shown in Table 6, for the rural sample: in Model 1, the BOC was positively correlated with the utility score of the older people (β = 0.0111, 95% CI = 0.0089–0.0134), while the BRC was negatively correlated with the utility score of the older people (β = −0.0039, 95% CI = −0.0062–0.0017). After adjusting for sociodemographic characteristics, socioeconomic status, number of chronic diseases, and healthy behaviors, in

TABLE 4 Distribution of VAS scores and utility index among older people (Mean ± SD).

Variables		Rural areas		Urban areas	
		VAS	Utility	VAS	Utility
Gender	Male	75.14 ± 14.39	0.929 ± 0.099	80.63 ± 13.77	0.953 ± 0.088
	Female	72.97 ± 15.69	0.917 ± 0.107	77.19 ± 14.91	0.938 ± 0.103
	T	3.845	2.826	5.203	3.355
	P	<0.001	0.005	<0.001	0.001
Age (years)	60–64	75.49 ± 15.02	0.947 ± 0.081	81.13 ± 14.66	0.963 ± 0.067
	65–69	75.92 ± 14.84	0.939 ± 0.091	79.21 ± 14.60	0.949 ± 0.101
	70–74	74.51 ± 13.81	0.922 ± 0.105	78.48 ± 13.92	0.947 ± 0.101
	75–79	73.21 ± 13.89	0.915 ± 0.102	78.75 ± 13.12	0.945 ± 0.090
	≥80	69.46 ± 17.10	0873 ± 0.129	76.93 ± 15.30	0.923 ± 0.105
	F	16.122	43.330	3.931	7.820
	P	<0.001	<0.001	0.003	<0.001
Marital status	Married	76.32 ± 14.36	0.936 ± 0.099	80.79 ± 13.66	0.955 ± 0.091
	Not married	70.73 ± 15.52	0.903 ± 0.108	74.91 ± 15.25	0.925 ± 0.103
	T	9.869	8.109	8.046	5.908
	P	<0.001	<0.001	<0.001	<0.001
Family annual income per capita (RMB)	<1,500	71.51 ± 17.00	0.907 ± 0.115	73.54 ± 17.63	0.916 ± 0.132
	1,500–3,000	74.12 ± 12.74	0.924 ± 0.086	75.46 ± 15.28	0.931 ± 0.101
	3,000–4,500	78.26 ± 10.66	0.951 ± 0.094	79.78 ± 12.71	0.952 ± 0.085
	>4,500	81.43 ± 13.75	0.960 ± 0.090	82.41 ± 12.35	0.961 ± 0.071
	F	42.124	29.730	37.834	21.508
	P	<0.001	<0.001	<0.001	<0.001
Educational level	Illiterate	71.57 ± 14.11	0.909 ± 0.107	75.59 ± 14.41	0.935 ± 0.082
	Elementary school	74.87 ± 15.93	0.929 ± 0.098	79.82 ± 14.11	0.945 ± 0.109
	Junior high school and above	77.86 ± 14.73	0.942 ± 0.102	79.26 ± 14.48	0.948 ± 0.090
	F	38.622	22.655	7.800	1.751
	P	<0.001	<0.001	<0.001	0.174
Employment	Unemployed	72.74 ± 16.21	0.911 ± 0.112	78.68 ± 14.69	0.943 ± 0.100
	Employed	76.11 ± 12.82	0.943 ± 0.084	80.03 ± 13.41	0.956 ± 0.076
	T	−6.142	−8.795	−1.646	−2.577
	P	<0.001	<0.001	<0.001	0.010
Number of chronic diseases	0	77.42 ± 14.57	0.945 ± 0.093	82.53 ± 12.57	0.962 ± 0.106
	1	73.69 ± 14.34	0.924 ± 0.096	77.27 ± 14.86	0.940 ± 0.106
	≥2	68.46 ± 15.31	0.882 ± 0.117	72.78 ± 15.64	0.915 ± 0.103
	F	88.534	91.827	75.638	38.199
	P	<0.001	<0.001	<0.001	<0.001
Smoking	Never smoke	74.21 ± 14.99	0.925 ± 0.104	79.44 ± 14.35	0.947 ± 0.097
	Used to smoke	74.54 ± 15.37	0.921 ± 0.100	78.37 ± 15.04	0.951 ± 0.099
	Smoking	73.40 ± 15.27	0.922 ± 0.104	77.19 ± 14.27	0.935 ± 0.090
	F	0.927	1.636	3.243	2.349
	P	0.396	0.195	0.039	0.096
Drinking	Never drink	73.63 ± 15.12	0.921 ± 0.106	77.45 ± 15.02	0.942 ± 0.095
	Used to drink	71.23 ± 14.81	0.897 ± 0.125	81.53 ± 11.82	0.955 ± 0.061
	Drinking	75.23 ± 14.81	0.929 ± 0.095	80.81 ± 13.94	0.950 ± 0.103
	F	7.412	8.599	13.926	2.495
	P	0.001	<0.001	<0.001	0.083
Regular exercise	No	69.92 ± 13.84	0.906 ± 0.102	68.37 ± 17.64	0.871 ± 0.155
	Yes	76.18 ± 15.26	0.931 ± 0.104	80.21 ± 13.42	0.955 ± 0.082
	T	−11.020	−5.975	−9.164	−7.448
	P	<0.001	<0.001	<0.001	<0.001

TABLE 5 The relationship between personal social capital and European Five Dimensions Questionnaire Visual Analogue Scale (EQ-VAS).

		Total		Rural		Urban	
		B (95% CI)	S.E	*B* (95% CI)	S.E	*B* (95% CI)	S.E
Model 1	BOC	0.888 (0.714–1.062)***	0.089	0.977 (0.75–1.21)***	0.116	0.752 (0.47–1.03)***	0.144
	BRC	0.425 (0.273–0.577)***	0.078	0.118 (–0.10–0.32)	0.109	0.697 (0.47–0.92)**	0.115
Model 2	BOC	0.722 (0.545–0.899)***	0.090	0.78 (0.55–1.01)***	0.118	0.638 (0.35–0.92)***	0.146
	BRC	0.451 (0.300–0.603)***	0.077	0.192 (–0.02–0.41)	0.109	0.689 (0.46–0.92)***	0.115
Model 3	BOC	0.699 (0.517–0.882)***	0.093	0.741 (0.50–0.98)***	0.122	0.672 (0.38–0.97)***	0.151
	BRC	0.385 (0.231–0.539)***	0.079	0.266 (0.05–0.48)*	0.110	0.568 (0.34–0.80)***	0.118
Model 4	BOC	0.734 (0.557–0.911)***	0.090	0.791 (0.56–1.02)***	0.119	0.705 (0.43–0.98)***	0.142
	BRC	0.252 (0.099–0.405)**	0.078	0.042 (–0.17–0.25)	0.110	0.414 (0.19–0.64)***	0.116
Model 5	BOC	0.568 (0.383–0.753)***	0.094	0.567 (0.32–0.81)***	0.124	0.614 (0.32–0.91)***	0.151
	BRC	0.262 (0.106–0.418)**	0.079	0.209 (–0.01–0.43)	0.112	0.349 (0.12–0.58)**	0.119

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; S.E, standard error. For the urban and rural samples: Model 1: the crude model of BOC and BRC, $R = 0.315$, $R^2 = 0.099$; Model 2: adjusted for sociodemographic characteristics (gender, age, marital status), $R = 0.350$, $R^2 = 0.122$; Model 3: adjusted for socioeconomic status (family income per capita, educational level, employment), $R = 0.372$, $R^2 = 0.139$; Model 4: adjusted for the number of chronic diseases and healthy behaviors (number of chronic diseases, smoking, drinking, regular exercise), $R = 0.409$, $R^2 = 0.167$; Model 5: adjusted for sociodemographic characteristics, socioeconomic status, number of chronic diseases, and healthy behaviors, $R = 0.460$, $R^2 = 0.212$.

model 5, the BOC was positively correlated with the EQ-5D utility score of the older people (β = 0.0065, 95% CI = 0.0041–0.0090), while the BRC was negatively correlated with the EQ-5D utility score of the older people (β = –0.0035, 95%-CI = –0.0057–0.0013).

For the urban sample: in Model 1, both the BOC (β = 0.0069, 95% CI = 0.0035–0.0103) and the BRC (β = 0.0076, 95% CI = 0.0048–0.0105) were positively correlated with the utility score of the older people. After adjusting for sociodemographic characteristics, socioeconomic status, number of chronic diseases, and healthy behaviors, in model 5, both the BOC (β = 0.0043, 95% CI = 0.0007–0.0078) and the BRC (β = 0.0031, 95% CI = 0.0003–0.0060) were still positively correlated with the EQ-5D utility score of the elderly.

Discussion

To our knowledge, this is the first study that measures the relationship between personal social capital and HRQoL among Chinese older people from an urban-rural perspective. This cross-sectional study found that personal social capital was significantly associated with HRQoL among rural and urban older people. Moreover, the correlation still existed after adjusting the sociodemographic characteristics, socioeconomic status, number of chronic diseases, and healthy behaviors.

Our data showed that the total score of PSC among older people in rural areas was significantly lower than those in urban areas, which was different from a previous study (43). We speculated that the Chinese urban-rural dual structure might cause the discrepancy. In Chinese traditional culture, rural areas are more likely to be an "acquaintance society" than urban areas. On the one hand, with the development of urbanization, the young migrate to urban areas for work; on the other hand, the intimates and friends of older people start to die, resulting in the PSC of the older people in rural areas are gradually losing (44). In addition, our study also found that BRC among older people was lower than BOC both in urban and rural areas. According to the definition of BRC and BOC, it means that rural and urban areas were facing the dilemma of community or village hollowing out (45). Because there is less social participation and lacking organizations/groups that could provide community public services such as medical services and cultural services for older people (46), which may make them feel less BRC than BOC subjectively. Therefore, the government must encourage the community or village to provide services for the older people by establishing more care facilities and volunteer organizations/groups which can improve the bridge social capital of the older people and give them a sense of belonging in these social organizations or groups. Consistent with previous studies (47, 48), pain/discomfort and anxiety/depression were the most significant health problems affecting older people. In this study, the average EQ-VAS score of the older people was 76.01 ± 14.99, lower than the result of the Fifth National Health Service Survey (80.91 ± 13.7) (49), indicating that the older people were not optimistic about their self-rated health. The average utility index score was 0.9323 ± 0.1016, lower than the fifth National Health Service Survey (0.985 ± 0.056) (39), indicating the urgency of further HRQoL improvement among older adults. In addition, our study found that the utility index score of the rural sample was lower than urban samples, which calls for more attention to the HRQoL of the rural older people.

TABLE 6 The relationship between personal social capital and utility index.

		Total			Rural areas			Urban areas		
		β	S.E	95% CI	β	S.E	95% CI	β	S.E	95% CI
Model 1	BOC	0.0009***	0.0010	0.00073–0.0111	0.0111***	0.0012	0.0089–0.0134	0.0069***	0.0018	0.0035–0.0103
	BRC	0.0015*	0.0009	0.0001–0.0003	−0.0039***	0.0011	−0.0062 to −0.0017	0.0076***	0.0014	0.0048–0.0105
Model 2	BOC	0.0068***	0.010	0.0049–0.0087	0.0086***	0.0012	0.0062–0.0109	0.0041*	0.0017	0.0006–0.0076
	BRC	0.0021*	0.0008	0.0004–0.0037	−0.0027*	0.0011	−0.0049 to −0.0006	0.0074***	0.0014	0.0045–0.0102
Model 3	BOC	0.0067***	0.0010	0.0047–0.0086	0.0082***	0.0012	0.0058 to −0.0106	0.0054**	0.0018	0.0018–0.0090
	BRC	0.0015*	0.0009	0.0002–0.0032	−0.0023*	0.0011	−0.0045 to −0.0001	0.0066***	0.0014	0.0038–0.0095
Model 4	BOC	0.0081***	0.0010	0.0061–0.0099	0.0098***	0.0012	0.0074–0.0122	0.0064***	0.0017	0.0030–0.0098
	BRC	−0.0011*	0.0008	−0.0028 to −0.005	−0.0056***	0.0011	−0.0078 to −0.0033	0.0040**	0.0014	0.0012–0.0068
Model 5	BOC	0.0051***	0.0010	0.0031–0.0071	0.0065***	0.0012	0.0041–0.0090	0.0043*	0.0017	0.0007–0.0078
	BRC	−0.0008*	0.0009	−0.0024 to −0.0009	−0.0035**	0.0011	−0.0057 to −0.0013	0.0031*	0.0014	0.0003–0.0060

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; S.E, standard error. For the urban and rural samples: Model 1: the crude model of BOC and BRC, Prob > Chi^2; Model 2: adjusted for sociodemographic characteristics (gender, age, marital status), Prob > Chi^2; Model 3: adjusted for socioeconomic status (family income per capita, educational level, employment), Prob > Chi^2; Model 4: adjusted for the number of chronic diseases and healthy behaviors (number of chronic diseases, smoking, drinking, regular exercise), Prob > Chi^2; Model 5: adjusted for sociodemographic characteristics, socioeconomic status, number of chronic diseases, and healthy behaviors, Prob > Chi^2.

Our results showed that only BOC was positively correlated with self-rated health for the rural samples. Understandably, neighborhood mutual assistance is a normal situation, even in the current rapid economic and social development, this tradition has not died out in rural areas. Rural older people were affected by traditional values, which emphasize more on the family relationship that emphasizes the family relationship more than in urban areas. At the same time, family relationships play an essential role in the health of family members. Moreover, Stafford et al. (50) found that neighborhood relationships' cohesion is positively related to self-rated health. Therefore, older people with more BOC have a higher level of self-rated fitness. Given that most older people in rural areas were engaged in agricultural production activities and lacked social organizations or groups, their communication scope was narrow and social participation was low (51). Another reason is that the self-esteem of rural older people is high (52), leading them to be unwilling to resort to help from social organizations/groups when experiencing health issues, which may also result in the insignificant relationship between BRC and self-rated health. In our study, both BOC and BRC were associated with self-rated health among urban older people. A previous study has proven that good interpersonal relationships and more social participation can improve the health of old citizens (53). Compared with the rural older people, the urban older people had a higher socioeconomic status and more resources to cope with adversity, which could increase their mutual communication, exchange and support, got help and encouragement from others, met their needs of economic and emotional support, relieving psychological pressure, and provided indirect protection for health (54, 55).

Our study indicated that the BOC was positively correlated with the EQ-5D utility index of all older people in rural and urban areas. That might be related to Chinese Confucianism's filial piety and family culture (56). Traditional values have a deep-rooted influence on the Chinese, especially older people. They attach more importance to their relationship with their family, relatives, and friends (57), the support and reciprocal network provided by people close to them and their living environment had a significant role in meeting their psychological and emotional needs and promoting the quality of life of the older people (58–60). Interestingly, the BRC was negatively correlated with the utility score of the rural older people, while it was positively correlated with the EQ-5D utility score of the urban older people. The BRC was generated from the weak network between the older people and the surrounding social organizations or groups. It improved the actual value of interpersonal communication among older people through individual participation in social activities (61). Compared with older people in urban areas, due to the influence of factors such as traffic, economic conditions, ideas, and consciousness, the rural older people had relatively weak connections with the outside world, rarely participated in social activities, and had a relatively simple social network, with limited help resources available. Urban older people could get help from communities and various social organizations. In addition, as more and more older people started to use smartphones and the Internet (62, 63), especially urban older people, they had more channels to contact the outside world and obtain information. Organizational participation and citizen participation can not only help the elderly to obtain a sense of belonging and self-worth and even directly promote their physical exercise, which is conducive to health promotion. Therefore, it is suggested that government should provide social assistance for older people in multi-levels and various forms; increase health education and promotion in healthy aging; and improve physical facilities, expand coverage of old-age care.

Limitations

There are still several limitations in our study. First, this is a cross-sectional study, which can only reflect the association between PSC and the HRQoL among older Chinese people. Therefore, causality cannot be determined. Second, this study is based on self-reported questionnaires, leading to some bias due to inaccurate responses. Third, the concept and measurement of PSC are still controversial. Though there are many ways to measure social capital, each instrument has its limitations and cannot cover all areas of social capital. For future studies, all the limitations should try to avoid. Four, we did not consider the regional and economical difference, although we conducted the survey in Henan province, Hubei province, Fujian province, Jiangsu province, etc., because we used the convenient sampling, indicating the limited representation of samples.

Conclusion

In Conclusion, our study found that (1) the PSC of the older people needs to improve further, and the PSC level of the rural older people was lower than that of the urban areas. (2) Pain/discomfort and anxiety/depression were the most significant health problems affecting older people. Older people in rural areas were more likely to have problems than older people in urban areas, and the level of health of rural older people was worse than urban older people. (3) The PSC of the older people was related to the HRQoL. The BOC was positive associated with the rural older people's HRQoL, while the BRC was negatively associated with the rural older people's HRQoL. BOC and the BRC were both positively correlated with the HRQoL of urban older people. Therefore, to improve the HRQoL of the older people, we should increase the BOC of the elderly in rural areas, and the BOC and BRC of the elderly in urban areas.

Data availability statement

The original contributions presented in this study are all included in the article. Further inquiries can be directed to the first or corresponding authors. The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Institutional Review Board, School of Public Health, and Faculty of Medical Sciences, Wuhan University. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

QW and DJ contributed to the study conception and design. DJ, YY, and HZ performed the material preparation, data collection, and analysis. DJ and YY wrote the first draft of the manuscript. QW revised and edited the draft. All authors commented on previous versions of the manuscript, read, and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Acute malnutrition and its contributing factors among children under-five years in rural kebeles of Shashemene Oromia, Ethiopia

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Introduction: Globally, more than 52 million under-five years old were wasted; One-third of these children live in Africa. Ethiopia is the seventh country among the ten top countries in which acute malnutrition (AM) is concentrated and currently 10% of under-five children are wasted. Even though Ethiopia has implemented a variety of nutritional interventions, acute malnutrition is still prevalent and spreading at an alarming rate. Therefore, this study aimed to assess the prevalence of acute malnutrition and its contributing factors among children under-five years of age.

Materials and methods: A community-based cross-sectional study was conducted from July 1 to 30, 2018 among 12 randomly selected kebeles. The sample sizes were proportionally allocated to the selected kebeles. A total of 457 mothers/caretakers of under-five children were interviewed using pre-tested structured questionnaires and anthropometric measurements of the children were taken using standard procedures. EPI data version 4.2 was used for data entry and Statistical Package for the Social Sciences (SPSS) Version 21 was used for statistical analysis. The World Health Organization (WHO) Anthro software was used to convert nutritional data indices. Binary logistic regression was used to determine the association between dependent and independent variables. The level of significance was declared at a *P*-value <0.05.

Results: The prevalence of acute malnutrition is 19.91% (95%CI; 16.24%, 23.57%) among under-five children. Factors contributing to acute malnutrition were mothers with no antenatal care (ANC) visits [adjusted odds ratio (AOR) = 2.26, 95% CI 1.14–4.46], mothers who had no autonomy in decision-making (AOR = 2.42, 95% CI 1.42–4.12), children with diarrheal disease in the last 2 weeks preceding the survey (AOR = 2.07, 95% CI 1.19–3.59), and not feeding colostrum (AOR = 1.99, 95% CI 1.07–3.71).

Conclusion and recommendation: The prevalence of acute malnutrition is high as compared to other findings in Ethiopia. Moreover, decision-making power, not feeding colostrum, no ANC visit, and a child's history of diarrhea were independent determinants of acute malnutrition. Therefore, the local

health department and health extension workers should consider imparting health education for women on nutritional counseling and timely treatment for children with diarrhea. Empowering women's decision-making is also a key element in addressing wasting among under-five children.

KEYWORDS

prevalence, acute malnutrition, children, rural, Ethiopia

Introduction

Malnutrition is the lack of the right kinds of food and nutrients needed by the body for appropriate growth and development. It includes undernutrition and overnutrition. Stunting, wasting, and being underweight are classified as among Anthropometric indicators commonly used to measure malnutrition in a population of under-five children (1). Acute malnutrition (AM) is classified into severe acute malnutrition (SAM) and moderate acute malnutrition (MAM) according to the degree of wasting and the presence of edema (2).

Acute malnutrition develops as a result of rapid weight loss or a failure to gain weight. In children, it is assessed via the nutritional index of Weight-for-height, Mid-Upper Arm Circumference (MUAC), and edema is used to decide acute malnourishment. If a child's weight for height measurement is <70% of the normal range for his age, or when the child's MUAC is <11 cm, then the child would be diagnosed with severe acute malnutrition. The presence of one criterion is sufficient to categorize a child as severely malnourished (3). Successful management of severe acute malnutrition requires a medical intervention combined with a community-based approach to help with the timely detection and appropriate provision of treatment (4).

Globally in 2015 about 480,000 under-five children continue to die every month. Undernutrition causes deaths in 53% of children under-five years, acute malnutrition is responsible for more than 28% (5), and around one million children under the age of five years die every year from severe acute malnutrition (6). Globally, about 52 million under-five years old were wasted and among this around 32% (16 million) were severely wasted (7), one-third of these children live in Africa, especially in Sub-Saharan Africa (SSA) (8).

In Ethiopia; the 2016 Ethiopian Demographic and Health Survey (EDHS) revealed that there has been an improvement in the nutritional status of children. The percentage of stunting fell from 40% in 2014 to 38% in 2016. Similarly, the percentage of underweight children declined from 25% to 24%, but the prevalence of wasting increased from 9% to 10%. Furthermore, the prevalence of wasting is different from region to region for instance in Oromia's national regional state, the percentage of children who were wasted is 10.6% and in the Somali regional state was 22.7% (9). Recent studies conducted in Kamashi district and Seqota district, Amhara region, Ethiopia revealed acute undernutrition accounted for 4.3% and 8%, respectively (10, 11).

Currently, there are different nutritional interventional programs and activities being held by the government concerned with policy-making and implementation programs like the Community based Nutrition Program (CBN), Essential Nutrition Action (ENA), Community Health Day (CHD), Infant and Young Child Feeding program (IYCF), Community Management of Acute Malnutrition (CMAM). In line with the government's role, there are also different local and international NGOs working in Ethiopia for the overall achievement of the sustainable development goals (SDG). Despite the entire effort, the trend of decline in the undernutrition problem is not satisfactory (12–14).

Even though Ethiopia has been implementing different nutritional programs, wasting is still the top leading public health problem for under-five years children (15, 16). Ethiopia is still the seventh country among the ten top countries in which wasting (acute malnutrition) is concentrated. Even though, the previous studies pointed out the prevalence of wasting, most of these studies do not identify the key determinants of wasting among the rural kebele community (17). Therefore, this study aimed to identify the prevalence of acute malnutrition and its contributing factors among children under-five years of age in rural kebeles of Shashemene district, Oromia region, Ethiopia.

Abbreviations: AM, acute malnutrition; ANC, antenatal care; AOR, adjusted odds ratio; BMI, body mass index; CI, confidence interval; CF, complementary feeding; COR, crude odds ratio; DDS, dietary diversity score; EBF, exclusive breast feeding; EDHS, Ethiopian Demographic and Health Survey; EFY, Ethiopian fiscal year; ETB, Ethiopian Birr; HH, households; HI, health institution; MAM, moderate acute malnutrition; MUAC, Mid-Upper Arm Circumference; SAM, severe acute malnutrition; SD, standard deviation; SDG, sustainable development goals; SSA, Sub-Saharan Africa; SPSS, Statistical Package for the Social Sciences; WHO, World Health Organization; W/H, weight/height.

Materials and methods

Study setting, design, and period

A community-based cross-sectional study was conducted from July 1 to 30, 2018 in the Shashemene district of Oromia, Ethiopia. The district is located 250 km far from

Addis Ababa; the capital city of Ethiopia. The district has 38 rural administrative kebeles with 265,109 total populations in 55,231 households with males to female ratio of 1:1.02. The projected number of under-five children is 43,557 projected from the 2007 national population census (18). Regarding health infrastructures, there are eight health centers, three private clinics, and thirty-eight health posts. The majority of the population was engaged in agricultural activities in the district and the main crops/products were Maize, Teff, and Sorghum, fruits and vegetables, and animal husbandry.

Populations

All children under-five years living in rural kebeles of sahshemene zone were the source population. Those selected children who lived in the selected households during the study period were the study population. Physically disabled children, ages below-five years, and critically ill children were excluded from the study.

Sample size determination and sampling procedures

The sample size was determined using single population proportion formula by considering an assumption of 95% confidence level, 5% margin of error, and 23.6% prevalence of acute malnutrition from a previous study done in Hawassa Zuria district, Southern Ethiopia (8).

The following assumption was used.

$$n = (Z_{\alpha/2})^{2^*} p\,(1-p)^2/d^2 = \frac{(0.764)\ (0.236)\ (1.96)^{\ 2}}{(0.05)^2} = 277.$$

After considering a design effect of 1.5 and 10% non-response rate compensation; the final sample size became **457**.

Sampling procedures

A multi-stage sampling technique was applied. From the 38 rural kebeles in the Shashemene district, 12 kebeles were selected using simple random sampling. From each kebele, three gotes were again randomly selected. The total sample size was proportionally distributed to each gote based on their population size. A maximum of one child aged younger than five years was included randomly in each selected household.

Study variables

The dependent variable was acute malnutrition (wasting). The independent variables were socio-demographic characteristics (maternal/parental education, maternal/parental occupation, family size), child and health-related characteristics (sex, age, morbidity status), child caring practices/nutritional care and practice [exclusive breastfeeding practice, complementary feeding (CF) practice, duration of breastfeeding, immunization status, feeding of sick child] maternal characteristics/obstetric factors (number of children ever born, maternal autonomy in decision making, use of extra food during pregnancy or lactation), environmental health condition (access to latrine, access to safe water, access to health facilities).

Operational definitions

Acute malnutrition (wasting): a child's weight for height measurement is <-2 SD or bilateral pitting edema.

Bilateral pitting edema: pitting edema of the feet verified when thumb pressure applied on top of both feet for 3 s leaves a pit (indentation) in the foot after the thumb is lifted (19).

Critically ill: a child who has chronic diseases like severe pneumonia, TB, CHF, DM, and HIV/AIDS.

The dietary diversity score (DDS) is the sum of the total number of food groups consumed over 24 h before the data collection (20).

Healthcare-seeking behavior: healthcare-seeking behavior by the caregiver of the child within 24 h of the onset of symptoms.

Immunization status: either vaccinated or not, if possible, look at the vaccination card or ask the mother (caregiver).

Morbidly status of the child: morbidity status in the last 2 weeks before the study period (fever, cough, diarrhea).

Complementary foods are foods that are required by the child, after 6 months of age, in addition to sustained breastfeeding.

Data collection procedures (instruments, personnel, measurements)

For face-to-face interviews, a pre-tested and standardized questionnaire with questions adopted and modified from different literature reviews was used to collect data. Trained data collectors were assigned to all gote to collect the data. The vaccination status of the children was assessed by looking at the vaccination card or asking the mother (caretaker).

Anthropometric data were collected through the measurement of the length/height and weight of all children. A Salter hanging spring scale with graduations of 0.1 kg and a capacity of 25 kg were used for measuring the weight of the children aged 6–23 month and a beam scale for children over 24 months of age were used for measuring weight with minimum clothing and no shoes to the nearest 0.1 kg. The recumbent length measurement was taken for children under 2 years of age, then subtract 0.7 cm to convert the result to height while

for children above 2 years stature was measured in a standing position in centimeters to the nearest of 0.1 cm (3). Edema of the feet was diagnosed if a bilateral depression (pitting) remained after the pressure was released (19).

Child dietary diversity score was calculated by summing a total of seven food groups: (1) grains, roots, and tubers; (2) vitamin a-rich fruits and vegetables; (3) dairy products; (4) flesh foods (meat, fish, poultry, and liver or organ meat); (5) other fruits and vegetables; (6) egg; (7) legumes and nuts; consumed over the reference period (24 h before the data collection). For example, if one child eats from each food group, his/her DDS will be 7 (20).

Data quality assurance

The questionnaire was translated into the local language, Afan Oromo, for the fieldwork and back to English to check its consistency among three health workers who are fluent speakers of Afan Oromo and English. Besides, it was pre-tested in Shalla district in 5% of the sample size. Twelve diploma nurses for data collection and four BSc nurses for supervision were trained for 2 days. The training covered in the questionnaire and the importance of disclosing the possible benefits and purpose of the study to the study participants before starting data collection. The data collection was supervised by the principal investigator. Every questionnaire was supervised and reviewed for completeness and logical consistency. The completeness of the questionnaire was also checked before data entry. Validation of instruments, measurements, and random auditing was done daily. The double data entry would be used to ensure data quality.

Data processing and analysis

EPI info version 7 software was used for data entry (21) and cleaning and then the data were exported to Statistical Package for the Social Sciences (SPSS) Version 21 for further processing and analysis (22). World Health Organization (WHO) Anthro software was used to convert nutritional data indices from anthropometric measurements into Z-scores. A binary logistic regression model was used to compute the association between each independent variable and dependent variable. Independent variables that show association with outcome during bivariate analysis at a *P*-value <0.25 were included in multivariable analysis to control for potential confounders. Descriptive analysis was used to describe the percentages and number of distributions of the respondents by socio-demographic characteristics and other relevant variables in the study.

Homer–Lemeshow goodness-of-fit was used to test for the model fitness and a backward step-wise (likelihood ratio) method was also conducted. Adjusted odds ratio (AOR) along with a 95% confidence interval (CI) was estimated to assess the strength of the association and a *P*-value <0.05 was considered to declare the statistical significance in the multivariable analysis in this study.

Ethical consideration

Ethical clearance was obtained from the Institutional Review Board at the College of Health Sciences of Arsi University. In addition, a permission letter from the Shashemene District Health Office was obtained before field activities started, and written informed consent was obtained from the parents/caretakers of the study subjects after explaining the study objective and procedures.

Results

Socio-demographic characteristics

A total of 457 under-five children participated with a response rate of 100%. The mean age (SD) of the children and mothers was 25 (3.4) months and 26.9 (4.3) years, respectively. A household headed by a male or a married person accounted for more than 90% of the respondents [433 (94.75%) and 414 (90.59%)], respectively. 14 (90.60%) of the mothers were Oromo, while 366 (80.09%) of the respondents identified as Muslims. In a similar proportion, 240 (52.52%) of the caregivers had formal education and were autonomous in households' decision-making (Table 1).

Maternal and child characteristics

Of the total children, 206 (45.08%) were delivered at home and 251 (54.92%) children were delivered at health facilities. Concerning vaccination status and vitamin A supplementation, 432 (94.53%) of children were vaccinated and 181 (41.51%) of children were supplemented with vitamin A, respectively. Among the surveyed 457 mothers 432 (94.53%) of mothers/caregivers of children were in the age group <35 years and 395 (86.43%) mothers of under-five children practiced at least one antenatal care (ANC) visit. While 135 (29.54%) and 118 (25.82%) mothers did not take extra meals during pregnancy and lactation, respectively (Table 2).

Child caring practice

Slightly above two-thirds 320 (70.02%) of children had breastfeeding that was initiated within 1 h after birth and about 90 (19.69%) of children took pre-lacteal feeding. About 281 (61.49%) mothers exclusively breastfeed their children for the

TABLE 1 Socio-demographic characteristics of study participants in Shashemene district, Oromia region, Ethiopia, July 2018 (457).

Variables	Categories	Total	
		Frequency	%
Head of the HH	Male	433	94.75
	Female	24	5.25
Ethnicity	Oromo	414	90.60
	Wolayita	30	6.56
	Others*	13	2.84
Religion	Muslim	366	80.09
	Protestant	42	9.19
	Orthodox	32	7.00
	Catholic	17	3.72
Land ownership	Yes	384	84.03
	No	73	15.97
Maternal literacy	Yes	240	52.52
	No	217	47.48
Paternal literacy	Yes	275	60.18
	No	182	39.82
Area of agricultural land	<1 hectare	16	4.17
	1–2 hectare	342	89.06
	>3 hectare	26	6.77
Occupation of the mother	Housewife	421	92.12
	Merchant	27	5.91
	Other**	9	1.97
Occupation of the husband	Farmer	374	81.84
	Merchant	60	13.13
	Other**	23	5.03
Family size	≤5	314	68.71
	>5	143	31.29
Maternal autonomy	Yes	240	52.52
	No	217	47.48
Marital status	Married	414	90.59
	Divorced	26	5.69
	Other***	17	3.72

*Amhara, Wolayita, Sidama.
**Employee, daily laborer.
***Widowed, separated, single.

first 6 months. Three-fourth 323 (74.08%) of the children started complementary feeding in addition to breastfeeding at the age of 6 months while 111 (25.46%) of the children started complementary feeding. Spoon feeding was practiced in 240 (55.04%) children while 147 (33.72%) and 49 (11.24%) used

TABLE 2 Maternal and child characteristics of study participants in Shashemene district, Oromia region, Ethiopia, July 2018 (457).

Variables	Categories	Total	
		Frequency	%
Age of the mothers/caregivers (years)	<35	432	94.53
	≥35	25	5.47
Maternal extra meal during the last pregnancy	0	135	29.54
	1	234	51.20
	2	88	19.26
Maternal extra meal during the last lactating	0	118	25.82
	1	242	52.95
	2	97	21.23
ANC visit	Yes	395	86.43
	No	62	13.57
Age of the mothers at first birth	≤20	384	84.03
	>20	73	15.97
Distance from the HH to the HF (min)	<30	317	69.37
	≥30	140	30.63
Age of the child (months)	0–5	21	4.60
	6–23	203	44.42
	24–59	233	50.98
Sex of the child	Male	213	46.61
	Female	244	53.39
Child received deworming	Yes	98	43.95
	No	125	56.05
The child received vitamin A	Yes	181	41.51
	No	255	58.49
Type of birth	Single	440	96.28
	Multiple/Twins	17	3.72
Child vaccination status	Yes	432	94.53
	No	25	5.47
Place of birth	Home	206	45.08
	HI	251	54.92
History of diarrhea in the last 2 weeks	Yes	111	24.29
	No	346	75.71
History of febrile illness in the last 2 weeks	Yes	28	6.13
	No	429	93.87

TABLE 3 Child caring practices of the study population in Shashemene district, Oromia region, Ethiopia, July 2018 (457).

Variables	Categories	Total	
		Frequency	%
Duration of breastfeeding	<6 months	19	4.16
	Up to 12 months	54	11.81
	For 24 months	296	64.77
	More than 24 months	88	19.26
DDS	<4	315	72.25
	≥4	121	27.75
Time of breastfeeding initiation	Within the first hour	320	70.02
	After the first hour of delivery	137	29.98
Child deprive colostrum	Yes	81	17.72
	No	376	82.28
EBF of the child during the first 6 months	Yes	281	61.49
	No	176	38.51
Age of the child while starting CF	<6 months	111	25.46
	At 6 months	323	74.08
	6–12 months	2	0.46
Method of feeding	Bottle	147	33.72
	Cup	49	11.24
	Spoon	240	55.04
Pre-lacteal feeding	Yes	90	19.69
	No	367	80.21
Frequency of breastfeeding	4–7	155	33.92
	≥8	302	66.08
Increase the pattern of feeding for a sick child	Yes	222	48.58
	No	235	51.42

bottle and cup feeding, respectively. In addition, 315 (72.25%) of children were consume diversified food groups <4 within 24 h while 121 (27.75%) of children were consume diversified food groups ≥4 within 24 h (Table 3).

Environmental factors

About 399 (87.30%) households got water from piped outside the compound. The average water utilized per household was 35 L per day and the average round trip to fetch water from the source of water was 37.24 min. Concerning household domestic liquid and solid waste disposal, 274 (59.96%) and 234 (51.20%) of the households disposed of domestic liquid and solid waste in open fields, respectively, and latrine was not available in 75 (16.41%) households. Regarding the residence house, 269 (58.86%) households had thatched homes while 188 (41.14%) were corrugated iron sheets (Table 4).

TABLE 4 Environmental characteristics of the study population in Shashemene district, Oromia region, Ethiopia, July 2018 (457).

Variables	Categories	Total	
		Frequency	%
Latrine availability	Yes	382	83.59
	No	75	16.41
Domestic liquid waste disposal	Open field	274	59.96
	Pit	183	40.04
HH domestic solid waste disposal	Open field	234	51.20
	Pit	133	29.10
	Burning	10	2.20
	Composting	80	17.50
Type of residence house	Thatched	269	58.86
	Corrugated iron sheet	188	41.14
Kitchen site	Inside residential house	140	30.63
	Separated	317	69.37
Live together with animals	Yes	127	27.80
	No	330	72.20
Source of drinking water	Piped outside the compound	399	87.30
	Covered well	21	4.60
	Protected spring	35	7.66
	Open well	2	0.44
Take to HI when the child is sick	Within 24 h	235	51.42
	More than 24 h	222	48.58

Prevalence of acute malnutrition

The prevalence of acute malnutrition among under-five children was 91 (19.91%) with (95% CI; 16.24%, 23.57%). In children aged 0–5, 6–11, 12–23, 24–35, and 36–47 months, the prevalence of wasting was 3 (14.29%), 26 (26.53%), 30

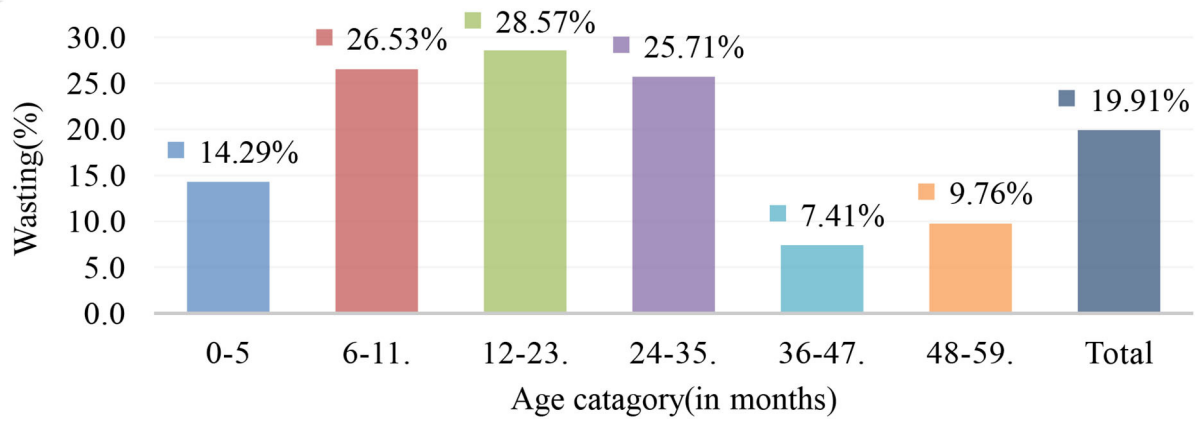

FIGURE 1
Prevalence of acute malnutrition (wasting) by age category among under-five children in Shashemene district, Oromia region, Ethiopia, July 2018.

(28.57%), 18 (25.71%), 6 (7.31%), and 8 (9.76%), respectively (Figure 1).

Factors associated with acute malnutrition (wasting)

In bivariate analysis, parental education, maternal autonomy in decision making, squeezed out, and throwing colostrums, ANC visit, history of diarrhea in the last 2 weeks, history of febrile disease in the last 2 weeks, age of mother at first birth, place of birth, maternal education, and pre lacteal feeding were the variables that showed an association with the outcome variable at the bivariate analysis with *P*-value <0.25 were entered into the final multivariable logistic regression to control potential confounders.

On multivariable logistic regression, maternal ANC visits were significant predictors determinants for acute malnutrition, children whose mothers were not on ANC visits at least once were two times more likely to be acutely malnourished than those children whose mothers were on ANC visits at least once (AOR = 2.26, 95% CI 1.14–4.46). The odds of developing wasting were two times higher among children whose mother has not autonomous in decision-making than those whose mother has autonomous in decision-making (AOR = 2.42, 95% CI 1.42–4.12).

The morbidity status of the child by diarrheal disease in the last 2 weeks preceding the survey was also seen as one of the determinants of acute malnutrition in under-five children. Acute malnutrition was two times more likely to occur in children who had diarrhea before 2 weeks than those children who had no diarrhea within 2 weeks (AOR = 2.07, 95% CI 1.19–3.59). Although children who had a fever in the last 2 weeks preceding the survey shows a significant association in bivariable analysis, no association was observed between children who had a fever in the last 2 weeks preceding the survey and wasting in multivariable analysis. Similarly, children whose mothers had squeezed out colostrum were two times more likely to be wasted than under-five children whose mothers had no squeeze-out colostrum (AOR = 1.99, 95% CI 1.07–3.71) (Table 5).

Discussion

In this study, the prevalence of acute malnutrition (wasting) is 19.91% (95%CI; 16.24%, 23.57%) and maternal autonomy in decision making, squeezing out, and throwing colostrum, ANC visit, history of diarrhea in the last 2 weeks, were the independent factors associated with acute malnutrition.

The above-stated prevalence of acute malnutrition (wasting) was higher as compared with 14.2% in Kwara State, Nigeria (23), and 16.5% in Nakaseke and Nakasongola districts, Uganda (24) from African countries. Moreover, the study is higher than 13.4% in the Bule Hora district (25), 16.7% in Hidabu Abote, North Shewa (26), and 9% in Damot Gale (27), studies in Ethiopia. This difference might be due to the variation in the study methodology used and the great variation between the rural and urban communities. Unlike this study, the previous studies mentioned above were conducted in the urban community.

Although present study showed that the prevalence of wasting was high in the district in comparison with the regional (10.6%) and national prevalence (11%) reported by EDHS 2016 (9). The discrepancy might be due to the sample size compared to that of national data. This finding was

TABLE 5 Factors associated with acute malnutrition (wasting) among children under-five years, of Shashemene district, Oromia region, Ethiopia, and July 2018 (457).

Variable	AM (wasting)		COR (95%, CI)	AOR (95%, CI)	*P*-values for AOR
	Yes	No			
Paternal literacy					
Yes	43	232	1		
No	48	134	1.93 (1.19–3.03)	1.36 (0.77–1.98)	0.453
Maternal autonomy					
Yes	39	201	1	1	
No	52	165	1.62 (1.02–2.58)	2.42 (1.42–4.12)	**0.001**
ANC visit					
Yes	71	324	1	1	
No	20	42	2.17 (1.20–33.92)	2.26 (1.14–4.46)	**0.019**
History of diarrhea in the last 2 weeks					
Yes	30	81	1.73 (1.05–2.56)	2.07 (1.19–3.59)	**0.010**
No	61	285	1	1	
History of febrile illness in the last 2 weeks					
Yes	10	18	2.39 (1.06–5.37)	1.94 (0.99–3.74)	0.067
No	81	348	1		
Child deprive colostrum					
Yes	28	53	2.62 (1.54–4.47)	1.99 (1.07–3.71)	**0.029**
No	63	313	1	1	
Age of the mother at first birth					
≤20	68	316	1		
>20	23	50	2.14 (1.22–3.74)	1.93 (0.95–2.74)	0.216
Place of birth					
Home	50	156	1.64 (1.03–2.61)	1.42 (0.86–2.56)	0.432
HI	41	210	1	1	
Maternal illiteracy					
Yes	37	203	1	1	
No	54	163	1.82 (1.14–2.89)	1.67 (0.87–2.95)	0.322
Pre-lacteal feeding					
Yes	31	59	2.69 (1.61–4.50)		
No	60	307	1		
Maternal extra meals during lactating					
0	27	91	2.90 (1.29–6.52)	2.14 (0.97–3.74)	0.065
1	55	187	2.88 (1.36–6.08)	2.04 (0.88–2.74)	0.087
2	9	88	1		

consistent with 23.6% in Hawassa Zuria district, Southern Ethiopia (28). This similarity may be due to socioeconomic, study design, and sample size. However, this finding was lower than 42.3% in Dolo Ado district, Somali region, Ethiopia (29). This may be due to Dolo Ado district being highly affected by drought and the community being pastoralists. Moreover, the finding was lower than 25% in Christ specialist hospital, Ogui, Enuu, Nigeria, and higher than 14.8% at the University of Nairobi, Kenya (30, 31). This difference might be due to the study design, sociodemographic characteristics, lifestyle, and cultural variation.

Maternal ANC visit was a significant determinant of acute malnutrition. Children whose mothers had no ANC visits were two times more likely to develop acute malnourished than those children whose mother has ANC visits. Since the overall aim of ANC is to produce a healthy mother and baby at the end of pregnancy, taking antenatal visits may help the mother and child to have better health and knowledge of the child-caring practice. This finding was consistent with a study conducted in Damot Gale district, South Ethiopia (27), which revealed that children whose mothers attended ANC were associated with acute malnutrition. However, another study conducted in Shone district, Hadiya zone, SNNPR (32), showed that children whose mothers haven't had antenatal care follow-up are associated with acute malnutrition of the children.

Children whose mothers were not autonomous in decision-making were two times more likely to be wasted than those children whose mothers were autonomous in decision-making. This result was consistent with studies conducted in Shashogo district and Machakel district (33, 34), and studies in Ethiopia. Such findings will require women's autonomy to participate in the decision-making process of the household equally with their husbands. Nowadays the policy of government also supports empowering women, and women's education and the increasing influence of women have a significant impact on the health of the family and community.

Children with diarrhea preceding 2 weeks before the onset of acute malnutrition are significantly associated with acute malnutrition (wasting) children. This can be due to excessive loss of fluids and electrolytes, loss of appetite, or lack of absorption of food in the intestine due to high motility of the intestine during diarrhea episodes (5). This finding was supported by studies done by Shibru and Tesfaye and Bantamen et al. (32, 33).

Squeezing out of first milk was significantly associated with acute malnutrition in under-five children. Children deprived of colostrum were two times more likely wasted than those children who have not deprived of colostrum. This result was consistent with a case-control study conducted in the Machakel district revealed that squeezing out of first milk showed a significant association with malnutrition (33). Exclusive breastfeeding is recommended because breast milk (colostrum) is containing necessary nutrients in the first few months of life. In addition, the mother's antibodies in breast milk provide the infant with immunity to disease. Early supplementation exposes infants to pathogens and thus increases their risk of infection, especially diarrheal disease and it decreases infants' intake of breast milk and therefore suckling, which in turn reduces breast milk production (35).

Strengths and limitations

The study considers a high-risk population (children 0–5 months of age group), using World Health Organization (WHO) Anthro software and close supervision throughout the field activities were the strength of the study. However, recall bias for some variables (for example DDS, frequency of breastfeeding, complementary feeding) is a limitation of the study.

Conclusion and recommendation

The prevalence rate of acute malnutrition (wasting) among under-five children in the district was high. Antenatal care visits, decision-making, squeezing out and throwing colostrum, and children who had diarrheal disease were the independent predictors of acute malnutrition. Therefore, the local health department and health extension workers should consider imparting health education for women on nutritional counseling and timely treatment for children with diarrhea. Moreover, the health departments try to consider the effects of these factors (women's decision-making, benefits of colostrum, diarrheal disease, and ANC) while proving services on nutrition.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Ethics statement

The studies involving human participants were reviewed and approved by Mizan Tepi University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

All authors wrote the protocol, participated in data collection, analyzed the data, and wrote the manuscript. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Dietary patterns and indicators of cardiometabolic risk among rural adolescents: A cross-sectional study at 15-year follow-up of the MINIMat cohort

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Background: Diet being a modifiable factor, its relationship with cardiometabolic risk is of public health interest. The vast majority of studies on associations of dietary patterns with cardiometabolic risk indicators among adolescents are from high-income countries and urban settings. We sought to describe dietary patterns and examine their associations with selected cardiometabolic risk indicators–waist circumference (WC), systolic blood pressure, fasting lipid profile and insulin resistance–along with its gender stratification among adolescents in a low-income, rural setting.

Methods: This cross-sectional study utilized data from the 15-year follow-up of the Maternal and Infant Nutrition Interventions in Matlab (MINIMat) cohort in southeast Bangladesh. The children who were born as singletons to the mothers randomized in the MINIMat trial and had valid birth anthropometrics were eligible for the follow-up. We employed a single, qualitative 24-hour recall to assess diet. Dietary patterns were derived from simple *K*-means cluster analysis, and calculation of dietary diversity score (DDS) using a validated instrument. Anthropometric parameters and systolic blood pressure were recorded. Fasting plasma triglyceride, total cholesterol, low- and high-density lipoproteins, insulin and glucose levels were measured. We calculated insulin resistance using the Homeostasis Model Assessment equation (HOMA-IR). Three right-skewed outcome variables were natural log (Ln) transformed: WC, triglyceride and HOMA-IR. Omnibus and gender-specific multiple linear regression models were fitted.

Results: Among 2,253 adolescents (52.1% girls, 7.1% overweight/obese), we identified four diet clusters: Traditional, Fish-dominant, Meat-dominant, and High-variety. No significant associations were found between the clusters and indicators. On gender-stratification, triglyceride levels were lower among boys in the Fish-dominant (Ln-triglyceride $\beta_{adjusted}$: −0.09; 95% confidence interval (CI): −0.15, −0.02) and Meat-dominant (Ln-triglyceride $\beta_{adjusted}$: −0.08; 95% CI: −0.15, −0.004) clusters than among boys in the Traditional cluster. Compared to boys in the bottom quartile of

DDS, boys in the top quartile had 2.1 mm of Hg (95% CI: 0.5, 3.6) higher systolic blood pressure and 1.9% (95% CI: 0.01–3.8%) higher WC.

Conclusion: While statistically significant, the gender-specific differences in triglyceride, systolic blood pressure, and waist circumference across dietary patterns were small. Associations between dietary patterns and cardiometabolic risk indicators may require a time lag beyond mid-adolescence to manifest in a rural setting. Prospective studies are warranted to delineate the magnitude and direction of those associations.

KEYWORDS

dietary patterns, cardiometabolic risk markers, blood pressure, lipid profile, waist circumference, rural adolescents, low- and middle-income country (LMIC), Bangladesh

Introduction

Elevated systolic blood pressure (SBP) and raised blood levels of glucose and lipids pose a major challenge to global health. The Global Burden of Disease (GBD) 2019 study (1) examined the morbidity and mortality attributable to these cardiometabolic risks. SBP > 115 mm of Hg accounted for an estimated 10.8 million deaths worldwide in 2019 (1). The corresponding estimates for fasting plasma glucose >5.4 mmol/L and low-density lipoprotein (LDL) >1.3 mmol/L were 6.2 million and 2.4 million deaths, respectively (1). Over the past decade, the population exposure to cardiometabolic risks has increased sharply in low- and middle-income countries (LMICs). For instance, between 2010 and 2019, the age-standardized, risk-weighted prevalence of high fasting plasma glucose increased by about 2.5% annually in lower-middle income countries. In the same period, the annual rate of increase was 1.3% globally and 1.8% in high-income countries (1). The escalating exposure in LMICs coincides with rapid nutrition transition and changes in population diets due to widening availability of unhealthy foods (2). Diet is a modifiable factor intricately related to these cardiometabolic risks (3). Hence, exploring dietary patterns (DPs) in relation to indicators of cardiometabolic risk is relevant to understanding how habitual diet shapes cardiometabolic risk profile in different populations.

Cardiometabolic risk profile emerging in adolescence may track into adulthood. Epidemiological studies have shown that adverse cardiometabolic risk profile in adolescence predicts hypertension, type 2 diabetes, dyslipidemias and cardiovascular events decades later in the adulthood (4–6). Similarly, food choices and DPs established in adolescence have been found to persist well into adulthood (7, 8). Therefore, identification of healthful or deleterious DPs in terms of cardiometabolic risk among adolescents could inform non-communicable disease prevention strategies. Nevertheless, the vast majority of the studies investigating associations between DPs and indicators of cardiometabolic risk among adolescents are from high-income countries (9–14) or urban settings of middle-income countries (15–19). These studies are unlikely to have captured the potentially higher biological susceptibility (20) from early-life undernutrition (21, 22) among rural adolescents of LMICs. Furthermore, the findings are heterogeneous, particularly regarding gender-based differences in association. At 14-year follow-up of an Australian birth cohort, a DP with higher shares of saturated fat, refined sugar and added salt was cross-sectionally associated with higher total cholesterol (TC) and waist circumference (WC) among girls only (9). Prospective analyses in the same cohort revealed positive associations of an "energy dense, high fat, and low fiber" DP with WC among girls and fasting glucose among boys at 17 years (11). In a cross-sectional study among Tunisian adolescents (n = 1,019, 44.4% rural), a "modern" DP consisting of white bread, high-fat dairy, sugar-sweetened beverage (SSB) and processed meat was positively associated with WC only among the boys (23). These diverse findings indicate the need for studying DPs in relation to cardiometabolic risk among adolescents in resource-limited, rural settings for context-specific empirical evidence.

Bangladesh is a lower-middle-income country in South Asia and home to 36 million adolescents, who represent one-fifth of the population. The majority of these adolescents live in rural areas (24). Yet studies on DPs and cardiometabolic risk among rural adolescents in Bangladesh remain markedly sparse. Aiming to address this gap, we sought to: (i) describe DPs in a rural birth cohort of Bangladeshi adolescents; and (ii) examine the associations of the DPs with WC, SBP, plasma levels of triglyceride (TG), TC, LDL and high-density lipoprotein (HDL), and insulin resistance (IR) along with potential difference in associations by gender.

Materials and methods

Study design, participants, and setting

This cross-sectional study availed data collected during the 15-year follow-up of MINIMat trial, conducted from September 2017 to June 2019. MINIMat (Maternal and Infant Nutrition Interventions in Matlab, reg#ISRCTN16581394) was a community-based, randomized trial that tested the effects of prenatal food and micronutrient supplementation on maternal and birth outcomes (25). Between 2001 and 2003, a total of 4,436 pregnant women from Matlab were randomized. This resulted in 3,267 singleton live births with valid birth anthropometrics, forming the MINIMat cohort that has been intensively followed up (26). The 15-year follow-up comprised three parts: formative phase, household survey, and clinic visit. Trained interviewers with at least 12 years of formal education interviewed the adolescent-mother/guardian dyads at their houses using a pre-tested, structured questionnaire. The clinic visit involved anthropometric assessment and collection of fasting blood sample.

Out of the 3,267 eligible adolescents, 2,465 (75.5%) completed the household survey and 2,300 (70.4%) completed the clinic visit. The participant flow and reasons for loss to follow-up are presented in **Figure 1**, "Results" section.

Matlab is a rural sub-district, located about 55 km to the southeast of the capital city of Dhaka. The community is agrarian and rice farming is the main occupation in Matlab, but a few villages rely on fishing as the means of income. An agricultural lean period usually occurs from September to November (27).

Dietary assessment

The foods consumed by Matlab adolescents were listed during the formative phase. Focus groups (28) and findings from previous follow-ups informed the listing process. There were 15 food groups in total, and the items included in each are presented in **Supplementary Table 1**. The details of the food grouping have been reported elsewhere (29, 30). Briefly, the foods other than ultra-processed and deep-fried foods were arranged into 10 groups using locally adapted version of a validated (31, 32) instrument endorsed by the Food and Agriculture Organization (33). The groups were: (i) grains, white roots and tubers, and plantains; (ii) vitamin A-rich vegetables, tubers and fruits; (iii) dark green leafy vegetables; (iv) other vegetables; (v) other fruits; (vi) meat; (vii) egg; (viii) fish; (ix) legumes, nuts and seeds; and (x) milk products. The ultra-processed foods (UPFs) were identified using the NOVA system proposed by Monteiro et al. (34), and consolidated into four groups: (i) ready-to-eat or "instant" foods; (ii) confectionery, sweets and similar packaged products; (iii) savory snacks, and (iv) sugar-sweetened beverage (SSB) including energy drinks. Foods submerged in heated oil while cooking were grouped as deep-fried foods.

A single, interactive, 24-hour, qualitative recall was employed to assess consumption. Reported consumption of one tablespoonful (~15 grams) or more of ≥1 item(s) belonging to a food group classified the adolescent as a consumer (coded "1"). Those who did not consume received a code of "0" for that food group. The one-tablespoon requirement was used to avoid trivial consumption from inflating the heterogeneity in DPs (35). The enumerators probed for unreported consumption after the initial recall using list and pictorial aid displaying charted photographs of foods. This double-pass approach has been recommended to minimize recall bias (36).

Assessment of cardiometabolic risk indicators

Trained nurses collected data following a standardized protocol. Body weight was recorded with a digital scale (Tanita BC-418 Body Composition Analyzer, 0.2 kg) and height with a stadiometer (Seca 214, 0.1 cm) while adolescents wore standard light clothes provided by the project and were barefoot. The weight of the clothes (200 gram) were deducted from the measured weight. Body mass index (BMI) was calculated by dividing body weight with height squared (kg/m^2). BMI-for-age z-score (BAZ) was calculated using the World Health Organization reference (37). For descriptive purpose, we categorized the adolescents as thin (BAZ < -2), normal-weight ($-2 \leq$ BAZ $\geq +1$), and overweight/obese (BAZ $> +1$). WC was measured midway between the lower margin of the least palpable rib and iliac crest with a non-elastic tape (TALC) to the nearest 0.1 cm. Sitting BP was measured in triplicates, at two-minute intervals, using an Omron M10 device after a 10-min seated rest. Venous blood samples (6 ml) after an overnight fast were collected in Lithium-heparin tubes (Sarstedt). The samples were centrifuged; plasma was separated, aliquoted and stored at −70°C. Plasma TC, TG, LDL, and HDL levels were measured in a Cobas Analyzer (Roche) through enzymatic colorimetric assay at the laboratory of the Department of Clinical Chemistry, Skåne University Hospital, Sweden. Plasma insulin level was measured at the icddr,b laboratory. Fasting glucose was measured using the Contour TS Blood Glucose Monitoring System (Bayer) during the clinic visit. We calculated IR using the Homeostasis Model Assessment (HOMA) equation: HOMA-IR = (fasting insulin mU/L × fasting glucose in mmol/L) ÷ 22.5 (38).

Socio-demographic variables

Gender was a dichotomous variable (girl/boy). An asset score was calculated for each household from principal component analysis (39) of the data on ownership of a set of durables (e.g., mobile phone, television, refrigerator, etc.), access to electricity and sanitary latrine, and nature of fuel used. We constructed a categorical variable (household wealth) by converting asset scores into tertiles: the lowest, intermediate and highest tertiles representing the poorest, middle-status and richest households, respectively. Educational status was categorized according to completed years of formal education: none, primary (1–5 years), and secondary (6–12 years) for adolescents or secondary and above (≥6 years) for mothers.

Statistical analysis

We adopted a predefined, *a priori* approach and a data-driven, *a posteriori* approach (40, 41) to derive DPs. The *a priori* approach entailed calculation of individual dietary diversity score (DDS) (33) by summing up the codes received for the 10 food groups (excluding five groups of ultra-processed and deep-fried foods). DDS could range from 0–10. A categorical variable representing quartiles of DDS was created. The *a posteriori* approach involved cluster analysis (40, 41), given our interest in data-driven grouping of the adolescents into mutually exclusive clusters based on consumption. Cluster analysis assigns participants with similar consumption pattern to the same cluster using Euclidean distance metrics (42). We implemented Simple *K*-means Clustering algorithm in Weka (maximum 500 iterations) (43) with 14 food groups. The "grains, white roots and tubers, and plantains" group was excluded as 99% of the adolescents consumed rice from that group, making it the least discriminative dietary variable. The algorithm generated cluster centroids representing proportions of consuming adolescents by food groups in that cluster. A line graph was created by plotting the cluster sums of squared errors against cluster numbers ranging from 2–10 (**Supplementary Figure 1**) to help decide the optimal number of clusters. The point where the slope of the line levels off (the "elbow") indicates the optimal number of clusters. We determined the number of clusters indicating DPs to be four based on the plot, cluster size and interpretability in Matlab context. The clusters were given descriptive labels and a categorical variable was created for further analysis.

Categorical variables are described with frequency and percentage, and continuous variables with mean and standard

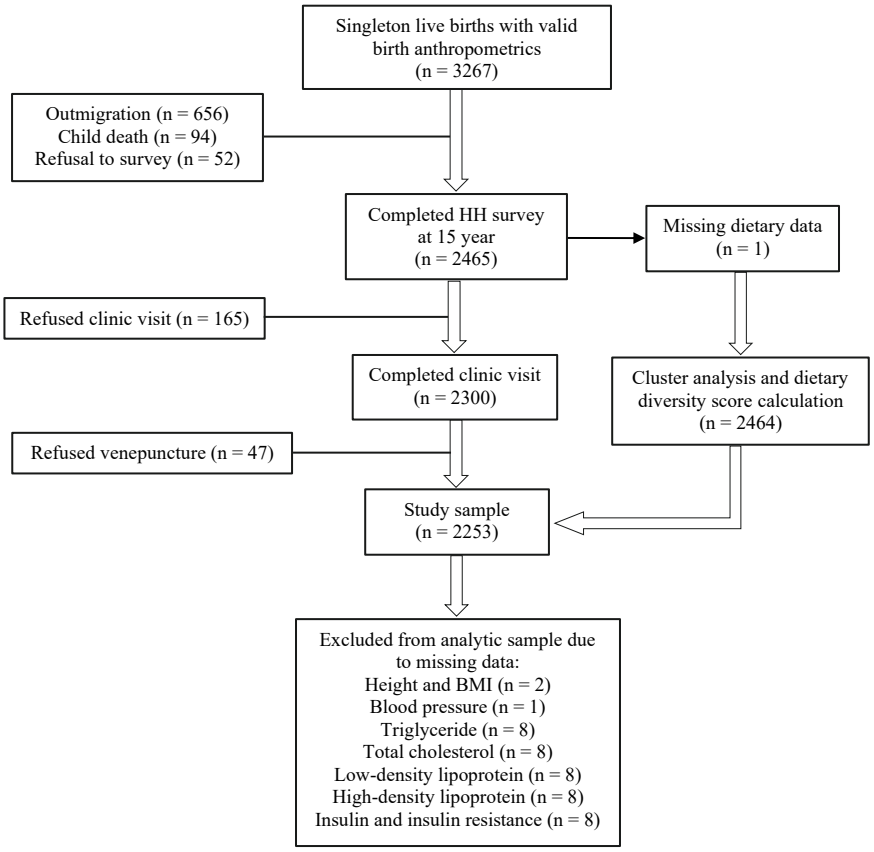

FIGURE 1
Flowchart for inclusion of Maternal and Infant Nutrition Intervention in Matlab (MINIMat) adolescents into the present study. HH, household.

deviation (SD) or median and interquartile range. We checked the distributions of the continuous variables by examining histograms and quantile-quantile plots. The following right-skewed variables were natural log (Ln) transformed: WC, TG, and HOMA-IR. Means across the clusters and DDS quartiles were compared with one-way analysis of variance (ANOVA). Linear regression models–for all participants and gender-specific–were fitted, and regression coefficients with 95% confidence intervals (CI) are reported. We examined quantile-quantile plots of the residuals and residuals versus fitted plots to rule out violation of assumptions. The adjusted models accounted for gender, household wealth and maternal education based on a directed acyclic graph (**Supplementary Figure 2**). We did not adjust for BMI considering it a mediator in the DP-cardiometabolic indicator relationship. All tests were two-tailed and *P*-values < 0.05 were considered statistically significant. The analyses were performed in R, version 4.1.2 (44). In this study, a sample size of 2,253 provides 80% power (two-tailed with alpha = 0.05) to detect a difference of 0.06 SD.

Ethics approval

The 15-year follow-up has been approved by the Ethical Review Committee at icddr,b in Dhaka, Bangladesh (PR–17029; date 2017/05/23). An additional approval has been obtained from the Ethics Review Authority (*Etikprövningsmyndigheten*) in Sweden (2021–02796; date 2021/11/15). We obtained written informed consent from the mothers and assent from the adolescents. The study was carried out in accordance with the Declaration of Helsinki.

Results

Of the 3,267 eligible adolescents, 2,465 completed the household survey. Loss to follow-up resulted from: outmigration ($n = 656$), child death ($n = 94$), and refusal to household visit ($n = 52$). Excluding one participant with missing diet data, the cluster analysis and calculation of DDS involved 2,464 adolescents. The clinic visit was refused by 165 adolescents and another 47 refused venepuncture. Thus, the study sample comprised 2,253 adolescents. Adolescents with missing data on height, and hence, BMI ($n = 1$); blood pressure ($n = 1$); TG ($n = 8$); TC ($n = 8$); LDL ($n = 8$); HDL ($n = 8$); and insulin, and hence, HOMA-IR ($n = 8$) were excluded from analyses involving the respective variables (**Figure 1**).

Description of the diet clusters

The four clusters were labeled as follows: Traditional ($n = 832$, 33.8%), Fish-dominant ($n = 604$, 24.5%), Meat-dominant ($n = 514$, 20.9%), and High-variety ($n = 514$, 20.9%). The cluster centroids for each food group–which represent the proportions of adolescents who consumed item(s) from that group–are presented in **Table 1**.

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TABLE 1 Proportion of adolescents who consumed at least one tablespoonful (~15 grams) of ≥1 item(s) from the 14 food groups by diet clusters.

Food group	All (n = 2,464)	Traditional cluster (n = 832)	Fish-dominant cluster (n = 604)	Meat-dominant (n = 514)	High-variety cluster (n = 514)
Vitamin A-rich[1] fruits, vegetables, and tubers	0.314	0.252	0.214	0.241	0.605
Dark green leafy vegetables	0.268	0.279	0.252	0.214	0.323
Other (non-vitamin-A-rich) vegetables	0.607	0.739	0.712	0.148	0.731
Other (non-vitamin-A-rich) fruits	0.452	0.296	0.364	0.381	0.877
Flesh and organ meat	0.352	0.139	0.238	0.765	0.418
Egg	0.349	0.279	0.316	0.333	0.517
Fish	0.732	0.907	0.924	0.179	0.774
Nuts, seeds, and legumes	0.462	0.346	0.290	0.465	0.850
Dairy	0.305	0.239	0.237	0.249	0.548
Ready-to-eat and "instant" foods (UPF)	0.130	0.112	0.134	0.095	0.189
Confectionery, sweets, and similar packaged products (UPF)	0.534	0.475	0.498	0.451	0.757
Savory snacks (UPF)	0.354	0.266	0.379	0.292	0.529
Sugar-sweetened beverage (UPF)	0.120	0.055	0.111	0.103	0.251
Deep-fried foods	0.413	0	1	0.278	0.529

UPF, ultra-processed foods.
[1]Based on the FAO guideline (35) that defines Vitamin A-rich fruits, vegetables, and tubers as those containing at least 120 Retinol Equivalent per 100 gram.

The Traditional cluster was characterized by a high reported consumption of fish along with low-carotenoid vegetables. About 47.5% of those in this cluster consumed packaged confectionery. The proportions of adolescents consuming animal-source foods (excluding fish) and dark green and vitamin-A-rich vegetables and fruits were fairly low in the cluster. Considering the pattern in Traditional cluster reflective of rural Bangladeshi diets, it was chosen as the reference category in further analyses. The proportion of adolescents consuming fish was highest in the Fish-dominant cluster (92.4%). Consumption of deep-fried foods was universal in this cluster and nearly 50% of the adolescents also consumed packaged confectionery. The Meat-dominant cluster was distinguished by the highest proportion of adolescents consuming meat (76.5%). Consumption of legumes (46.5%) and packaged confectionery (45.1%) was high as well, whereas that of fish was markedly low (17.9%). The proportion of adolescents with consumption exceeded 50% for 10 out of the 14 food groups in the High-variety cluster. Three-fourths of the adolescents in this cluster consumed packaged confectionery and about 53% consumed savory snacks and deep-fried foods. Consumption of low-carotenoid fruits, nuts, seeds, and legumes was also high.

The mean DDS across the clusters were as follows: Traditional (4.4; 95% CI: 4.3–4.5), Fish-dominant (4.5; 95% CI: 4.4–4.6), Meat-dominant (3.9; 95% CI: 3.8–4.0), and High-variety (6.6; 95% CI: 6.5–6.7). The mean BAZ of the adolescents in these clusters were as follows: Traditional (−0.89; 95% CI: −0.98, −0.80), Fish-dominant (−0.91; 95% CI: −1.01, −0.81), Meat-dominant (−1.01; 95% CI: −1.12, −0.89), and High-variety (−0.96; 95% CI: −1.08, −0.84).

Characteristics of the study participants

Table 2 demonstrates the socio-demographic and anthropometric characteristics and cardiometabolic profile of the MINIMat adolescents. The girls were slightly over-represented in the sample (52.1%). On average, the boys were taller and heavier than the girls; but the median BMI was higher among the girls. Overweight/obesity was more prevalent among the girls than the boys (7.9 versus 6.2%). Approximately 40% of the girls belonged to the poorest households, whereas 28.5% of the boys came from the poorest households. There were more girls than boys in the Traditional cluster and in the first quartile of DDS. The median WC in the sample was 62.4 cm and it did not differ by gender.

Bivariate analysis

The mean levels of WC, SBP, and blood markers by cluster and DDS quartile are presented in Table 3. There was a small but statistically significant difference in TG level by cluster. Adolescents in the Traditional cluster had the highest mean TG (geometric mean 0.99 mmol/L, 95% CI: 0.96–1.02), while those in the Fish-dominant cluster had the lowest mean TG (geometric mean 0.92 mmol/L, 95% CI: 0.89–0.95). Small but statistically significant differences in means of WC, SBP, and HDL were observed across DDS quartiles.

Associations of diet clusters with cardiometabolic risk indicators

Table 4 shows the regression coefficients with 95% CIs from crude and adjusted linear models for associations between the clusters and cardiometabolic risk indicators. Overall, the diet clusters were not associated with the indicators. On gender stratification, TG levels were significantly lower among boys in the Fish-dominant cluster (Ln TG β_{adj}: −0.089; 95% CI: −0.155, −0.022) and Meat-dominant cluster (Ln TG β_{adj}: −0.076; 95% CI: −0.149, −0.004) compared to boys in the Traditional cluster. No statistically significant association was observed among the girls.

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TABLE 2 Descriptive characteristics of the adolescents participating in the study.

Characteristics	All (n = 2253)		Boys (n = 1079)		Girls (n = 1174)		P^1
	n	Value	n	Value	n	Value	
Age (years)	2,253	15.0 (0.1)	1,079	15.0 (0.1)	1,174	15.0 (0.1)	0.382
Height (cm)	2,251	156.5 (7.6)	1,078	160.5 (7.7)	1,173	152.9 (5.4)	<**0.001**
Weight (kg)	2,253	43.9 (39.3–49.7)	1,079	45.3 (39.3–51.0)	1,174	43.1 (39.2–48.5)	<**0.001**
BMI (kg/m^2)	2,251	17.8 (16.3–19.8)	1,078	17.2 (15.9–18.9)	1,173	18.4 (16.9–20.5)	<**0.001**
BAZ categories[2]	2,251						<**0.001**
Normal	1,649	73.3	707	65.6	942	80.3	
Thin	442	19.6	304	28.2	138	11.8	
Overweight/obese	160	7.1	67	6.2	93	7.9	
Household wealth	2,253						<**0.001**
Poorest	775	34.4	308	28.5	467	39.8	
Intermediate	723	32.1	397	36.8	326	27.8	
Richest	755	33.5	374	34.7	381	32.4	
Maternal education	2,253						**0.027**
None	447	19.8	210	19.5	237	20.2	
Primary	800	35.5	357	33.1	443	37.7	
Secondary or above	1,006	44.7	512	47.4	494	42.1	
Adolescent education							<**0.001**
None	355	15.8	214	19.8	141	12.0	
Primary	57	2.5	45	4.2	12	1.0	
Secondary	1,841	81.7	820	76.0	1,021	87.0	
Diet clusters	2,253						<**0.001**
Traditional	764	33.9	282	26.1	482	41.0	
Fish-dominant	559	24.8	316	29.3	243	20.7	
Meat-dominant	468	20.8	222	20.6	246	21.0	
High-variety	462	20.5	259	24.0	203	17.3	
DDS quartiles	2,253						**0.026**
Q1 (DDS ≤ 4)	965	42.8	439	40.7	526	44.8	
Q2 (DDS = 5)	568	25.2	262	24.3	306	26.1	
Q3 (DDS = 6)	427	19.0	227	21.0	200	17.0	
Q4 (DDS ≥ 7)	293	13.0	151	14.0	142	12.1	
DDS	2,253	4.8 (1.5)	1,079	4.9 (1.6)	1,174	4.7 (1.4)	
WC (cm)	2,253	62.4 (58.9–66.8)	1,079	62.4 (59.3–66.4)	1,174	62.4 (58.8–67.2)	0.989
SBP (mm of Hg)	2,252	108.8 (8.0)	1,078	110.3 (8.2)	1,174	107.4 (7.6)	<**0.001**
TG (mmol/L)	2,245	0.9 (0.7–1.2)	1,077	0.9 (0.7–1.1)	1,168	1.0 (0.8–1.3)	<**0.001**
TC (mmol/L)	2,245	3.6 (0.7)	1,077	3.4 (0.6)	1,168	3.7 (0.7)	<**0.001**
LDL (mmol/L)	2,245	2.1 (0.6)	1,077	2.0 (0.5)	1,168	2.2 (0.6)	<**0.001**
HDL (mmol/L)	2,245	1.0 (0.2)	1,077	1.0 (0.2)	1,168	1.0 (0.2)	0.441
Insulin (μU/L)	2,245	11.4 (7.8–18.3)	1,078	9.6 (6.6–16.3)	1,167	12.9 (9.3–20.2)	<**0.001**
Glucose (mmol/L)	2,253	5.2 (0.5)	1,079	5.3 (0.5)	1,174	5.1 (0.4)	<**0.001**
HOMA-IR	2,245	2.6 (1.7–4.2)	1,078	2.2 (1.5–3.8)	1,167	2.9 (2.1–4.7)	<**0.001**

BMI, body mass index; BAZ, BMI-for-age z-score; WC, waist circumference; DDS, dietary diversity score; Q, quartile; SBP, systolic blood pressure; TG, triglyceride; TC, total cholesterol; LDL, low-density lipoprotein; HDL, high-density lipoprotein; HOMA-IR, insulin resistance from Homeostasis Model Assessment.

Values represent percentage for categorical variables, mean with standard deviation for continuous variables (approximately) normally distributed, or median with inter-quartile range for continuous variables that were skewed. P-values in bold indicate statistical significance.

Missing data: height and BMI (n = 2), SBP (n = 1), TG (n = 8), TC (n = 8), LDL (n = 8), HDL (n = 8), and insulin and HOMA-IR (n = 8).

[1] P-value for gender difference from Chi-squared test, independent samples t-test, or Wilcoxon rank-sum test.

[2] BAZ below −2 SD and above + 1 SD define thinness and overweight/obesity, respectively.

TABLE 3 Levels of cardiometabolic risk markers by diet clusters and quartiles of dietary diversity score.

Diet clusters	WC[1] (cm)	SBP (mm of Hg)	TG[1] (mmol/L)	TC (mmol/L)	LDL (mmol/L)	HDL (mmol/L)	HOMA-IR[1]
Mean (95% confidence interval)							
Traditional	63.3 (62.8–63.8)	108.5 (107.9–109.0)	0.99 (0.96–1.02)	3.62 (3.57–3.67)	2.16 (2.12–2.20)	1.02 (1.004–1.04)	3.1 (2.9–3.2)
Fish-dominant	63.6 (63.0–64.2)	109.0 (108.3–109.6)	0.92 (0.89–0.95)	3.54 (3.49–3.59)	2.12 (2.07–2.16)	1.02 (1.004–1.04)	2.8 (2.6–2.9)
Meat-dominant	63.0 (62.4–63.6)	108.4 (107.7–109.2)	0.94 (0.91–0.98)	3.54 (3.48–3.60)	2.11 (2.06–2.16)	1.01 (0.99–1.03)	2.8 (2.6–3.0)
High-variety	63.5 (62.9–64.1)	109.5 (108.8–110.3)	0.93 (0.89–0.96)	3.55 (3.48–3.61)	2.12 (2.07–2.18)	1.01 (0.99–1.03)	3.0 (2.8–3.2)
P^2	0.524	0.115	**0.003**	0.086	0.424	0.779	0.070
DDS quartiles							
Q1 (DDS ≤ 4)	63.2 (62.7–63.6)	108.2 (107.7–108.8)	0.96 (0.93–0.98)	3.57 (3.53–3.61)	2.13 (2.09–2.17)	1.01 (1.001–1.03)	2.8 (2.7–3.0)
Q2 (DDS = 5)	63.5 (63.0–64.1)	109.2 (108.6–109.9)	0.97 (0.94–1.00)	3.57 (3.52–3.62)	2.13 (2.08–2.17)	1.01 (0.99–1.03)	3.1 (2.9–3.3)
Q3 (DDS = 6)	62.9 (62.3–63.5)	108.7 (108.0–109.4)	0.92 (0.89–0.96)	3.57 (3.50–3.64)	2.12 (2.06–2.18)	1.04 (1.02–1.07)	2.9 (2.7–3.1)
Q4 (DDS ≥ 7)	64.3 (63.5–65.1)	110.0 (109.1–111.0)	0.94 (0.89–0.98)	3.56 (3.48–3.64)	2.14 (2.07–2.21)	0.99 (0.97–1.02)	3.0 (2.7–3.2)
P^2	**0.03**	**0.005**	0.275	0.992	0.962	**0.017**	0.076

WC, waist circumference; SBP, systolic blood pressure; TG, triglyceride; TC, total cholesterol; LDL, low-density lipoprotein; HDL, high-density lipoprotein; HOMA-IR, insulin resistance from Homeostasis Model Assessment; DDS, dietary diversity score; Q, quartile. *P*-values in bold indicate statistical significance.
[1]WC, TG, and HOMA-IR were right skewed and (natural) log transformed, and their geometric means with 95% confidence intervals reported here.
[2]From one-way analysis of variance.

Associations of DDS quartiles with cardiometabolic risk indicators

The adjusted linear regression models analyzing associations between DDS quartiles and cardiometabolic risk indicators are presented in **Table 5**. On average, those in the second (DDS = 5) and top (DDS ≥ 7) quartiles had 0.9 (95% CI: 0.1–1.7) and 1.4 (95% CI: 0.4–2.4) mm of Hg higher SBP, respectively, than their peers in the bottom quartile (DDS ≤ 4). Although on gender stratification the association disappeared among the girls, it persisted among the boys (β_{adj} for boys in the top quartile: 2.1; 95% CI: 0.5–3.6). Compared to the boys in the bottom quartile, WC was 1.9% (95% CI: 0.01–3.8%) higher among the boys in the top quartile. Boys in the third quartile (DDS = 6) had 0.04 mmol/L (95% CI: 0.01–0.08) higher HDL than the boys in the bottom quartile. These associations were not observed among the girls.

Discussion

We explored cross-sectional associations of DPs derived from cluster analysis and DDS with conventional cardiometabolic risk indicators in a rural birth cohort. Four distinct clusters were identified: Traditional, Fish-dominant, Meat-dominant, and High-variety; and none was associated with the indicators overall. However, gender-stratified analyses revealed lower plasma TG levels among boys in the Fish- and Meat-dominant clusters than boys in the Traditional cluster. The associations of DDS quartiles with WC, SBP, and HDL were significant only among the boys as well. Compared to boys in the bottom quartile of DDS, higher WC, and SBP were observed among boys in the top quartile.

The diet clusters identified in our study aligned with those found among 9–15 years old adolescents (n = 30,702, mean age 11.6 years, 49.6% girls) in rural, northwest Bangladesh between 2015 and 2017 (45). The researchers identified five *a posteriori* DPs using latent class analysis of dietary data collected through a food frequency questionnaire in that study. Despite the methodological differences, the "traditional", "moderately high meat", and "most diverse" DPs identified in that study (45) resemble the Traditional, Meat-dominant, and High-variety DPs from the present study, respectively. High consumption of fish and low-carotenoid vegetables along with low consumption of animal-source foods including dairy characterized the DP considered traditional in both analyses. Moreover, a DP with higher diversity from consumption of nutrient-rich foods (e.g., vitamin-A-rich fruits and vegetables, animal-source foods and legumes) alongside unhealthy ultra-processed and deep-fried foods emerged in both analyses. Adolescents from relatively well-off households tended to have this DP in both studies. This potentially indicates a socio-economic gradient in rural Bangladesh (46) that allows consumption of a combination of nutrient-rich and empty-calorie foods among adolescents of relatively affluent families. Interestingly, the mean BAZ was about 0.1 SD higher among those with the diverse DP ("most diverse" and High-variety) than those with the traditional DP in both studies.

The *a posteriori* DPs did not show an overall association with the cardiometabolic risk indicators in this study. Several previous studies conducted among adolescents that employed cluster analysis (10, 13, 14, 47) also reported a general lack of association. This can be related to the variation in the relationship between diet and cardiometabolic risk across life phases. It has been shown that short-term associations between DPs and cardiometabolic risk indicators are attenuated among adolescents compared to adults in their fourth to sixth decades of life (48). Adolescents usually remain metabolically healthy around mid-adolescence, even including a proportion of those with obesity (49), and the impact of diet on specific cardiometabolic indicators may require a longer period to manifest (48). Moreover, the dietary share of foods that are major sources of saturated and trans fats, such as red and processed meat, full-fat dairy products and ready-to-eat/heat UPFs (50), were probably much lower in the rural setting of Matlab than in high-income settings. These foods contribute to more than 50% of the daily energy intake among adolescents in some high-income countries (51–53). Alternatively, DP-indicator associations might have been masked by differences in portion size and preparation style (e.g., deep versus shallow frying),

TABLE 4 Overall and gender-stratified associations of diet clusters with anthropometric and blood markers of cardiometabolic risk among the Maternal and Infant Nutrition Intervention in Matlab (MINIMat) adolescents.

Marker	Diet clusters	All (*N* = 2,253)		Boys (*N* = 1,079)		Girls (*N* = 1,174)	
		β (95% CI)	*P*	β (95% CI)	*P*	β (95% CI)	*P*
Ln WC Crude model	Traditional	Ref		Ref		Ref	
	Fish-dominant	0.005 (−0.007, 0.016)	0.435	0.007 (−0.009, 0.024)	0.376	0.003 (−0.014, 0.019)	0.766
	Meat-dominant	−0.005 (−0.017, 0.007)	0.434	−0.003 (−0.021, 0.015)	0.720	−0.006 (−0.022, 0.011)	0.517
	High-variety	0.003 (−0.010, 0.015)	0.674	0.007 (−0.010, 0.025)	0.402	−0.002 (−0.020, 0.016)	0.835
Ln WC Adjusted[1] model	Traditional	Ref		Ref		Ref	
	Fish-dominant	0.002 (−0.009, 0.013)	0.724	0.009 (−0.007, 0.025)	0.281	−0.003 (−0.019, 0.014)	0.739
	Meat-dominant	−0.007 (−0.019, 0.004)	0.221	−0.004 (−0.021, 0.014)	0.669	−0.009 (−0.025, 0.007)	0.284
	High-variety	−0.004 (−0.016, 0.009)	0.567	0.002 (−0.015, 0.019)	0.840	−0.008 (−0.026, 0.009)	0.356
SBP Crude model	Traditional	Ref		Ref		Ref	
	Fish-dominant	0.473 (−0.403, 1.348)	0.290	−0.007 (−1.332, 1.317)	0.992	−0.120 (−1.290, 1.049)	0.840
	Meat-dominant	−0.051 (−0.975, 0.873)	0.913	−0.221 (−1.674, 1.231)	0.765	−0.432 (−1.596, 0.733)	0.467
	High-variety	**1.049 (0.121, 1.976)**	**0.027**	0.815 (−0.577, 2.206)	0.251	0.171 (−1.072, 1.415)	0.787
SBP Adjusted[1] model	Traditional	Ref		Ref		Ref	
	Fish-dominant	−0.130 (−1.002, 0.742)	0.770	0.047 (−1.275, 1.369)	0.944	−0.169 (−1.346, 1.008)	0.778
	Meat-dominant	−0.405 (−1.319, 0.508)	0.384	−0.263 (−1.713, 1.188)	0.722	−0.443 (−1.614, 0.728)	0.458
	High-variety	0.356 (−0.570, 1.281)	0.451	0.602 (−0.796, 2.001)	0.398	0.098 (−1.155, 1.350)	0.878
Ln TG Crude model	Traditional	Ref		Ref		Ref	
	Fish-dominant	−0.076 (−0.121, −0.032)	<0.001	**−0.089 (−0.155, −0.023)**	**0.008**	−0.007 (−0.069, 0.054)	0.814
	Meat-dominant	−0.049 (−0.096, −0.002)	0.041	**−0.076 (−0.148, −0.004)**	**0.039**	−0.003 (−0.063, 0.058)	0.932
	High-variety	−0.067 (−0.114, −0.020)	0.005	−0.052 (−0.121, 0.017)	0.140	−0.038 (−0.102, 0.027)	0.257
Ln TG Adjusted[1] model	Traditional	Ref		Ref		Ref	
	Fish-dominant	−0.045 (−0.089, 0.00007)	0.050	**−0.089 (−0.155, −0.022)**	**0.009**	0.001 (−0.060, 0.062)	0.974
	Meat-dominant	−0.031 (−0.077, 0.016)	0.196	**−0.076 (−0.149, −0.004)**	**0.039**	0.006 (−0.055, 0.067)	0.846
	High-variety	−0.032 (−0.079, 0.015)	0.181	−0.053 (−0.122, 0.017)	0.140	−0.026 (−0.091, −0.032)	0.439
TC Crude model	Traditional	Ref		Ref		Ref	
	Fish-dominant	**−0.078 (−0.151, −0.005)**	**0.037**	−0.025 (−0.121, 0.071)	0.614	−0.005 (−0.113, 0.103)	0.924
	Meat-dominant	**−0.081 (−0.158, −0.003)**	**0.040**	−0.064 (−0.170, 0.041)	0.229	−0.034 (−0.142, 0.073)	0.527
	High-variety	−0.070 (−0.147, 0.007)	0.077	−0.026 (−0.127, 0.074)	0.606	0.009 (−0.105, 0.124)	0.875
TC Adjusted[1] model	Traditional	Ref		Ref		Ref	
	Fish-dominant	−0.019 (−0.091, 0.053)	0.610	−0.024 (−0.120, 0.071)	0.615	−0.009 (−0.118, 0.010)	0.864
	Meat-dominant	−0.044 (−0.120, 0.031)	0.248	−0.060 (−0.165, 0.045)	0.262	−0.029 (−0.136, 0.079)	0.600
	High-variety	−0.013 (−0.089, 0.064)	0.746	−0.032 (−0.133, 0.070)	0.539	0.006 (−0.109, 0.121)	0.921
LDL Crude model	Traditional	Ref		Ref		Ref	
	Fish-dominant	−0.041 (−0.103, 0.022)	0.202	0.007 (−0.073, 0.088)	0.855	0.016 (−0.078, 0.110)	0.743
	Meat-dominant	−0.049 (−0.115, 0.017)	0.146	−0.025 (−0.113, 0.063)	0.579	−0.019 (−0.112, 0.074)	0.685
	High-variety	−0.035 (−0.101, 0.031)	0.296	0.008 (−0.076, 0.092)	0.850	0.022 (−0.077, 0.122)	0.657
LDL Adjusted[1] model	Traditional	Ref		Ref		Ref	
	Fish-dominant	0.006 (−0.056, 0.067)	0.860	0.008 (−0.072, 0.087)	0.853	0.009 (−0.085, 0.103)	0.854
	Meat-dominant	−0.021 (−0.085, 0.044)	0.531	−0.021 (−0.109, 0.066)	0.631	−0.017 (−0.110, 0.077)	0.728
	High-variety	0.007 (−0.058, 0.072)	0.844	−0.003 (−0.087, 0.082)	0.952	0.016 (−0.084, 0.115)	0.759
HDL Crude model	Traditional	Ref		Ref		Ref	
	Fish-dominant	0.002 (−0.022, 0.026)	0.867	0.003 (−0.033, 0.039)	0.876	−0.005 (−0.040, 0.029)	0.761

(Continued)

TABLE 4 (Continued)

Marker	Diet clusters	All (N = 2,253)		Boys (N = 1,079)		Girls (N = 1,174)	
		β (95% CI)	*P*	β (95% CI)	*P*	β (95% CI)	*P*
	Meat-dominant	−0.011 (−0.036, 0.015)	0.402	−0.016 (−0.055, 0.023)	0.429	−0.009 (−0.043, 0.025)	0.593
	High-variety	−0.006 (−0.031, 0.020)	0.664	−0.023 (−0.061, 0.014)	0.228	0.010 (−0.026, 0.047)	0.573
HDL Adjusted[1] model	Traditional	Ref		Ref		Ref	
	Fish-dominant	−0.00001 (−0.025, 0.025)	0.998	0.002 (−0.034, 0.038)	0.913	−0.007 (−0.042, 0.028)	0.691
	Meat-dominant	−0.011 (−0.036, 0.015)	0.418	−0.013 (−0.053, 0.026)	0.498	−0.010 (−0.044, 0.024)	0.558
	High-variety	−0.006 (−0.032, 0.020)	0.646	−0.016 (−0.054, 0.022)	0.408	0.008 (−0.029, 0.045)	0.673
Ln HOMA-IR Crude model	Traditional	Ref		Ref		Ref	
	Fish-dominant	**−0.103 (−0.188, −0.018)**	**0.017**	−0.092 (−0.222, 0.037)	0.163	−0.008 (−0.121, 0.104)	0.884
	Meat-dominant	−0.087 (−0.176, 0.002)	0.057	−0.072 (−0.214, 0.070)	0.322	−0.054 (−0.165, 0.057)	0.342
	High-variety	−0.033 (−0.122, 0.057)	0.476	0.019 (−0.117, 0.156)	0.781	0.003 (−0.116, 0.122)	0.958
Ln HOMA-IR Adjusted[2] model	Traditional	Ref		Ref		Ref	
	Fish-dominant	−0.055 (−0.138, 0.027)	0.189	−0.090 (−0.218, 0.038)	0.170	−0.026 (−0.135, 0.082)	0.634
	Meat-dominant	−0.052 (−0.139, 0.034)	0.236	−0.068 (−0.209, 0.072)	0.340	−0.040 (−0.148, 0.068)	0.464
	High-variety	−0.028 (−0.116, 0.059)	0.527	−0.016 (−0.152, 0.120)	0.814	−0.043 (−0.158, 0.072)	0.464

Ref, reference category; Ln, natural-log transformed variable where the base of the log was 2.71828; b, regression coefficient; WC, waist circumference; SBP, systolic blood pressure; TG, triglyceride; TC, total cholesterol; LDL, low-density lipoprotein; HDL, high-density lipoprotein; HOMA-IR, insulin resistance from Homeostasis Model Assessment.

[1] Adjusted for gender, household wealth, and maternal education.

[2] Additionally adjusted for sample storage time, that showed a negative correlation with fasting insulin level (Spearman's $\rho = -0.2$, $P < 0.001$). Statistically significant coefficients are presented in bold.

and thus, in energy intake, as we did not quantify and adjust for total energy intake. Nevertheless, precise assessment of portion size is challenging in a rural setting where family members share food from a common bowl (54).

We found gender-specific negative associations of Fish- and Meat-dominant DPs with plasma TG. These translated into 8.5% lower TG among boys in the Fish-dominant cluster and 7.3% lower TG among boys in the Meat-dominant cluster than among boys in the Traditional cluster. The mechanism underlying this gender specificity remains unclear. While statistically significant, the "effect size" in terms of differences in TG level appeared small from a public health perspective (55). Adherence to a Mediterranean DP was inversely associated with serum TG among adolescent boys from Mexico City (19). Conversely, a "Rice and Kimchi" DP among South Korean adolescents with about 45% of the energy intake from white rice was associated with an elevated TG in both gender (14). The traditional DP in rural Bangladesh is dominated by white rice–a starchy staple with high glycemic index (GI) (56)–that contributes to up to 76% of the total energy intake among adolescents (57). Diets dominated by white rice have been linked to raised TG levels (58). It has been postulated that substantial intake of high-GI foods combined with relatively low intake of cholesterol and saturated fat, that is more likely in the Traditional cluster, may stimulate production of triglycerides (59). The negative associations with TG could be related to a replacement of white rice to some extent by protein intake from fish and meat in the Fish- and Meat-dominant clusters (60). Nonetheless, the qualitative recall precluded quantification of the dietary share of white rice across the clusters and further studies are needed to examine this assumption.

Some unanticipated associations emerged in relation to *a priori* DPs based on the quartiles of DDS. Having a DDS ≥ 7 was associated with higher SBP and the association was slightly amplified among the boys on gender stratification. A recent meta-analysis of studies among adults could not find any significant association between DDS and systolic or diastolic blood pressure (61). However, studies among adolescents involving *a priori* DPs generated conflicting results. Truthmann and colleagues (12) documented a positive association between dietary diversity and SBP among girls in a cross-sectional study (n = 5,198, mean age 15.1 years, 49.1% girls) from Germany. In contrast, DASH (Dietary Approaches to Stop Hypertension) scores showed no association with SBP in several studies (10, 62, 63). The instruments and the number and composition of food groups used to construct the *a priori* scores varied substantially between these studies, and limited the comparability. The positive associations with SBP and WC in our study may imply a greater intake of added salt and unhealthy fats from ultra-processed and deep-fried foods among the boys in the top DDS quartile. Among the boys in the top quartile (n = 151), the proportions of those who consumed these foods were high: 22.5% for ready-to-eat foods, 72.2% for confectioneries, 51.6% for savory snacks, 29.1% for SSB, and 56.9% for deep-fried foods (data not shown). Adjusting for total energy intake might have attenuated these associations. For instance, in a cross-sectional study among Iranian adolescents (n = 456, mean age 14 years, 58.5% girls), introduction of total energy intake in the regression model rendered the positive association between DDS and abdominal obesity (WC ≥ 85th percentile) statistically non-significant (17). The reason for the isolated association of having a DDS = 6 with higher HDL remains inconspicuous. The simple method used for calculating DDS in this study (33) satisfactorily predicted micronutrient adequacy among Bangladeshi adolescents (32). Nevertheless, it perhaps lacks the nuance and sensitivity required to capture associations between diet and cardiometabolic risk at mid-adolescence (61).

TABLE 5 Overall and gender-stratified associations of dietary diversity score (DDS) quartiles with anthropometric and blood markers of cardiometabolic risk among the Maternal and Infant Nutrition Intervention in Matlab (MINIMat) adolescents.

Marker		All (*N* = 2,253)		Boys (*N* = 1,079)		Girls (*N* = 1,174)	
		β (95% CI)	*P*	β (95% CI)	*P*	β (95% CI)	*P*
Ln WC Adjusted[1] model	Q1 (DDS ≤ 4)	Ref		Ref		Ref	
	Q2 (DDS = 5)	0.003 (−0.008, 0.013)	0.604	0.012 (−0.003, 0.027)	0.133	−0.005 (−0.020, 0.010)	0.550
	Q3 (DDS = 6)	−0.009 (−0.020, 0.003)	0.153	−0.012 (−0.028, 0.004)	0.140	−0.005 (−0.022, 0.013)	0.598
	Q4 (DDS ≥ 7)	0.009 (−0.004, 0.023)	0.178	**0.019 (0.0001, 0.037)**	**0.048**	−0.001 (−0.020, 0.019)	0.945
SBP Adjusted[1] model	Q1 (DDS ≤ 4)	Ref		Ref		Ref	
	Q2 (DDS = 5)	**0.913 (0.094, 1.732)**	**0.029**	1.158 (−0.010, 2.415)	0.071	0.706 (−0.367, 1.779)	0.197
	Q3 (DDS = 6)	0.140 (−0.764, 1.044)	0.761	0.167 (−1.157, 1.492)	0.804	0.092 (−1.148, 1.333)	0.884
	Q4 (DDS ≥ 7)	**1.413 (0.373, 2.453)**	**0.008**	**2.078 (0.543, 3.612)**	**0.008**	0.704 (−0.710, 2.118)	0.329
Ln TG Adjusted[1] model	Q1 (DDS ≤ 4)	Ref		Ref		Ref	
	Q2 (DDS = 5)	0.019 (−0.023, 0.060)	0.384	0.051 (−0.012, 0.114)	0.112	−0.007 (−0.063, 0.048)	0.795
	Q3 (DDS = 6)	−0.016 (−0.063, 0.030)	0.487	0.003 (−0.063, 0.070)	0.922	−0.035 (−0.099, 0.030)	0.290
	Q4 (DDS ≥ 7)	−0.003 (−0.056, 0.050)	0.906	0.061 (−0.016, 0.138)	0.120	−0.070 (−0.143, 0.003)	0.061
TC Adjusted[1] model	Q1 (DDS ≤ 4)	Ref		Ref		Ref	
	Q2 (DDS = 5)	0.009 (−0.059, 0.077)	0.794	0.053 (−0.038, 0.145)	0.252	−0.027 (−0.126, 0.072)	0.595
	Q3 (DDS = 6)	0.028 (−0.047, 0.102)	0.468	0.018 (−0.079, 0.114)	0.719	0.041 (−0.073, 0.155)	0.477
	Q4 (DDS ≥ 7)	0.002 (−0.083, 0.088)	0.954	0.057 (−0.054, 0.169)	0.316	−0.055 (−0.185, 0.075)	0.407
LDL Adjusted[1] model	Q1 (DDS ≤ 4)	Ref		Ref		Ref	
	Q2 (DDS = 5)	−0.008 (−0.066, 0.049)	0.772	0.022 (−0.054, 0.098)	0.573	−0.033 (−0.118, 0.053)	0.456
	Q3 (DDS = 6)	0.006 (−0.058, 0.070)	0.854	−0.023 (−0.103, 0.056)	0.565	0.038 (−0.060, 0.137)	0.446
	Q4 (DDS ≥ 7)	0.010 (−0.063, 0.083)	0.782	0.045 (−0.047, 0.138)	0.340	−0.029 (−0.142, 0.084)	0.612
HDL Adjusted[1] model	Q1 (DDS ≤ 4)	Ref		Ref		Ref	
	Q2 (DDS = 5)	−0.001 (−0.024, 0.022)	0.929	−0.003 (−0.037, 0.031)	0.855	−0.0002 (−0.032, 0.031)	0.990
	Q3 (DDS = 6)	**0.032 (0.006, 0.057)**	**0.014**	**0.045 (0.009, 0.080)**	**0.014**	0.019 (−0.017, 0.056)	0.299
	Q4 (DDS ≥ 7)	−0.020 (−0.049, 0.009)	0.182	−0.040 (−0.081, 0.001)	0.056	0.004 (−0.037, 0.045)	0.849
Ln HOMA-IR Adjusted[1,2] model	Q1 (DDS ≤ 4)	Ref		Ref		Ref	
	Q2 (DDS = 5)	0.052 (−0.026, 0.130)	0.191	0.076 (−0.047, 0.198)	0.226	0.027 (−0.072, 0.127)	0.594
	Q3 (DDS = 6)	−0.034 (−0.121, 0.052)	0.435	−0.013 (−0.144, 0.117)	0.839	−0.049 (−0.163, 0.066)	0.406
	Q4 (DDS ≥ 7)	−0.013 (−0.113, 0.085)	0.788	−0.018 (−0.168, 0.132)	0.812	−0.003 (−0.134, 0.128)	0.965

Ref, reference category; Ln, natural-log transformed variable where the base of the log was 2.71828; WC, waist circumference; SBP, systolic blood pressure; TG, triglyceride; TC, total cholesterol; LDL, low-density lipoprotein; HDL, high-density lipoprotein; HOMA-IR, insulin resistance from Homeostasis Model Assessment; DDS, dietary diversity score; Q, quartile.

[1] Adjusted for gender, household wealth, and maternal education.

[2] Additionally adjusted for sample storage time, that showed a negative correlation with fasting insulin level (Spearman's $\rho = -0.2$, $P < 0.001$). Statistically significant coefficients are presented in bold.

This study complements a growing body of literature (50) on the links between DPs and cardiometabolic risk among adolescents. Key strengths of the study include: a moderately large sample size based on a well-characterized, rural birth cohort (26), application of a double-pass method for dietary assessment that offered cost-effectiveness, high inter-rater reliability and low respondent burden while minimizing recall bias, and combination of *a priori* and *a posteriori* approaches to analyzing DPs. The findings are generalizable to adolescents in Matlab because of the area-wide recruitment of pregnant women in the MINIMat trial (25) and also to other rural, agrarian settings in Bangladesh due to the similarity in socio-cultural context. However, some critical limitations of this study need to be acknowledged. Drawing any causal inference from the associations would be erroneous owing to the cross-sectional design. We did not ascertain portion size and could not adjust the analyses for total energy intake. A single, 24-hour recall might not be entirely representative of the adolescents' habitual dietary consumption. Under-reporting of sweet and savory snacks and SSBs in a 24-hour recall has been documented among LMIC adolescents (64, 65), but a recent validation study demonstrates the degree of under-reporting to be acceptable (64)–especially with larger samples. Although the decision to fix the number of clusters at four was based on the scree plot and the size and interpretability of clusters in Matlab context, it may limit comparability with other studies. Finally, we could not completely rule out residual confounding.

Conclusion

We identified four DPs using cluster analysis in a birth cohort of adolescents in rural Bangladesh: Traditional, Fish-dominant, Meat-dominant, and High-variety clusters. No significant associations were observed between these clusters and selected cardiometabolic risk indicators, apart from small, negative associations of Fish- and Meat-dominant clusters with plasma TG among the boys. Furthermore, belonging to the top quartile of DDS was associated with higher SBP and WC among the boys. Associations between DPs and cardiometabolic risk indicators may require a time lag beyond mid-adolescence to be evident in a rural setting. Prospective studies with adjustment for energy intake are warranted to delineate the magnitude and direction of those associations.

Data availability statement

The study under consideration availed data from the 15-year follow-up of the MINIMat (Maternal and Infant Nutrition Intervention in Matlab) trial. The 15-year follow-up was a large, collaborative project involving Uppsala University, Karolinska Institute, Finnish Institute for Health and Welfare, University of Oulu and International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b). Because of the statutory requirements, internal data policies and regulations existing in the collaborating bodies along with the over-arching General Data Protection Regulation (GDPR), the data must be stored in institutional repository (storage platforms) and cannot be made directly accessible without a review of the request for access to data. Data availability is further limited because the data contain information on gender and health-related and behavioral attributes, and thus, considered to be "sensitive personal data" as per GDPR. While the data are pseudonymized in accordance with GDPR, **Supplementary material** that can link the data to each study participant exist and are preserved following regulations in place at the collaborating bodies. Therefore, the data can be accessed only upon formal request that details the purpose of such request. Requests to access these datasets should be directed to the principal investigators of the MINIMat15y project: E-CE (email: lotta. ekstrom@kbh.uu.se) and AR (email: arahman@icddrb.org).

Ethics statement

This study was a part of the 15-year follow-up of the MINIMat trial. The 15-year follow-up has been approved by the Ethical Review Committee at icddr, b in Dhaka, Bangladesh (PR-17029; date 2017/05/23). An additional approval has been obtained from the Ethics Review Authority (Etikprövningsmyndigheten) in Sweden (#2021–02796; date 2021/11/15). We obtained written informed consent from the mothers and assent from the adolescents.

Author contributions

AR, MRI, and E-CE: conceptualization and design. MRI, E-CE, and KS: analyses. EK and MK: analysis of blood markers. AR, JP, SR, EK, MK, and E-CE: data curation. MRI: First complete draft. All authors contributed to the critical reviewing and redrafting, read, and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnut.2023.1058965/full#supplementary-material

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Undernutrition and associated factors among internally displaced lactating mothers in Sekota camps, northern Ethiopia: A cross-sectional study

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Background: Undernutrition is the term used to describe when a person consumes insufficient amounts of nutrients and energy to meet their needs for maintaining health. Despite substantial progress, undernutrition remains a serious public health concern in many low and middle-income nations, including Ethiopia. Women and children are, in reality, the most nutritionally vulnerable individuals, particularly in times of crisis. In Ethiopia, 27 percent of lactating women are thin or malnourished, and 38% of children are stunted. Although the issue of undernutrition may worsen in times of emergency, like war, there are limited studies available in Ethiopia that show the nutritional status of lactating mothers in humanitarian settings.

Objectives: The main aim of this study was to determine the prevalence and investigate the factors associated with undernutrition among internally displaced lactating mothers in Sekota camps, in northern Ethiopia.

Methods: A cross-sectional study through a simple random sampling technique was conducted among 420 randomly selected lactating mothers in Sekota Internally Displaced Persons (IDP) camps. Data were collected using a structured questionnaire and anthropometric measurements. Logistic regression analysis was employed to identify independent factors associated with maternal undernutrition.

Results: Using a cut-off mid-upper arm circumference <23 cm, the prevalence of undernutrition among internally displaced lactating mothers was 54.8%. Large family size [adjusted odds ratio (AOR) = 4.35; 95% CI: 1.32, 10.22], short birth interval (AOR = 4.85; 95% CI: 1.24, 10.00), low maternal daily meal frequency (AOR = 2.54; 95% CI: 1.12, 5.75), and low dietary diversity score (AOR = 1.79; 95% CI: 1.03, 3.10) were all significantly associated with undernutrition.

Conclusion: The prevalence of undernutrition among internally displaced lactating mothers is relatively high. Governments and other concerned organizations involved in providing care and support to Sekota IDP camps should increase their efforts to improve the nutritional status of lactating mothers

KEYWORDS

lactating mothers, internally displaced people, Sekota, Ethiopia, undernutrition

Background

Ethiopia is Africa's oldest independent country and it is the second largest in terms of the population (1). Ethiopia in the northern area has experienced internal conflict during the last 2 years between the government of Ethiopia and forces in its northern Tigray region (2). The conflict has had severe impacts on the civilian population. Many families have been forced to flee their homes (internally displaced) because of the armed conflict. Internally Displaced Persons (IDP) are people who have been forced to leave their homes due to war or other circumstances but do not meet the legal standards of refugees (3). Conflicts have a negative influence on food security by causing huge displacements, severe economic downturns, increased inflation and unemployment, and eroding funds for social protection and healthcare (4). Armed conflict is a significant contributor to the rising burden of malnutrition, resulting from decreased food availability, social disruption, higher food prices, and, eventually, starvation and/or disease. Internally displaced women and children are, in reality, the most vulnerable and conflict-affected individuals in the world (5). Generally, malnutrition among vulnerable and marginalized groups (including lactating women) because of armed conflict is a multifaceted problem that requires a multidisciplinary remedy (6).

Undernutrition is the term used to describe when a person consumes insufficient amounts of nutrients and energy to meet their needs for maintaining health (7). Despite substantial progress, malnutrition remains a serious public health concern in many low and middle-income nations, including Ethiopia, particularly in times of crisis (8). Due to their greater nutritional needs and the harmful consequences of inadequate nutrition on the health of both mothers and their children, lactating women and their children are among the most susceptible categories of the population during emergencies such as war (9). Undernutrition is a serious issue among lactating mothers in developing nations, particularly in Sub-Saharan Africa (10). In Ethiopia, both maternal and child malnutrition are common problems. Generally, 27 percent of Ethiopian women are thin or malnourished, and 38% of children are stunted (11). The prevalence of malnutrition among lactating women in Ethiopia varies by area, as does the anthropometric measurement technique. Some studies utilize mid-upper arm circumference (MUAC), whereas others employ body mass index (BMI). A community-based survey in Ethiopia's Afar region revealed that 33.3% of mothers were malnourished based on MUAC (12). Using BMI, 21.2 and 17.4% of lactating mothers in the Angecha and Arba Minch districts of southern Ethiopia, respectively, were undernourished (13, 14). Malnutrition among lactating women was reported to be 21.8% in the Dega Damot district (15) and 21% in Dessie town (16) in northern Ethiopia. Another study in the Bale Zone of Oromia regional state found that 24% of lactating mothers living in humanitarian settings were malnourished (17). Although both BMI and MUAC can be used to determine undernutrition in adults, MUAC has long been used as a community-based assessment of undernutrition because it is easier to implement than BMI. Prior research also suggests that MUAC can be an effective indicator of female adult malnutrition, comparable to or even better than BMI (18, 19). Most published research uses the terms malnutrition and undernutrition interchangeably, while malnutrition is a broader term that includes both over-nutrition and undernutrition (20). However, undernutrition is the focus of this study. Although there have been a few studies to assess the nutritional status of lactating mothers in various regions of Ethiopia, screening, and management of malnutrition in humanitarian settings is limited, and there is no published evidence reporting maternal nutritional status in most conflict-affected areas in Ethiopia, particularly to the study setting. Furthermore, it is critical to identify the issue of undernutrition and its risk factors among people living in humanitarian settings, as this could help the government and other humanitarian organizations in designing their interventions. Hence, the objective of this study was to determine the prevalence and investigate the risk factors of undernutrition among internally displaced lactating mothers in Sekota camps, in northern Ethiopia.

Materials and methods

Study design, setting, and period

A cross-sectional study design was employed in IDP camps found in Sekota town. Sekota is the capital city of the Waghimra zone, Amhara region in northern Ethiopia. It is 436 and 876 kilometers away from Bahir Dar (the capital city of the Amhara region) and Addis Ababa (the capital city of Ethiopia), respectively. Sekota town is bounded by Gazbibla on the south, Zikuala on the west, Abergele on the north, and the east by the Tigray region. There are currently three temporary IDP camps in the town. These are Weleh, Mindikri, and Tirki. The town currently encompasses more than 65, 000 IDPs in all camps. Of these IDPs, around 3,000 residents are known to be lactating mothers, 4,200 are pregnant and 16,000 children less than 5 years of age collectively live in Sekota camps. The study was conducted from June 3 to July 10, 2022.

Sample size determination

The minimum sample size required for the study was determined by using Epi info version 7.2 StatCalc software with the following assumptions. 95% CI, 5% margin of error, the number of lactating mothers found in Sekota IDP camps, which was 3,000, a 24% prevalence of undernutrition among lactating women in humanitarian settings from a previous study conducted in Ethiopia (17), and a design effect of 1.5. The calculated sample size was 384. Taking 10% of the possible non-response rate into account, the final sample size for the study is 422.

Sampling procedures

As a first step, a camp registration list of lactating mothers was identified using information from a rural health center. The total sample was then proportionately allocated to each camp. Then, using a computer-generated method at the household level, simple random sampling techniques were used to select study participants (**Figure 1**). When an eligible participant was not identified at their assigned campsite, the interviewers returned to the site at a later time during the data-collecting period.

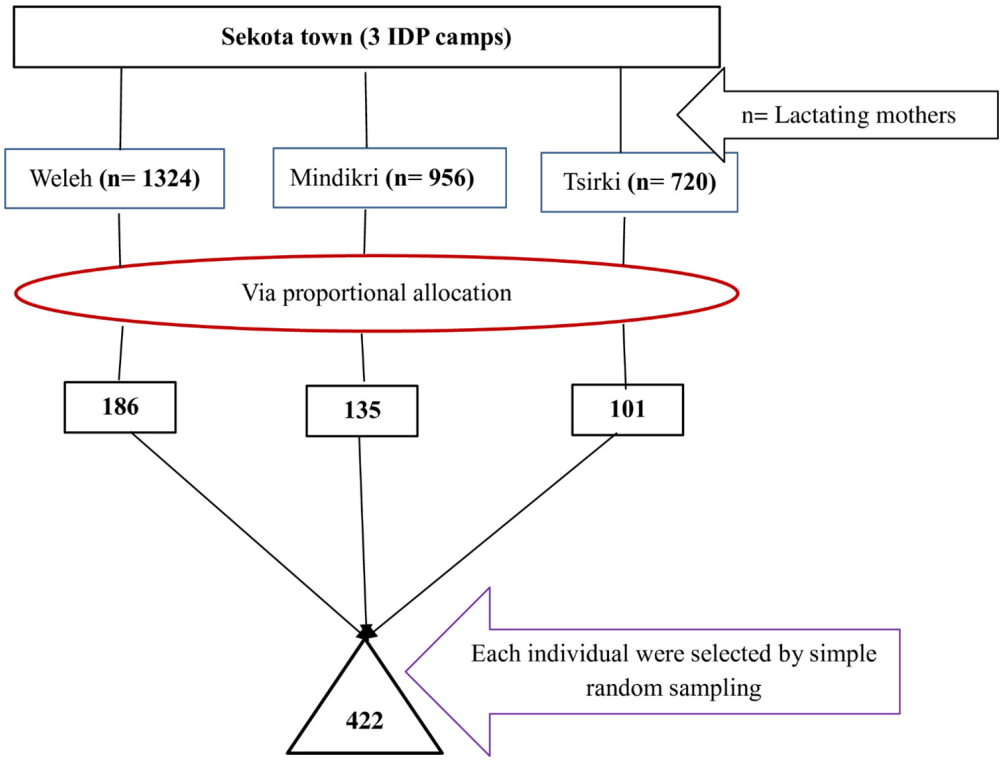

FIGURE 1
Schematic presentation of the sampling procedure for the study conducted among lactating mothers in Sekota camps, Ethiopia, 2022.

Eligibility criteria

The source population was all internally displaced lactating mothers living in all Sekota camps. The study population was randomly selected from internally displaced lactating mothers during the specified study period. Lactating mothers who visited the IDP camp during the study period were excluded from the study.

Data collection tools and procedure

Data were collected using an interviewer-administered structured questionnaire and anthropometric measurement. The questionnaire has three sections including sociodemographic variables, maternal reproductive and healthcare-related questions, and dietary diversity-related questions. The individual dietary diversity of lactating mothers was evaluated using the qualitative recall of the mothers' food consumption over the previous 24-h period. The tool includes 10 food groups (starchy staples, legumes and nuts, dairy, organ meat, any egg, meat poultry and fish, dark green leafy vegetables, other vitamin-A rich fruits and vegetables, other vegetables, and other fruits). It was then determined using a simple count and sum of the number of food groups consumed by each respondent during the prior 24-h recall period.

The MUAC of each lactating mother was measured using non-elastic, non-stretchable adult-size MUAC tapes at the midpoint between the points of the shoulder and elbow of the left upper arm. Since the development of the triceps and biceps muscles may be asymmetrical physiologically, with more muscularity in the dominant (right) arm than the non-dominant (left), the left upper arm has come to be used for MUAC measurement (21). The arm was then flexed 90 degrees from the elbow, and the tape was wrapped around the midpoint, not too tight or too loose. Two measurements were taken and the average was recorded as the final MUAC. The measurements were taken to the nearest 0.1 cm. Three BSc nurses as data collectors and two master-holder public health professionals as supervisors were recruited to collect the data.

Study variables

Dependent variable: Undernutrition.

Independent variables: Sociodemographic variables (age, marital status, educational status, occupation, residence, and family member size), maternal reproductive and healthcare-related variables (age at first pregnancy, ANC follow-up, gravidity, birth interval, place of birth, frequency of breastfeeding, maternal illness, maternal meal frequency, and sources of food), and minimum dietary diversity score.

Operational definitions

Undernutrition: MUAC of less than 23 cm (22).

Illness in the past 2 months: If a lactating, mother encountered any type of illness after entering the camps in the previous 2 months.

Minimum dietary diversity for women (MDD-W): Is defined using the ten food group categories according to the recommendation of the Food and Agriculture Organization (FAO) and the United States Agency of International Development (USAID)

(23). The mother was asked what type of food she ate in the 24 h preceding the survey, independent of portion quantity. The Minimum Dietary Diversity Score (MDDS) is classified as;

Low: If the mother consumed <5, food groups out of the 10 food groups.

Adequate: If the mother consumed ≥5, food groups out of the ten food groups.

Data processing and analysis

Data were checked for completeness, entered into EPI data (version 3.1), and exported to Statistical Package for Social Science (SPSS) (version 20) for statistical analysis. Descriptive statistics (mean and standard deviation for continuous variables; and frequencies and percentages for categorical variables) were computed. All variables were checked for normality and fulfillment of assumptions using histograms, boxplots, and scatter plots before analysis. In this study, the outcome variable was nutritional status coded 0 as undernutrition and 1 as normal (well nutrition). Binary logistic regression was used to identify the crude relationship of factors associated with undernutrition in lactating mothers, then variables significant at $P < 0.25$ were entered into the final multivariate model to identify significant factors independently predicting undernutrition among lactating mothers. Both crude odds ratio (COR) and adjusted odds ratios (AOR) together with their corresponding 95% confidence intervals were computed to assess the strength of association between the outcome and independent variables. In the multivariate analysis, variables with a *p*-value of less than 0.05 were considered significant. In the final model, the Hosmer–Lemeshow test was used to determine model fitness, and a value greater than 0.05 was considered a good fit.

Data quality management

To assure data quality, all data collectors and supervisors received training and proper orientation before the actual commencement of data collection. To maintain consistency, the English version of the questionnaire was translated into the local language (Amharic) and then back into English. Two weeks before the actual data collection, the questionnaire was pre-tested on 5% of the study population at other sites with a similar population (Ebinat IDP site), and a few modifications were made. Furthermore, the accuracy, clarity, and completeness of data were reviewed on daily basis by the supervisors and principal investigators.

Results

Sociodemographic characteristics of respondents

A total of 420 lactating mothers participated in this study with a response rate of 99.5%. The mean (± SD) age of study participants was 26.5 (±5) years ranging from 17 to 45 years. Nearly half (51.4%) of the respondents were found in the age group of 25–34. The majority of the study participants (85.7%) were married, 38.6% of them had no formal education, and 52.8% were residing in urban areas. One hundred fifty-nine study participants had at least two under-five children in their households (Table 1).

Maternal reproductive and healthcare-related characteristics

Less than half (48.6%) of lactating mothers attended antenatal care (ANC) follow-ups in their last pregnancy. The majority of the study participants (63.6%) had their first pregnancy while still in their teenage. One hundred eighty (42.9%) study participants had a birth interval of fewer than 36 months. More than half of the participants (52.9%) gave birth to their current child at home. The majority (84.3%) of study participants obtained their food from various groups that provide food assistance (Table 2).

TABLE 1 Sociodemographic characteristics of lactating mothers in Sekota Internally Displaced Persons (IDP) camps, northern Ethiopia, 2022.

Variables	Category	Frequency (n)	Percentage (%)
Age in a year	15–24	159	37.9
	25–34	216	51.4
	≥35	45	10.7
	Mean (± SD)	26.5 (±5)	
Marital status	Married	360	85.7
	Divorced	45	10.7
	Widowed	15	3.6
Educational status	No formal education	162	38.6
	Primary (1–8)	132	31.4
	Secondary (9–12)	69	16.4
	Above secondary (12^{+})	57	13.6
Occupational status	Housewife	228	54.3
	Government employee	54	12.9
	Private employee	96	22.9
	Others*	42	10
Family size	≤4	300	71.4
	5–8	108	25.7
	≥9	12	2.9
	Mean (± SD)	4.2 (± 1.6)	
Number of U-5 children in the household	One child	261	62.1
	Two or more	159	37.9
Sex of child	Male	273	65
	Female	147	35
Age of child (in a month)**	<6	87	20.7
	6–11	33	7.9
	12–23	99	23.6
	≥24	201	47.9
	Mean (± SD)	19.3 (±12.7)	

*Merchant, daily laborer; **Age of breast-feeding child recorded in a month.

TABLE 2 Maternal reproductive and healthcare-related characteristics among lactating mothers in Sekota Internally Displaced Persons (IDP) camps, northern Ethiopia, 2022.

Variables	Category	Frequency (n)	Percentage (%)
Age at first pregnancy	<20 years	267	63.6
	≥20 years	153	36.4
Antenatal care (ANC)	Yes	204	48.6
	No	216	51.4
Gravidity	Primi-gravida	144	34.3
	(2–4)	222	52.9
	≥5	54	12.9
Birth interval	First child	147	35
	<24 month	180	42.9
	≥24 month	93	22.1
Birthplace of current child	Home	222	52.9
	Institution	198	47.1
Frequency of breastfeeding/day	<8 times	318	75.7
	≥8 times	102	24.3
Illness in the past 2 months	Yes	105	25
	No	315	75
Maternal meal frequency/day	≤ two meals	72	17.1
	Three meals	258	61.4
	> three meals	90	21.4
Sources of food	Purchasing	36	8.6
	Food aid	354	84.3
	Others	30	7.1

Dietary diversity characteristics of respondents

Regarding the food groups consumed by lactating mothers in the previous 24 h, all women consumed starchy staples. Whereas 80.5 and 76.9% of respondents consumed legumes and nuts, and other vegetables, respectively 24 h preceding the survey. More than one-third (42.4%) of lactating mothers' minimal dietary diversity score was low or inadequate (Table 3).

Nutritional status of lactating mothers

The nutritional status of lactating mothers was assessed using MUAC. Accordingly, 54.8% (95% CI: 49.9, 59.6) of lactating women were undernourished (Table 4).

Factors associated with undernutrition among lactating mothers

The Hosmer–Lemeshow test was used to determine binary regression model fitness. The model fits with a *P*-value of 0.863

TABLE 3 Dietary diversity frequency among lactating mothers in Sekota Internally Displaced Persons (IDP) camps, northern Ethiopia, 2022.

Food groups consumed in the previous 24 h		Number (percent)
Starchy staples		420 (100)
Legumes and nuts		338 (80.5)
Diary		165 (39.3)
Organ meat		147 (35)
Any egg		45 (10.7)
Meat, poultry, and fish		167 (39.8)
Dark green leafy vegetables		249 (59.3)
Other vitamin A-rich fruits and vegetables		264 (62.9)
Other vegetables		323 (76.9)
Other fruits		3 (0.7)
Minimum dietary diversity score (MDDS)	Low	178 (42.4)
	Adequate	242 (57.6)

(Table 5). Then, to identify factors associated with undernutrition among lactating mothers in the study population, bivariate and multivariable logistic regression analyses were performed. MUAC was used to determine whether lactating women were undernourished (MUAC < 23 cm) or not (MUAC ≥ 23 cm). On binary logistic regression analysis, maternal age, family size, gravidity, birth interval, the birthplace of the current child, maternal illness in the past 2 months, maternal daily meal frequency, source of food, and minimum dietary diversity score were significantly associated with undernutrition at a *p*-value of < 0.25. However, in the final multivariate logistic regression model, age, family size, birth interval, daily maternal meal frequency, and dietary diversity score were significantly associated with undernutrition at a *p*-value of 0.05 (Table 6). Based on the principle of the logistic regression model, we used techniques like the normative category, the smallest value, and the category whose mean is in the middle to choose the reference category (24).

Discussion

The prevalence of undernutrition among lactating mothers was found to be 54.8% in this study. In comparison to the findings of this study, most Ethiopian studies reported a lower prevalence of undernutrition among lactating women, such as in the Afar region 33.3% (12), Angecha district 21.2% (13), Arba Minch districts 17.4% (14), Dega Damot district 21.8% (15), Dessie town 21% (16), Moyale district 17.7% (25), and Shebedino district, Sidama region 25.9% (26). The possible reason might be due to the different sociodemographic and economic natures of the study population. It could also be because our study participants are displaced individuals as a result of the civil war, which has had a significant impact on their agricultural productivity and economy in comparison to other regions of the country that have been stable without civil conflicts (27). The finding is even greater than that of a study conducted in the Bale zone of Oromia regional state, which revealed 24% undernutrition among lactating women in a humanitarian setting (17). The higher prevalence in the current study could be attributed to insufficient

TABLE 4 Nutritional status among lactating mothers in Sekota Internally Displaced Persons (IDP) camps, northern Ethiopia, 2022.

Variables	Category	Frequency	Percentage	95% CI
MUAC (cm)	<23	230	54.8	49.9, 59.6
	≥23	190	45.2	40.4. 50.1
	Mean (± SD)	22.6 ± 1.5		

TABLE 5 Hosmer and Lemeshow goodness of fit test result.

Step	Chi-square	Df	Sig.
1	4.993	8	0.863

humanitarian support by the national government or international humanitarian groups in the selected IDP camps.

Predictors of undernutrition among lactating mothers are maternal age, family size, birth interval, maternal meal frequency, and MDDS (Table 6). In this study, young age (<35 years old) has a significantly low risk of undernutrition than those older ages. This could be due to biological changes caused by aging, such as changes in body composition and energy calories contributing to an increased risk of undernutrition (28). Lactating mothers with a family size of ≥9 are 4.35 times more likely to be malnourished than those with smaller family sizes. The finding is similar to the studies conducted in Nekemte (Oromia region) and Wenberma district (Amhara region), Ethiopia (29, 30). The possible reason could be due to the household food insecurity issue in women with large family sizes resulting in undernutrition (31). In this study, lactating mothers with short birth intervals (<24 months) were 4.85 times more likely to be undernourished than their counterparts. This is consistent with the studies conducted in the Afar region (12) and Arba Minch district (14). It might be due to the recurrent loss of macronutrients and micronutrients from the woman's body during pregnancy, delivery, and breastfeeding as a result of short birth spacing and repeated childbearing. Additionally, a short birth interval does not provide the mother with enough time to recover from the nutritional burden (32). Short birth intervals have also been associated with adverse outcomes in a woman's nutritional status, such as nutritional depletion, folate depletion, and micronutrient insufficiency (33). Lactating mothers with a low daily meal frequency (≤2 meals) were 2.54 times more

TABLE 6 Factors associated with undernutrition among lactating mothers in Sekota Internally Displaced Persons (IDP) camps, northern Ethiopia, 2022.

Variables	Category	Undernourished (MUAC < 23 cm)		COR (95% CI)	*P*-value	AOR (95% CI)	*P*-value
		Yes	No				
Age (in a year)	15–24	99	60	0.94 (0.44, 1.99)	0.703	0.21 (0.07, 0.65)	0.006*
	25–34	104	112	0.07 (0.02, 0.31)	0.012	0.20 (0.07, 0.57)	0.002*
	≥35	27	18	1		1	
Family size	≤4	182	118	1		1	
	(5–8)	45	63	0.05 (0.01, 0.36)	0.004	1.69 (0.30, 4.21)	0.240
	≥9	3	9	4.14 (1.74, 9.88)	0.001	4.35 (1.32, 10.22)	0.004*
Gravidity	Primi-gravida	96	48	0.32 (0.06, 1.65)	0.174	0.35 (0.05, 2.43)	0.370
	(2–4)	113	109	0.50 (0.06, 4.03)	0.514	1.56 (0.58, 4.12)	0.330
	≥5	21	33	1		1	
Birth interval	<24 month	83	97	4.60 (1.47, 9.93)	0.016	4.85 (1.24, 10.00)	0.012*
	≥24 month	45	48	1		1	
Place of birth	Home	119	103	0.35 (0.14. 0.84)	0.020	0.73 (0.45, 1.17)	0.388
	Institution	111	87	1		1	
Illness in the past 2 months	Yes	66	39	1.48 (0.77, 2.84)	0.244	1.35 (0.76, 2.40)	0.430
	No	164	151	1		1	
Maternal meal frequency/day	≤ two meals	45	27	2.98 (1.00, 8.84)	0.049	2.54 (1.12, 5.75)	0.016*
	Three meals	152	106	1.10 (0.48, 2.52)	0.818	0.98 (0.67, 3.94)	0.056
	> three meals	33	57	1		1	
Sources of food	Purchasing	9	27	0.23 (0.04, 1.39)	0.109	0.12 (0.03, 0.40)	0.487
	Food aid	200	154	0.08 (0.01, 0.47)	0.006	0.48 (0.18, 1.28)	0.070
	Others	21	9	1		1	
MDDS	Low	106	72	1.78 (0.81, 3.99)	0.153	1.79 (1.03, 3.10)	0.019*
	Adequate	124	118	1		1	

*Significant at a *p*-value of < 0.05 in multivariate logistic regression analysis, 1 indicates reference category, MDDS is minimum dietary diversity score.

likely to be malnourished than those who consumed more frequent feeding. MDDS was also statistically associated with undernutrition among lactating mothers. Lactating mothers with inadequate MDDS were approximately twice more malnourished as those with adequate MDDS. The finding is consistent with the study done in the Afar region (12), Dessie town (16), and Angecha district (13). Taking at least two extra meals per day during lactation is recommended by the essential nutrition action (ENA) for all lactating women (34). Poor dietary intake is clearly one of the immediate causes of malnutrition, even in lactating women. It was also demonstrated that inadequate minimal dietary diversity among lactating mothers is a potential cause of maternal undernutrition since consumption of a variety of food types gives various vital nutrients for optimum growth (35). As a result, dietary sufficiency and a varied diet are crucial for lactating mothers throughout the postpartum period (36). Furthermore, dietary deficiency combined with a lack of diversity may jeopardize maternal health, worsening malnutrition in lactating mothers (37).

Our study, however, has the following limitations. First, we did not include the wealth index, household food security, and the presence of comorbidities (health status) of participants as independent factors, which might have caused a confounding effect. Second, dietary diversity and meal frequency were examined using a 24-h recall, which may not represent the study participants' regular intake.

Conclusion

The prevalence of undernutrition among internally displaced lactating mothers in Sekota IDP camps was found to be very high. Older Age, large family size, short birth interval, maternal meal frequency, and low dietary diversity score are the factors associated with undernutrition. Governments and other concerned organizations involved in providing care and support to Sekota IDP camps should increase their efforts to improve the nutritional status of lactating mothers.

Data availability statement

The original contributions presented in this study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by from the Debre Tabor University College of Health Sciences Research Ethics Review Committee. The patients/participants provided their written informed consent to participate in this study.

Author contributions

MM and MTA conceived and designed the study. MW and EC were actively involved in the guidance of the conception of research and critical review of the manuscript. YB, TA, and MA were involved in the proposal development and data collection. MM was actively working on data analysis, and writing the research report, and was a major contributor to drafting the manuscript. All authors have read, provide critical feedback, and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Factors affecting fruit and vegetable consumption and purchase behavior of adults in sub-Saharan Africa: A rapid review

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In order to achieve the Sustainable Development Goals, considerable dietary shifts, including an increase in the consumption of fruit and vegetables (FV) will be required. However, worldwide consumption of FV is far below international recommendations, including in many low- and middle-income countries (LMICs), particularly in Africa. Understanding what, where, when, and how people choose to eat requires an understanding of how individuals are influenced by factors in their social, physical, and macro-level environments. In order to develop effective interventions to increase fruit and vegetable consumption, the factors influencing consumer behavior need to be better understood. We conducted a rapid review to assess and synthesize data on individual, social, physical, and macro-level factors that enable or constrain fruit and vegetable consumption and purchase among adults living in sub-Saharan Africa. Our conceptual framework is based on a socio-ecological model which has been adapted to settings in LMICs and Africa. We systematically searched four electronic databases including Scopus, Medline (PubMed), PsycInfo, and African Index Medicus, and screened Google Scholar for gray literature. We included a total of 52 studies and narratively summarized the existing evidence for each identified factor across the different levels. We found that most studies assessed demographic factors at the individual level including household or family income, socio-economic status and education. Furthermore we identified a variety of important factors that influence FV consumption, in the social, physical, and macro environment. These include women's empowerment and gender inequalities, the influence of neighborhood and retail food environment such as distance to market and price of FV as well as the importance of natural landscapes including forest areas for FV consumption. This review identified the need to develop and improve indicators both for exposure and outcome variables but also to diversify research approaches.

KEYWORDS

food environment, consumer behavior, diets, sub-Saharan Africa, sustainable food systems, fruit, vegetables

Introduction

Dietary patterns are changing worldwide with a general trend toward unhealthy diets (1, 2). Suboptimal diets are key risk factors for all forms of malnutrition, including undernutrition, micronutrient deficiencies, overweight and are among the greatest societal challenges which lead to health, economic and environmental burdens (3, 4). Most low-and middle-income countries (LMICs), particularly in Africa, are experiencing a dietary transition from traditional to highly processed foods, mostly driven by globalization and urbanization (5, 6).

Fruit and vegetables (FV) are rich in vitamins, minerals, phytochemicals and fiber, and are regarded as essential for healthy and sustainable diets (2, 7). Diets that are rich in FV provide promising solutions to micronutrient deficiencies and are associated with a reduced risk of non-communicable diseases such as cardiovascular diseases, diabetes, hypertension, and cancer (4, 8). However, despite the positive benefits of FV, global consumption is far below the WHO recommendation of 400 grams or more FV (equivalent to 5 servings of 80 g each) per day. In LMICs, over 80% of the population consume less than the recommended amounts (7, 9, 10).

What, where, how, and when people choose to eat or acquire food requires an understanding of the multiple influences ranging from a variety of personal and interpersonal factors to more distant, structural issues (11–15). The importance of improving diets through a holistic food systems perspective is widely acknowledged in the literature (14, 16, 17). Within the sustainable food systems framework developed by the High-Level Panel of Experts on Food Security and Nutrition (HLPE), food supply chains, food environments, and consumer behavior are core elements influencing diets (14, 16). Food environments connecting the wider food system with diets have received increasing attention in global policy and research agendas (14, 16) and different conceptual frameworks have been developed for LMICs in recent years (18, 19). They often focus on personal (e.g., affordability, convenience) and external domains (e.g., availability, price, marketing regulations), but less on social aspects including influences through social interactions, social support, gender and social norms, or role modeling (13). For the present review, we therefore followed a socio-ecological model (12) which was adapted for the African context (13, 20). It focuses on the relationship between people and their social (e.g., family, friend, community influence), physical (e.g., access and availability in the neighborhood, at home, in food outlets) and macro-level (e.g., sociocultural norms, agricultural policies) environments in understanding fruit and vegetable consumption and purchase.

Previous systematic reviews in Africa focused either on dietary behavior in urban African environments (20, 21), on dietary and physical activity behaviors in urban sub-Saharan Africa (SSA) (22) or on household economic and demographic determinants of fruit and vegetables (23). Currently, no review has assessed consumption and purchase behavior with regard to FV in sub-Saharan Africa and their multiple factors of influence. This review, therefore, aims to assess and synthesize data at the individual level and at the social, physical, and macro-level environment that affect fruit and vegetable consumption and purchase by adults in sub-Saharan Africa. The findings of our review will identify gaps and help guide future research and policy.

Methods

Review typology

To ensure methodological quality, we followed the Cochrane rapid review recommendations (24) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (25). Rapid reviews follow the systematic approach of traditional systematic reviews, but aim to fasten the process to achieve manageable and timely evidence. Restrictions include for example, limiting the publication language to English, limiting the number of outcomes, or date restrictions (24). We drafted a review protocol and registered it a priori on PROSPERO (CRD42021248475 available from https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=248475). Due to resource limitations, we made an amendment to the protocol by excluding experimental studies.

Conceptual framework

We developed an initial conceptual framework based on a socio-ecological model (12) and its adaptation for Africa (11) to guide our review. The socio-ecological model describes the multiple influences on what people eat at the individual/household level (e.g., biological, demographic lifestyle/behavioral factors), the social level (e.g., influence of family, friend, community), the physical level (e.g., access and availability in the neighborhood, at home, in food outlets), and the macro-level (e.g., sociocultural norms, agricultural policies). In addition, we used two food environment frameworks for LMICs (18, 19) for potential exposure variables such as convenience, food safety, and distance to market and the food systems framework from the High-Level Panel of Experts on Food Security and Nutrition (HLPE), for the outcome variables (16) to inform our initial framework.

The outcome variable "consumer behavior" was adapted from the HLPE framework, which defines consumer behavior as "all the choices and decisions made by consumers, at the household or individual level, on what food to acquire, store, prepare, cook and eat, and on the allocation of food within the household (including gender repartition and feeding of children) (16). In our review, consumer behavior refers to the purchase and consumption of FV in terms of "what," "how," "where" and "when" FV is consumed or purchased. "What" includes the quantity of FV consumed or purchased, or if FV were consumed and purchased or not. "How" refers to the frequency of FV consumption and food combinations, and how people interact with the social and physical environment to consume and purchase FV. "Where" refers to the location of FV consumption or purchase, and "When" refers to the timing of consumption or purchase. The adapted framework is presented in Figure 3 in the Results section.

Inclusion and exclusion criteria

We used the Population, Exposure, Context, Outcome (PECO) framework to develop the eligibility criteria. We selected articles following these inclusion criteria: (i) Population: healthy adults, men, and women, aged 18–65 years (80% of all participants in the papers falling in this range); (ii) Exposure: individual, social, physical and macro-level factors affecting food and purchase behavior; (iii) Context: all sub-Saharan African countries, rural-urban, peri-urban areas; (iv) Outcome: fruit and vegetable consumption, or purchase behavior at individual level; Study designs eligible for our review were: observational studies including cross-sectional, cohort or case-control study. Only studies published in English between January 2000 to April 2022 were included The timeframe was chosen to include all articles published since WHO recommended to eat 400 g or more FV per day at the beginning of the 2000s (7). Studies were excluded if they addressed non-human or clinical populations, qualitative study design, non-English publications, and were outside of sub-Saharan Africa.

Literature search

For this review, we systematically searched four electronic databases: Scopus, MEDLINE (PubMed), PsycInfo, and African Index Medicus. For each database, we applied specific indexing terms, such as Medical Subject Headings (MeSH) terms for MEDLINE (PubMed) and free text terms. We developed an initial search syntax for Scopus and thereafter adapted it for the respective databases. In addition, we screened reference lists of relevant reviews to identify relevant articles. We searched Google Scholar for gray literature.

Screening

We imported all references into the CADIMA platform (https://cadima.info) to check titles and abstracts against inclusion and exclusion criteria and to document the review process. The first author (BS) conducted title and abstract screening with a 40% dual screening of title and abstracts by co-authors (UT, LH, IS, AK, SM). In case of doubt, we included the reference to the next stage. For full-text screening, we transferred included titles and abstracts from CADIMA to Excel. The first author (BS) screened all included full-text articles and co-authors (UT, LH, IS, and AK) double-screened 40% full-texts. Disagreements in selection were resolved through discussion among authors.

Data extraction

We extracted data by applying a standardized data extraction spreadsheet in Excel. The first author (BS) extracted data from included studies. Co-authors (UT, LH, and AK) checked the correctness and completeness of extracted data (40%). Extracted data included (1) study characteristics: title, author(s), year of publication, country, setting (urban, rural, peri-urban), study design, primary or secondary data; (2) sample characteristic: gender/sex, age (range and/or mean), sample size; (3) exposures: individual, social, physical and macro level factors categorized based on a socio-ecological framework, exposure tool, unit of exposure; (4) outcome: outcome unit, outcome measurement tool; and (5) results: methods of analysis, effect sizes, p values.

We were interested in exploring relationships between the exposure/factor and outcome variables assessed by correlation or regression analysis. In addition, we also considered methods that assessed statistically significant differences between groups, e.g., seasonal differences in FV consumption, using t-tests, Wilcoxon signed- rank tests, or ANOVA to include a wide range of factors that are listed separately in the evidence tables. The cut-off for statistical significance was a p-value of < 0.05.

Risk of bias assessment

The risk of bias was assessed alongside the data extraction process using the Appraisal tool for Cross-Sectional Studies (AXIS) (26). For longitudinal studies, we adapted the AXIS tool with questions from a Quality Assessment Tool for Quantitative Studies developed by the Effective Public Health Practice Project (EPHPP) (27). The first author (BS) rated the risk of bias and co-authors (UT, LH, AK) verified 30% of the judgments (Supplementary material 1: Risk of bias assessment). Risk of bias was categorized into high, moderate and low.

Data synthesis

Due to the heterogeneity of studies and variation in outcome reporting, we performed a narrative synthesis of the findings from the included studies, guided by the levels of our conceptual framework. We categorized the identified factors at the different levels according to the socio-ecological model, as described above. We synthesized FV consumer behavior as (i) consumption or purchase, followed by (ii) fruit and vegetable categories: fruit and vegetables as a separate measure (F, V), combined measure of fruit and vegetables (FV), only fruit (F), or only vegetables (V), and (iii) what, where, when, and how they were purchased or consumed.

Results

Characteristics of included studies

The search in four databases and Google scholar identified 8,821 records. After the removal of duplicates, we screened 6,918 records at the title and abstract stage. We identified 259 studies for full-text screening, out of which 52 studies (53 records) met the eligibility criteria and were included in the review. Figure 1 shows the study selection process and related PRISMA flow diagram.

In total, 53 references, representing 52 studies, met the inclusion criteria and were considered in the review. Table 1 provides an overview of the characteristics of the included studies.

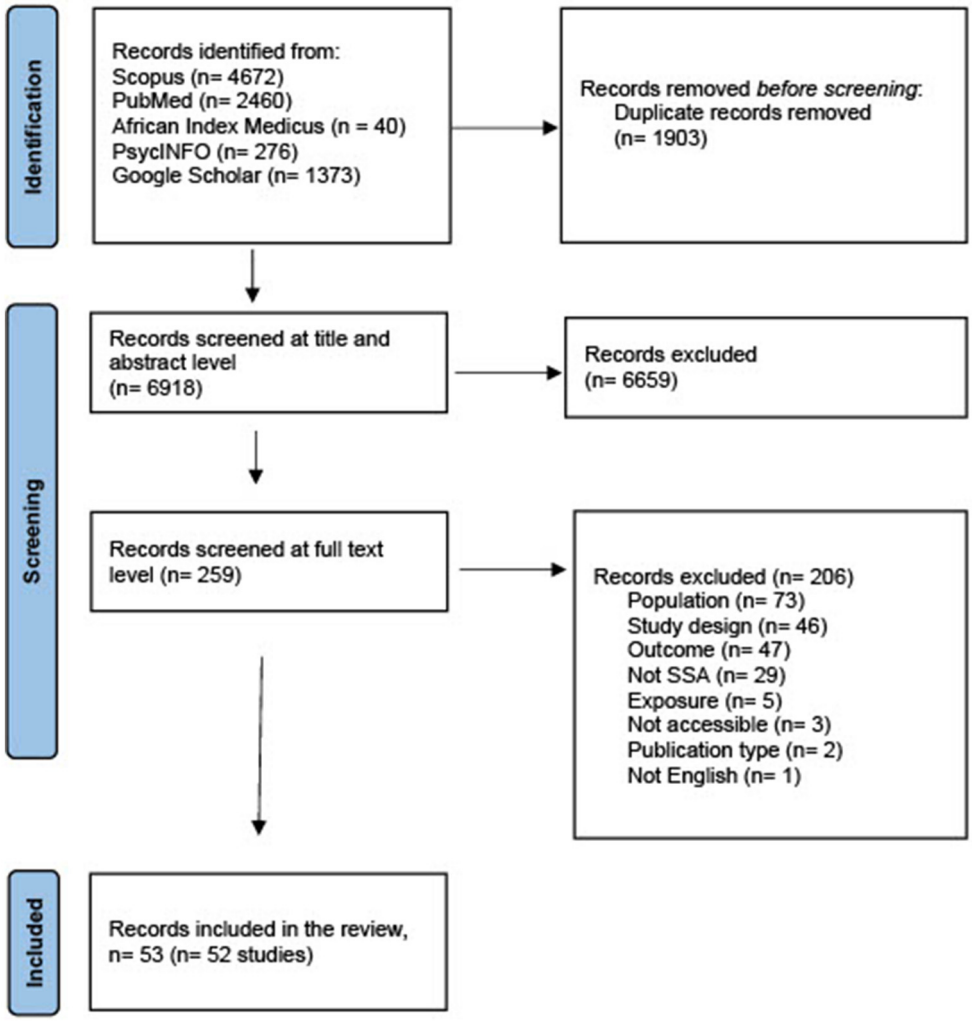

FIGURE 1
Flow diagram.

Figure 2 shows the geographic distribution of included studies across SSA.

The majority of the observational studies adopted a cross-sectional design (81%) and the remaining studies (19%) adopted a longitudinal study design, out of which two were panel studies with time intervals of several years. Most studies (73%) collected original data (primary studies), followed by studies that were based on secondary data (17%), or on both primary and secondary data (10%).

Most of the studies included adult women and men (79%). While fewer studies (21%) focused solely on women, and no study looked at the fruit and vegetable consumer behavior of only men. Population characteristics across the studies were heterogeneous and included women of reproductive age, supermarket shoppers, university students, low-income urban residents, adults in rural areas, adults in resource-poor communities, consumers that purchased fresh vegetables at open-air markets.

Fruit and vegetables were mainly assessed at the food group level (83%) and only a few assessed single food items (17%). The outcome variables were presented in the studies either as separate measures (F, V), as a combined measure (FV), or separately and combined (F, V, and FV) (31%, 29%, and 21%, respectively). Only a few studies focused only on vegetables (V) or only on fruit (F) (12% and 8%, respectively). It was often unclear what was counted as fruit or vegetable, e.g., some studies included potatoes within the vegetable category. As fruit and vegetables were often assessed in combination, it was not possible to systematically distinguish whether fruit or vegetable consumption may be linked to different factors.

Fruit and vegetable consumption in terms of quantity (what) and frequency (how) were the dominant outcome measures. "What" was expressed in various units including grams, portion sizes, number of servings, adequate or inadequate consumption, or percentage of adults that consumed FV. "How" FV were consumed referred mostly to the frequency of consumption expressed either

TABLE 1 Characteristics of included studies.

References	Risk of bias[1]	Country	Setting[2]	Data source[3]	Study design[4]	Gender, sex[5]	Age in years	Sample size	Individual	Social	Physical	Macro	F, V, FV[6]	Consumer behavior	
														Consumption, purchase	What, how, where, when
Adenegan et al. (28)	H	Nigeria	U, R	P	CSS	F, M	NR	200	✓				F, V	Purchase	What
Adeoye et al. (29)	H	Nigeria	U	P	CSS	F, M	21–60+	150	✓	✓	✓		V	Purchase	What
Amare et al. (30)	L	Ethiopia	U	P	CSS	F, M	18–65+	356	✓				F, V	Consumption	What, how
Amo-Adjei and Kumi-Kyereme (31)	M	Ghana	U, R	S	CSS	F, M	15–59	9,484	✓	✓		✓	F, V	Consumption	What
Badurally et al. (32)	H	Mauritius	U, R	P	CSS	F, M	NR	374	✓	✓			F, V	Consumption	What
Banwat et al. (33)	H	Nigeria	U	P	CSS	F, M	18–60+	250	✓				FV	Consumption	What
Bhurosy and Jeewon (34)	M	Mauritius	U, R	P	CSS	F	18–65	400	✓				F, V	Consumption	How
Bloomfield et al. (35)	L	Kenya	PU	P	CSS	F, M	16–64 +	4,037	✓				FV	Consumption	What
Bosha et al. (36)	M	Ethiopia	R	P	LONGL	F	20–40	578				✓	FV, F, V	Consumption	What
De Filippo et al. (37)	L	Nigeria	U, PU	P	CSS	F, M	18–65	632	✓	✓	✓		FV	Consumption	What
Demmler et al. (38)	L	Kenya	U	P, S	LONGL	F, M	18 +	1,199			✓		FV	Consumption	What
Gelibo et al. (39)	M	Ethiopia	U, R	P	CSS	F, M	15–69	10,260	✓	✓			FV	Consumption	What
Hall et al. (40)	L	Tanzania	R	S	LONGL	F, M	NR	1,256	✓	✓		✓	FV, F, V	Consumption	What
Jordan et al. (41)	L	Uganda	U, R	P	LONGL	F	30.95	445				✓	FV, F, V	Consumption	What, where
Kabwama et al. (42)	L	Uganda	U, R	S	CSS	F, M	18–69	3,962	✓	✓			FV	Consumption	What
Keding et al. (43)	L	Kenya	R	P	LONGL	F	40.2 (±16.5)	272	✓		✓	✓	FV, F, V	Consumption	What, how, when
Keetile et al. (44)	M	Botswana	U, R	S	CSS	F, M	< 24–65+	1,178	✓				FV	Consumption	What
Kibr (45)	M	Ethiopia	U	P	CSS	F	15–49	423	✓	✓	✓	✓	FV	Consumption	What
Labadarios et al. (46)	M	South Africa	U, R	P	CSS	F, M	16 +	3,287	✓				FV, F, V	Consumption	What
Lagerkvist et al. (47)	M	Ghana	U	P	CSS	F, M	17–60	332			✓		V	Consumption	How*, when
Layade et al. (48)	H	Nigeria	U	P	CSS	F, M	15–34	200	✓		✓	✓	FV	Purchase	What
Leyna et al. (49)	M	Tanzania	R	P	CSS	F, M	15-44	1,014	✓				F, V	Consumption	How
Lomira et al. (50)	M	Uganda	U, R	P	CSS	F, M	NR	400	✓	✓			FV	Consumption	What
MacIntyre et al. (51)	L	South Africa	U, R	P	CSS	F, M	15–80	1,751				✓	F, V	Consumption	What
Mayén et al. (52)	L	Seychelles	U, R	S	CSS	F, M	25–64	2,476	✓				FV	Consumption	How
Modibedi et al. (53)	M	South Africa	U	P	CSS	F, M	NR	254	✓	✓			V	Consumption	How

(Continued)

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TABLE 1 (Continued)

References	Risk of bias[1]	Country	Setting[2]	Data source[3]	Study design[4]	Gender, sex[5]	Age in years	Sample size	Individual	Social	Physical	Macro	F, V, FV[6]	Consumer behavior	
														Consumption, purchase	What, how, where, when
Msambichaka et al. (54)	M	Tanzania	SU	S	CSS	F, M	15–60+	7,953	✓	✓		✓	FV, F, V	Consumption	What, how
Musaiger et al. (55)	M	Sudan	U	P	CSS	F, M	18–30	400	✓				F, V	Consumption	How
Neergheen-Bhujun et al. (56)	M	Mauritius	U, R	P	CSS	F, M	18–65 +	675	✓	✓			V	Consumption	How
Obayelu et al. (57)	H	Nigeria	U	P	CSS	F, M	< 20–50 +	100	✓	✓	✓		F	Purchase	What
Odunitan-Wayas et al.[b] (58)	M	South Africa	U	P	CSS	F, M	≥ 18	422			✓		FV	Purchase	How
Odunitan-Wayas et al.[b] (59)	M	South Africa	U	P	CSS	F, M	18–55+	395	✓		✓		F, V	Purchase	What
Okop et al. (60)	M	South Africa	U, R	P	CSS	F, M	30–75	535	✓		✓		FV	Consumption	What
Onah et al. (61)	M	Uganda, Rwanda, Malawi, Zambia, Mozambique	R	S	CSS	F	28.95	10,041		✓			FV, V	Consumption	What
Oyedele et al. (62)	H	Nigeria	U	P	CSS	F, M	36.7 ± 9.2	311	✓	✓			V	Purchase	What
Padrão et al. (63)	L	Mozambique	U, R	P	CSS	F, M	25–64	12,902	✓				F, V	Consumption	How
Padrão et al. (64)	L	Mozambique	U, R	P	CSS	F, M	25–64	3,298	✓			✓	F, V	Consumption	What
Peltzer and Pengpid (65)	L	South Africa	U, R	S	CSS	F, M	15+	15,310	✓				F, V	Consumption	What
Peltzer and Promtussananon (66)	M	South Africa	R, PU	P	CSS	F, M	18–64	200	✓				FV	Consumption	What
Pengpid and Peltzer (67)	M	Kenya	U, R	S	CSS	F, M	18–69	4,479	✓				FV, F, V	Consumption	What
Raaijmakers et al. (68)	M	Nigeria	U	P	CSS	F	18–55	1,220	✓		✓		V	Consumption	What, how
Ravaoarisoa et al. (69)	L	Madagascar	R	P	LONGL	F	18–45	608				✓	F, V	Consumption	How
Reyes-García et al. (70)	L	Cameroon	R	P	LONGL	F, M	16+	160				✓	FV, F, V	Consumption, Acquisition	What, where
Riha et al. (71)	L	Uganda	R	P, S	CSS	F, M	13+	7,340				✓	FV	Consumption	What
Savy et al. (72)	L	Burkina Faso	R	P	LONGL	F	<20–30+	550				✓	FV, F, V	Consumption	What
Sinyolo et al. (73)	M	South Africa	U, R	P, S	CSS	F, M	45.72	20,908	✓	✓	✓		F, V	Consumption	What, how
Subratty and Jowaheer (74)	H	Mauritius	U, R	P	CSS	F, M	15–60	1,213	✓				F	Consumption	How, when
Tata et al. (75)	M	Cameroon	R	P, S	CSS	F	29.7 ± 7.032	247				✓	FV, F, V	Consumption	What

(Continued)

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TABLE 1 (Continued)

References	Risk of bias[1]	Country	Setting[2]	Data source[3]	Study design[4]	Gender, sex[5]	Age in years	Sample size	Individual	Social	Physical	Macro	F, V, FV[6]	Consumer behavior	
														Consumption, purchase	What, how, where, when
Thakwalakwa et al. (76)	L	Malawi	U, R	P	LONGL	F	27.8 ± 6.0	274	✓	✓	✓	✓	F, V	Consumption	What, when
Torheim et al. (77)	M	Mali	R	P	CSS	F, M	15–45	491	✓				F	Consumption	What
Unwin et al. (78)	M	Tanzania	U, R	P	LONGL	F, M	15-59	209				✓	F, V	Consumption	What
Wang et al. (79)	H	Ghana	U	P	CSS	F, M	39.2	1,100	✓	✓			F	Consumption	How
Yaya and Bishwajit (80)	M	Namibia	U, R	S	CSS	F, M	15–49	14,185	✓	✓	✓		FV	Consumption	What

[1]Risk of bias: H, high; M, moderate; L, low; [2]Setting: R, rural; U, urban; PU, peri-urban; SU, semi-urban; [3]Data source: P, primary; S, secondary; [4]Study design: CSS, Cross-sectional study; LONGL, longitudinal study; [5]Gender, sex: F, female; M, male; [6]F;V;FV; F, Fruit; V, Vegetable; FV, Fruit and vegetables combined; [a,b]References referring to one study; How*: referring to how foods were treated before consumption.

as daily or weekly FV consumption, reduction in the frequency of FV consumed per week and many more.

The most frequently applied measures were self-reported semi-quantitative food frequency questionnaires (FFQ), that assessed consumption frequency and also the portion sizes with showcards or photographs. Several studies used qualitative 24 h recall assessing whether adults consumed FV food groups the previous day or not, while only few studies applied quantitative 24 h recall tools assessing the actual intake (see Supplementary material 2). Few studies focused on the purchase or acquisition of fruit and vegetables (11%). Moreover, few studies were found to assess consumer behavior, other than dietary intakes, such as "when," referring to the timing or "where," referring to the location of FV consumption or purchase.

Out of the 48 countries in sub-Saharan Africa, literature from 20 countries was available for inclusion in this review (see Figure 2). The majority of the included studies were conducted in South Africa ($n = 9$) followed by Nigeria ($n = 8$), and Uganda ($n = 5$). Figure 2 shows the geographic distribution of included studies across SSA.

Risk of bias assessment

Out of the 52 studies included in this review, most studies showed moderate risk of bias ($n = 25$), followed by low risk ($n = 18$) and high risk ($n = 9$). The main weaknesses in several studies was that the sampling frame was not representative of the target population. For example, the target population was referring to adults from a certain geographic region, but the sampling frame was restricted to adults living in one selected town in that region. In addition, several studies did not describe the selection process well. For example, while it was often stated that random sampling was conducted, only a few studies described the sampling in detail or provided information on situational aspects such as how and in what frequency respondents were contacted. Exposure and outcome variables were also poorly described, as information on validated measures were often not mentioned or described superficially. The full risk of bias assessment is provided in the Supplementary material 1: Risk of bias assessment.

Socio-ecological factors affecting fruit and vegetable consumption and purchase

In this section we present the identified factors, categorized in line with the previously described conceptual framework, and their relevance for fruit, vegetable, and combined FV consumption or purchase among adults in sub-Saharan Africa. Results are presented narratively for each factor. Tables 2–5 provide an overview of the evidence, and Figure 3 illustrates factors that significantly affected FV consumption or purchase among adults in SSA. We adapted our initial conceptual framework by adding new exposure variables/factors that we identified in the literature. Furthermore, we adapted sub-levels within the social, physical, and macro-levels according to the results of our data, after discussion among the review authors. For example, we added the sub-level "Gender

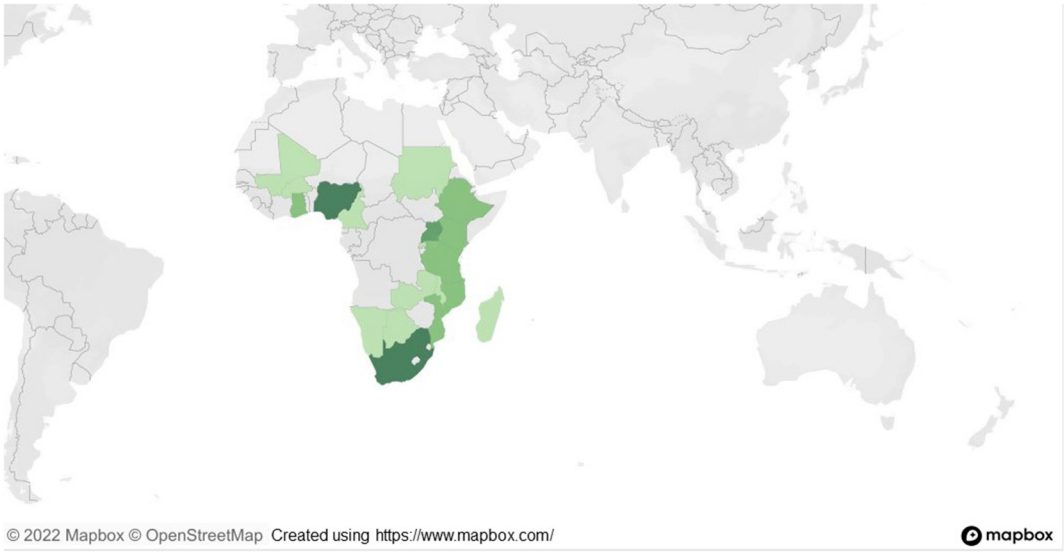

FIGURE 2
Geographic distribution of included studies across SSA (series: number of studies). Created using https://www.mapbox.com/.

roles/empowerment" to the social environment level. In the macro-level environment, we added the sub-level "Natural landscapes," where we categorized the factors "Ecological zones" and "Forest cover." The framework shows the diversity of factors across the different levels of influence which highlight the need for multiple, context-specific approaches to improve FV consumption.

Individual level

Factors identified at the individual/household level were divided into four sub-levels, including biological, demographic, lifestyle and behavior, and cognition. Altogether, we identified 33 individual-level factors across 45 studies.

Biological factors

Biological factors include gender in terms of differences due to biological sex, age, body mass index and pre- to post-menopause comparisons.

Gender/biological sex differences

Gender in terms of biological sex differences in fruit, vegetable and combined FV consumption and purchase was investigated in 22 studies (28–30, 32, 33, 35, 39, 40, 42, 46, 48, 50, 52–55, 57, 60, 62, 64, 67, 73). A higher or more frequent intake of fruit, vegetables or combined FV in women than men, was observed across nine studies (30, 33, 39, 40, 46, 52, 54, 64, 67). In four studies the highest intake or purchase of fruit, vegetables or combined FV was observed among men (28, 35, 40, 48). No differences between men and women, neither for fruit, nor for vegetable consumption or purchase was observed in ten studies (29, 32, 42, 50, 53, 55, 57, 60, 62, 73).

Age

The relevance of age was examined in 21 studies (28, 29, 31, 32, 35, 40, 42, 43, 46, 50, 52–54, 56, 57, 60, 62, 64, 67, 73, 74). Twelve studies found that the frequency and quantity of fruit, combined FV, and vegetable consumption increased with increasing age (31, 35, 46, 50, 52–54, 56, 60, 64, 67, 73). Two studies found opposing results in which fruit and combined FV consumption decreased with increasing age of consumers (40, 43). One study among adults in Mauritius examined the frequency and also the timing of fruit consumption between age groups and found significant differences between younger and older adults and whether fruit was consumed after lunch or after dinner (74). In seven studies, no association was found between age and fruit; between age and vegetable; or age and combined FV consumption or purchase (28, 29, 32, 42, 50, 57, 62).

Other biological factors

The relationship between body mass index and fruit, vegetable and combined FV consumption was examined in three studies (30, 42, 67). One study among urban residents in Ethiopia found positive associations between body mass index and frequency of fruit and vegetable consumption (30), while two studies found no associations (42, 67). One study among women in Mauritius aimed to assess factors affecting food habits between pre-menopausal and post-menopausal women. The results revealed that the consumption of fruit was the highest among pre-menopausal women, whereas raw vegetables were mostly consumed by post-menopausal women (34).

Demographic factors

Family or household income

The relevance of income was investigated in 15 studies (29, 32, 37, 39, 48, 52, 56, 57, 60, 62, 64, 73, 77, 79, 80). Nine of these studies found that the frequency and quantity of fruit, vegetable and combined FV consumption and combined FV purchase increased

TABLE 2A Individual/household level factors—biological.

Sub-level	Factor	Consumer behavior					Evidence* (References)			
		Consumption	Purchase/ acquired	What	How	When	Positive association	Negative association	Significant difference	No association/no significant difference
Biological	Gender/sex (women vs. men)	F		x				(40)	(30)	(32, 40, 46, 64, 67, 73)
		F			x		(54)			(55, 73)
			F	x				(28)		(28, 57)
		V		x			(40, 64, 67)			(30, 32, 40, 46, 64, 73)
		V			x		(54)			(53, 55, 73)
			V	x				(28)		(28, 29, 62)
		FV		x			(39, 52, 54)	(35)	(33, 46)	(40, 42, 50, 60)
			FV	x				(48)		
	Age	F		x			(64)	(40)		(31, 32, 40, 46, 64, 67, 73)
		F			x		(54)	(43)	(74)	(73)
		F				x			(74)	
			F	x						(28, 57)
		V		x			(31, 64, 67, 73)		(46)	(32, 40, 64)
		V			x		(53, 54, 73)		(56)	
			V	x						(29, 62)
		FV		x			(35, 50, 60)	(40)	(46)	(35, 42, 50, 67)
		FV			x		(52, 54)			
	Body mass index (BMI)	F		x						(67)
		F			x		(30)			
		V		x						(67)
		V			x		(30)			
		FV		x						(42, 67)
	Pre-post menopause	F			x				(34)	
		V			x				(34)	

*Evidence: Positive or negative association: Relationship for positive or negative association qualified as statistically significant at the 5% level, based on correlation and regression analysis. Significant differences: tested e.g.,, via t-tests; ANOVA as statistically significant at the 5% level; No association, no significant difference: not statistically significant, or no association. F, Fruit; FV, combined Fruit and Vegetables; V, Vegetables; What: Quantities consumed, amount spent for purchasing FV; % of people consuming F, V, FV; How: Frequency of consumption or purchase; When: referring to the timing of FV consumption.

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TABLE 2B Individual/household level factors—demographic.

Sub-level	Factor	Consumer behavior					Evidence* (References)			
		Consumption	Purchase	What	How	When	Positive association	Negative association	Significant difference	No association/no significant difference
Demographic	Residence (urban vs. rural)	F		x				(31, 64)	(46)	(31, 32, 64, 67, 73)
		F		x		x				(76)
		F			x					(73)
		V		x				(64, 67, 73)	(46)	(31, 32, 64)
		V			x			(73)	(56)	
		FV		x				(67)		(42, 46, 60, 80)
	Education	F		x			(31, 64, 67, 73)		(32)	(40)
		F		x		x				(76)
		F			x		(30, 43, 54, 73, 79)	(79)		
		V		x			(31, 40)	(64)	(32)	(31, 40, 64, 67, 73)
		V			x		(30, 53, 73)		(56)	(54, 73)
			V	x			(62)			(29)
		FV		x			(50, 54, 80)	(35)		(35, 40, 42, 52, 67, 80)
	Employment/occupation	F		x			(31, 43, 73)	(73)		(31, 32, 73)
		F			x		(54, 73, 79)	(73, 79)		(54, 73)
			F	x						(28, 57)
		V		x			(31, 73)	(73)		(31, 32, 73)
		V			x		(73)	(53, 73)	(54)	(54, 56, 73)
			V	x				(28)		(28)
		FV		x			(39, 50, 54)	(54)		(42, 54, 80)
	Ethnicity	F		x			(31, 67, 73)	(31, 73)	(32, 46)	(31, 73)
		F			x		(54, 73)	(73)		(54, 73)
		V		x			(31, 67, 73)	(31, 73)	(32, 46)	(31, 67)
		V			x		(54, 73)	(73)		(54)
		FV		x			(54, 67)		(46)	(54, 67)
	Food insecurity	F		x				(43)	(32)	

(Continued)

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TABLE 2B (Continued)

Sub-level	Factor	Consumer behavior					Evidence* (References)			
		Consumption	Purchase	What	How	When	Positive association	Negative association	Significant difference	No association/no significant difference
		F		x		x		(76)		(76)
		F			x			(49)		
			F	x						(59)
		V		x					(32)	
		V		x		x				(76)
		V			x			(49)		
			V	x						(59)
	Socio-economic status	F		x					(46, 77)	
		F			x				(34)	
		V		x					(46, 68)	
		V			x				(34)	(34)
		FV		x					(46)	
	Wealth status (high vs. low)	F		x			(31, 43, 67, 73)			(31, 40)
		F			x		(73)			
		V		x			(73)	(31)		(31, 40, 67)
		FV		x			(44, 80)			(40, 67)
	Income (family income, household income, parents income, having money)	F		x			(64, 73)		(32)	(64)
		F			x		(30, 73, 79)	(79)		
			F	x						(57)
		V		x			(73)	(64)	(32)	(64)
		V			x		(30, 73)		(56)	
			V	x						(29, 62)
		FV		x			(39)			(37, 60)
		FV			x		(52)			
			FV	x			(48)			

*Evidence: Positive or negative association: Relationship for positive or negative association qualified as statistically significant at the 5% level, based on correlation and regression analysis. Significant differences: tested e.g.„ via t-tests; ANOVA; No association, no significant difference: not statistically significant, or no association. F, Fruit; FV, Fruit and vegetables combined; V, Vegetables; What: Quantities consumed, amount spent for purchasing FV; % of people consuming F, V or FV; How: Represents the frequency of consumption or purchase; When: in reference 76 is referring to season (dry vs. rainy).

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TABLE 2C Individual/household level factors—lifestyle.

Sub-level	Factor	Consumer behavior				Evidence* (References)			
		Consumption	Purchase	What	How	Positive association	Negative association	Significant difference	No association/no significant difference
Lifestyle	Tobacco use/smoking	F		x			(65)		(32, 65, 67)
		F			x	(63)	(63)		(54, 63)
		V		x					(32, 65, 67)
		V			x	(63)	(63)		(54, 63)
		FV		x					(54, 67)
	Alcohol consumption/drinking habits	F		x					(32, 67)
		F			x		(54)		
		V		x					(32, 67)
		V			x		(54)		
		FV		x			(54)		(67)
	Convenience	V		x					(68)
		FV		x					(45)
	Time	FV		x					(37, 66)
	Physical activity	F		x					(67)
		V		x					(67)
		FV		x					(67)
	Purchased sugar-sweetened beverages	FV		x			(60)		
	Vegetarianism	F		x					(32)
		V		x					(32)
		V			x			(56)	
	Eating out	FV		x					(66)
	Buy FV daily or weekly	FV		x					(60)

(Continued)

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TABLE 2C (Continued)

Sub-level	Factor	Consumer behavior				Evidence* (References)			
		Consumption	Purchase	What	How	Positive association	Negative association	Significant difference	No association/no significant difference
	Ownership of a vehicle, Travel to purchase groceries, Ease of transportation	F		x		(73)			
		F			x	(73)			
		V		x		(73)			
		V			x				(73)
		FV		x		(60)			(60)
	Access to information technology (internet, radio, nr. of mobile phones)	F		x		(73)			(73)
		V		x		(73)			
		F			x	(73)			(73)
		V			x	(73)			
	Exposure to media—reading newspapers, magazines	F		x		(31)			
		V		x		(31)			(31)
	Exposure to media—listening to radio	F		x		(31)			(31)
		V		x					(31)
	Exposure to media—watching television	F		x		(31)			(31)
		V		x					(31)

*Evidence: Positive or negative association: Relationship for positive or negative association qualified as statistically significant at the 5% level, based on correlation and regression analysis. Significant differences: tested e.g.„ via t-tests; ANOVA; No association, no significant difference: not statistically significant, or no association. F, Fruit; FV, Fruit and vegetables combined; V, Vegetables; What: Quantities consumed, amount spent for purchasing FV; % of people consuming F, V or FV; How: Represents the frequency of consumption or purchase.

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TABLE 2D Individual/household level factors—Cognition.

Sub-level	Factor	Consumer behavior					Evidence* (References)			
		Consumption	Purchase	What	How	When	Positive association	Negative association	Significant difference	No association/no significant difference
Cognition	Knowledge	V		x			(68)			
		V			x				(56)	
		FV		x						(37, 50, 66)
	Attitude toward FV consumption	FV					(50)			
	Nutrition education	F		x						(32)
		V		x						(32)
		FV		x			(50)			(50)
	Self-efficacy	V		x			(68)			
	Good heating habits (perceived)	FV		x					(66)	
	Food choice motive "health"	V		x			(68)			
	Perceived FV health benefits	FV		x						(37, 45, 60, 66)
	Personal preference	FV		x						(37, 45)
	Mothers preference and perceptions of healthy body size	F		x		x				(76)
	Taste	V		x		x	(76)			
		FV		x						(37)
			FV	x						(48)
	Ethical concern	V		x						(68)
	Mood	V		x			(68)			
		FV		x			(45)			
	Familiar	V		x						(68)

*Evidence: Positive or negative association: Relationship for positive or negative association qualified as statistically significant at the 5% level, based on correlation and regression analysis. Significant differences: tested e.g., via t-tests; ANOVA; No association, no significant difference: not statistically significant, or no association. F, Fruit; FV, Fruit and vegetables combined; V, Vegetables; What: Quantities consumed, amount spent for purchasing FV; % of people consuming F, V or FV; How: Represents the frequency of consumption or purchase; When: in 76 is referring to season (dry vs. rainy).

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TABLE 3 Social environment.

Sub-level	Factor	Consumer behavior					Evidence* (References)			
		Consumption	Purchase	What	How	When	Positive association	Negative association	Significant difference	No association/no significant difference
Family	Household size	F			x			(73)		
		F		x			(40)	(40, 73, 79)		(32, 40)
		V			x					(53, 73)
		V		x				(40, 73)		(32)
		V		x	x			(40)		
		FV		x				(40, 50)		(50)
			V	x						(29)
	Number of adults in household	F		x				(79)		
	Number of females 15 years or older in household	F		x						(73)
		F			x		(73)			
		V		x			(73)			
		V			x					(73)
	Number of children in household	F		x			(73)	(79)		
		F			x		(73)			
		V		x	x					(73)
		V		x		x				(76)
	Marital status	F		x						(32)
		F			x		(54)			(31)
			F	x						(57)
		V			x		(54)		(56)	
		V		x						(32)

(Continued)

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TABLE 3 (Continued)

Sub-level	Factor	Consumer behavior					Evidence* (References)			
		Consumption	Purchase	What	How	When	Positive association	Negative association	Significant difference	No association/no significant difference
			V	x						(31, 62)
		FV		x			(39, 42)	(50)		(50, 54)
	Help with procurement and preparation	FV		x						(37)
	Family preferences and habits	FV		x						(37)
	Purchase special foods for children	F		x		x				(76)
		V		x		x				(76)
	Who purchases food within the family (mother; husband; both; other family member)	F		x		x				(76)
		V		x		x				(76)
Gender roles/empowerment	Influence of husband/husband encouragement	FV		x			(45)			
	Woman decides on how family income is used	FV		x						(50)
	Woman decides on type of food eaten in the household	FV		x						(50)
	Women's autonomy in production decision	V		x			(61)			
		FV		x			(61)			(61)
	Women's Input in production decision	V		x			(61)			
		FV		x			(61)			
	Women comfortable speaking in public	V		x						(61)
		FV		x			(61)			

*Evidence: Relationships for positive or negative associations qualified as statistically significant at the 5% level. Relationship for positive or negative association qualified as statistically significant at the 5% level, based on correlation and regression analysis. Significant differences: tested e.g., via t-tests; ANOVA; No association, no significant difference: not statistically significant, or no association. F, Fruit; FV, Fruit and vegetables combined; V, Vegetables; What: Quantities consumed, amount spent for purchasing FV; % of people consuming F, V or FV; How: Represents the frequency of consumption or purchase; When: is referring to seasonal difference (dry vs. rainy) in 76.

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TABLE 4 Physical environment.

Sub-level	Factor	Consumer behavior					Evidence* (References)			
		Consumption	Purchase	What	How	When	Positive association	Negative association	Significant difference	No association/no significant difference
Home	Availability of FV at home	FV		x			(45)			
	Home garden for FV consumption/own production of FV	V		x			(73)			
		V			x		(73)			
		F		x						(73)
		F			x					(73)
		FV		x						(37)
	Storage of FV at home	FV		x						(37)
University	Availability of FV at university		F	x			(57)			
			FV	x				(48)		
Neighborhood/ retail food environment	Socio-economic areas		F	x	x				(58, 59)	
			V	x	x				(58, 59)	
	Availability of FV in the neighborhood	FV		x						(37)
	Supermarket vs. traditional retail outlets	FV		x				(38)		
	Distance to market	F			x			(43)		
		F		x		x				(76)
		FV		x						(37)
	Price	V								(68)
		FV		x					(37)	(45)
Product property and food safety	Poor product quality	FV		x						(37)
	Size of vegetable item		V	x						(29)
	Type/variety of vegetable item		V	x						(29)
	Food safety and hygiene	V			x	x	(47)	(47)		(47)

*Evidence: Relationship for positive or negative association qualified as statistically significant at the 5% level, based on correlation and regression analysis. Significant differences: tested e.g., via t-tests; ANOVA; No association, no significant difference: not statistically significant, or no association. F, Fruit; FV, Fruit and vegetables combined; V, Vegetables What: Quantities consumed, amount spent for purchasing FV; % of people consuming F, V or FV; How: Represents the frequency of consumption or purchase and how V were prepared at home in case of 47.When: is referring to the timing, i.e. delay in V consumption in 47 and to seasonal differences in 7.

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TABLE 5 Macro environment.

Sub-level	Factor	Consumer behavior					Evidence* (References)			
		Consumption	Purchase	What	How	When	Positive association	Negative association	Significant difference	No association/no significant difference
Natural landscape	Ecological zone (forest vs. coastal)	F			x		(31)			
		V			x		(31)			
	Ecological zone (Savannah vs. coastal)	F			x			(31)		
		V			x			(31)		(31)
	Forest cover	F		x			(40)			(40)
		V		x			(40)			(40)
		FV		x			(40)			
	Forest vs. non-forest area	F		x						(75)
		V		x					(75)	(75)
		FV		x					(75)	
Season	Season	F		x				(40)	(43, 72, 76)	(36, 40, 72)
		F		x		x			(41)	(41)
		F			x				(69)	
		V		x					(36, 43, 70, 72, 76)	
		V			x				(69)	(40)
		V		x		x			(41)	(41)
			V			X			(70)	
		FV		x					(43, 70)	(36, 40, 70, 72)
		FV		x		x			(41)	(41)
			FV			x			(70)	
Urbanization	Strata of urbanization	F		x					(51)	
		V		x					(51)	

(Continued)

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TABLE 5 (Continued)

Sub-level	Factor	Consumer behavior					Evidence* (References)			
		Consumption	Purchase	What	How	When	Positive association	Negative association	Significant difference	No association/no significant difference
	Urbanicity level (various levels compared to least urban)	FV		x				(71)		
	Rural to urban migration	FV		x					(78)	(78)
Societal and cultural norms	Religion	F		x				(31)		(31, 54)
		V		x			(31)	(31)		(31, 54)
		FV		x			(45)			(54)
			FV	x						(48)

*Evidence: Relationship for positive or negative association qualified as statistically significant at the 5% level, based on correlation and regression analysis. Significant differences: tested e.g., via t-tests; ANOVA; No association, no significant difference: not statistically significant, or no association. F, Fruit; FV, Fruit and vegetables combined; V, Vegetables; What: Quantities consumed, amount spent for purchasing FV; % of people consuming F, V or FV; How: Represents the frequency of consumption or purchase; Where: is referring to urban/rural areas; in 70 where is referring to where the consumed FV were obtained from, e.g., from the market or from the wild.

with higher family or household income (32, 39, 48, 52, 64, 73, 77, 79, 80). Two studies found positive associations but also opposing results or no associations (64, 79). For example despite a higher intake of fruit, wealthier rural Mozambican women reported a lower consumption of vegetable, while there was no significant variation with income and FV consumption of male or urban respondents (64). Studies discussed that vegetables were components of cheapest meals in rural areas where they grow, while while fruit was more affordable year-round to wealthier families (64). In four studies, household income, or having money was not associated with vegetable purchases or combined FV intake (29, 37, 60, 62).

Socio-economic status

The importance of socio-economic status (SES) was assessed in four studies (34, 46, 68, 77). Significant differences between socio-economic status were found among all studies. In one study, significant differences were found for cooked vegetables, but not for vegetable salads (34). Overall results revealed that more people from higher SES consumed fruit and vegetables compared to people from lower SES.

Wealth status

The influence of wealth status was investigated in seven studies (31, 40, 43, 44, 67, 77, 80). Six of these studies found that the quantity and frequency of fruit, vegetable or combined FV consumption increased with higher wealth status (31, 43, 44, 67, 77, 80). One study found positive associations but also opposing results (31), showing a decrease in the weekly number of vegetable servings consumed by women in Ghana with increasing wealth status. The relationship was also negative for men, but not significant (31). One study found no association (40).

Food insecurity

Food insecurity was assessed in five studies (32, 43, 49, 59, 76). Four studies found that food insecurity was associated with lower or less frequent fruit and vegetable consumption (32, 43, 49, 76). One study found no association between food insecurity and fruit and vegetable purchase among supermarket shoppers from different South African socio-economic communities and discussed that this could be due to the short form of the food security questionnaire used in the study (59). Another study found no association between food insecurity and vegetable consumption, but found that food insecurity was associated with a low amount of fruit consumed during the dry season, while not during the rainy season (76).

Education

Twenty studies examined the role of education (29–32, 35, 40, 42, 43, 50, 52–54, 56, 62, 64, 67, 73, 76, 79, 80). Fourteen of these studies found that the frequency and quantity of fruit, vegetable and/or combined FV consumption and purchase increased with higher level of education (30–32, 40, 43, 50, 53, 54, 62, 64, 67, 73, 79, 80). The majority of these studies referred to positive associations between education and fruit consumption for men and women (30, 31, 43, 54, 64, 67, 73, 79). For vegetables, the results were less unambiguous, i.e., more studies showed no associations. Overall, four studies found mixed results, including positive, and opposing results, i.e., higher education was associated with reduced fruit, vegetable, or combined FV consumption (35, 56, 64, 79). Reasons

for that contradiction were discussed only in one paper, where vegetable intake was threefold lower in the more educated urban men, while fruit intake was positively associated with education. The authors speculated that families with higher education were more likely to work outside the home, thereby leaving less time for preparing meals which could lead to a greater preference for ready to eat foods including fruit while omitting vegetables (64). Five studies found no associations (29, 42, 52, 67, 76).

Occupation/employment

The relevance of occupation or employment status was investigated in 14 studies (28, 31, 32, 39, 42, 43, 50, 53, 54, 56, 57, 73, 79, 80). Nine of these found associations between different types of occupation and fruit, vegetable or combined FV consumption (28, 31, 39, 43, 50, 53, 54, 73, 79). However, no pattern regarding a certain occupation type and its positive or negative relationship with fruit, vegetable or combined FV consumption was observed across the studies. In addition, five studies found no association between employment status and combined FV consumption or purchase behavior (32, 42, 56, 57, 80).

Residence

The difference between urban and rural residence in fruit, vegetable, and combined FV consumption was assessed in 11 studies (31, 32, 42, 46, 56, 60, 64, 67, 73, 76, 80). Four studies found that adults living in urban areas consumed less, or less frequently, fruit, vegetables, or combined FV, as compared to adults living in rural areas (31, 64, 67, 73). Four studies found no association between residence and fruit consumption (32, 67, 73, 76), followed by four studies that found no association between residence and combined FV consumption (30, 42, 46, 60), and one study found no association between residence and vegetable consumption (32). Mixed results within studies and within fruit and vegetable groups were observed in two studies relating to biological sex differences, in addition to the difference in urban and rural residence (31, 64).

Ethnicity

The influence of ethnicity was assessed in six studies and all of them found associations (31, 32, 46, 54, 67, 73). The results were however inconsistent, depending on which ethnic groups were compared.

Lifestyle/behaviors

Within the sub-level "lifestyle/behaviors," ten factors were identified. Tobacco smoking and drinking habits were the factors investigated by most studies and showed associations with fruit and vegetable consumer behavior, as well as the factors of ease of transportation, vegetarianism, and purchase of sugar-sweetened beverages.

Tobacco use/smoking

The factor smoking was assessed in five studies (32, 54, 63, 65, 67). In two of these, smoking compared to non-smoking was associated with a decrease in the amount and frequency of fruit and/or vegetable consumption (63, 65). One study investigated smoking habits in terms of different cigarette types and frequency of tobacco consumption and found negative associations between manufactured cigarette smoking and frequency of fruit and vegetable intake, while also positive association between smokeless tobacco consumption or hand-rolled cigarette smoking and frequency of fruit and vegetable consumption among adults (63). This shows that the negative association between smoking and FV consumption is not the same for all forms of tobacco use. Three studies found no association between smoking and fruit consumption (32, 54, 67); smoking and vegetable consumption (32, 54, 67), or smoking and combined FV intake (54, 67).

Alcohol consumption/drinking habits

The relationship between alcohol consumption and the frequency and quantity of fruit, vegetable and combined FV intake was investigated in three studies (32, 54, 67). One study found that drinking was associated with a decrease in combined FV consumption (54). Two studies found no association (32, 67).

Travel to purchase groceries

Two studies (combined rural and urban areas) assessed the association between ownership of a vehicle or different modes of travel (e.g., walk, personal vehicle, bus, taxi) to purchase groceries, and FV consumption (60, 73). Results revealed overall positive associations between vehicle ownership or use of a personal vehicle to purchase groceries and fruit, vegetable, and combined FV consumption. Among the discussed reasons was that ownership of a vehicle was considered as a proxy for mobility and ease of transportation, which can enhance the chances of these households accessing cheaper or better-quality FV (73).

Access to information technology

The relevance of access to information technology was examined in one study in South Africa (73). Household access to mobile phones, radio, television, and internet was associated with increasing frequency of and higher chances of consuming adequate amounts of fruit and vegetables among adults. The authors argue that access to nutrition information disseminated through various media channels could positively influence nutrition awareness, and point to the promotion of nutritious foods through programs in South Africa, but do not elaborate on specific campaigns, their content, or duration.

Other lifestyle factors

The frequency of purchasing sugar-sweetened beverages was associated with a decrease in combined FV consumption (60). The influence of vegetarianism was measured in two studies (32, 56). While one study showed no association between vegetarianism and fruit and vegetable consumption (32), another study showed that vegetarians ate Moringa leaves and pods more often, compared to non-vegetarians (56). Other factors including convenience (45, 68), time (37, 66), physical activity (67), eating out (66), and buying FV daily or weekly (60) and its relationship with fruit and vegetable consumption were examined only by few studies and revealed no associations.

Cognition

Nine studies examined the sub-level cognition (37, 45, 48, 50, 56, 60, 66, 68, 76). Five factors, namely, taste preference for vegetables (76), mood (45, 68), higher belief in one's own ability to prepare vegetables (self-efficacy) (68), valuing "health" as food

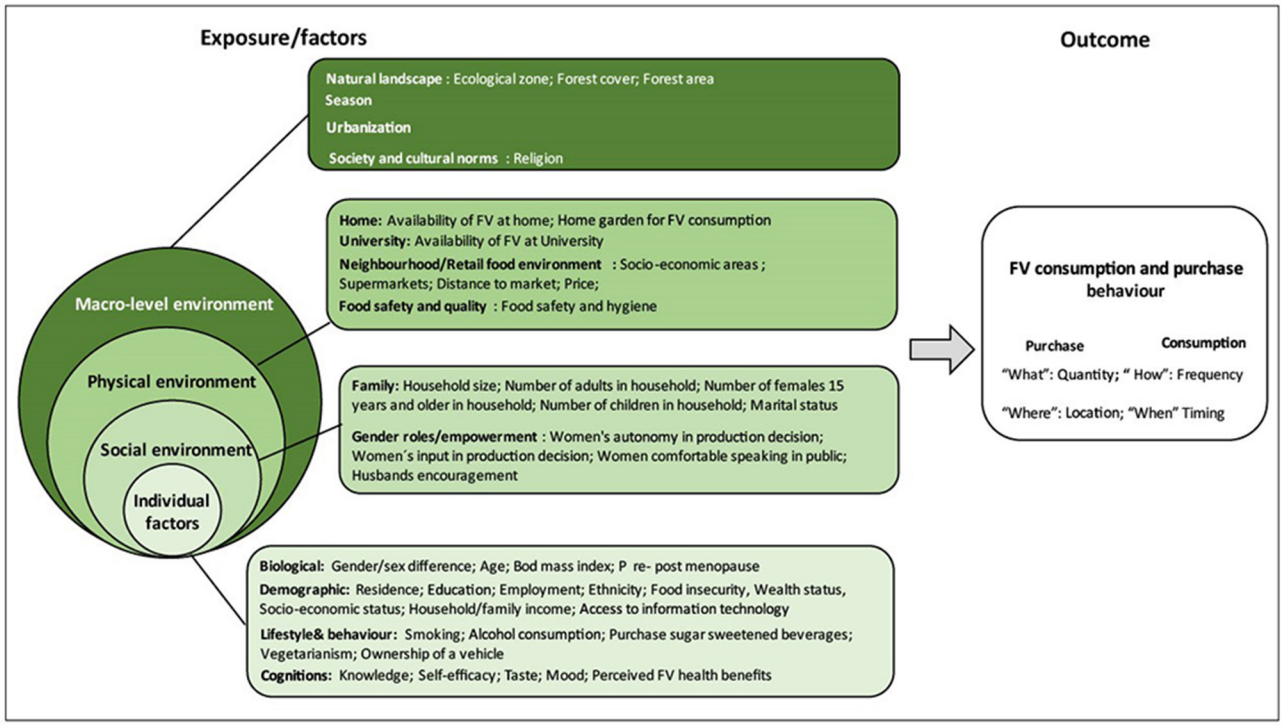

FIGURE 3
Conceptual framework based on a socio-ecological framework (12) and its adaptation for LMICs (18, 19) and Africa (11) illustrating identified factors in the review that affect fruit and vegetable consumption and purchase. Exposure/factors represented showed an association with the outcome variable or significant differences in the outcome variable. (ii) Outcome: Most outcome variables refers to FV consumption in terms of quantity ("What") and frequency ("How").

choice motive (68) and attitude toward FV consumption (50) showed positive associations with vegetable and combined FV consumption. The factors knowledge (50, 56, 68) and nutrition education (32, 50), showed mixed results, and personal preferences (37, 45) as well as ethical concern (68) showed no associations with FV consumer behavior.

Social environment

Thirteen studies explored factors within the social environment which may influence consumer behavior through social interactions, social support or role modeling (12).

Family

Household size and composition

The role of household size and household composition was investigated in eight studies (29, 32, 40, 50, 53, 73, 76, 79). Household size was most frequently assessed (32, 40, 50, 53, 73, 79). The results revealed that higher household size is associated with less frequent or lower quantity of fruit, vegetables, and combined FV consumption among adults (40, 73, 79). Three studies found no association (29, 32, 53), and three studies found mixed results (40, 50, 73). For example, one study among adults in South Africa found negative associations with fruit consumption, as well as no association between family size and vegetable consumption (73). Another study among adults in rural Tanzania found negative associations between household size and combined FV consumption, as well as a positive association, and no association for specific fruit items (40). And one study in Uganda found a negative association between household size and combined FV consumption in urban, but not in rural areas (50). The composition of the household in terms of the number of adults, the number of females 15 years and older, or the number of children in the household was assessed by three studies (73, 76, 79). One study in South Africa showed overall positive associations between the number of children below 5 years of age and fruit, but not vegetable consumption by adults. In addition, in the same study, the number of females 15 years and older in the households was also positively associated with adults' fruit and vegetable consumption (73). On the contrary, one study in Ghana found a negative association between the number of children in a household and the quantity of fruit consumption among urban dwellers in Ghana, but the results were not further discussed (79). One study among mothers in Malawi found a negative but not significant association between the number of children in a household and the amount of vegetables consumed by mothers (76).

Marital status

The factor marital status was examined in nine studies (31, 32, 39, 42, 50, 54, 56, 57, 62). The positive associations between marital status and fruit, vegetable, and combined FV consumption of men and women referred overall to being married or cohabiting vs. not being married (39, 42, 54). One study among adults in Mauritius found an opposing result showing that widowed

participants reported higher consumption frequencies of the vegetables "Moringa leaves" and "Moringa pods" compared to those that were single, married or cohabiting (56). Four studies found no associations or no significant differences (31, 32, 57, 62) and one study in Uganda found mixed results, showing a negative association between being married and FV consumption among adults in rural areas, while no association with adults in urban areas (50).

Habits and behavior within the family

Factors assessing habits and behavior within the family such as perceived family preferences and eating habits or whether it was the father or mother who purchased food within the family, were sparsely investigated and revealed no association or significant differences in two studies (37, 76).

Gender roles and empowerment

The influence of gender roles and empowerment on diets has been investigated in three studies (45, 50, 61). One study among women across five African countries explored the relationship between women's empowerment and the consumption of vegetables and combined FV. Results showed that women's autonomy and input in production decisions were positively associated with the consumption of dark green leafy vegetables, as well as with the consumption of vitamin A-rich FV, while leadership opportunities measured as "women are comfortable speaking in public" was associated only with combined FV consumption (e.g., other fruit and vegetables), but not with dark green leafy vegetables or combined FV (e.g., other vitamin A-rich FV) (61). In one study in urban Ethiopia, "husband's encouragement," which was described as a social support within the household, was positively associated with women's combined FV consumption (45). One study in Uganda found no association between intra-households decision makings and FV consumption (50).

Physical environment

Within the physical environment, which includes the different surroundings, where people consume, purchase or acquire food we identified 13 factors divided in the sub-levels availability and access at home, availability at university, neighborhood and retail environment and product property and food safety.

Availability and access at home

The importance of the availability of FV in the home for fruit, vegetable, and combined FV consumption was investigated by three studies (37, 45, 73). Two of these studies investigated home-garden/own production for FV consumption once assessed as a binary variable (households engaged in own FV production—yes/no) (73), and once assessed as participants' perception (if participants perceived home-gardens as an enabler for FV consumption) (37). While household engagement in own FV production was associated with more frequent and higher vegetable intake among adults in South Africa (combined urban and rural areas), it showed no association with fruit intake (73). Discussed reasons included that households either produced mainly vegetables or that fruit was sold at the market rather than for own consumption (73). In contrast, home-gardens as a perceived enabler for FV consumption did not enable combined FV consumption among low-income urban residents in Ibadan, Nigeria (37). The same study also examined the influence of storage of FV at home as a perceived enabler for combined FV consumption and found no significant difference between people who consumed and those who did not consume adequate amounts of FV (37). However, women's perception of fruit and vegetable availability in homes was positively associated with adequate combined FV consumption among women in urban Central Amhara Region in Ethiopia (45).

Availability at university

The availability of fruit and vegetables at universities and its association with fruit and combined FV purchase among students in Nigeria was explored in two studies (48, 57). While one study showed that availability was positively associated with the amount students spent on fruit per month (57) another study found that availability was negatively associated with combined FV purchases, without further discussing the possible reasons (48).

Neighborhood and retail environment

Distance to market

The relevance of market access, measured in terms of walking time, km distance of village to market, or as a perceived barrier or enabler for FV consumption was investigated by three studies (37, 43, 76). One study among smallholder women farmers from different agro-ecological zones in rural Western Kenya showed that distance in walking time from home to the closest tarmac road was negatively associated with the weekly fruit consumption of women in the dry season (43). Similarly, one study among women with children less than 5 years in urban and rural Central Regions of Malawi examined market access in terms of minutes to the nearest food market/shop and also found a negative, but not significant association with the amount of fruit consumed by women during the dry season (76). Among low-income urban residents in Ibadan, Nigeria, the market access assessed was not detected as a significant determinant for adequate FV intake (37).

Availability of FV in the neighborhood

Availability of FV in the neighborhood as a perceived enabler or barrier to FV consumption was explored in one study among low-income residents in Ibadan, Nigeria, but revealed no significant difference between adults who consumed adequate amounts of FV daily, and those who did not (37).

Socio-economic areas

The interplay between socio-economic areas and the food purchasing behavior of urban supermarket shoppers was investigated by one study, reported in two publications in South Africa (58, 59). Results revealed that urban supermarket shoppers living in low socio-economic neighborhoods purchased fruit and vegetables less frequently than shoppers from high and middle socio-economic areas (58). Moreover, shoppers from high

socio-economic areas spent a significantly higher proportion of their expenditure on fruit compared to shoppers from low and middle-income socio-economic areas (59).

Supermarkets

The consequences of modernizing retail environments investigated as the effect of supermarkets on consumers' diets were assessed by one study in three towns in Kenya. The results showed that shopping in supermarkets contributed to a significant decrease in energy consumption from FV among adults (38).

Price

The relevance of price was investigated in three studies among urban consumers in Nigeria and Ethiopia (37, 45, 68). Price was found to be the only determinant of combined daily FV consumption among low-income residents in Ibadan, Nigeria (37). Another study among urban women in Nigeria found that price was considered an important food choice motive, overall for women from lower socio-economic status, however, no association was found with vegetable intake (68). Similarly, concerns about food prices were mentioned as a key driver of food choice among women in urban central Amhara region, Ethiopia, but was not associated with the combined FV intake of the women (45).

Product property and food safety

The importance of product properties as factors affecting FV consumption and vegetable purchase among adults was assessed in two studies in Ibadan, Nigeria (29, 37). One study (29) examined whether the preferred size or the preferred type/variety of fresh tomato was associated with the weekly amount spent on fresh tomatoes. The results showed that the size of the tomato (medium compared to others) was positively associated with the weekly amount spent on fresh tomatoes, while other variables including the type/variety of fresh tomatoes showed no association (29). Poor product quality as a perceived barrier showed no significant difference between low-income residents in Ibadan, Nigeria, who consumed five portions of FV daily, and those who did not (37). The role of consumers' confidence in food safety actions for vegetables sold in open markets and how it influences the vegetable handling of adults at home was investigated by one study in urban Ghana (47). Results revealed that a higher confidence in food safety actions related to cleanliness and contact exposure, increased the probability of delayed consumption of vegetables and treatment of vegetables at home (47).

Macro-level environment

Nineteen studies investigated the role of the macro environment, which has a more distant and indirect, but powerful role in influencing consumer behavior.

Season

Seasonal differences in fruit, vegetable, and combined FV consumption or acquisition were investigated in eight studies (36, 40, 41, 43, 69, 70, 72, 76). Six out of eight studies found significant differences in the quantity and frequency overall of vegetable consumption (36, 41, 43, 69, 70, 72, 76), followed by fruit (41, 43, 69, 72, 76) and combined FV (41, 43, 70) consumption among adults between seasons. Besides the quantity and frequency of fruit and vegetable consumption, one study assessed whether seasonality influenced "where" fruit and vegetables were obtained for consumption, differentiating between "cultivated," "from the wild" or "from the market" (70). Results showed that in the rainy season, where fruit and vegetables were overall less frequently consumed, the acquisition of fruit and vegetables "from the wild" as well as "from cultivation" was crucial for the supply compared to "from the market." The majority of the studies analyzed seasonal variations in rural areas (36, 40, 43, 69, 70, 72) and one study determined the influence of season in rural and urban settings (41). Seasonal differences were mostly expressed as a comparison between two seasons, e.g., rainy vs. dry season, lean vs. post-harvest, or beginning of cereal shortage season vs. to end of cereal shortage season (36, 40, 43, 69, 70, 72, 76). One study analyzed the difference between three agricultural seasons, harvest, post-harvest, and lean season (41).

Natural landscape

Within the sub-level natural landscape, the role of ecological zones as well as forests in terms of forest cover and proximity to forests was assessed among three studies (31, 40, 75). The association between ecological zones and fruit and vegetable consumption was examined by one study in Ghana and revealed that adults living in Forest zones consumed more weekly fruit and vegetable servings than those from the Coastal and Savannah zones (31). One study in rural Tanzania assessed whether deforestation over a five-year period affected people's dietary quality including per capita consumption of fruit, vegetables, and combined FV (40). The authors used a modeling approach based on secondary data and showed that forest cover was positively associated with per capita consumption of the food group "fruit and vegetables." The authors argue that deforestation most likely reduced the local supply for gathering and consuming wild fruit and vegetables in the selected study area. In addition, the authors analyzed individual fruit and vegetable categories responsible for this relationship and showed positive associations between forest cover and the vegetable group "spinach, cabbage, and other green vegetables," as well as the fruit group "mango, avocado, and other fruit." Forest cover was, however, not associated with any other fruit or vegetable category (40). In one cross-sectional study in Southwest Cameroon, women of reproductive age from forest-based villages were more likely to consume vitamin A-rich fruit and vegetables than women from non-forest-based villages, while no significant differences were observed for other fruit and dark green leafy vegetables (75).

Urbanization

Urbanization in terms of strata of urbanization, and rural-to-urban migration and urbanicity level in rural areas, was investigated in three studies (51, 71, 78). One study among men and women living in the North West Province of South Africa found significant differences among the strata of urbanization (rural, farm, informal settlement, middle class, urban, upper class urban) and fruit and

vegetable consumption of adults (51). Another study in Tanzania investigated changes in diet among adults migrating from rural to urban Tanzania over 12 months and found that rural-to-urban migration led to a significant increase in the weekly number of combined FV portions consumed by women, but not by men (78). On the contrary, one study in Uganda that examined the distribution of urban characteristics across rural communities found that higher urbanicity was associated with lower combined FV consumption among adults (71).

Cultural and societal norms

The role of religion was investigated in four studies (31, 45, 48, 54). Three of these studies analyzed religion and its association with fruit, vegetable, or combined FV consumption, and one study looked at combined FV purchase. Two studies found associations between religion and fruit, vegetable, and combined FV consumption, one among adults in Ghana (31) and one among urban residents in Central Amhara, Ethiopia (45). One argument in the study in urban Ethiopia on why religious practices are associated with FV consumption was that fruit and vegetables are fasting foods and consumed in the fasting time especially by people who belong to the Orthodox religion, which was most of the women in the study area (45).

Two studies found no association between religion and fruit and vegetable consumption (48, 54).

Discussion

To the best of our knowledge, this review is the first and most current comprehensive synthesis of factors, identified across four levels of a socio-ecological framework that has been contextualized to the fruit and vegetable consumption and purchase behavior of adults in sub-Saharan Africa. Most evidence in our review was found for demographic factors at the individual/household level. Due to the focus on individual/household level factors, we identified research gaps in the other levels of influence (social, physical, macro), which is consistent with previous reviews in urban Africa (11, 20, 22, 81) and LMICs (82, 83). Nevertheless, we found important evidence for several key variables in the social, physical and macro-level environment, which emphasizes the need for holistic, systemic approaches to promote FV consumption.

Individual, social, physical and macro level—Where is the evidence?

Most consistent evidence within the individual/household level exists for demographic factors including household or family income, socio-economic status and wealth status which were mostly all positively associated with adults' fruit and vegetable consumption and purchase. These variables are often used as proxy for affordability and demonstrate that equity issues are key among individuals and households in accessing fruit and vegetable. The results are not surprising as affordability, defined as the cost of diets or price relative to income, is known as critical barrier to the consumption of fruit and vegetables, as these foods are among the most expensive components in diets in LMIC in particular (84–87). The consumption of fruit and vegetables is particularly unaffordable for many people from low-income countries including in Africa (86). While it is indisputable that fruit and vegetables must first be made available and affordable for everyone, additional factors including individual preferences, taste, convenience, as well as time are regarded as important drivers of choice among affordable items (18, 88), but these aspects have only been sparsely investigated in the included studies.

Within the social environment, the most consistent evidence exists for household size and marital status, while family habits or interaction within the family or community were rarely assessed. Evidence for household size showed that increasing size was related to lower or less frequent fruit and vegetable consumption. This implies that larger households require more resources to provide for the needs of all household members than smaller households, and are therefore less likely to consume adequate amounts of fruit and vegetables (73). With regards to marital status, some evidence exists that being married or cohabiting is associated with higher and more frequent fruit and vegetable consumption. Authors argued that marriage involve social interactions including regular meals, as well as possible control over the health behavior of the spouse (42). While evidence exists in the wider literature that gender equality and women's empowerment can lead to better food security, nutrition and sustainable food systems (89), only three studies included in our review examined these issues. Evidence from two studies showed positive associations between women's autonomy and input in production decisions, leadership opportunities and husbands encouragement explained as "social support" within the household and women's FV consumption (45, 61). A possible explanation for the lack of research, might be that gender aspects are assessed in relation to other measures, such as dietary diversity (90) or household nutrition (91) and not in relation to specific food items at individual level. Furthermore, intra-household relations and empowerment are difficult to assess with quantitative measures only (92, 93).

Similarly, as for the social environment, evidence in the physical environment was only scattered around a few variables. A potential explanation is that research on food environments has rarely been studied in LMICs, especially in Africa and is only yet emerging (81, 94). Nevertheless, we found some evidence to support arguments that (i) the rapidly changing physical environment in urban areas leads to shifts in the availability and types of food consumed (81, 95, 96) and (ii) that supermarkets do not necessarily provide access to healthy and affordable food (95). This was confirmed by a panel data study in three Kenyan cities, which showed that that shopping in supermarkets contributed to lower consumption of FV, but higher consumption of processed and highly processed foods (38). Authors argued that unprocessed foods like FV are hardly sold in small-town supermarkets in Kenya, compared to processed foods, because they are available from local wet markets (38). Another study discussed issues of FV quality in supermarkets and the general higher prices of FV compared to staples and snacks as a possible reason why urban supermarket shoppers in low socio-economic neighborhoods in urban South Africa purchased fruit and vegetables less frequently than shoppers from high and middle socio-economic areas (58, 59). While food safety concerns are growing barriers to fruit and vegetable consumption in urban LMIC settings (83), we found only a few studies on these aspects in our review.

At the macro-level environment, seasonality was the most frequently studied factor and results were consistent across studies showing significant differences in FV consumption between seasons. Among the main arguments within the studies was that seasonality is a crucial element of food availability, particularly in rural areas, where smallholder farm households depend on rainfed agricultural production. Moreover, seasonality leads to price fluctuations, particularly in Africa, affecting overall perishable food like fruit and vegetables (97). Additional related factors and evidence found at macro-level include the importance of the natural landscape including forests for fruit and vegetable consumption by overcoming seasonal gaps in subsistence settings, but also by providing fresh fruit and vegetables at local markets (31, 40, 75). We found no studies on other factors that are known to influence dietary behavior at the macro level including advertising and marketing, agricultural policies, subsidies or distribution systems.

Research recommendations

Our analysis reveals some issues regarding research methodology and metrics applied for exposure and outcome variables and allows us to provide some recommendations for future research. See also Box 1 Key messages for future research.

BOX 1 Key messages for future research.

Study population

> Need for more gender- differentiated studies including both men and women in different social, economic and geographic contexts

Exposure/factors

Need for more research on:

> preferences, perceptions attitudes as well as on time and convenience aspects at the individual level

> habits and behavior within the family, social identity, social networks, gender equality and women's empowerment at the social environment level

> food safety concern and interactions within the diverse physical food environments

> advertising and marketing of FV, agricultural policies, subsidies or distribution systems of FV

Outcome

> Need for more research beyond dietary intake (frequency and quantity of FV), assessing consumer behavior in terms of how, where, when FV are consumed, purchased, acquired or gathered

> Need for more diverse classification of fruit and vegetables, beyond the level of food groups

> Need for more tools and standardized indicators for exposure and outcome variables, and different types of research methodologies and approaches, including qualitative and participatory research methods (see Research Recommendations)

Need for new tools and standardized indicators

We observed an absence of metrics and indicators to assess exposure variables across the different levels of influence. For example, "distance to markets" included measures such as "walking time" or "kilometer distance," as well as asking consumers about their "perception of market access." This makes comparisons across studies difficult. The lack of standardized indicators and tools is consistent with findings from previous reviews on food environment research in LMICs (19, 94). Downs et al. (19) provide a toolbox of objective and subjective tools to overcome this gap, but highlight that new tools and methods are needed to assess the diverse food environment landscapes in LMICs. With regards to the outcome variables, we found few studies that assessed consumer behavior other than dietary intake. Similarly, as for the exposure variables, reasons for this absence include a lack of validated metrics and indicators to assess consumer behavior, as pointed out in the literature (98).

Need for different types of research methodologies

The focus on "objective" observable facts clearly highlights how limited the positivist paradigm is in studying influences on consumer behavior, as reflected in the limited research we have identified on the social, physical, and macro level environment. Moreover, following a conventional hierarchy of evidence only reflects the dominant scientific view, while other knowledges including indigenous knowledge systems, which are key particularly for understanding context specific issues, are left out (99). Several exposure variables can be measured objectively and require standardized indicators. However, other aspects of influence, which are influenced by contextual factors such as habits and behavior within the family, social identity, social networks, interactions within the food environments, or individual perceptions require different types of research methodologies (19, 82, 92), which were not included in this review. Hence as suggested in recent reviews and the literature, to better explore the social and physical environments, different approaches are recommended, that bring the perspective of the consumers to the forefront, such as photovoice or transect walks and other participatory methods (15, 19, 20, 100, 101).

Need to address underlying and structural issues

In order to achieve healthy, sustainable and just transformations of food systems, underlying political and structural issues of food environments, of inequity and power imbalances should not be neglected (102, 103). Global food trade and transnational food corporations determine what food is available, affordable or advertised in local food environments of LMIC, which should be taken into account when assessing FV intakes (102). Crucial factors related to increasing local production diversity, such as farmers' access to seeds and exchange of planting materials or land tenure issues (104) were not captured in the reviewed literature. Reasons for might include the focus of this review on observational, overall cross-sectional studies, but also the restriction of outcome variables to consumption and purchase behavior. We could have found studies on these topics, by either adding additional outcome variables such as acquisition, gathering or production of FV or by including qualitative studies. The need to address political economy drivers to transform food systems is increasingly emphasized in the wider literature (102, 103). Scholars from feminist theories, food sovereignty and right-to-food activists emphasize the importance of knowledge co-production with actors outside of academia, giving a voice to marginalized groups, to address issues of inequity and power imbalances (105).

Need for more diverse classification of fruit and vegetables

Fruit and vegetables were mainly assessed at the food group level and information on single food items at the species level or below species level, i.e., at cultivar level or on indigenous fruit or vegetables species was mostly lacking. This is unfortunate as it undermines the importance of agricultural biodiversity in local food systems, which plays a central role in supporting and strengthening food, nutrition, health and livelihood security, overall in rural subsistence settings (106). The limitation has also been highlighted in recent reviews on vegetables for healthy diets (107) and in a review on biodiversity in food consumption studies (108). Harris et al. (107) argue that a higher nuance in classifying vegetables related to dietary outcomes is needed to assess the diversity within food groups. We support this argument which should also be extended for fruit, while also considering local species including indigenous and orphan crops.

Policy recommendations

Despite the paucity of evidence due to a lack of research across the different levels of influence, the review identified some policy recommendations. To address issues of economic access to fruit and vegetable consumption, interventions aimed at reaching lower socio-economic groups, such as social protection programs improving access to credit or voucher systems have been suggested by studies in this review (37) and in the wider literature (84). Moreover, making FV more affordable was further discussed as a regulatory strategy in articles included in this review (68) and in other literature (11, 84, 87, 109). Recommended actions to lower the prices discussed in the wider literature encompass subsidies on fruit and vegetable production, as well as improving local production, marketing, trade, and storage (11, 84, 87, 109). Incentivizing the sale of healthier foods, such as fruit and vegetables in retail markets has also been suggested in included studies (38). However, as formal retail outlets are often competitive with informal food economies, context-specific solutions are required (95, 96). For example, an approach discussed in the literature is to support traditional markets, including wet markets and farmers' markets that sell fresh products around supermarkets, which can support the livelihoods of small informal vendors that might be replaced by large retail outlets (83, 95, 96). Supporting the sale of FV through small vendors could also improve access to FV since supermarkets are often out of reach especially for lower socio-economic groups.

To ensure the year-round harvest of FV overall in subsistence settings, location-specific production calendars with a focus on trees and shrubs adapted to agro-ecological conditions have been suggested as solutions by studies in this review (43) and in the wider literature (110). Other strategies mentioned included focusing on improved methods of food storage and processing techniques for FV to maintain dietary diversity (41), and to improve the utilization of FV in value chain developments (43). In addition, gathering fruit and vegetables from the wild, from near forests was mentioned as coping strategy to overcome seasonal unavailability of FV among studies within the review (70, 75). Local production of fruit and vegetables has the potential for direct consumption in subsistence settings. In addition, production at the local landscape can ensure access to the nutritious, but perishable FV in local markets, especially in areas where infrastructure is not well developed (overall rural), thus avoiding seasonal price fluctuations (111). Moreover, in order to sustainably transform our food systems, scientists have emphasized the importance to recognize, protect and support forests and agroforestry landscapes in the discourse around food and nutrition security. These systems are important suppliers particularly of FV, and provide ecosystem services essential for producing other food (111–114).

Strengths and limitations of the review approach

This review has several strengths and limitations. One strength is that we followed a systematic review methodology with a comprehensive search in the electronic databases Scopus, PubMed, PsycINFO, African Index Medicus, and Google Scholar. While previous reviews in Africa assessed factors on general dietary behavior, limited to urban areas (11, 20, 22), we focused on the specific food categories fruit and vegetables and included both urban and rural settings. In addition to exposure and outcome associations, we included descriptive studies, if significance tests were presented. This allowed us to include a wide range of potential factors, such as the most studied factor at the macro level (seasonality) which was mainly assessed *via* descriptive statistics, lacking the assessment of potential confounders. This review is a synthesis of observational studies, with overall cross-sectional study design, as this type of studies was predominant in an initial scoping search. Nevertheless, cross-sectional studies provide only a snapshot of the present moment and do not allow conclusive statements on causality between exposure and outcome. We performed a critical appraisal for each study to identify potential bias, but did not rate the quality of evidence. This is a limitation of our review, because it is recommended to not only base evidence evaluations on statistical significance, but to consider the strengths of the association and other aspects that could lead to imprecision or inconsistency (115). Another limitation is that only English studies were included, which restricted the inclusion of studies in French or Portuguese speaking African regions, which is reflected in the geographic distribution. We found most studies were located in East and Southern Africa, but few in West and Central Africa. The restriction to individual level outcome measures excluded many purchase outcomes, which might have covered more aspects in the physical environment.

Conclusion

This review fills a knowledge gap to better understand the various factors that enable or constrain fruit and vegetable consumption and purchase among adults in sub-Saharan Africa. Most consistent evidence was found at the individual/household level for demographic factors including household or family income and socio-economic status. While fewer studies assessed other levels of influence, we found important evidence for several factors at the social, physical, and macro levels. These include the importance of women's empowerment, the influence

of neighborhood and food retail environment including distance to market and price, and the importance of natural landscapes, including forest areas, on consumption of FV. This underscores the need for context-specific approaches at multiple levels to promote FV consumption. The lack of evidence, particularly on aspects such as social interaction within the family, community, or food environment, as well as consumer behavior beyond dietary intake, was identified as a limitation. It highlights the need to develop and improve indicators for both exposure and outcome variables, but also the need to diversify research approaches to reflect not only the dominant scientific view but also to include other knowledge, including indigenous knowledge systems, that are, particularly critical to understanding context-specific issues.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

BS with contributions from UT, IB, IS, SM, MW, LH, and AK worked on the conceptualization of the review. UT and IS provided guidance on the methodology of the review process. BS conducted the literature search, screened all articles, extracted data, conducted data analysis, wrote the original draft, and integrated feedback from co-authors in the final version. UT, IS, AK, LH, and SM assisted BS in the double screening of articles and checks in data extraction and risk of bias assessment. SL, UT, and IS provided substantial feedback in the draft and final version. SL, UT, MW, IS, SM, and PR contributed review and editing. All authors read and approved the final version of the manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnut.2023.1113013/full#supplementary-material

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Dietary patterns derived using principal component analysis and associations with sociodemographic characteristics and overweight and obesity: A cross-sectional analysis of Iranian adults

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Introduction: This study examined the cross-sectional association between household dietary patterns and sociodemographic characteristics and BMI in a nationally representative sample of Iranian adults.

Methods: Data on 6,833 households (n = 17,824 adults) from the National Comprehensive Study on Household Food Consumption Pattern and Nutritional Status 2001–2003 were used. Principal component analysis (PCA) was used to extract dietary patterns from three household 24-h dietary recalls. Linear regression analyses were used to examine associations between dietary patterns and sociodemographic characteristics and BMI.

Results: Three dietary patterns were identified: the first was characterized by high citrus fruit intake, the second by high hydrogenated fats intake and the third by high non-leafy vegetables intake. The first and third patterns were associated with household heads with higher education and living in urban areas, while the second was associated with household heads with lower education and living in rural areas. All dietary patterns were positively associated with BMI. The strongest association was found with the first dietary pattern (β: 0.49, 95% CI: 0.43, 0.55).

Discussion: While all three dietary patterns were positively associated with BMI, the sociodemographic characteristics of Iranian adults who consumed them differed. These findings inform the design of population-level dietary interventions to address rising obesity rates in Iran.

KEYWORDS

dietary patterns, principal component analysis, obesity, Iranians, adults

Introduction

Middle-Eastern countries, such as Iran, have faced an accelerated nutrition transition over recent decades (1). Consequently, shifts in dietary patterns from traditional Iranian diets towards Western diets high in added sugars and fat have resulted in higher rates of diet-related chronic diseases and obesity (1, 2). According to the latest available national estimates in 2016, the prevalence of obesity and overweight/obesity among Iranian adults was 23 and 59%, respectively (3). As a poor diet is a significant risk factor for obesity (4) and diet consists of a combination of foods and nutrients, (5) it is crucial to understand the factors that influence overall dietary patterns, such as sociodemographic characteristics, and their associations with overweight and obesity. This will inform the design of strategies to address the health impact of the Iranian nutrition transition.

In our previous study of a nationally representative sample of Iranian adults, the use of overall diet quality indices was shown to be appropriate for use in the population (6–8). However, as Iran is a Middle-Eastern county with a culturally-specific diet, (1) data driven approaches, such as principal component analysis (PCA), present an opportunity to explore the patterns of dietary intake that exist in the population, which diet quality indices may not adequately capture (9–11). PCA has previously been used to assess the dietary patterns of Iranian adults, (12–14) with most identifying an increasingly westernized dietary pattern. For example, in a sample of 10,693 Iranian adults from Yazd, a large urban city, a dietary pattern was identified that was characterized by high intakes of confectionary, sugars and snacks, (12) while findings from a cross-sectional analysis of 4,834 Iranian adults identified a Western dietary pattern, a fast-food dietary pattern and an animal fat dietary pattern (15).

Little is known about the data-driven dietary patterns of Iranians and their associations with sociodemographic characteristics and overweight and obesity (16–19). Research to date has shown mixed associations with BMI, (12, 15) and evidence is inconsistent for the relationship between empirical dietary patterns and sociodemographic characteristics, including age (12, 17, 20, 21) and education (12, 15, 17, 20, 21). Further, no studies have investigated associations with area of residence. Previous research has been conducted in populations from large Iranian cities, such as Shiraz, (22) Isfahan (15, 21) and Tehran, (17, 23) thus limiting the ability to identify culturally specific dietary patterns at a national level and by key sociodemographic characteristics, such as sex and area of residence. Since Iran has experienced rising rates of obesity and urbanization due to the nutrition transition, (2) and obesity is more prevalent in Iranian females than males, (24, 25) understanding the effects of sex and area of residence on the association between dietary patterns and overweight and obesity is of significance. Thus, this study aimed to examine the associations between empirical dietary patterns, sociodemographic characteristics, and overweight and obesity in the National Comprehensive Study on Household Food Consumption Pattern and Nutritional Status 2001–2003. As a secondary aim, this study investigated interactions by sex and area of residence on associations between dietary patterns and overweight and obesity.

Abbreviations: BMI, Body mass index; DAG, Directed acyclic graph; DQI-I, Diet quality index-international; HEI, Healthy eating index; PCA, Principal Component analysis; WHO, World Health Organization.

Methods

Subjects and study design

Dietary, demographic, and anthropometric data were used from 7,248 households (36,014 individuals) from the National Comprehensive Study on Household Food Consumption Pattern and Nutritional Status 2001–2003 (26). Participants from all provinces of Iran (28 at that time) were recruited using a cluster sampling method between March 2001 and November 2003. Trained nutritionists working in the health sector collected information on dietary intake, sociodemographic characteristics, and anthropometry (27). Participants were excluded from the present analysis if (i) they were aged <18 years and (ii) any member of the household reported implausible body weight or height (as detailed later), (iii) households with 0 or >1 custodian to maximize comparability between household dietary recalls. Ethics for the study was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences and was exempted by the Deakin University Human Research Ethics Committee (reference number 2019–288). This manuscript is reported according to the Strengthening the Reporting of Observational Studies in Epidemiology—Nutritional Epidemiology (STROBE-Nut) reporting checklist (Supplementary Table 1) (28).

Study measures

Dietary intake

Three 24-h dietary recalls were used to collect data on household food and beverage intake over consecutive days (27). The household member who was responsible for cooking in the household provided these data. Households with complete data for 2 days (129 households) or 3 days (7,119 households) of these 24-h dietary recalls were included in the survey. The dietary data were collected in every province throughout the year (except for Ramadan and New Year public holiday period) to capture seasonal variation in dietary intake. Variation was also captured throughout the week by including week days and weekends (27). Dietary data were collected in the household using the *per capita* approach. This dietary assessment methodology considers the equal distribution of intake of food between all members in the household (29). Dietary surveys in low-middle-income countries often collect data at the household-level due to the high cost and complexity of dietary surveys at the individual-level (30–32). To calculate the total food intake per day *per capita*, the total grams of the food consumed in each meal was divided by the number of persons present (including visitors). The intake for each food in each meal was then summed up to calculate the total food intake (g/day/capita) (27). The interviews to collect dietary intake were conducted at the house of the participants. The interviewers used the conversion rate shown on the labels of food products (created by Food and Drug Administration of Iran). For example, for liquid vegetables oils, 1.1 ml was used to convert from volume (cc) to weight (grams). For milk, 1 ml was considered as the conversion rate. Average food and nutrient intake of the 2 or 3 days of 24-h dietary recalls was calculated. An estimate of the ratio of household energy intake to household energy requirement was calculated to adjust for energy intake misreporting. The Iranian Food Composition Dataset was applied to evaluate food items and their energy (kcal/day) and nutrient content. Nutrients

examined included sodium (mg/day), fiber (g/day), iron (mg/day), calcium (mg/day), vitamin C (mg/day), and total fat (% of energy), protein (% of energy), and carbohydrate (% of energy) (27). The Iranian Food Composition Dataset was used to evaluate the average content of energy of food groups contributed in PCA to evaluate the percentage of energy contribution from each food groups.

Principal component analysis

Dietary data were used to derive dietary patterns using PCA, using varimax rotation. Consistent with the PCA methodology, dietary patterns were constructed based on linear combinations of the food groups, reflecting combinations of foods frequently consumed together. The dietary pattern scores thus indicate the degree to which the participant's diet conforms to the pattern (33). A total of 43 food groups were created for use in PCA analyses (34). These groupings and the number of food groups were based on previous dietary pattern studies in Iranian adults and the similarity of the nutrient composition of foods, and were pilot tested to avoid low proportions of consumers in each food group (16–19). Input variables for the food groups were grams *per capita* per day. A list of the food groups used is provided in Supplementary Table 2.

The number of dietary patterns was identified based on factors with eigenvalues >1.5, breaks in the scree plots and the interpretability and meaningfulness of the patterns using previous Iranian surveys (16–19). Patterns were described in relation to the food groups that loaded most positively or negatively (factor loading >0.20) for the respective patterns. A factor loading of >0.20 was selected based on previous dietary pattern research in Iranian populations (17–19). The Stata postestimation predict command was used to generate standardized dietary pattern scores.

Sociodemographic characteristics

Information on age, sex, education and area of residence were collected during in person interviews with each individual in the household. Area of residence was assessed based on location data provided by the National Statistics Centre, which was used to classify households as living in a rural or urban area (binary variable). For the purpose of regression analyses with household dietary patterns, age and education at the household level were created for the household head (household custodian). Age of adults, and the household heads, was categorized into 18 to ≤40 years (young adults), >40–≤60 years (mid-aged adults), >60 years (older adults) based on previous Iranian research on obesity (35, 36). Education level of adults, and household heads, was categorized into three levels based on the total number of the years of education: low (0–5 years; equivalent to completed primary school), moderate (6–12 years; equivalent to completed secondary school), and high (more than 12 years; equivalent to university education).

Anthropometric characteristics

Body weight and height were measured for individuals in households. Weight was measured without shoes and twice to the nearest 100 g using a Seca scale and the mean of these values was used. The accuracy of the scale was adjusted with a control scale (5 kg). Height was measured without shoes and to the nearest 0.1 centimeter with tape measures. Adults with biologically implausible weight (<24.9 or >453.6 kg) and biologically implausible height (<111.8 or >228.6 cm) were excluded from the analysis based on established cut points (37). Body Mass Index (BMI; weight kg/height m^2) was calculated for every adult in the household. Using the World Health Organization (WHO) cut points, adults were grouped into non-overweight/obese (<25 kg/m^2) or overweight/obese (≥25 kg/m^2) (38).

Data analysis

Data analysis was performed using Stata (version 16.0; StataCorp). The number and percentage of participants were reported for categorical variables and means and standard deviations were reported for continuous variables. The Xtile command was used to create tertiles of dietary patterns. To be able to easily quantify and understand the underlying composition of the dietary patterns, unadjusted linear regression analysis was used to examine nutrient intake across tertiles of each of the three dietary patterns. Furthermore, to evaluate the healthfulness of the identified dietary patterns, the Healthy Eating Index (HEI) and Diet Quality Index International (DQI-I) diet quality indices were examined across tertiles of the dietary patterns. The calculation of these indices has been described in full elsewhere (6, 7). The margins command was used to report the adjusted mean (SD) of food group intakes used in the PCA analysis. Linear regression analysis was used to assess how household dietary patterns (continuous dependent variables) varied across household sociodemographic characteristics (independent variables): the age of household heads (categorical), sex of household heads (binary), education level of household heads (categorical), and area of residence (binary). Multi-level linear regression analysis was used to assess how individual-level BMI (continuous dependent variable) varied by dietary patterns of households (continuous independent variable). Multi-level logistic regression analysis was used to assess the association between household dietary patterns (continuous independent variable) and individual-level obesity (binary and dependent variable). Confounders were identified using a Directed Acyclic Graph (DAG) and previous research (Supplementary Figure 1). DAGs are visual tools used to better understand the relationship between exposures, outcomes and potential confounders (39). A DAG was used to identify the confounders for the association between dietary patterns and overweight/obesity, where age, sex, education, area of residence and energy intake were identified as confounders available for use in this study. Analyses for the associations with BMI and overweight/obesity were adjusted for age (continuous), sex (binary), education (categorical), area of residence (binary) and energy intakes in adults. To examine interactions by sex and area of residence, interaction terms were added to the regression models. Considering the lack of available data on physical activity, and that 50% of the Iranian adult population has insufficient physical activity (40) a sensitivity analysis was conducted to examine whether adjusting analyses for the ratio of energy intake: energy requirement (instead of adjusting for energy intake) changed the direction and strength of associations. As this study used dietary data collected at the household level, a further sensitivity analysis was conducted to examine if adjusting for household size changed the direction or strength of the association between household dietary patterns and adults' individual-level BMI. Household size was operationalized as no children (<18 years), less than three children and more than three children. The number of children was based on the 1996 Iranian census - the latest

census in Iran at the time of the survey (41). A complete case analysis approach was used to manage any missing data. p value < 0.05 was considered to determine statistical significance.

Results

Of the 36,014 individuals (n = 7,248 households) with available data from the National Comprehensive Study on Household Food Consumption Pattern and Nutritional Status 2001–2003, 797 adults were excluded for being ineligible (implausible weight and height and 0 or > 1 custodian) and 2,545 adults were excluded for missing data (Figure 1). A total of 17,824 adults were included in the present study. The mean age of adults was 37.3 (15.1) years, the mean energy intake of adults was 2,660 (692.27) kcal, and mean weight and BMI were 66.2 (13.7) kg and 25.2 (5.0) kg/m^2, respectively. Forty seven percent were overweight or obese. As shown in Table 1, the majority of adults were young (18–40 years; 62%), female (55%), had low education (50%) and lived in urban areas (65%), with a mean energy intake of 2,660 (696) kcal/day. At the household level, the mean age of household heads was 45.5 (13.3) years and the mean energy intake of household heads was 2,635 (694.45) kcal. The majority of household heads were males (95%), middle aged (44%), lived in urban areas (65%), and had low levels of education (57%).

Three dietary patterns were extracted using PCA. Factor loadings for the dietary patterns are presented in Figure 2. The first dietary pattern, referred to as mixed dietary pattern 1, was characterized by higher intake of citrus fruits, leafy vegetables, non-hydrogenated fats, nuts, root vegetables, rice, milk, cakes and poultry meat and low intake of breads. The second dietary pattern, referred to as traditional dietary pattern, was characterized by higher intake of hydrogenated fats, onions, potatoes, tomato pastes, legumes and breads. The third dietary pattern, referred to as mixed dietary pattern 2, was characterized by higher intake of non-leafy vegetables, fruits grown on the ground, soft drinks, cream and fruits grown on trees and low intake of citrus fruits and legumes. Nutrient intake (mean and standard error) and diet quality indices according to tertiles of each dietary pattern are presented in Table 2. Energy intake was significantly higher with increasing tertiles of the traditional dietary pattern. In contrast, energy intake was lower in the second tertile of the mixed dietary patterns, and higher in the third tertile. Intake of sodium, calcium, fiber, and vitamin C were higher across tertiles of all dietary patterns, while iron intake was higher across tertiles of the mixed dietary pattern 1 and traditional dietary pattern. The percentage of energy from fat was higher across tertiles of all three dietary patterns, while the percentage of energy from carbohydrates was lower. The percentage of energy from protein was higher across tertiles of mixed dietary pattern 1 but was lower across tertiles of the traditional dietary pattern. The mean HEI score was higher across tertiles of the mixed dietary patterns while the mean DQI-I score was higher across all three dietary patterns.

The mixed dietary pattern 1 and traditional dietary pattern were associated with household heads with higher education levels and living in urban areas, while the traditional dietary pattern was associated with household heads with lower education levels and living in rural areas (Table 3). The Iranian Food Composition Dataset was used to evaluate the percentage of energy contribution from each food group used in the PCA. The food groups that contributed most to energy intakes were breads (36.7%), rice (14.7%), hydrogenated fats (12.5%), and sugars (7.4%) (Supplementary Table 3).

The adjusted intakes of food groups used in the PCA are presented stratified by weight status (non-overweight/obesity, overweight/obesity) in Supplementary Table 4. While intakes of breads and sugars intake were significantly higher in non-overweight/obese groups, the intake of all other food groups (rice, other grains, leafy vegetables, non-leafy vegetables, tomato paste, onions, root vegetables, citrus fruits, fruits grown on trees, fresh fruit juice, dried fruits, red meat, poultry meat, processed meats, fish and sea foods, eggs, cheese, cream, non-hydrogenated fats, cakes and desserts, sweet biscuits, soft drinks, sweetened beverages, condiments, and spices) was significantly higher in adults with overweight/obesity than adults with non-overweight/obesity.

The association between household dietary patterns and individual-level BMI and obesity are presented in Table 4. All three dietary patterns were positively associated with BMI. A one-unit increase in mixed dietary pattern 1, the traditional dietary pattern and mixed dietary patterns 2 was associated with a 0.49, 0.17, and 0.17 -unit increase in BMI, respectively. Furthermore, households with higher scores for all three dietary patterns were more likely to be overweight/obese.

The direction of associations was comparable for all patterns after adjusting models for the ratio of energy intake: energy requirement, instead of energy intake. However, the strength of the association for the traditional dietary pattern became larger (mixed dietary pattern 1: β 0.57, 95% CI: 0.52, 0.63; traditional dietary pattern: β 0.69, 95% CI: 0.62, 0.77; mixed dietary pattern 2: β 0.24, 95% CI: 0.17, 0.30). Furthermore, results showed that 29, 46, and 25% of adults came from households with no children, less than three children, and more than three children, respectively. The direction and strength of associations with BMI were comparable for all patterns after adjusting for household size: mixed dietary pattern 1: β 0.50, 95% CI: 0.44, 0.56; traditional dietary pattern: β 0.17, 95% CI: 0.09, 0.25; mixed dietary pattern 2: β 0.17, 95% CI: 0.11, 0.24.

Tests for interaction by area of residence and sex showed a significant interaction for area of residence on the association between mixed dietary pattern 1 and BMI (P-interaction ≤0.001) and overweight/obesity (P-interaction = 0.001), while the interactions for area of residence on the association between the traditional dietary pattern and mixed dietary pattern 2 and BMI and overweight/obesity were not significant (interaction p-values all >0.05). Sex did not modify the association between dietary patterns and BMI and overweight/obesity (interaction p-values all >0.05). As shown in Table 4, findings by area of residence for BMI and overweight/obesity showed strong evidence for larger effect sizes in rural areas for mixed dietary pattern 1.

Discussion

The aim of this study was to examine the association between PCA-derived dietary patterns and sociodemographic characteristics and overweight and obesity in Iranian adults. Three dietary patterns were identified that demonstrated unique characteristics. The first and third dietary patterns were mixed, including both healthier and unhealthier foods, whereas the second dietary pattern was closer to a traditional Iranian dietary pattern. In turn, the mixed dietary patterns

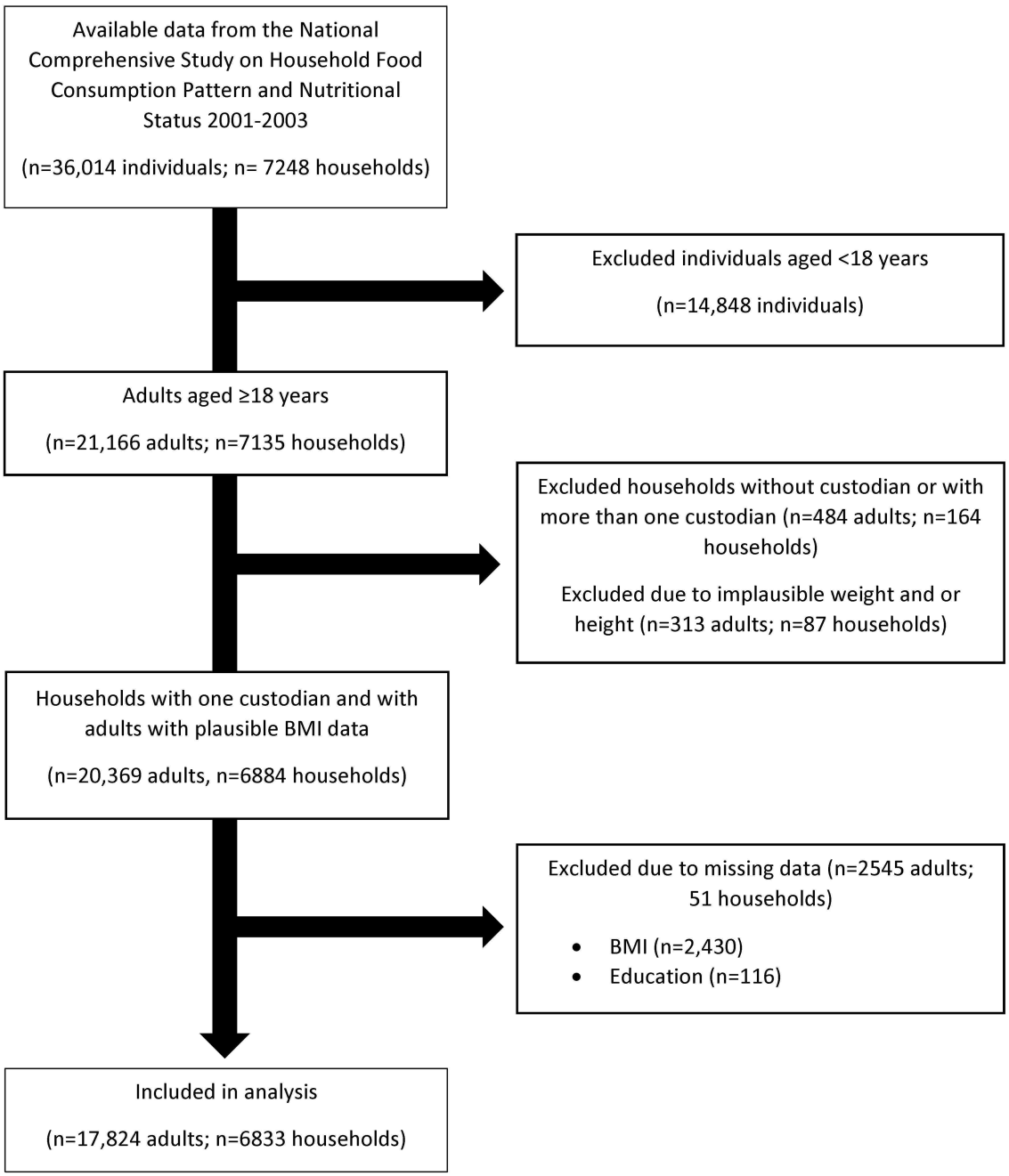

FIGURE 1
Participants flow diagram.

were associated with higher education and living in urban areas while the traditional pattern was associated with lower levels of education and living in rural areas. While all three dietary patterns were positively associated with obesity, mixed dietary pattern 1 showed the strongest association. Furthermore, the association was stronger in rural areas for mixed dietary pattern 1. This study provides insights into culturally-specific dietary patterns in a nationally representative sample of Iranian adults and will help inform the design of population-level dietary interventions and policies to address obesity.

The traditional dietary pattern identified in this study is similar to an Iranian dietary pattern identified by Esmaillzadeh et al. (17). The diet of Middle-Eastern countries, including Iran, is characterized by high consumption of refined grains and hydrogenated fats (17). These foods were observed in the traditional dietary pattern, which was comprised of higher amounts of hydrogenated fats, onions, potatoes, tomato pastes, legumes and breads. In addition, higher intake of this pattern was associated with the highest intake of iron and sodium of all three patterns. This may reflect the highest factor loading for intake of red meat in this pattern, as well as national data on sodium intake, where it is estimated that 41% of the Iranian population consume salt at least two times more than the WHO recommended level (42). However, Iran, like other Middle-Eastern

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TABLE 1 Characteristics of Iranian adults overall and by household heads.

Characteristics	Overall, *n* =17,824 adults *N* (%) or Mean (SD)	Household Heads, *n* =6,833 households *N* (%) or Mean (SD)
Age[1], *N* (%)		
Young age	11,041 (61.94)	2,736 (40.04)
Middle-aged	4,463 (25.04)	2,979 (43.60)
Older	2,320 (13.02)	1,118 (16.36)
Sex, *N* (%)		
Males	8,067 (45.30)	6,501 (95.14)
Females	9,757 (54.74)	332 (4.86)
Level of education[2], *N* (%)		
Low	8,891 (50.00)	3,869 (56.62)
Moderate	7,220 (40.51)	2,312 (33.84)
High	1,713 (9.61)	652 (9.54)
Area of residence, *N* (%)		
Rural	6,289 (35.30)	2,386 (34.92)
Urban	11,535 (64.72)	4,447 (65.08)
Anthropometrics, mean (SD), *N* (%)[3]		
Overweight/obesity, *N* (%)	8,381 (47.02)	3,999 (58.52)
Weight (kg)	66.2 (13.69)	71.1 (13.41)
BMI (kg/m^2)	25.2 (5.02)	25.2 (4.34)
Energy intake (kcal), mean (SD)	2,660 (692.27)	2,635 (694.45)

[1]Young aged (18- ≤ 40 years old), middle aged (>40- ≤ 60 years old), older (>60 years old).
[2]Low (no formal schooling, less than primary school, the primary school completed), medium (secondary school completed, high school completed), and high (college/university completed).
[3]Data on anthropometrics were available for 5,666 household heads only.

countries, has experienced a nutrition transition over the last three decades and diets have shifted towards unhealthier dietary patterns (1). Some unhealthier foods found in Western and unhealthy dietary patterns in other studies were also observed in the present study (17, 19). For example, mixed dietary pattern 1 included high intake of cakes, and the mixed dietary pattern 2 included high intake of soft drinks and creams and low intake of legumes and citrus fruits. This is comparable to a recent study that examined trends in dietary patterns of 6,508 Iranian adults aged 18 years and over from Tehran. A mixed dietary pattern, characterized by higher simple sugars intake was identified, for which adherence increased from 29.7 to 34.1% between the years 2006 to 2017 (43).

No studies have examined associations between overall dietary patterns and area of residence in Iran. In terms of associations with specific foods, previous research is inconsistent. While a study reported higher consumption of fruits and vegetables in provinces with higher rates of urbanization (44), another study did not find any difference in fruits and vegetable intake between rural and urban areas (45). The present study identified that the mixed dietary patterns were associated with living in urban areas, while the traditional dietary pattern was associated with living in rural areas. While the nutrition transition has been occurring across Iran, these findings, and that of others, suggest that rural regions may be more inclined to uphold traditional dietary habits (46). This may be due to limited availability of Western foods in rural areas, or differences in cultural and socio-economic determinants of diet, where adults who reside in rural areas are older and more inclined to prepare traditional meals (47). However, given no studies have examined dietary patterns in relation to area of residence, and this study identified stronger associations between mixed dietary pattern 1 and obesity in rural areas, prospective research is needed to confirm these findings and to determine which dietary factors should be targeted as part of obesity prevention interventions in these population groups.

TABLE 2 Household nutrient intakes and diet quality indices according to tertiles of dietary patterns (*n* =6,833 households)[1].

	Mixed dietary pattern 1			Traditional dietary pattern			Mixed dietary pattern 2		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
Nutrients									
Protein (%E)	10.74 (0.0)	10.96 (0.0)	11.48 (0.0)	11.4 (0.0)	11.0 (0.0)	10.8 (0.0)	11.08 (0.0)	11.06 (0.0)	11.07 (0.0) *
Fat (%E)	21.10 (0.2)	24.85 (0.1)	27.50 (0.2)	22.9 (0.2)	24.1 (0.1)	26.8 (0.2)	22.34 (0.2)	24.41 (0.2)	27.00 (0.2)
Carbohydrate (%E)	68.69 (0.1)	64.66 (0.1)	61.54 (0.2)	66.2 (0.2)	65.4 (0.1)	62.10 (0.2)	67.07 (0.2)	65.00 (0.2)	62.56 (0.2)
Sodium (mg/day)	1,730 (34.8)	2,196 (44.2)	2,812 (70.1)	1,649 (24.7)	2,112 (33.2)	3,042 (81.4)	2,084 (41.0)	2,147 (53.7)	2,551 (63.6)
Calcium (mg/day)	521.80 (4.8)	551.50 (4.4)	698.1 (5.4)	518.25 (4.5)	579.72 (4.7)	683.70 (5.6)	573.23 (5.2)	564.30 (4.8)	641.04 (5.4)
Iron (mg/day)	15.02 (0.1)	14.23 (0.1)	15.61 (0.1)	12.18 (0.1)	14.65 (0.1)	18.13 (0.1)	15.30 (0.1)	14.43 (0.1)	15.17 (0.1) *
Fiber (g/day)	11.2 (0.1)	11.3 (0.1)	13.1 (0.1)	9.5 (0.1)	11.6 (0.1)	14.7 (0.1)	11.90 (0.1)	11.30 (0.1)	12.55 (0.1)
Vitamin C (mg/day)	35.8 (0.7)	54.6 (0.7)	93.6 (1.2)	51.12 (0.9)	60.00 (0.9)	75.93 (1.1)	61.82 (1.2)	49.78 (0.8)	74.70 (1.0)
Energy intake (kcal)	2,611(15.54)	2,530 (13.27)	2,758 (14.41)	2,136 (10.18)	2,580 (10.06)	3,202 (13.30)	2,611 (14.96)	2,563(14.25)	2,728 (14.21)
Diet quality indices									
HEI	29.9 (0.11)	33.9 (0.12)	37.5 (0.13)	34.5 (0.14)	33.8 (0.13)	33.5 (0.13)	32.7 (0.14)	33.1 (0.12)	35.9 (0.13)
DQI-I	37.2 (0.14)	36.5 (0.16)	39.3 (0.17)	36.5 (0.15)	37.6 (0.16)	39.0 (0.17)	36.9 (0.15)	36.7 (0.15)	39.5 (0.17)

Abbreviations: HEI, healthy eating index; DQI-I, diet quality index international[1]Wald test in unadjusted linear regression analysis for the association between nutrient intakes (continuous dependent) and tertiles of dietary patterns (categorical independent). Values represent mean and standard errors.
*The trends of nutrient intakes and diet quality indices across dietary pattern tertiles are significant $p < 0.001$ apart from protein and iron intake across third dietary pattern.

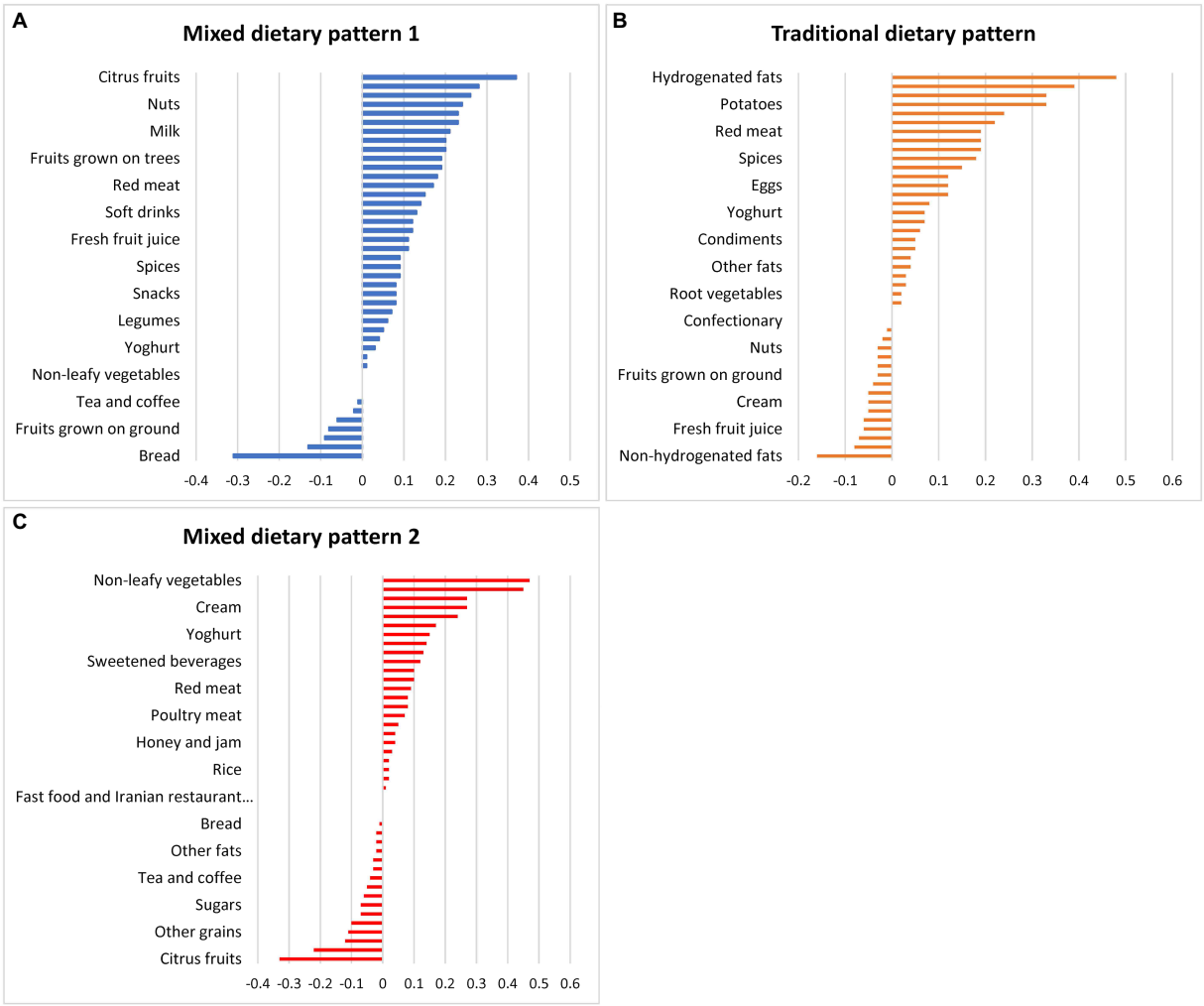

FIGURE 2
Factor loadings for the **(A)** mixed dietary pattern 1, **(B)** traditional dietary pattern, and **(C)** mixed dietary pattern 2 in Iranian household identified by principal component analysis.

The existing evidence for associations between dietary patterns and age, sex and education are mixed (15, 16, 18, 20–22). In line with our study, previous studies have found no evidence of associations between age and sex and dietary patterns (16, 18), however, other studies in Iranian populations suggest positive associations between age, being female and consuming a healthy dietary pattern (15, 20–22). A likely explanation for the lack of associations observed in this study is that age and sex of household head were assessed, where over 95% of household heads were male and were mostly middle-aged, compared to 5% female and mostly of younger age in the overall sample. As females are more likely to be the food providers in Middle Eastern countries, and males may be more likely to consume foods outside of the home, further research is needed to quantify the individual-level sociodemographic correlates of dietary patterns in Iran (15, 48, 49).

The current findings showed that all three dietary patterns were positively associated with BMI and overweight and obesity, despite being characterized by both healthy and unhealthy food groups and higher overall diet quality. All three dietary patterns comprise both healthy and less healthy food groups and share some similarities, however each had some unique characteristics. For example, the mixed dietary pattern 1 comprises components including cakes and desserts, the traditional dietary pattern includes hydrogenated fats and the mixed dietary pattern 2 consists of cream and soft drink. Evidence for associations between dietary patterns and BMI and obesity in Iranian populations is inconsistent (12, 15–17, 22), with some studies reporting that healthier dietary patterns were associated with lower BMI (12, 16, 17), and others reporting that higher consumption of an unhealthier dietary pattern was associated with lower BMI and prevalence of obesity (15, 22). The large variation in sample size and representativeness in previous research may explain these differences, ranging from 10,693 adults from Yazd (12), 418 adults from Shiraz (22), 267 adults from Tehran (16), 486 women from Tehran (17) and 4,834 adults from Isfahan (15). In addition to the distinct sample differences, another possible explanation for these discrepancies could be the measurement of dietary intake and the availability of physical activity data. While this study collected dietary data at the household level, other studies measured dietary intakes at the

TABLE 3 Associations between sociodemographic characteristics of household heads and principal component dietary patterns (n=6,833 households).

Characteristics	Mixed dietary pattern 1[4]			Traditional dietary pattern[4]			Mixed dietary pattern 2[4]		
	β - Coeff	95% CI	*p*-Value[3]	β - Coeff	95% CI	*p*-Value[3]	β - Coeff	95% CI	*p*-Value[3]
Age of household head[1]									
Young age (reference)	-	-	-	-	-	-	-	-	-
Middle-aged	−0.08	−0.20, 0.04	0.18	−0.01	−0.13, 0.11	0.89	0.04	−0.08, 0.15	0.54
Older	−0.21	−0.41, 0.03	0.09	0.13	−0.12, 0.37	0.30	−0.05	−0.27, 0.17	0.64
Sex of household head									
Males (reference)	-	-	-	-	-	-			
Females	−0.03	−0.18, 0.13	0.73	0.04	−0.12, 0.19	0.63	0.10	−0.04, 0.25	0.15
Level of education of household head[2]									
Low (reference)	-	-	-	-	-	-	-	-	-
Moderate	0.90	0.82, 0.98	<0.001	−0.04	−0.12, 0.04	0.31	0.42	0.34, 0.49	<0.001
High	1.46	1.34, 1.58	<0.001	−0.19	−0.31, −0.07	0.002	0.68	0.57, 0.79	<0.001
Area of residence									
Rural (reference)	-	-	-	-	-	-	-	-	-
Urban	0.57	0.50, 0.64	<0.001	−0.24	−0.31, −0.17	<0.001	0.33	0.27, 0.40	<0.001

[1]Young aged (18- ≤ 40 years old), middle aged (>40- ≤ 60 years old), older (>60 years old).
[2]Low (no formal schooling, less than primary school, the primary school completed), medium (secondary school completed, high school completed), and high (college/university completed).
[3]Wald test in linear regression analysis for the association between sociodemographic characteristics (categorical independent) and dietary patterns (continuous dependent) were adjusted for age, sex, education of household head, and area of residence.
[4]The first dietary pattern was characterized by higher intake of citrus fruits, non-hydrogenated fats, leafy and root vegetables, rice and low intake of breads. The second dietary pattern was characterized by higher intake of hydrogenated fats, onions, potatoes, legumes and breads. The third dietary pattern was characterized by higher intake of fruits grown on trees, cream, soft drink, and lower intake of citrus fruits and legumes.

individual level (12, 15–17, 22). Moreover, the present study did not adjust for physical activity, yet other studies did (12, 16, 17). Thus, the positive associations with BMI identified in this study should be interpreted with this in mind. Furthermore, this study has revealed that 47% of adults had overweight/obesity in 2002–2003, which was comparable to evidence from 2005 that showed the prevalence of overweight/obesity was 43 and 52% in Iranian men and women, respectively (50). However, the most recent national data on overweight and obesity in Iran (2016) indicates that the prevalence of overweight/obesity has risen to 59%, thus future research is needed to determine if associations between dietary patterns and BMI persist in more recent national data (3). Nevertheless, the mixed dietary patterns identified in the current study was similar to the unhealthy dietary patterns identified by previous studies. These dietary patterns were high in soft drinks, red meat, confectionary, and vegetable oils and were positively associated with obesity (16, 17, 19). Furthermore, high intakes of legumes, grains, and potatoes in the traditional dietary pattern of Sarkhosh-Khorasani et al. (12) are comparable to the traditional dietary pattern identified in the present study, which were both positively associated with obesity. Despite both traditional and mixed dietary patterns being positively associated with obesity, the larger effect size for dietary pattern 1 suggests that a more Western dietary pattern, particularly one high in soft drinks and low in vegetables, is most detrimental to risk of obesity. The possible explanation may be that, while all models were adjusted for total energy intake, this association was driven by high consumption of energy-dense foods and beverages. This dietary pattern was the only one characterized by intake of soft drinks, and contributed to the highest percentage of energy from total fat. Given the percentage from saturated fats and added sugars was not available, it was not possible to determine whether these were highest in this dietary pattern, thus this warrants further investigation.

This study has several strengths. This study included a nationally representative sample, which allowed us to examine dietary patterns across key demographic variables. Three 24-h dietary recalls were used to collect data on foods and beverages consumed in the previous 24 h. These were collected in every province throughout the year (except for Ramadan and New Year public holiday period) to capture seasonal variation in dietary intake. Variation was also captured throughout the week by including week days and weekends. The 24-h dietary recall interview required at least 20 min to be completed and could be administered through a phone call or a face-to-face interview by a trained interviewer. Since trained interviewers administered the questionnaires, literate respondents were not required, and as the recall period was over the last 24-h, respondents are likely to mostly recall what they have consumed. However, recall biases may still be present (51–53). With limited information available regarding the characteristics of dietary patterns nationally and in rural areas, this study addresses this gap. In addition, this study uses a statistical dietary pattern method that creates patterns based on foods that are commonly consumed together, thus enabling investigation of culturally-specific combinations of foods as part of an overall dietary pattern.

This study acknowledges several limitations that should be considered in the interpretation of the present findings. Firstly, the household dietary data is likely to be less precise than

TABLE 4 Associations between household principal component dietary patterns and adult BMI (continuous and binary) overall and by area of residence (n =17,824 adults).

Dietary patterns	BMI			Overweight/Obesity[1]		
	β - Coeff	95% CI	p-Value[2]	OR	95% CI	p-Value[3]
Mixed dietary pattern 1						
Overall	0.49	0.43, 0.55	<0.001	1.28	1.24, 1.32	<0.001
Rural (n =6,289)	0.71	0.61, 0.82	<0.001	1.40	1.35, 1.52	<0.001
Urban (n =11,535)	0.38	0.31, 0.45	<0.001	1.20	1.17, 1.26	<0.001
Traditional dietary pattern						
Overall	0.17	0.09, 0.25	<0.001	1.08	1.04, 1.13	<0.001
Rural (n =6,289)	0.33	0.18, 0.47	<0.001	1.20	1.11, 1.29	<0.001
Urban (n =11,535)	0.08	−0.02, 0.18	0.105	1.02	0.97, 1.08	0.36
Mixed dietary pattern 2						
Overall	0.17	0.11, 0.24	<0.001	1.07	1.04, 1.11	<0.001
Rural (n =6,289)	0.16	0.04, 0.28	0.010	1.08	1.01, 1.15	0.025
Urban (n =11,535)	0.17	0.10, 0.25	<0.001	1.07	1.03, 1.11	0.001

[1]BMI≥ 25 kg/m^2.
[2]Wald test in multi-level linear regression analysis for the association between dietary patterns (continuous independent) and BMI (continuous dependent) adjusted for age (continuous), sex, education, area of residence and energy intake in adults, with a mean energy intake of 2,660 kcal (SD 696).
[3]Wald test in multi-level logistic regression analysis for the association between dietary patterns (continuous independent) and obesity (categorical dependent), adjusted for age, sex, education, area of residence and energy in adults; non-obese considered as reference group.

individual dietary data because it assumes that each household member has consumed the foods relative to his/her energy and nutrient requirements (31). Although adjustment for household size did not change the direction or strength of the associations, the impact of excluding children when assessing household-level dietary data warrants further investigation. Secondly, the cross-sectional study design is susceptible to reverse causality when examining the association between dietary patterns and overweight and obesity, thus future prospective research is needed to confirm our findings. Thirdly, one of the limitations of studies conducted in the Middle East is the lack of data on alcohol intake (54). The present study did not collect data on alcohol intake, physical activity and smoking habits, which may be important confounders and should be considered in the interpretation of associations between dietary patterns and overweight and obesity. Fourthly, while the number of fast-foods outlets is likely to have increased in Iran over recent decades, data on foods consumed out of the home were not collected in this survey. This could be important for examining dietary patterns of Iranians in the advent of more Westernized diets. Fifthly, as the Iranian population, like other Middle Eastern countries, is susceptible to central obesity and the complications of this type of obesity (55), further research is needed to measure both waist circumference and BMI. Sixthly, there was evidence of underreporting in dietary intake as the effect size for the association between the traditional dietary pattern and BMI increased after adjusting for the ratio of energy intake to requirement. The lower levels of education and adults living in rural areas may be proxies for underreporting of energy intake as our results showed positive associations between these sociodemographic characteristics and the traditional dietary pattern. Seventhly, 2% of households had only two recalls, which may impact on the variety of foods consumed over two rather than 3 days. Lastly, although this study used data collected in 2001–2003, this period of time marks the beginning of the nutrition transition in Iran (2). Thus, this study will be important for future research aiming to understand how diets have changed during the nutrition transition. Moreover, as most research in national Iranian data has focused on single foods and nutrients (27), this study addressed an important gap by providing the most recent evidence on the dietary patterns of a national sample of Iranians.

Conclusion

The present study identified three distinct PCA-derived dietary patterns in a large and nationally representative sample of Iranian adults. While all three patterns were associated with higher BMI and odds of overweight and obesity, the socio-demographic characteristics of Iranian adults who consumed them were different. As Iran is undergoing a nutrition transition, future research is needed to examine dietary patterns at the individual level, in both rural and urban areas of Iran. As all dietary patterns identified were positively associated with obesity, further research in Iranian adults is required to identify the foods that characterize a healthful dietary pattern and are protective with respect to obesity. Moreover, analysis of are prospective cohorts that include relevant confounding factors is needed to be able to understand and compare the current results.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences and was exempted by the Deakin University Human Research Ethics Committee (reference number 2019-288). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

MA and AH designed and carried out the National Comprehensive Study on Household Food Consumption Pattern and Nutritional Status 2001–2003. SE, RL, SM, and KL designed the analysis. SE conducted the statistical analysis and drafted the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnut.2023.1091555/full#supplementary-material

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School-based intervention impacts availability of vegetables and beverages in participants' homes

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As rates of metabolic syndrome rise, children consume too few vegetables and too much added sugar. Because children tend to eat what is available at home, the home environment plays a key role in shaping dietary habits. This secondary analysis evaluated the effects of a school-based gardening, cooking, and nutrition education intervention (TX Sprouts) compared to control on the availability of vegetables, fruit juice, and sugar-sweetened beverages (SSBs) at home. In the TX Sprouts cluster-randomized trial, 16 schools were randomized to TX Sprouts (n =8 schools) or control (n =8 schools) for one academic year. All schools served predominately Hispanic families with low incomes. TX Sprouts built school gardens and taught 18 lessons to all 3rd-5th grade students at intervention schools. TX Sprouts also offered monthly caregiver lessons before and/or after school. Caregivers completed questionnaires pre and post, providing demographics and information about home availability of vegetables, fruit juice, and SSBs. Summary statistics were used to describe the sociodemographic characteristics of participants. Linear regression assessed the change in scores (pre to post) for the food/ beverage availability question. The model was adjusted for the caregiver's education, employment status, child's grade, and free or reduced-price lunch eligibility. The analytic sample included 895 participants. Compared to control, the intervention positively changed the home availability of targeted foods and beverages, largely by improving the availability of vegetables and vegetable juice. This study showed that a school gardening, nutrition, and cooking program delivered to elementary children may positively influence the home food environment.

KEYWORDS

school garden, home food environment, home food availability, school-based intervention, nutrition education, Hispanic (demographic), low-income children

Introduction

A healthy dietary pattern that includes vegetables and whole fruits and limits added sugar helps maintain health and reduces the risk of metabolic disorders like type 2 diabetes (1–3). Early childhood dietary habits can shape lifelong food preferences and eating behavior (4, 5). In addition, unhealthy eating patterns can lead to metabolic syndrome in childhood (2, 3),

increasing the risk of lifelong metabolic disorders (6–8). Yet in the United States, children's diets fail to meet the recommendations for a healthy dietary pattern, with too few fruits and vegetables and too much added sugar, often in the form of sugar-sweetened beverages (SSBs) (9, 10). As children enter adolescence, they tend to consume even fewer vegetables and more added sugar (11, 12), making early childhood a crucial period to establish healthy dietary habits (4, 5).

Children's dietary habits are affected by environmental characteristics in their homes and school; therefore, both environments are important intervention points to promote healthy eating habits. At home, children may be influenced by parental modeling (i.e., children choose foods they see caregivers eat) (13). A child's food choices may also be shaped by their level of nutrition security at home, i.e., whether foods that fit a healthy dietary pattern are regularly available, accessible, and affordable in their homes (14). Nutrition security requires access to and availability of foods and beverages that promote well-being, prevent disease, and align with cultural, social, or dietary preferences (14). Children typically eat what is available in their homes. For example, higher availability of vegetables in the home is associated with higher vegetable consumption in children, and higher availability of SSBs is associated with increased SSB intake (15–17). Although caregivers largely determine the foods and beverages available in the home, a child's preferences can also influence the foods and beverages their caregiver purchases and brings into the home (15, 16, 18).

School-based gardening interventions are a promising approach to addressing food preferences and promoting healthy dietary patterns in children. Prior studies demonstrate that garden-centered interventions can increase child knowledge and preference for vegetables through exposure, education, and experience growing, harvesting, and tasting vegetables (19, 20) and improve vegetable consumption (6, 21, 22). Many gardening interventions with children also provide classes and resources to caregivers of the participating children, which teach the skills and knowledge to prepare these foods (23). Given their multilayered influence, school-based garden interventions have the potential to improve the home food environment, yet few studies have reported on such findings (24–26).

One such study, Texas! Go! Eat! Grow! (TGEG), was a school-based garden intervention that measured the availability of vegetables, fruit juice, and SSBs in participants' homes. In the 5-month TGEG pilot, the program improved the availability of vegetables in the homes of third-grade students (24). However, when the TGEG intervention was tested in a cluster randomized controlled trial (cRCT) across 28 schools, TGEG did not measurably change the vegetable, fruit juice, and SSB availability in the participants' homes (25). This result may be explained by the inconsistent principal and teacher commitment to the program resulting in lower student participation in the cRCT than in the pilot (24, 25).

The TX Sprouts cRCT examined the effect of its school-based gardening, cooking, and nutrition education program on home food environment changes among all 3rd-5th grade children in participating elementary schools (27). TX Sprouts provided a culturally tailored curriculum in elementary schools across central Texas, serving predominantly low-income Hispanic children and their families, and received strong support from teachers and school administrators. TX Sprouts was developed and tested with Hispanic stakeholders, whose feedback was incorporated into the curriculum (28). The nutrition curriculum targets included increasing vegetable consumption, decreasing SSBs and fruit juice, and educating students and caregivers about preparing vegetables in ways aligned with cultural preferences. We previously found that TX Sprouts participants compared to control showed increased vegetable intake (6, 29) and decreased added sugar (6), which aligns with the intervention targets. Based on these nutrition targets and our previous findings, this study aims to determine whether the TX Sprouts intervention compared to control improved the availability of foods and beverages in the home.

Methods

Participants and recruitment

This study is a secondary analysis of data from the TX Sprouts program, a cluster-randomized school-based gardening, cooking, and nutrition education intervention. This study enrolled 3rd to 5th-grade children and their caregivers from 16 elementary schools in the greater Austin area. Methods and main outcomes for TX Sprouts are published elsewhere (27, 29–31). Briefly, schools were randomized to TX Sprouts intervention (n = 8 schools) or control (delayed intervention; n = 8 schools) using block randomization for one academic year. In each of the schools recruited, the majority of students were of Hispanic ethnicity (63.6%) and were eligible for the free- and reduced-price lunch (FRL) program (66.0%).

Children and caregivers at the recruited schools were contacted to participate during "Back to School" and "Meet the Teacher" events, via flyers sent home with children, and through teachers' in-class announcements. All caregiver participants provided written informed consent, and assent was obtained from each participating child. The study was conducted according to the guidelines in the Declaration of Helsinki, and all procedures involving human subjects were approved by the Institutional Review Board of the University of Texas at Austin and the individual school district review boards. The trial is registered at ClinicalTrials.gov (NCT02668744).

Description of TX Sprouts intervention

The TX Sprouts program was based on the social-ecological-transactional model, which suggests that child behavior and adaptation are shaped by bidirectional influences across levels of ecological systems (32, 33). This model treats the child as nested within micro-systems (e.g., school and family) that reciprocally interact with each other to shape development and behaviors (32, 33). The logic model for the TX Sprouts program proposed that by intervening at the child and school levels, the program could impact the family and home environment (29).

The intervention was implemented in three waves across three academic years from 2016 to 2019. In each wave, the intervention schools each received the same TX Sprouts intervention for one academic year, and the delayed intervention schools received the same intervention the following year. The TX Sprouts research team built a 0.25-acre outdoor teaching garden at each intervention school before the academic year of baseline measurements. At least 6 months before the intervention, Garden Leadership Committees (GLC) were formed and comprised key stakeholders, including teachers and school staff. The GLC frequently met during the planning year to prepare to implement the program

long-term. The program provided the schools with all supplies for maintaining the garden. Because the program was culturally tailored to Hispanic populations living in Texas, produce such as squash, peppers, and cilantro were planted and used in the TX Sprouts recipes.

Throughout the academic year, TX Sprouts nutrition and garden educators taught 18-one hour TX Sprouts lessons to each 3rd-5th grade class at the intervention school as part of the students' typical school day. TX Sprouts provided all material to teach each of these lessons. The 3rd-5th grade teachers attended the lessons, but did not deliver them. The TX Sprouts curriculum was adapted from LA Sprouts (28) and the Junior Master Gardener program developed by Texas A&M AgriLife Extension (34). The student curriculum was designed to be culturally tailored to Hispanic children in Texas, including culturally appropriate recipes, content, and activities.

TX Sprouts lessons aimed to improve a variety of diet-related psychosocial constructs, including increasing nutrition, gardening, and cooking knowledge, self-efficacy, and willingness to try and prefer fruits and vegetables. The curriculum included the following nutrition concepts: (a) cooking/preparing fruits and vegetables consistent with cultural preferences; (b) making nutritious food choices; (c) eating locally produced food; (d) choosing low-sugar beverages made with fresh fruits and vegetables, but not fruit juice, as alternatives to SSBs, like *agua frescas*; and (e) understanding health benefits of fruits and vegetables. Every lesson included either a garden taste test (7 lessons) or a cooking activity (11 lessons), and information and recipe cards were sent home to caregivers following the lessons. The control schools received a delayed intervention in the following academic year, which was identical to the TX Sprouts intervention described above.

During the trial, garden and nutrition educators also taught nine monthly, in-person, 60-min TX Sprouts lessons for caregivers at each school. At the beginning of the year, TX Sprouts educators met with caregivers and school administrators at each school to schedule these classes according to the caregiver preferences at each school. The dates and times varied widely, including mornings, after school, evenings, and weekends based on caregiver preferences. The caregiver lessons were delivered in person in English and Spanish.

The curriculum for the caregivers paralleled the nutrition and gardening topics and activities taught to the children and shared similar skills and knowledge with the caregivers as was previously taught in the student lessons. Each lesson included preparing culturally tailored recipes using fresh produce. These lessons also addressed family shopping, parent modeling, and positive parenting approaches. Incentives to attend the lessons included free meals, produce giveaways, groceries, and free childcare for children and siblings. In addition, children in the TX Sprouts program were invited to attend and encouraged to teach their caregivers how to cook meals with fresh produce, empowering the child to be the champion for healthy changes in the family.

Instruments and measures

At the beginning and end of the academic school year (pre and post), caregivers were asked to complete a self-administered questionnaire packet, which took 20–30 min to complete. Questionnaires were provided in both English and Spanish and bilingual research assistants were available to assist caregivers in completing them. Caregivers were given a $15 gift card to a local grocery store for completing each questionnaire. The questionnaires asked about the caregiver's and child's demographics, eligibility for FRL, caregiver-child grocery shopping behavior, and the availability of vegetables, fruit juice, and SSBs in the home, using the same scale administered in the TGEG trials (24). The questions addressing co-shopping behavior asked whether (yes or no) caregivers did the following activities with their child the previous week: "took your child to the store to get vegetables" or "chose vegetables to buy at the grocery store together."

The survey concerning home food/beverage availability included seven items that were specifically targeted in the TX Sprouts curriculum: (a) 100% fruit juice; (b) vegetable juice; (c) fresh vegetables; (d) canned, frozen, or dried vegetables; (e) salad; (f) cut up fresh vegetables in a place that is easy for kids to reach; and (g) soft drinks or sugar-sweetened beverages (15). Caregivers were asked to indicate the frequency that each item was available in their home the previous week on a 4-point Likert-type scale: never, some of the time, most of the time, or all of the time. The survey items aligned with the TX Sprouts curriculum, which emphasized eating more vegetables and reducing high-sugar beverage consumption. This same survey about home food/beverage availability has been used in other pediatric populations, reporting a Cronbach's alpha of 0.7, indicating satisfactory internal consistency (15, 35, 36). A previously published cross-sectional analysis from the TX Sprouts study also incorporated these questions (37). Another Texas-based school garden intervention previously used this survey, which allows clearer comparison of the results.

The responses for each item were converted to numeric values where "never" = 0 and "all of the time" = 3, except for two categories—(1) 100% fruit juice and (2) soft drinks or SSBs—which were coded such that "all of the time" = 0 and "never" = 3. Consistent with the TX Sprouts curriculum, these beverages were reverse-coded due to their deleterious effect on health outcomes when consumed in high amounts (38–42). Scores for each item were summed to yield a composite score for pre and post. A higher composite score indicated a greater availability of vegetables and lower availability of fruit juice and SSBs in the home. The availability scores ranged from 0 to 3 for each item and 0 to 19 for the composite score. A change variable was created representing the difference between pre and post in the composite score and for each of the seven items in the survey.

Data analysis

Summary statistics were used to describe the sociodemographic characteristics of participants in the intervention and control groups of the analytical sample, using information from the caregivers' pre-intervention questionnaires. Texas Education Agency data was used to compare the demographics of the eligible students to those in the analytical samples. Chi-square tests and *t*-tests were used to determine differences in demographics between participants in the analytic sample and those excluded due to incomplete survey data. Chi-square tests and t-tests were also used to determine demographic differences between intervention and control. Participant characteristics that significantly differed between intervention and control groups were identified as covariates. Inter-factor correlations were calculated to ensure independence of covariates from each other. Descriptive statistics and *t*-tests were used to analyze the questions regarding caregiver-child co-shopping and evaluate differences pre and post and between intervention and control.

Because this was a cRCT, the necessity of a multilevel model was assessed. A random intercept model in which the intercept varied across schools was fitted and compared to the fixed intercept model. Residual variance at the school level was evaluated, and intraclass correlation coefficients (ICCs) were calculated for the composite score and the score for each of the seven survey items. The intercepts did not vary significantly across the schools, and calculated ICCs further suggested that a multilevel model was not warranted (Supplementary Table 1) (43).

Linear regression was used to assess the change from pre to post in the composite score between intervention and control. The change in each item of the food and beverage availability question was also analyzed with linear regression. The models were adjusted for covariates: caregiver's education, employment status, child's grade, and FRL eligibility. Results were considered significant when $p < 0.05$. All analyses were performed using R (version 4.2.0) and R Studio (version 2021.09.0 + 351) software.

Results

Fidelity of TX Sprouts intervention

Fidelity to the intervention has previously been described (27, 29). In brief, 100% of the classes were taught to each 3rd-5th grade classroom, less than 1% of the 18 lessons were modified across the eight intervention schools due to school-related interruptions, and 34% of classes were taught indoors due to inclement weather. Caregiver classes were poorly attended; some had to be canceled because no caregivers attended. As a result, only 88.9% of the caregiver classes were taught. Only 7.1% ($n = 106$) of caregivers attended one or more classes, and less than 1% ($n = 11$) attended 50% or more of the nine classes.

Study sample

Of the 4,353 eligible children at the 16 schools, 3,302 students consented to participate in TX Sprouts. Pre-intervention questionnaire packets were completed by 2,882 caregivers, and 1,153 caregivers completed the packet post-intervention. Given that the 13-page parent questionnaire packet included close to 200 questions and the home availability items included in this analysis were in the middle of the packet, there were many incomplete survey items at both pre- and post-intervention. A complete case analysis, in which inclusion required completion of the 7-item home availability by caregivers at pre- and post-intervention, resulted in an analytical sample of 895 participants ($n = 414$ in intervention; $n = 481$ in control) (Figure 1).

The sociodemographic characteristics of all children eligible to participate ($n = 4,353$), those enrolled in the clinical study

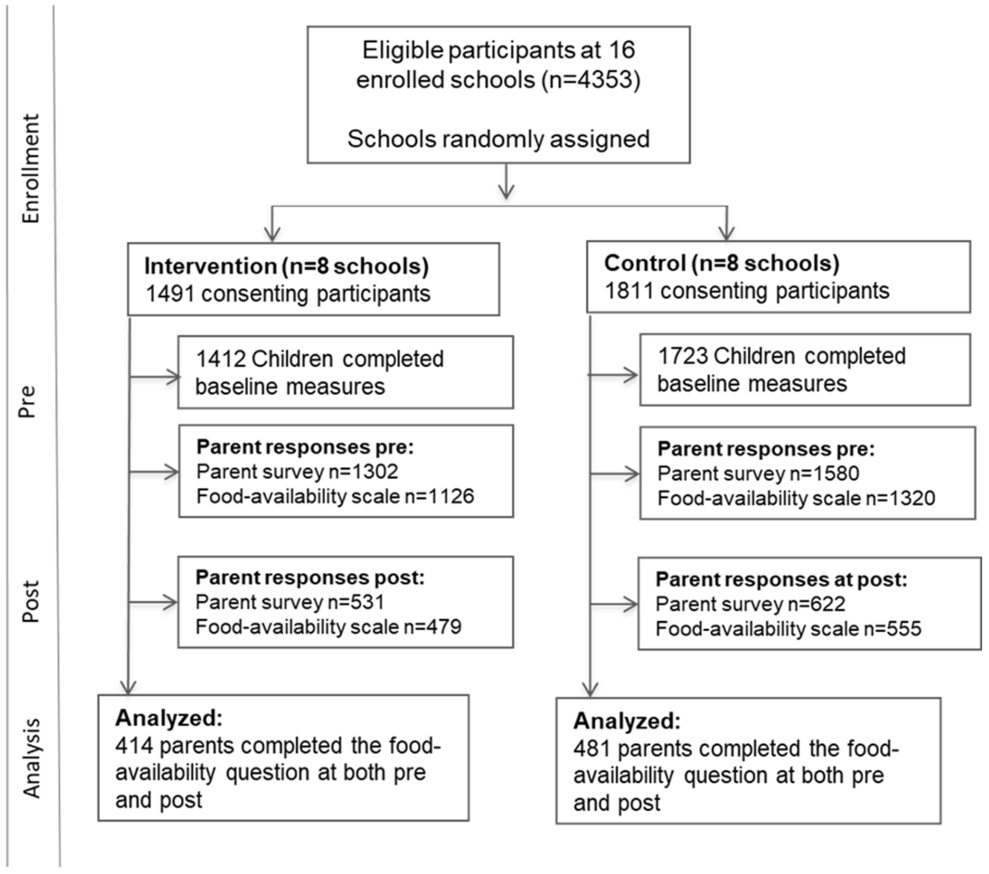

FIGURE 1
TX Sprouts CONSORT diagram.

($n = 3,135$), those enrolled in the study with incomplete survey data ($n = 2,240$), and the children in the analytic sample ($n = 895$) are presented in Table 1. There were significantly more children who were female (58%), identified as being Hispanic (62.8%) or Non-Hispanic White (20.2%), and eligible for FRL (66.0%) included in the study than those with incomplete survey data ($p < 0.001$ for all). There was a significant between-group difference in the children's grade levels between intervention and control, with a higher percentage of older students in the intervention schools because only 4th and 5th grade students were enrolled in some larger schools due to budgetary contraints (Table 1).

Caregivers were predominantly female (92.3%), and over half worked at least full-time outside the home (54.0%). Caregivers who completed the survey had higher rates of part-time or full-time jobs, had a higher education level, and were comprised of more females compared to those caregivers with incomplete survey data ($p < 0.001$). There were no significant differences between the caregivers' age or number of children at home in the analytical sample compared to those with incomplete survey data.

Table 1 also compares the sociodemographic characteristics of the caregivers in intervention and control groups. In this study, the intervention had a higher percentage of caregivers working least full-time outside the home than the control (56.8% vs. 51.6%, $p = 0.004$). In addition, the intervention had a lower rate of caregivers with college degrees (22.0% vs. 25.4%) but also a lower percentage of caregivers without at least a high school diploma or GED than the control (27.1% vs. 34.1%) ($p = 0.024$).

At pre-intervention, 70% of caregivers reported that in the previous week they had taken their child to the store to buy vegetables, and 66% of caregivers had chosen vegetables to buy with their child. At post-intervention, the percentage of caregivers reporting that they had co-shopped for vegetables with their child in the past week was similar to pre with 69.9% of caregivers reporting co-shopping with their children. There was no significant difference between intervention and control in either co-shopping question pre or post.

Home food/beverage availability

The pre- and post-intervention means with standard deviations are shown in Table 2. The change in the composite score ranged from −11 to 15. The intervention increased home availability of the measured foods/beverages consistent with a healthy dietary pattern compared to control ($\beta = 0.528$, 95% CI: 0.115, 0.941), as shown in Table 2 and further illustrated in Figure 2. After adjusting for education level and employment status of the caregiver, child's grade, and eligibility for FRL, the change in the composite score in the intervention remained significant compared to control ($\beta = 0.428$, 95% CI: 0.009, 0.847).

In similar analyses considering each component item, the intervention significantly increased vegetable juice and fresh vegetable availability compared to control ($\beta = 0.269$, 95% CI: 0.123, 0.415; $\beta = 0.126$, 95% CI: 0.006, 0.247, respectively). However, after adjustment, the change in vegetable juice availability was the only individual item that significantly improved compared to control ($\beta = 0.246$, 95% CI: 0.098, 0.394).

Discussion

This study found that the TX Sprouts school-based gardening, nutrition, and education intervention improved home availability of foods/beverages consistent with a healthy dietary pattern compared to the control group. Specifically, compared to control, the intervention improved the availability of vegetable juice, and there was a trend toward more fresh vegetable availability at home.

As children age, they tend to prefer and consume more sugar-sweetened beverages and fewer vegetables (11, 12). These changes in preferences can influence their household food environment. Though much literature focuses on the role of caregivers in shaping the home food environment, this is not a unidirectional relationship (16, 18). Prior research confirms that children who co-shop with their parents influence their caregivers' buying behavior at grocery stores (44, 45). This is particularly true with Hispanic children, who co-shop more frequently with their parents than the general U.S. population (44). Similarly, marketing research has found that Hispanic families make more grocery trips per week, and their shopping behavior is more likely to be influenced by their children compared to the general U.S. population (16, 44, 46). In the present study, over two-thirds of all caregivers reported co-shopping with their children within the previous week. The high frequency of caregiver-child co-shopping provides more opportunities for children to influence the food purchased and, therefore, their home food environment (44).

The TX Sprouts program was designed to leverage this interconnectedness between children and the micro-systems to which they belong, such as schools and families using the socio-ecological model (33). The model acknowledges a dynamic, reciprocal influence among children and their micro-systems that influence behavior change (33, 47). Through exposing children to gardening, cooking, and hands-on nutrition education, TX Sprouts compared to control children had increased vegetable intake and decreased SSB consumption, as previously reported (6, 29). This may be explained, in part, by the changes in the child's home food environment. Similarly, by recognizing the child's influence on the home food environment, the intervention may have protected against greater adverse changes to the home food environment, such as larger increases in fruit juice availability.

These results may also be attributable to the high fidelity of the TX Sprouts intervention in the participating schools. In one of the few studies reporting the impact of a school-based garden program on the home availability of foods and beverages, the TGEG cRCT trial found no significant changes in the home food and beverage environment using the same survey as TX Sprouts (24, 25). The authors attributed this to low caregiver participation in the home component of the intervention (25). Like TGEG, TX Sprouts had limited caregiver involvement, with less than 7% of participating caregivers attending a single class (29). Though the caregiver involvement was low, the fidelity of the TX Sprouts intervention was high (27, 29). This contrasts with the TGEG cRCT, where student participation varied widely among schools, with only a mean participation rate of 55.7% (25). The high fidelity of the TX Sprouts intervention may explain the program's success despite the lack of caregiver involvement.

These findings may be further explained by the culturally-tailored recipes and handouts sent home to the intervention households following the student lessons. All schools served predominantly

TABLE 1 Sociodemographic characteristics of children eligible for TX Sprouts; sociodemographic characteristics of total participating children and caregivers, analytical sample, intervention, and control.

	Eligible participants[a] (*n* = 4,353)		Enrolled participants (*n* = 3,135)		Participants with incomplete data (*n* = 2,240)		Total analytical sample (*n* = 895)		*p*-value[b]	Intervention (*n* = 414)		Control (*n* = 481)		*p*-value[c]
	No	%	No	%	No	% or ±SD	No	% or ±SD		No	% or SD	No	% or ± SD	
Intervention	1,830	42%	1,412	45.0%	998	44.6%	414	46.3%	0.409	414	100%			
Children's characteristics														
Sex									<0.001					0.541
Male	2,237	51%	1,485	47.4%	1,111	49.6%	374	41.8%		196	40.7%	178	43.0%	
Female	2,116	49%	1,650	52.6%	1,129	50.4%	521	58.2%		285	59.3%	236	57.0%	
Grade									0.712					0.018*
3rd	1,239	28%	923	29.4%	650	29.0%	273	30.5%		108	56.1%	165	34.3%	
4th	1,554	36%	1,128	36.0%	811	36.2%	317	35.4%		150	36.2%	167	34.7%	
5th	1,560	36%	1,084	34.6%	779	34.8%	305	34.1%		156	37.7%	149	31.0%	
Race or ethnicity[d]									<0.001					0.707
Black or African American	302	7%	264	8.4%	191	8.53%	73	8.16%		36	8.7%	37	7.7%	
Hispanic	2,177	50%	1,869	59.6%	1,307	58.3%	562	62.8%		255	61.6%	307	63.8%	
White (not Hispanic)	498	11%	562	17.9%	381	17.0%	181	20.2%		89	21.5%	92	19.1%	
Eligible for FRL[e]	3,371	77%	1,903	60.7%	1,312	58.6%	591	66.0%	<0.001	276	66.7%	31	65.5%	0.235
Caregivers' characteristics														
Age			36.89	±6.85	36.8	±6.89	37.1	±6.76	0.181	37.2	±6.55	37.1	±6.95	0.942
Female			2,457	78.4%	1,631	72.8%	826	92.3%	<0.001	389	94.0%	437	90.9%	0.328
Highest level of education									<0.001					0.024*
College degree or higher			552	17.6%	339	15.1%	213	22.8%		91	22.0%	122	25.4%	
Some college			642	20.5%	441	19.7%	201	22.5%		99	23.9%	102	21.2%	
High school diploma or GED			551	17.6%	369	16.5%	182	20.3%		100	24.2%	82	17.0%	
No high school diploma or GED			1,026	32.7%	750	33.5%	276	30.8%		112	27.1%	164	34.1%	
Employment status									<0.001					0.004*
Full-time or more			1,584	50.5%	1,101	49.2%	483	54.0%		235	56.8%	248	51.6%	
Part-time			322	10.3%	213	9.5%	109	12.2%		62	15.0%	47	9.77%	
Retired/not working outside home			814	26%	541	24.2%	273	30.5%		105	25.4%	168	34.9%	
Number of children at home			2.75	±1.21	2.76	±1.22	2.72	±1.18	0.476	2.78	±1.21	2.74	±1.24	0.495

[a]Data gathered from the Texas Education Agency (TEA).

[b]*P*-value for the difference between eligible participants with incomplete survey data and the analytic sample from chi-square tests or independent *t*-tests.

[c]*P*-value for the difference between intervention and control from chi-square tests or independent *t*-tests.

[d]Only three most prominent race and ethnicities were included in this sample to provide a comparison to school-wide data from TEA.

[e]Free- or reduced-price lunches.

*Indicates a statistically significant value of $p < 0.05$.

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TABLE 2 Means and standard deviations of responses to home food/beverage availability question, change in score pre and post, and effect of TX Sprouts on that change using linear regression.

Variable	Intervention (n = 414)			Control (n = 481)				
	Pre Mean ± SD	Post Mean ± SD	Change Mean ± SD	Pre Mean ± SD	Post Mean ± SD	Change Mean ± SD	Change analysis p-value	Adjusted[1] p-value
Composite score[2]	11.7 (3.19)	12.0 (3.02)	0.29 (3.07)	12.0 (3.38)	11.8 (3.33)	−0.24 (3.19)	0.012*	0.046*
Individual items								
Fruit juice	1.20 (1.06)	1.36 (1.00)	0.15 (1.05)	1.09 (1.04)	1.33 (1.07)	0.23 (1.04)	0.250	0.434
Vegetable juice	0.80 (0.95)	0.84 (1.00)	0.04 (1.01)	1.01 (1.10)	0.77 (0.98)	−0.23 (1.19)	<0.001*	0.001*
Fresh vegetables	2.27 (0.85)	2.29 (0.84)	0.03 (0.94)	2.36 (0.84)	2.26 (0.87)	−0.10 (0.89)	0.039*	0.122
Canned, frozen, or dried vegetables	2.00 (1.03)	1.98 (1.00)	−0.02 (1.10)	1.95 (1.08)	1.88 (1.08)	−0.07 (1.06)	0.460	0.582
Salad	1.95 (0.97)	1.92 (0.91)	−0.03 (0.98)	2.02 (0.96)	1.94 (0.93)	−0.08 (0.95)	0.442	0.804
Cut up vegetables easy for kids to reach	1.84 (1.07)	1.77 (1.01)	−0.07 (1.16)	1.96 (1.01)	1.81 (1.05)	−0.15 (1.12)	0.295	0.617
Soft drinks or SSBs	1.65 (0.96)	1.84 (0.78)	0.19 (0.91)	1.61 (0.96)	1.77 (0.89)	0.16 (1.00)	0.636	0.480

Adjusted R^2 for adjusted model = 0.016.

*Indicates a statistically significant value of $p < 0.05$.

[1]Adjusted for caregiver's education, caregiver's employment status, child's grade, and child's eligibility for free- or reduced-priced lunches.

[2]The Composite Score reflects the sum of participant responses to the 7-item food/beverage availability Likert-type question. Consistent with the TX Sprouts curriculum, fruit juice and soft-drinks or SSBs (sugar-sweetened beverages) were coded such that "never" = 3 and "all of the time" = 0; all other items were coded with "never" = 0.

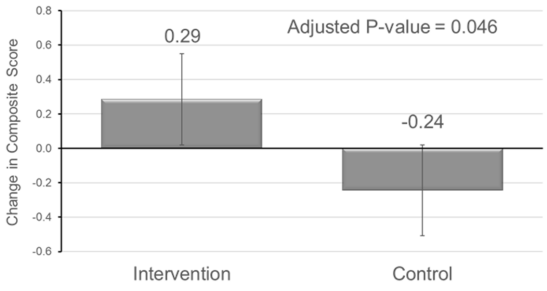

FIGURE 2
Boxplot showing results of linear regression model examining the effect of TX Sprouts on home availability of vegetables and beverages.

Hispanic families, and TX Sprouts gardens grew culturally-specific produce. In each lesson, students tasted culturally-familiar fresh produce and/or prepared culturally-tailored recipes and were given accompanying handouts and recipes to take home. Past research shows that incorporating culturally familiar foods and recipes can promote acceptance of dietary changes (48, 49). Thus, the resulting improvements in the home environment may have been driven by incorporating culturally tailored TX Sprouts recipes sent home to the caregivers.

The current study has some limitations that must be considered. First, the analytical sample in this complete case analysis (n = 895) represents less than one-third of the caregiver participants enrolled in the study, which means data was unavailable for many participants, reducing power and introducing potential bias. There were no significant differences between the caregivers' age, race/ethnicity, or the number of children or adults in the home in the analytical sample compared to those with incomplete survey data, which mitigates some concerns raised by the attrition rate. However, children in the analytical sample were more likely to be female, Hispanic, and FRL eligible. In addition, the caregivers in the analytical sample had higher education and were more likely to work outside the home compared to those with incomplete survey data. These findings suggest that the analytic sample may have had higher risk factors than eligible participants without complete data. Thus, these variables were included in the adjusted model, minimizing the potential bias due to these differences.

Another weakness of this study is that the food and beverage question was limited to only seven items and did not capture all foods and beverages available in participants' homes. With over 200 questions in the survey packet, a more detailed examination of all foods available in the home was not possible. It was also not feasible to directly observe foods available in the homes of hundreds of students. Instead, the self-report survey focused on items covered in the curricula and mirrored that used in a similar Texas-based garden intervention, TGEG.

This study was also limited in its duration to one academic school year, and the long-term effects of the intervention on the home food environment were not measured. The improvement in the intervention compared to control was significant but small in this 9-month intervention. A multiple school-year intervention could amplify the at-home impact, particularly if caregivers were more involved. Given the acceptance of remote learning since 2020, online lessons could be a potential avenue to boost caregiver involvement in a longer-term study.

Another limitation was that the sample was predominantly low-income and Hispanic families in Central Texas, so the results may not be generalizable to other populations. However, the study was intentionally designed to target Hispanic children, who are at high risk of metabolic syndrome and similar chronic diseases. As a result, this

study sheds light on a potential avenue to improve the home food environment in this population.

In sum, compared to control, the TX Sprouts intervention demonstrated modest improvements in the availability of healthy foods and beverages in the home compared to control over the course of one school year, independent of direct caregiver participation in the program. These findings indicate that children can be agents for positive family nutrition changes. These results further suggest that a school-based program taught only to elementary children may protect nutrition security in families and homes by impacting the availability of foods and beverages that promote well-being, prevent disease, and align with cultural and dietary preferences. Future interventions may build on these findings and incorporate strategies to further empower children to influence the availability of healthier food options in their homes in longer-term education programs, particularly when serving predominantly Hispanic children and their families.

Data availability statement

The data contains sensitive information concerning minors. De-identified data will be available by request to JD (Jaimie.davis@austin.utexas.edu), and a data sharing agreement will need to be completed. Protocols, analytics, and study material are also available upon request.

Ethics statement

The studies involving humans were approved by Institutional Review Board at the University of Texas at Austin. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

EH: Conceptualization, Formal analysis, Methodology, Writing – original draft. MB: Conceptualization, Methodology, Supervision, Writing – review & editing. SI: Conceptualization, Formal analysis, Methodology, Writing – review & editing. MJ: Data curation, Investigation, Writing – review & editing. SV: Data curation, Investigation, Writing – review & editing. ML: Data curation, Investigation, Project administration, Writing – review & editing. RS-F: Conceptualization, Writing – review & editing. JC: Writing – review & editing. JD: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnut.2023.1278125/full#supplementary-material

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Exploring disparities in malnutrition among under-five children in Nigeria and potential solutions: a scoping review

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Introduction: Triple burden of malnutrition in children remains a significant public health issue. This scoping review aims to assess the information on undernutrition, micronutrient deficiencies and the quality of complementary feeding in various regions in Nigeria.

Methods: A literature search was conducted using PubMed and Google Scholar databases from January 1, 2018 to January 31, 2023 to include studies focusing on 0 to 5 years old children in Nigeria, reporting data on nutritional status, nutrient deficiencies, and published in English.

Results: 73 out of 1,545 articles were included. Stunting remained alarmingly high ranging from 7.2% (Osun, South West) to 61% (Kaduna, North Central), while wasting varied from 1% (Ibadan, South West) to 29% (FCT Abuja, Central) and underweight from 5.9% (Osun, South West) to 42.6% (Kano, North West) respectively. The overall prevalence of anemia and vitamin A deficiency ranged between 55.2 to 75.1 % and 5.3 to 67.6%, respectively. Low rates of achieving minimum dietary diversity and minimum meal frequency were reported across different states depicting the suboptimal quality of complementary feeding. The prevalence of overweight/obesity ranged from 1.5% (Rivers, South South) to 25.9% (Benue, North Central).

Conclusion: Multiple early childhood malnutrition issues exist with a wide disparity across states in Nigeria, particularly in the Northern region. Targeted nutrition interventions must be implemented to improve the situation.

KEYWORDS

children below 5 years, Nigeria, poor quality of complementary feedings, multiple undernutrition issues, targeted interventions

Introduction

Malnutrition is defined as a "*pathological state resulting from inadequate or excess nutrition*" (1). According to the World Health Organization (WHO), 'poor nutrition status' is the sole important threat to the world's health, with adequate nutrition being the critical element in helping individuals to live healthy and productive lives. Malnutrition impacts the intergenerational economic growth of a country. Morbidity related to malnutrition leads to a loss in human capital through an education gap and a resultant low-skilled workforce owing to poor cognitive development and reduced school attainment (2). Inadequate food intake and poor dietary quality are directly or indirectly responsible for causing poor health, with the top 6 of the 11 global risk factors associated with dietary imbalances (3).

Malnutrition is expressed through undernutrition (stunting, wasting, and underweight) and/or overnutrition, which is related to a high intake of protein and energy (1). The WHO in 2021 has defined complementary feeding indicators, including minimum dietary diversity (MDD), minimum meal frequency (MMF), and minimum acceptable diet (MAD) (4), as essential in the early years of life to the formation of eating habits that may eventually have short- and long-term implications on the child's health (5). Severe acute malnutrition (SAM) or protein energy malnutrition (PEM) is a life-threatening condition requiring urgent attention. Over the years, it has been known by different names such as protein-calorie malnutrition, PEM, oedematous malnutrition, nutritional oedema, severe wasting, or based on clinical manifestations including marasmus, kwashiorkor, or marasmic kwashiorkor (6).

Globally there are over 150 million stunted children, 50 million wasted children, and 38 million underweight children (6). In addition, over 40 million children under the age of 5 years are overweight (6). While more countries are dealing with several forms of malnutrition indices, individual children are known to suffer from more than one form of malnutrition indicators across the world (7).

Nigeria is one of the top 10 countries with malnutrition in children aged under 5 years (7). It has the second-highest burden of stunted children in the world and a higher-than-the-world average child-wasting prevalence (8). Within Nigeria, nearly half of all under-5 children were stunted in the North East and North West geopolitical zones, while the rest of Nigeria contributed to 22.0 % of under-5 stunting prevalence (9).

Despite the availability of studies on stunting, there is a paucity of information on other nutritional issues across all the regions of Nigeria. Hence, the objective of this study was to review the current evidence on nutritional status, nutrient intake, and quality of complementary feeding in under-5 children across all the geopolitical zones and states of Nigeria.

Methodology

Search strategy

Literature searches were carried out using the PubMed and Google Scholar databases. The main search terms used in the literature search were malnutrition, nutritional deficiency, Nigeria, stunting, wasting, or underweight. The details of the search are provided in Table 1. The results are reported according to the PRISMA guidelines for scoping reviews (Figure 1).

Screening of articles and selection of studies

For all the articles, the search results were extracted and imported into reference management software (Mendeley). All duplicates were removed, and a researcher screened the results based on manuscript's title and abstract based on the following criteria:

Inclusion criteria

- Studies including infants and children from 0 to 60 months of age of either gender living in Nigeria.
- Studies reporting data on nutritional status and nutrient deficiencies through dietary intake and measurement studies.
- Baseline data from intervention studies.
- Specific case reports if relevant.
- Review articles
- Articles published from 01-01-2018 to 31-01-2023 to focus on recent available data.
- Articles published in peer-reviewed journals in the English language.

TABLE 1 Summary of search strategy and results.

Search engine	Search key string	Number of results returned	Articles screened
Google Scholar	Nigeria* AND (child* OR toddler OR infant) AND (inadequate OR problem OR intake OR condition OR situation OR status) AND nutrition* AND ("under-five" OR "pre-school")	5,370	470
	Nigeria* AND (child* OR toddler OR infant) AND (inadequate OR problem OR intake OR condition OR situation OR status) AND nutrition* AND ("under-five" OR "pre-school") -"		299
	Nigeria* AND (child* OR toddler OR infant OR nursery OR baby) AND (inadequate OR condition OR status OR deficien* OR insufficient OR maln* OR undern* OR wast* OR stunt*) AND nutritional* AND ("pre-school" OR "under-five") -primary		343
PubMed	((Nigeria*[Title/Abstract]) AND (child*)) AND (nutrition)		235
	Nigeria* AND (child* OR toddler OR infant) AND (malnutrition OR nutritional deficiency) AND nutrition* AND ("under-five" OR "pre-school")		198

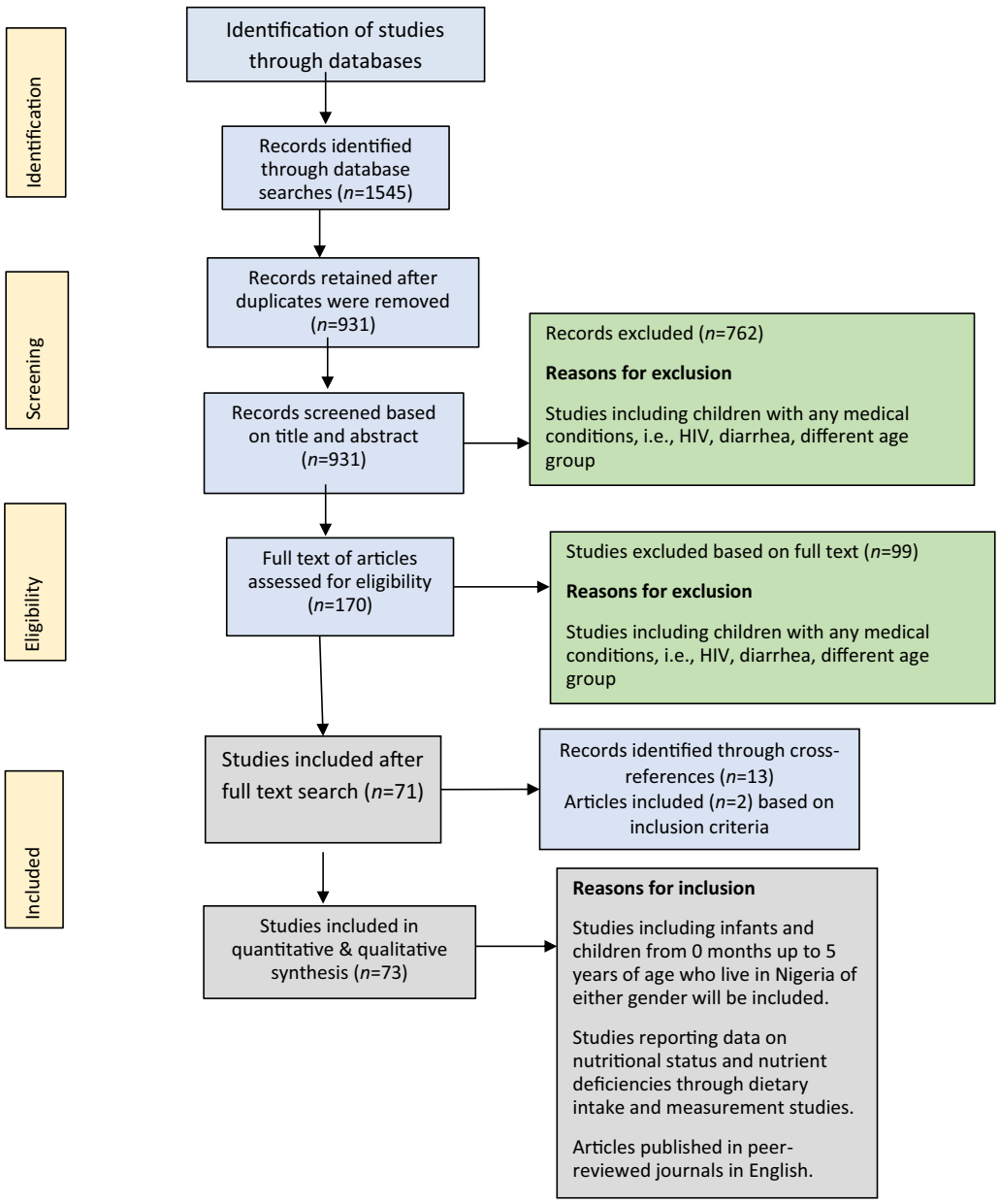

FIGURE 1
PRISMA flow diagram of study search and selection process.

Exclusion criteria

- Studies including children with any medical conditions, such as sickle-cell anemia, human immunodeficiency virus (HIV), and diarrhea.
- Grey literature such as reports.
- Single case reports on a specific disease.

Two authors (CJ and LM) reviewed the retrieved full-text articles for final inclusion in the study. If there were any disagreements in the selection of the articles, a third author (PBK or MYJ) acted as a referee to decide whether the article under consideration should be excluded or included. LM extracted date from the eligible retrieved articles to provide extraction of information. No assessment on data quality was implemented.

Data extraction

Data for the following outcomes of interest were extracted from relevant research articles: participant characteristics (age, sex, geographical location, socioeconomic status, weight, and height); nutritional status (stunting, wasting, underweight,) acute malnutrition, overweight, and obesity; nutrient deficiencies biochemical analysis (including iron deficiency anemia, vitamin A, and zinc deficiency); from dietary intake studies including energy; macronutrients (protein, total fat, total calorie); and micronutrients (iron, zinc, vitamin A, calcium, magnesium, phosphorus, vitamin D, B-vitamins, vitamin C, zinc, folate).

Results were pooled by region to facilitate regional comparison. Available data describing the estimation of malnutrition, nutrient status, and dietary quality, including differences by age, gender, and

setting (urban vs. rural), are also discussed in the narrative findings for each outcome. The data in the review is incorporated as a range from the lowest to the highest percentage values or as per geopolitical zones in Nigeria, namely North Central, North East, North West, Central, South East, South South, South West or the year of study or publication.

Definitions of important terms

In this study, WHO definitions for various malnutrition status were used. Stunting in a child is defined with a height-for-age Z-score (HAZ) of below minus two standard deviations (−2SD) from the median; wasting as a weight-for-age Z-score of below minus two standard deviations (−2SD) from the median. An underweight is weight-for-height Z-score is less than minus two standard deviations (−2SD) from the median and could be a composite extraction of both stunting and wasting child's status; a child with severe stunting has HAZ < −3SD and moderately stunting as −3SD ≤ HAZ ≤ −2SD. The same classification also holds for other anthropometric indicators of undernutrition (1). The WHO in 2021 has defined complementary feeding indicators, including MDD (percentage of children 6–23 months of age who consumed foods and beverages from at least 5 out of 8 defined food groups during the previous day), MMF (percentage of children 6–23 months of age who consumed solid, semi-solid or soft foods the minimum number of times or more during the previous day), and MAD (percentage of children 6–23 months of age who consumed at least MDD and MMF during the previous day) (4). Inadequate energy intake used in the study is defined as energy intake less than 80% of recommended daily intake (570–1742 kcal). Similarly, inadequate intake of other micronutrients is also defined as less than 80% of recommended daily nutrient intake (10). Severe and moderate anaemia is defined as <7 g/dl and 7.0–9.9 g/dl, respectively (11).

Results

Seventy-three articles were included in the study based on the inclusion–exclusion criteria. Along with the national prevalence, data was also available from 20 states covering all six geopolitical zones of Nigeria. Amongst the included articles, a majority of studies (84.9%) reported data for the prevalence of undernutrition status (stunting, wasting, and underweight), overweight, and obesity. Articles reporting stunting prevalence (61.6%) were the highest in number, while that reporting wasting (53.4%) and underweight (46.6%) prevalence was relatively less. Only six articles provided information on SAM/PEM (8.2%). Approximately 28.8% of articles reported nutrient intake data, 47.6% reported anemia prevalence, 33.3% reported vitamin A deficiency prevalence, 19.0% reported zinc deficiency, 14.3% reported iron and vitamin D deficiency, while only 1 article each was identified reporting the prevalence of vitamin B12, vitamin C, and potassium deficiency.

On average, only 15% of the articles mentioned the year the study was conducted. Some of the selected articles with year of publication after January 1, 2018, did however cite data from earlier date including those from 2003.

Severe acute malnutrition/protein-energy malnutrition

The average national prevalence of SAM/PEM in Nigeria was 8.8% (12, 13); however, the prevalence data reported a wide region-wise variance in prevalence, ranging from 1.9 to 46.0% (14–17) (Supplementary Table 1A). The highest SAM/PEM prevalence was reported from the South West and North West geopolitical zone of Nigeria (15, 16). In the Osun state (South West), the prevalence of Marasmus, Kwashiorkor, and Marasmus-Kwashiorkor were as low as 2.0, 3.0, and 2.0%, respectively (15).

Overall prevalence of undernutrition (stunting, wasting, and underweight)

From several retrieved literature, the national prevalence of undernutrition has been reported to decline from 2003 to 2013 and 2018 (45% vs. 37% vs. 36.8 % for stunting, 13% vs. 8% vs. 6.7% for wasting, and 27.2% vs. 28.9 % vs. 21.4% for underweight) (18–20). The regional prevalence of stunting, wasting, and underweight reported a difference from the national prevalence in Nigeria, as seen in the geopolitical zone mapping of Nigeria (Figure 2).

As per National Demographic Health Survey (NDHS) 2018, the national stunting prevalence among under-5 children in Nigeria was reported to be 36.1 % (21). The prevalence by zone reported stunting to be the highest in Kaduna in North West (61.3%) (22) and Kwara in the North Central zone (55.8%; Supplementary Table 2) (23). The lowest prevalence of stunting was reported from Osun state in the South West region (7.2%) (24). The severity of stunting varied among states from 3.4% in Rivers (South West) (25) to 54.5% in Kaduna (North West) (26). The prevalence of moderate stunting ranged from 8.2% in Anambra (South East) (27) to 28.8% in Kaduna (North West) (26) (Supplementary Table 2). From 2003 to 2018, the national prevalence of severe stunting reduced from 22.8 to 16.9% (28).

Several states in Nigeria reported a high prevalence of wasting, which was above the national prevalence in Nigeria, including Anambra (South East; 30%) (29), FCT, Abuja (North Central; 29.3%) (30), Bida, Niger (North Central; 27.8%) (31), Ondo (South West; 25.3%) (32), Enugu (South East; 25.0%) (33), Osun (South West; 24.0%) (34), and Kano (North West; 22.8%) (35). The lowest prevalence of wasting (1.0%) was seen in Ifedore, Ondo state (South West) (36). However, none of these studies cited the year of data collection.

The underweight prevalence in Nigerian states ranged from 5.9% in the Osun state (South West) (34) to 42.6% in the North West zone of Nigeria (37). Several states reported underweight prevalence above the national prevalence, with the highest prevalence in North West including Kano State (around 41.9%-42.6%) (35, 37), followed by Enugu state (South East; 39.8%) (24).

There are more than 10 reported risk factors for undernutrition, among others: malaria and anemia (38), having more than four children and religious belief (39), having a respiratory or diarrheal infection (28, 40). However, immunization status, maternal education, parental income, maternal height and body mass index (BMI); as well as having antenatal care less than four times are among commonly reported risk factors (28, 39–43).

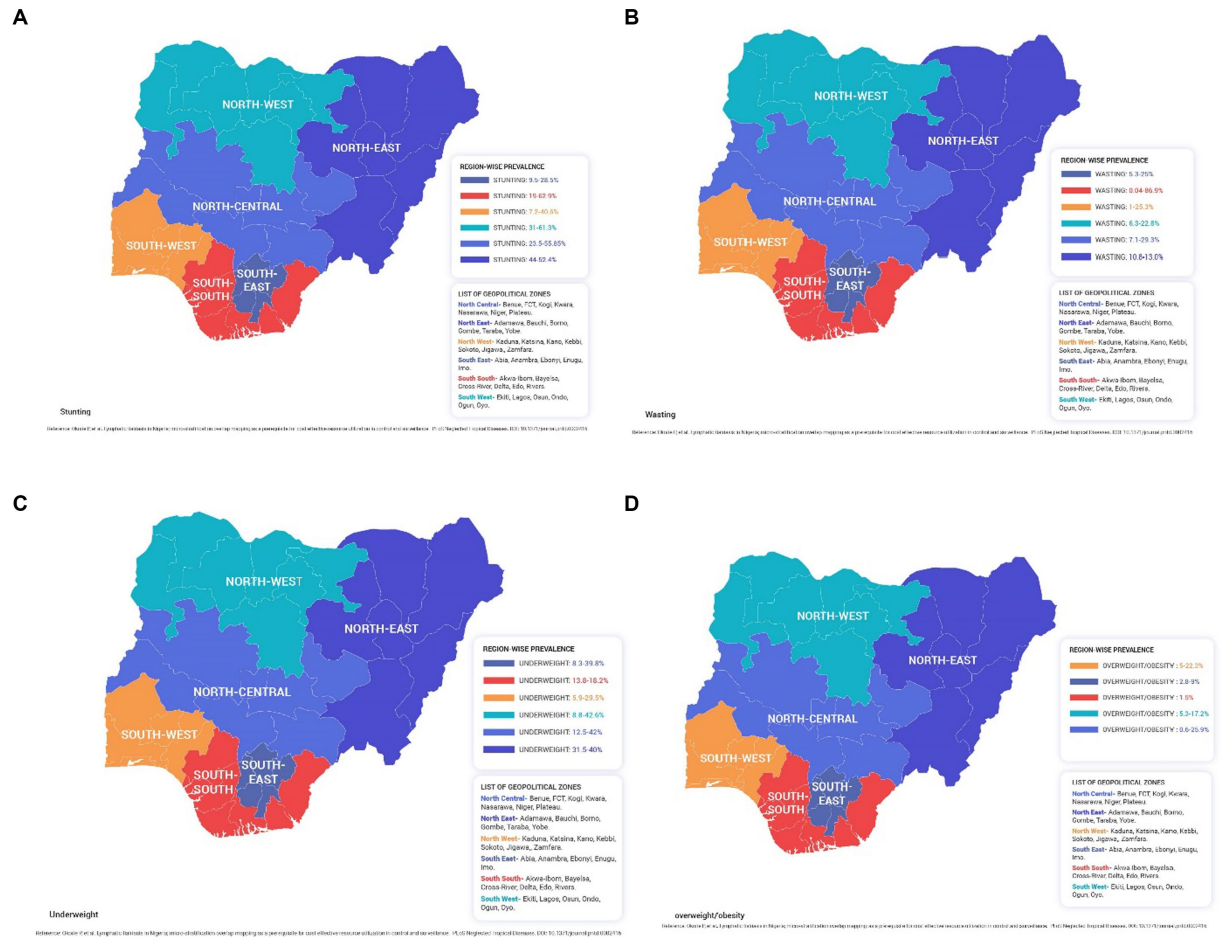

FIGURE 2
Malnutrition map of Nigeria for **(A)** stunting, **(B)** wasting, **(C)** underweight, **(D)** overweight and obesity.

Urban vs. rural prevalence of undernutrition

It was seen that the overall national prevalence of stunting, wasting, and underweight in urban areas of Nigeria ranged between 26.8–30.6%, 10.5–35.6%, and 23.0–31.2%, respectively, while in the rural regions, it was 44.8–72.8%, 10.5–69.9%, and 35.5–72.9%, respectively (Supplementary Table 3). The highest prevalence of stunting was reported in the urban Ibadan, Oyo state (44) and rural regions of Lagos (39). State-wide prevalence of wasting was almost similar in rural regions compared to urban regions, with the highest prevalence reported from Lagos state (urban: 8.7%; rural: 9.3%) (38). The Ibadan urban region in Oyo state showed a wasting prevalence of 1.8% which was much below the national prevalence (10). The prevalence of underweight was considerably higher in rural compared to urban (19, 37, 45–47) (Figure 3).

Gender-based prevalence of undernutrition

There was no definitive pattern has been noticed in the prevalence of gender-based undernutrition (Supplementary Table 4). A few studies have reported higher stunting prevalence in males compared to females. The regional prevalence differs from the national prevalence in that the males depict a higher prevalence of stunting and wasting but not underweight (48–51). In contrast, wasting prevalence was slightly higher amongst females than males (22, 50, 52, 53). There were no differences between males and females regarding underweight prevalence (18, 45) (Supplementary Table 4).

In males, wasting prevalence ranged from 2.5 to 50.0%; underweight ranged from 6.0 to 78.0%, while in females, wasting prevalence was reported from 8.0 to 61.0% and underweight from 7.0 to 61.4% (16, 22, 48, 50, 54, 55).

Age-based prevalence of undernutrition

Between 2008 and 2018, the NDHS data reported that the prevalence of stunting among children 6–11 months ranged from 28.9 to 35.4%, while the prevalence of stunting among 0–23 months old was 39.1%, and among 24 to 59 months was 53.3% (55). The prevalence of underweight was stable of around 10% among infants 0–6 months and 6–11 months. However, this number doubled to around 20.0% in older children of 12–60 months.

The prevalence of wasting was the highest among children 12–35 months (Figure 4).

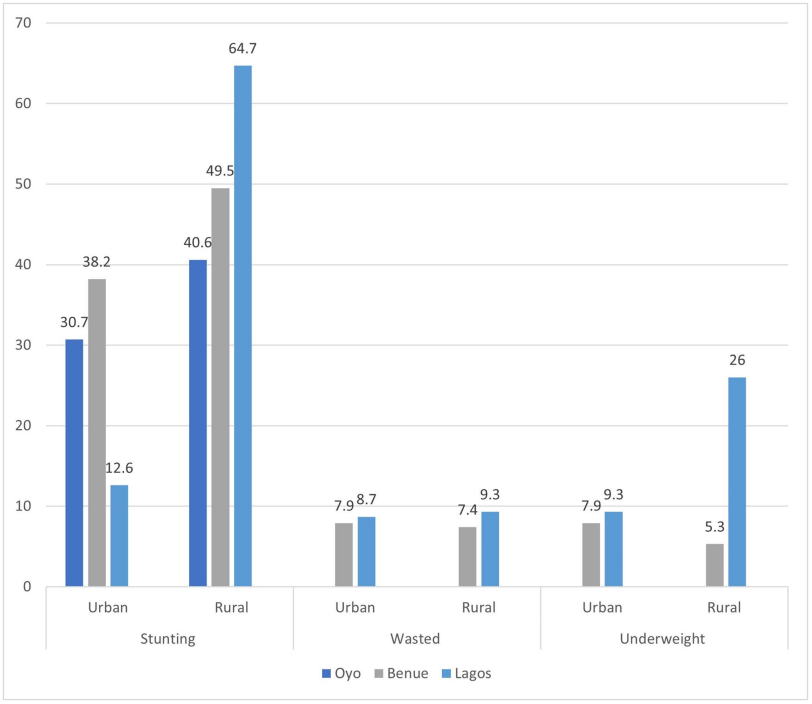

FIGURE 3
Urban–rural prevalence of undernutrition across a few states in Nigeria.

Overweight and obesity

The data collected across 13 states reported the national prevalence of obesity in 2013 to be 4.0% (20, 43), while in 2018, it declined to 2.0%. The overweight prevalence ranged from 1.5 to 25.2%, while obesity ranged from 0.6 to 25.9% among under-5 children in different regions of Nigeria (21, 25, 30, 56, 57). The prevalence of overweight in male children in Ondo and Benue states was 9.8 and 10.5%, while in female children, it was 10.7 and 8.4%, respectively (53, 58) (Supplementary Table 5).

Dietary intake

The prevalence of inadequate energy intake ranged from 18.0 to 34.0% (36, 59). A study in Ibadan, Oyo State (South West), reported an inadequate intake of fat (92.0%), protein (46.0%), and carbohydrates (30.0%) (10, 11). Other studies reported that the prevalence of inadequate intake for different micronutrients in under-5 children including zinc 32.0–91.0%, potassium 91.0%, vitamin A 82.0%, vitamin C 80.0%, iron 74.0%, and folate 44.0% (59, 60).

Anemia and iron deficiency

Data from the NDHS shows the national prevalence of anemia among children under-5 years of age in Nigeria has slightly declined from 67.0% reported in 2013 to 58% in 2018 (20). However, the anemia prevalence has shown an upward trend in urban regions from 55.2% in 2010 to 62.0% in 2018, while in rural regions; the prevalence remains similar which was reported around 75.1% in 2010 and 72.5% in 2018 (61).

The prevalence of severe and moderate anemia in males was reported to be 3.6 and 43.3%, respectively, and in females, the prevalence of severe and moderate anemia was 2.9 and 38.4%, respectively (11). The highest prevalence of severe and moderate anemia was reported in children under 1 year (11) (Figure 5A). Moderate iron deficiency ranged from 1.1 to 32.2%, while severe deficiency ranged from 1.1 to 67.8% (16). Having vitamin A deficiency and malaria are some of the risk factors reported to be associated with anemia (62, 63).

Other micronutrient deficiencies

Vitamin A deficiency ranged from 5.3 to 67.6% (24, 64), with a severe deficiency of 77.0 and 20.7% of moderate deficiency (Figure 5B) (16). The prevalence of vitamin A deficiency in a study of children 3 to 5 years of age ranged from 8.0 to 10.0% (65). Factors reported to be associated with vitamin A deficiency are anaemia (16) and low consumption of vitamin A-rich foods (26).

Based on baseline data of an intervention study among toddlers in Lagos (South West), it was reported a deficiency of vitamin D (9.0–37.0%), folate (8.0–21.1%), and vitamin B12 (7.1%) (66). Moderate vitamin D deficiency ranged from 1.15 to 24.14%, while severe deficiency ranging from 2.3 to 50.6% was reported in Kaduna state (16). Low serum zinc was reported in 12.4–26.0%, being higher in males (32.1%) than in females (19.1%) (33, 67).

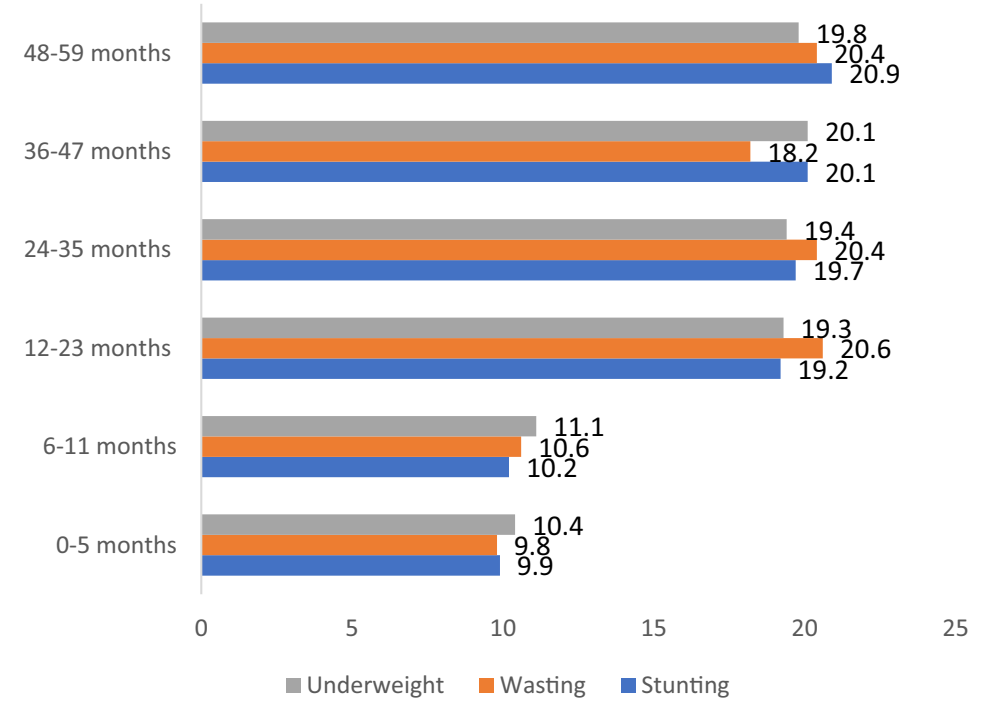

FIGURE 4
Prevalence of undernutrition among children according to age.

Quality of complementary feed (MDD, MAF, and MAD)

The proportion of children achieving MDD ranged from 3.0 to 55.2% in Nigeria (37, 54, 68–71) (Table 2). Dietary diversity was classified into low (meals comprising 1–6 food groups) and high (meals comprising 6–12 food groups). The prevalence of low and high dietary diversity reported in one study was 68.5 and 31.5%, respectively (22). While another study reported a total of 85.5% among 6- to 24-month-old children fulfilled the MDD, with the highest prevalence seen in 9- to 11-month-old infants (36.0%) (70).

The proportion of children achieving MMF ranged from 33.4 to 76.3% (37, 54, 68–70). In a study by Samuel and Ibidapo, the highest prevalence of MMF was 30.0% in infants 9 to 11 months of age. A high prevalence of MAD (90.8%) was reported in children in Osun state (70). Several factors reported in this review to be associated with poor quality of complementary foods are antenatal care visit, child's welfare clinic visit, mother's work place and education, as well as household size (70).

Discussion

This scoping review summarizes available evidence on the burden of malnutrition in under-5 children in various regions of Nigeria as well as the nutrient deficiency and quality of complementary feeding. It highlights the disparities across regions, age groups and gender across several indicators of malnutrition, such as stunting, wasting, underweight, and anemia. While a total of 73 studies were identified, most reported data on nutritional status; only 6 reported the prevalence of SAM/PEM, and a few studies (less than 30%) revealed information on nutrient intake/deficiency or quality of complementary feeding.

The prevalence of stunting, wasting, and underweight in under-5 children was high, exhibiting considerable variations across different zones. The North West and North Central zones have been reported to have the highest prevalence of SAM, stunting, wasting, underweight, iron deficiency anemia, and moderate/severe vitamin D deficiencies and the lowest proportion of children under 6 months who met the MDD and MAD. In contrast, the prevalence of undernutrition was found to be generally lower in South East Nigeria compared to other zones (72).

The high prevalence of poor nutritional status among under-5 children in the Northern zones could be attributed to the militant insurgency, banditry, and cattle rustling hindering a large number of farmers and livestock herders from accessing their farmlands for almost a decade. These disastrous scenarios not only lead to restrictions on agricultural produce but also severe food insecurity, affecting many households residing in these zones, particularly in the rural regions (9, 22, 37, 48, 55). This situation also drives more consumption of staple foods as accessible sources of energy (37). In addition, there were some food taboos for

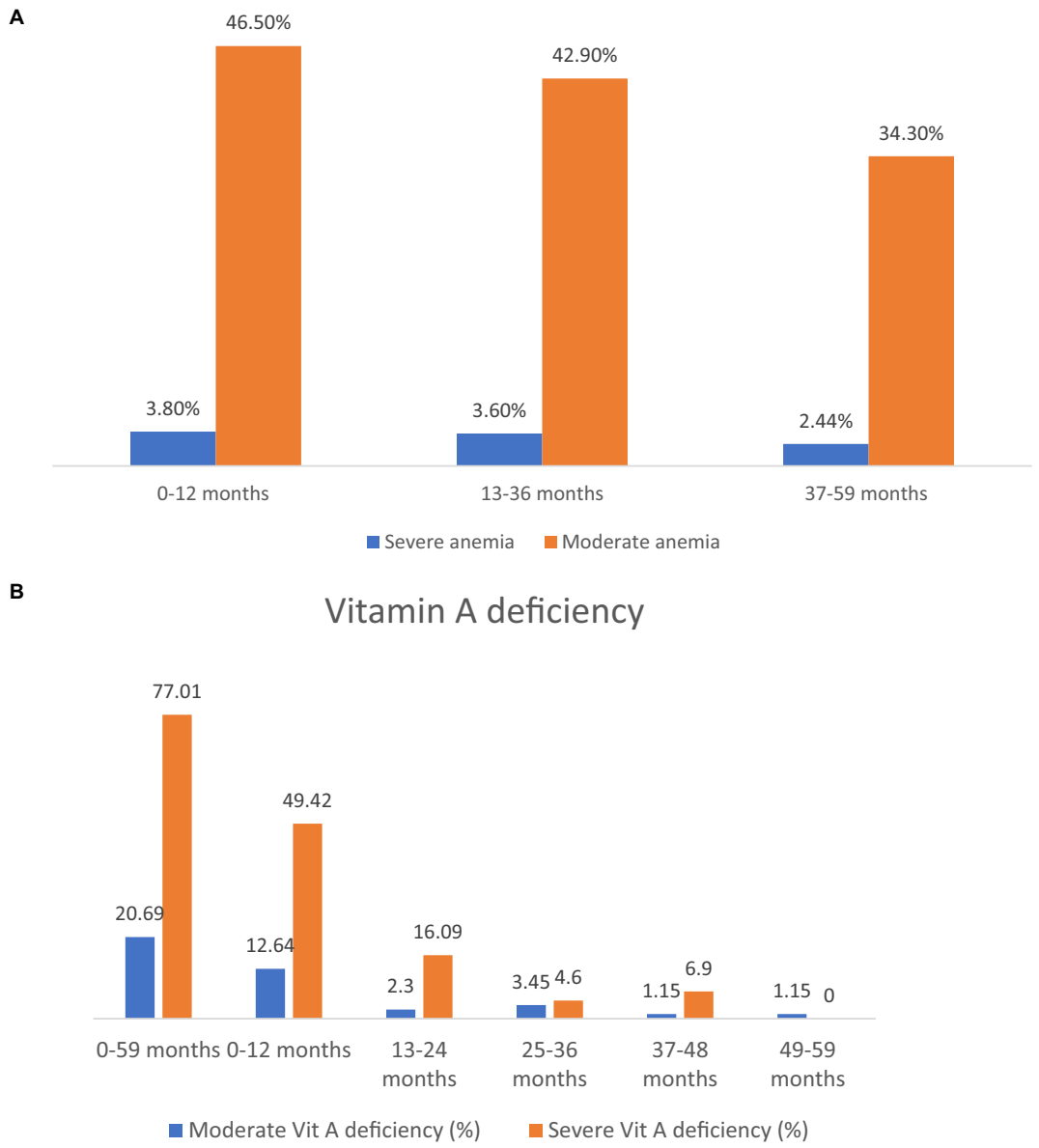

FIGURE 5
(A) Anemia prevalence in different age groups. **(B)** Severe vs. moderate vitamin A deficiency in different age groups.

children and pregnant women that restrict their access to certain foods, such as eggs which were more prominent in the Northern region (37). It was also clearly seen that undernutrition prevalence was more pronounced in rural regions than in urban regions.

More than half of the under-5 children have anemia with a higher prevalence reported in rural areas than in urban regions. Studies have shown that anemia in children leads to poor cognition, school achievement, and more behavioral issues as they grow, particularly into middle childhood (73). In several cases, it may lead to irreversible damage to the child's development (73); hence, efforts to alleviate the anemia burden are necessary in Nigeria. This review also noted that a substantial prevalence of vitamin A deficiency in Nigeria.

Undernutrition particularly in the first 2 years of life, has been reported to lead to an impairment of their ability to resist disease (74, 75), undertake physical activity, and progress in study and school (74, 75). The impact of not achieving growth potential impedes the cognitive development of the child, with enormous and adverse implications on well-being and economic prospects as the child grows into adulthood. Undernutrition in the early years of life leads to reduced educational completion, lower economic productivity, increased morbidity, and reduced life expectancy (9). Studies have shown that children who suffer from undernutrition are not able to complete their education and show deficiencies in vocabulary and mathematics, along with other learning or intellectual disabilities, which leads to reduced economic productivity in adulthood (73, 78). This depletion of human capital not only poses social and economic challenges in disadvantaged communities of Nigeria but also hinders the overall economic and social progress of the country in general.

TABLE 2 Proportion of children who meet the minimum dietary diversity, minimum meal frequency, and minimum acceptable diet across different regions in Nigeria.

Region	State	Year of data collection	Minimum dietary diversity (%)	Minimum meal frequency (%)	Minimum acceptable diet (%)	Reference
North East		2016-2017	31.7	47.0	15.8	(36)
North West		2016-2017	37.5	40.1	14.4	(36)
	Kano	2019	31.3			(63)
	Kaduna	2019	28.0			(63)
North Central		2016-2017	41.5	46.5	16.6	(36)
South East		2016-2017				
		2016-2017	52.3	48.1	16.9	(36)
South West		2016-2017	46.8	33.4	12.8	(36)
	Ogun	2019	85.5	66.4	90.8	(65)
	Ijero, Ekiti	NA			40.7	(66)
	Ikole, Ekiti	NA			29.4	(66)
South South	Edo	NA		76.3		(51)
		2016-2017	55.2	43.1	18.9	(36)

NA: not available.

In addition, this report also shows the high prevalence of overweight and obesity in several states in North Central and South West Nigeria. This confirms the presence of a triple burden of malnutrition among children under 5 years of age in Nigeria which further worsens the dire situation of these children as resources need to be allocated to address these three problems simultaneously (79, 80).

The review reported a high prevalence of underweight and wasting among children between 12-35 months while the highest prevalence of stunting was in children 24-59 months old. In addition, the highest prevalence of severe and moderate anemia was reported in children under 1 year of age. These three conditions could be the root cause of why the prevalence of stunting remained and will continue to be high in Nigeria as has been shown in other countries (81). Studies have shown that underweight/wasting in the early life can persist into failure to thrive and will continue to stunting at a later age (82, 83).

Undernutrition among under-5 children is driven by a mesh of influencing factors, including cultural, behavioral, and environmental factors. The quality of complementary feeding practices is one of the important factors in determining the child's nutritional status. The 6- to 24-month age group is characterized by increased energy expenditure and need for nutritional requirements through complementary feeding. Inappropriate complementary feeding practices significantly contribute to undernutrition among children contributing as a major cause of disease burden, especially in developing countries (84). Maternal characteristics such as education and BMI were frequently reported in this review as influencing factors for stunting and the quality of complementary foods. This points out the importance to have better education and nutrition status of the mothers to ensure a healthy period during the first 1,000 days. In addition, malaria and anemia seem to counter-influence each other, thus it is important to address both factors together whenever one of these health issues occurred.

Potential solutions to overcome the disparities in nutritional issues

Possible interventions that have been shown to reduce the prevalence of malnutrition should be able to address the problem at different levels. These are itemized as follows: (1) at an individual level: increased uptake and attendance of antenatal care visits, lower average number of birth and mandatory vaccination for children and women (81, 85), and improvement of nutrition and health knowledge among girls and pre-pregnant women (81); (2) at the household level: change in behavior to include the use of clean fuel for cooking, encouragement for more hygienic behavior including a reduction in the practice of open defecation (81); (3) at regional level: food subsidies or food-based intervention in the northern region of Nigeria has been shown to simultaneously overcoming multiple nutritional challenges in the area; and (4) at the national level to support at least four times minimal antenatal care, address anemia and malaria (86), to enhance awareness of vaccination in young children (85), create more equitable household economic growth (81, 87), and build infrastructure for greater access to improve toilet facilities (81, 88).

It is crucial to prioritize efforts that enhance, among others, access to nutritious food, improve healthcare services, and implement effective, targeted interventions. Furthermore, there is a need for more monitoring efforts to evaluate the effectiveness of these interventions as a basis for further refinement of the interventions in the future.

Strengths and limitations

This scoping review offers a comprehensive assessment of the nutritional status of children in Nigeria, as well as various related indicators, providing invaluable insights to guide future research endeavours. Furthermore, it highlights the need to invest in public

policies and socioeconomic strategies that can foster improved nutrition status and address the underlying issues. This study meticulously collates an array of essential undernutrition parameters, complementary feeding indicators, and dietary intake status pertaining to under-5 children in Nigeria. Drawing from recent data sourced from national health surveys, regional surveys, and other pertinent studies, a spectrum of prevalence rates spanning from low to high has been thoughtfully incorporated based on geopolitical zone. To enhance accessibility, the amassed data has been meticulously organized and presented in a user-friendly mapping format.

Due to the heterogeneity of studies, the absence of precise study years, and limited results for some regions, the undertaking of a comprehensive meta-analysis or applying statistical analysis to individual study results was not feasible.

Areas for further research

There is a dearth of data available for micronutrient intake and deficiency. For example, in this review, there were no data retrieved on nutrients related to immunity, such as vitamin C and E (89), or nutrients that are important for bone growth, such as calcium, phosphorus, magnesium (90), and also nutrients that are commonly reported to be deficient in other populations (such as pregnant women in Nigeria) like thiamine and riboflavin (91, 92). For macronutrients, total protein and LCPUFA intake in under-5 children, for example, was notably absent in all of the selected studies.

Conclusion

The culmination of this comprehensive analysis has brought to the forefront a multitude of pressing nutritional problems, prominently underscored by the pervasive triple burden of malnutrition encompassing stunting, overweight, and anemia. The northern zones in Nigeria have emerged as particularly vulnerable, grappling with a more acute undernutrition crisis as evidenced by the array of indicators examined.

Gender differentials further paint a nuanced picture, whereby stunting exhibited a higher prevalence among males, while the prevalence of wasting in several states, was skewed toward females. The widespread occurrence of anemia across diverse geographical regions, reveals noteworthy disparities between urban and rural areas. The high prevalence of vitamin A and D deficiency, along with inadequate nutrient intake, were also notable.

Compounding these challenges, a significant proportion of children were found to lack access to a diverse range of food groups, and fell short of consuming the recommended number of meals per day in their complementary diets.

In light of the far-reaching impact of malnutrition, encompassing the loss of human capital and reduced economic productivity across Nigeria, the imperative for targeted and expeditious nutrition interventions becomes evident. Swift and concerted action are crucial to rectify the prevailing disparities in nutrition status among young children in Nigeria, securing a healthier and more prosperous future for the nation at large.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

CJ: Conceptualization, Data curation, Investigation, Methodology, Writing – review & editing, Formal analysis. BP: Conceptualization, Data curation, Investigation, Writing – review & editing, Formal analysis. MJ: Conceptualization, Formal analysis, Writing – review & editing, Methodology. GM: Formal analysis, Methodology, Writing – review & editing, Data curation. IA: Formal analysis, Methodology, Writing – review & editing, Investigation. OE: Formal analysis, Investigation, Writing – review & editing, Data curation. BA: Formal analysis, Writing – review & editing, Methodology. NC: Formal analysis, Methodology, Writing – review & editing, Data curation. VB: Writing – review & editing. LM: Writing – review & editing, Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision.

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Conflict of interest

VB and LM are employees of FrieslandCampina.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnut.2023.1279130/full#supplementary-material

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A cross-sectional study on the moderating effect of self-efficacy on the relationship between sociodemographic variables and nutrition literacy among older adults in rural areas of North Sichuan

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Objective: The purpose of this study is to examine the moderating role of self-efficacy among rural elderly individuals in northern Sichuan Province in the relationship between certain sociodemographic variables and nutritional literacy.

Methods: Convenience sampling was used to select 264 elderly individuals aged 60 and above from rural communities in Cangxi County, Guangyuan City, Yilong County, Nanchong City, and Bazhou District, Bazhong City, Sichuan Province. A self-designed questionnaire, including sociodemographic variables, the General Self-Efficacy Scale (GSES), and the Nutrition Literacy Questionnaire for the Elderly (NLQ-E), was administered through face-to-face interviews using a paper-based version. The relationships between sociodemographic variables, self-efficacy, and nutritional literacy in the elderly were analyzed using SPSS 26.0 and the Process plugin to examine the relationships between variables and to test for moderation effects.

Results: (1) There were significant differences in nutrition literacy scores among elderly people of different ages, genders, marital statuses, educational levels, personal monthly living expenses, dental conditions, and number of chronic diseases ($p < 0.05$). (2) When elderly individuals have lower self-efficacy, their nutritional literacy is lower as they become older, and they have poorer nutritional literacy with a higher number of chronic diseases.

Conclusion: General population demographic data has a significant impact on the nutritional literacy level of elderly people in rural areas of northern Sichuan. Self-efficacy plays a moderating role in the relationship between age and nutritional literacy, as well as the relationship between the number of chronic diseases and nutritional literacy.

KEYWORDS

elderly, demographic variables, nutrition literacy, self-efficacy, moderating effect

1 Introduction

Health is the cornerstone of human development, and nutrition is the cornerstone of maintaining health. Nutrition refers to the process by which the human body ingests, digests, and absorbs various nutrients from the outside world to maintain life activities and regulate the immune system to change the course of disease (1). With age, the body's metabolism slows down, and the physiological functions of various systems decline, making the elderly more prone to poor nutrition and overnutrition. According to statistics, the risk of malnutrition in Chinese elderly is as high as 48% (2). As of 2019, the population aged 65 and above in China reached 176.03 million, accounting for12.6% of the total population; the population aged 80 and above reached 26 million; by 2050, the elderly population aged 65 and above will reach 365 million, accounting for 26.1% of the total population (3). Therefore, if effective measures are not implemented, the current situation 30 years later will be that about 1 in 12 people will be malnourished elderly. And due to the differences in conditions between rural and urban areas in China (4), this situation will be even more worrying. Therefore, reducing the risk of malnutrition and improving the current situation of malnutrition is essential for personal and social harmony and development.

Nutrition literacy is the ability of individuals to understand nutritional knowledge, their own nutritional status, and guide themselves in selecting foods to obtain nutrition, which is a part of health literacy (5, 6). At the same time, healthcare professionals also regard improving the nutrition literacy of chronic disease patients as an important part of their health guidance, and these measures play an important role in the prevention and treatment of nutrition and metabolism-related diseases such as hypertension, diabetes, obesity, and cancer (7–10). Therefore, from the concept and application, nutrition literacy is the upstream theory of nutrition, that is, an individual's level of nutrition literacy directly affects their nutritional status.

The differences in physiological and psychological status, living environment, cultural level, and economic level among the elderly lead to differences in their nutrition literacy (11). Aihara used a nutrition literacy scale suitable for the Japanese elderly based on the Japanese Dietary Guidelines to assess the elderly's understanding of nutrition-related knowledge. He found that there was a significant difference in nutrition literacy between genders, and lower cultural and economic status were related to limited nutrition literacy among elderly women (12). Prof. Zhang from the School of Public Health, Peking University, developed a nutrition literacy questionnaire suitable for Chinese elderly, and pointed out that elderly people with lower age, higher BMI, and higher cultural level have significantly higher nutrition literacy (2). In addition, the nutrition literacy of the elderly is also related to their oral health. A cross-sectional study from Finland found that elderly people who wear full dentures tend to choose unhealthy foods, leading to malnutrition (13).

Improving nutrition literacy is an important foundation for individuals to maintain a healthy state and an important means for the country to promote healthy aging. With the development of social psychology, the impact of positive psychological resources on health-promoting behaviors has received widespread attention, and more and more research has begun to pay attention to the relationship between elderly people's psychological changes and their health status (14, 15). In this field, research on the relationship between self-efficacy and health-promoting behaviors among the elderly involves more (16). This relationship refers to whether the elderly can adopt adaptive behaviors to reduce the harm of events to their own health when facing stress or challenges in the environment, and self-efficacy is a psychological cognition related to this behavior (17–19). A survey on adult health literacy in Germany showed that demographic factors have an important impact on their health literacy level. But the effect size of these factors changed after adding self-efficacy to the regression model (20). The phenomenon of change occurring due to the addition of self-efficacy aligns with Bandura's theory of self-efficacy (21). Therefore, in formulating research on improving nutritional literacy in the elderly, it would be highly valuable to explore the relationship between sociodemographic factors and nutritional literacy, while incorporating Bandura's theory of self-efficacy.

Currently, nutrition literacy related research in the Chinese population mainly focuses on the development of scales (22). While the relationship between demographic data and nutrition literacy, as well as the underlying mechanisms, are not clearly understood. Therefore, this study aims to investigate the current status of nutrition literacy among elderly people in rural areas and promote local healthy aging. Based on the research objects and significance of the study, we proposed two hypotheses:

> *Hypothesis 1*: The nutritional literacy of the elderly varies with differences in certain demographic variables.
>
> *Hypothesis 2*: According to the theory of self-efficacy, this study assumes that general self-efficacy has a moderating effect on the relationship between certain demographic factors and nutrition literacy.

2 Materials and methods

The present study is based on the promotion effect of positive psychological resources on health behaviors. It explores the moderating effect of self-efficacy in rural elderly individuals on the relationship between sociodemographic variables and nutritional literacy. General sociodemographic data are used as independent variables, general self-efficacy is the moderating variable, and nutritional literacy is the dependent variable to examine the relationship among the three factors. The path relationships are presented in Figure 1.

2.1 Study population

This study used convenience sampling to select three rural communities in Guangyuan, Nanchong, and Bazhong cities in Sichuan Province, China. The selected participants were aged 60 years or older and had lived in the local rural areas for at least 1 year. The research team, accompanied by local community workers, we asked elderly individuals who voluntarily answered the questions and had normal cognitive function (not diagnosed with dementia or any mental illness by a doctor). Since the ultimate goal of this study was to investigate the nutrition self-management status of elderly people, elderly people who were completely unable to take care of themselves were excluded during the questionnaire survey stage. According to the Kendall sample calculation method, the sample size should be 5–10 times the maximum number of items on the scale. Taking into account a 20% sample loss,

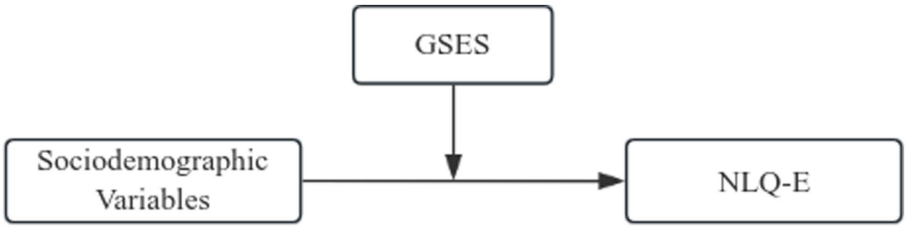

FIGURE 1
Moderation effect pathway.

the minimum sample size required for this study is 240. The final number of questionnaires collected that met the inclusion criteria is 264.

2.2 Selection of demographic variables

The survey questionnaire for this project included seven demographic variables, including five basic characteristics: age, gender, marital status, education level, and personal monthly living expenses. According to a systematic review published by the Department of Periodontology of the Federal University Rio Grande do Sul, elderly people with more teeth and functional teeth units have better nutritional status (23). Therefore, this study also added the dental status of elderly people in the local area as a basic characteristic in the questionnaire. It has been reported that elderly people with nutrition-related chronic diseases tend to a Mediterranean-style diet, while those who choose a high-calorie, high-fat, and high-salt diet have little knowledge about diet and disease (24). Therefore, the number of chronic diseases related to health in elderly people was also added to the basic information questionnaire in this study.

2.3 General self-efficacy scale

Self-efficacy is a core concept in Bandura's social cognitive theory. According to Bandura's theory, people with different levels of self-efficacy feel, think, and act differently (25). People with high self-efficacy tend to choose more challenging tasks, work harder once they start, persist longer, and quickly recover from setbacks. The General Self-Efficacy Scale (GSES) was revised by (26) and is a quantitative measure of an individual's psychological activity and self-confidence when facing setbacks or difficulties. The initial version consisted of 20 items, but it was later revised in 1997 to include 10 items and 1 dimension. The score of the GSES is obtained by summing the scores of the 10 items. The scores are rated on a 4-point Likert scale, where "1" means "completely incorrect," "2" means ewhat correct," "3" means "mostly correct," and "4" means "completely correct." The scale has been translated into 25 languages and is widely used. The Chinese version of the General Self-Efficacy Scale was used in this study, and its Cronbach's α coefficient was 0.89 (27).

2.4 Nutrition literacy questionnaire for the Chinese elderly

There are many different versions of nutrition literacy scales published both domestically and internationally. The Nutrition Literacy Assessment Instrument (NLit) was designed by Gibbs (28). The scale covers all stages of obtaining nutrition and has been well validated in various populations. The Iranian version of FNLIT and the Turkish version of ANLS are nutrition and food literacy evaluation scales (29, 30). The questionnaire used in this study was the Chinese Elderly Nutrition Literacy Survey Questionnaire developed by Professor Zhang from the School of Public Health at Peking University (2). The questionnaire has 20 core items in three dimensions: the first 6 items evaluate the elderly's nutritional knowledge, the next 9 items evaluate the elderly's knowledge of healthy lifestyles and dietary behaviors, and the last 5 items evaluate the elderly's knowledge of promoting nutrition-related skills. The scores are rated on a 5-point Likert scale, where "1" means "strongly disagree," "2" means "disagree," "3" means "uncertain," "4" means "agree," and "5" means "strongly agree." The total score ranges from 20 to 100, with a higher score indicating higher nutrition literacy, The Cronbach's α coefficient for the scale used in this study is 0.926.

2.5 Statistical analysis

Before conducting statistical analysis, the first author reviewed all the included questionnaires again, and the data were entered independently by the first and second authors. SPSS26.0 was used for statistical. Since the sample data did not meet the normal distribution, median was used to describe the general information. The K-W test was used for intergroup comparison of nutrition literacy scores. The relationship between elderly self-efficacy and nutrition literacy was analyzed using Spearman's correlation. The moderating effect analysis was performed using PROCESS plug-in (by conducting 5,000 simulations using self-sampling, a 95% confidence interval is obtained), with chronic disease number and age as independent variables, self-efficacy score as moderating variable, and nutrition literacy score as dependent variable. Based on the results, a Johnson-Neyman plot was created (31). To ensure the accuracy of data analysis, data standardization, dummy variables, and multicollinearity diagnosis were performed before regression analysis. Considering that the questionnaires used in this study are widely used and established scales, no common method bias test was performed.

3 Results

3.1 Nutritional literacy score for the elderly based on demographic data

In this study, significant differences were found in the nutritional literacy scores of elderly individuals across various demographic

TABLE 1 Comparison of nutritional literacy scores among older adults based on demographic data ($n = 264$).

Characteristics		*n* (%)	NLQ-E(median)	*p*
Age	60–69	115 (43.6%)	80 (77, 97)	<0.001
	70–79	109 (41.3%)	77 (66, 80)	
	≥80	40 (15.2%)	62 (40, 72)	
Gender	Male	131 (49.6%)	80 (76, 97)	<0.001
	Female	133 (50.4%)	73 (63, 78)	
Marriage status	Never married	1 (0.4%)	79	<0.05
	Married	200 (75.8%)	78 (71, 88)	
	Divorced/Widowhood	63 (23.9%)	72 (61, 80)	
Education level	Illiteracy	97 (36.7%)	66 (51, 77)	<0.001
	Primary school diploma	94 (35.6%)	79 (73, 82)	
	Junior high school diploma	70 (26.5%)	88 (80, 98)	
	High school diploma or above	3 (1.1%)	100 (88,100)	
living expenses CNY/month	≤500	101 (38.3%)	68 (53, 78)	<0.001
	501–999	112 (42.4%)	78 (73, 87)	
	1,000–1999	46 (17.4%)	97 (81, 100)	
	≥2000	5 (1.9%)	91 (77, 100)	
Tooth condition	False tooth	100 (37.9%)	73 (66, 78)	<0.001
	Damaged teeth without dentures	90 (34.1%)	78 (66, 80)	
	Intact teeth	71 (26.9%)	84 (77, 97)	
	Toothless	3 (1.1%)	63 (40, 68)	
Chronic diseases	0	117 (44.3%)	80 (77, 97)	<0.001
	1	113 (42.8%)	72 (66, 80)	
	2	32 (12.1%)	71 (52, 80)	
	≥3	2 (0.8%)	41 (40, 42)	

TABLE 2 Spearman correlation coefficients between self-efficacy and nutritional literacy dimensions.

Variables	Healthy lifestyle and dietary behavior	Healthy lifestyle and dietary behavior	Skill	Total
GSES	0.779**	0.764**	0.754**	0.800**

*$p < 0.05$, **$p < 0.01$.

variables, including age, gender, marital status, education level, monthly living expenses, tooth condition, and chronic diseases ($p < 0.05$). Please refer to Table 1 for detailed results. Additionally, comparative analysis was conducted within each demographic variable for all samples that exceeded the minimum required sample size. Further information can be found in the supplementary materials.

3.2 Correlation analysis between self-efficacy and nutrient literacy scores among rural elderly

As shown in Table 2, based on Spearman correlation, the correlation coefficients between self-efficacy scores and nutrient literacy scores in each dimension ranged from 0.754 to 0.779 among the 264 elderly participants in this study. The correlation coefficient between self-efficacy scores and the total score of the nutrient literacy questionnaire was 0.800, indicating a strong positive correlation between self-efficacy and nutrient literacy among the population surveyed in this study.

3.3 Self-efficacy moderates the effects of sociodemographic variables on nutritional literacy among elderly individuals in rural areas

Before performing the moderation analysis, this study conducted a collinearity diagnosis on the included variables. The test results showed that the VIF < 5. The results are shown in Table 3, indicating that when the elderly residents' self-efficacy score is used as the moderating variable, there is a significant effect ($p < 0.05$) on the impact of age and the number of chronic diseases on their nutritional status. To demonstrate the moderating effect of self-efficacy among elderly residents, this study will quantify the impact of age and the number of chronic diseases on nutritional status under different self-efficacy scores, and present the results in two Johnson-Neyman graphs.

3.3.1 Analysis of the impact of self-efficacy regulation age on nutritional literacy in older adults

As shown in Figure 2, when the self-efficacy score of elderly people is below 32 points, the effect of age on nutritional status is below 0, indicating a significant negative effect of age on nutritional status. While when the self-efficacy score is above 32 points (The confidence interval of the effect size includes 0) indicating that the effect size in this stage is meaningless. According to relevant literature, elderly people with self-efficacy below 30 points generally belong to the group of poor self-efficacy (32). However, this study found a critical score of 32 points. Therefore, the study results indicate that elderly people with lower self-efficacy generally have lower nutritional status scores with increasing age, implying that this group of elderly people has lower ability to obtain nutrition.

TABLE 3 Results of regression analysis on regulatory effectiveness.

		β	se	*t*	*p*	95%CI	
Model 1	Constant	0.052	0.041	1.267	0.206	−0.029	0.133
	Age	−0.130	0.043	−3.030	0.003	−0.214	−0.045
	GSES	0.691	0.043	16.108	0.000	0.607	0.776
	Int_1	0.107	0.039	2.738	0.007	0.030	0.184
	R^2	0.651			0.000		
	$\triangle R^2$	0.010			0.007		
Model 2	Constant	0.044	0.041	1.070	0.286	−0.037	0.125
	Chronic diseases	−0.099	0.042	−2.367	0.019	−0.182	−0.017
	GSES	0.726	0.042	17.231	0.000	0.643	0.809
	Int_1	0.097	0.040	2.454	0.015	0.019	0.175
	R^2	0.641			0.000		
	$\triangle R^2$	0.008			0.015		

3.3.2 The effect of self-efficacy in regulating the number of chronic diseases on the nutritional literacy score in elderly individuals was analyzed

As shown in Figure 3, the confidence intervals for the impact of the number of chronic diseases on nutritional status among older adults do not include zero when the self-efficacy score is below 30, and they are all below 0. This indicates that the effect of having fewer chronic diseases on higher nutritional status is significant only among older adults with self-efficacy scores below 30. However, among older adults with higher self-efficacy scores, the impact of the number of chronic diseases on nutritional status loses theoretical significance (The confidence interval of the effect size includes 0).

4 Discussion

4.1 Focus on the baseline characteristics of the elderly population and improve the nutritional literacy of key populations

The results of this study indicate that age is an important influencing factor in evaluating the nutritional literacy of the elderly. As age increases, the physiological indicators of the elderly decline, and their bodily functions decrease. Which may lead to the need for

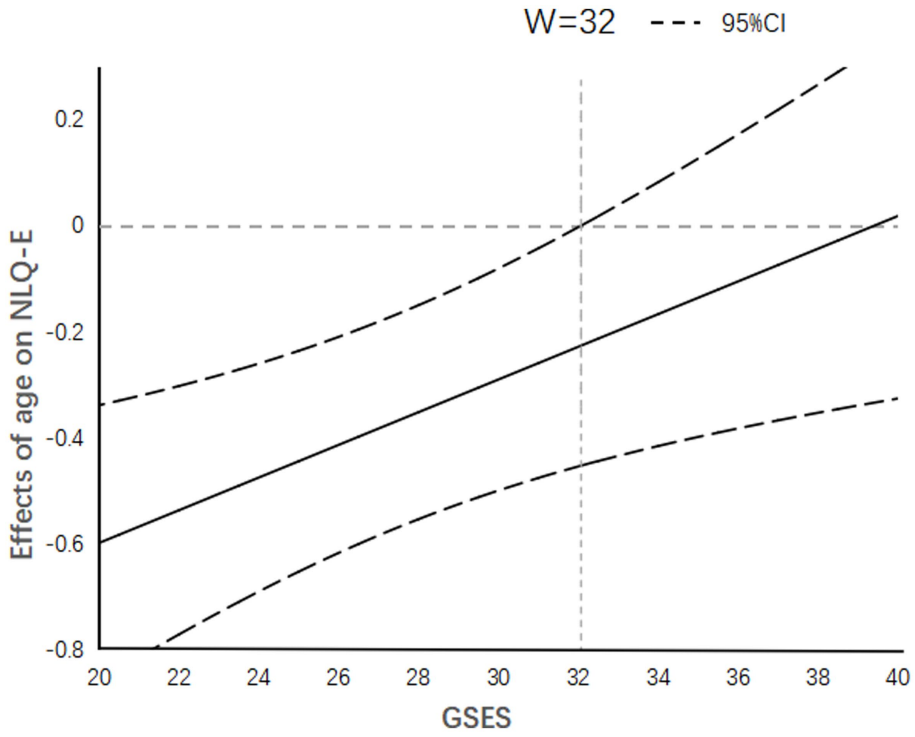

FIGURE 2
Age has a significant negative effect on nutritional literacy when self-efficacy score is below 32.

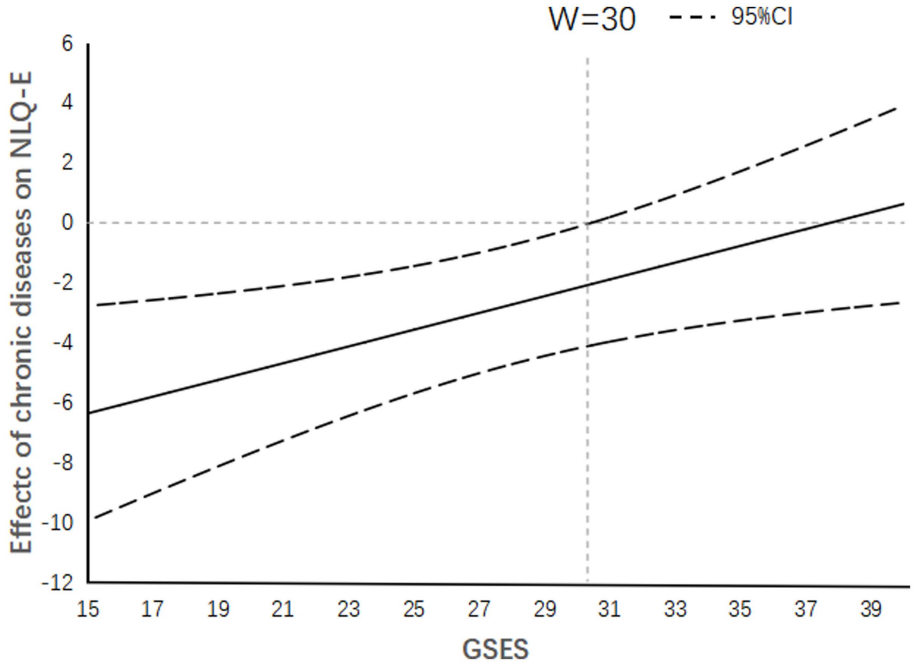

FIGURE 3
When the self-efficacy score is less than 30 points, the number of chronic diseases has a significant negative effect on nutritional literacy.

more nutritional substances but also require more energy to obtain (33). However, they often lower their nutritional requirements due to lack of energy, forcing them to have insufficient ability to obtain nutrients, resulting in a significant decrease in nutritional literacy with increasing age. A study on the age distribution of nutritional and health knowledge among Chinese adults (34) conducted a multicenter large-sample survey. The results showed that as age increases, nutritional knowledge among Chinese adults declines significantly. These elderly individuals have not obtained more information about nutrition from healthcare providers to compensate for this knowledge gap (35). Therefore, this study explained the relationship between age and nutritional literacy from a more specific dimension.

However, there is a lack of multicenter large-sample studies on the impact of gender on the nutritional literacy of the elderly. A study in Taiwan, China, on the impact of gender on food choices among the study population (11) supports the view of this article that the nutritional literacy score of elderly males is higher than that of elderly females. That is, elderly males show significantly higher initiative in adopting health-related dietary behaviors than females. Another cross-sectional survey with a larger sample size from Japan showed that nutritional literacy shows gender differences in different dimensions of dietary quality and food choice value (36). Therefore, further research may be needed on the analysis of the impact of gender on nutritional literacy.

The results of this study showed that the nutritional status of married elderly people was significantly higher than that of divorced or widowed individuals. However, there is currently a lack of literature to support or refute the impact of marital status on the nutritional status of elderly people. Married elderly people may be more willing to invest more energy in obtaining better nutrition due to emotional support from their spouses and daily care. Previous literature has reported that elderly people living alone suffer more severe health impacts due to a lack of social support (37).

The nutritional status of the elderly people surveyed in this study showed significant differences in the cultural background level. A large-scale survey conducted in China showed that elderly people in low-culture rural areas had limited nutritional status due to their lack of knowledge about diet (38). Using the theory of knowledge, attitudes, and behavior, it can be inferred that a person's cultural level has a direct impact on their nutritional behavior (39). Therefore, the conclusion drawn in this study also confirms the reliability of this theoretical model. Another study on the nutritional status of elderly people in Spain, although using different questionnaires (40), also drew similar conclusions to this study: the nutritional status of elderly people with lower cultural education is significantly lower than that of college-educated elderly people, indicating that the nutritional status of elderly people increases with higher cultural education.

The economic source of rural elderly people surveyed in this study is mainly from farming (41), and the basic part of their daily diet is self-sufficient. A large part of their personal monthly living expenses is used to pay for additional nutritional supplements. Therefore, this study selected the personal monthly living expenses of elderly people as an economic indicator to measure their nutritional support expenditure. According to the results of this study, it is speculated that under a relatively low socioeconomic status, the reason why personal monthly living expenses have a significant impact on their nutritional status may be due to the differences in their purchasing power resulting in significant differences in the nutritional substances they choose. Currently, research has shown that guiding low-income people to choose nutritious and affordable foods can reduce the difference in nutritional status (42). The promotion of such intervention measures may have significant benefits in improving the nutritional status of low-income elderly people.

In this study, the nutritional status scores of elderly people with intact teeth and those with damaged teeth differed significantly, but

the difference in whether dentures were worn by elderly people with damaged teeth was not clear. The convincing reason for this conclusion comes from the fact that the oral environment, especially the condition of the teeth, has a significant impact on the food choices of most elderly people. The limited medical level in rural areas of China means that elderly people cannot choose more scientific treatment options after their teeth are damaged, and most elderly people's dentures cannot effectively chew food (43). The number of edentulous elderly people included in this study was limited, so effective statistical analysis was not carried out. The wearing of dentures was not further subdivided into more detailed categories, so it was not possible to make a more accurate judgment. However, research has shown that patients wearing full dentures tend to choose unhealthy foods (13), leading to a higher risk of malnutrition, which needs further exploration in future studies.

Elderly people with chronic diseases, especially those related to nutrition, often have dietary habits and lifestyles that are closely related to the occurrence and development of chronic diseases (44). The results of this survey show that the nutritional literacy scores of elderly people with chronic diseases are significantly lower than those of healthy elderly people, indicating a certain relationship between chronic diseases and nutritional literacy. An experimental study in the United States provided food resources and cooking skills for hypertensive patients, which can improve their self-management level and increase their nutritional literacy (45). Based on this idea, promoting healthy lifestyles, especially dietary-related skills, to the public may reduce the incidence of chronic diseases by improving nutritional literacy. Finally, this study also showed that there was no significant difference in the effect of the number of chronic diseases on the nutritional literacy of the elderly. There is currently no relevant evidence to prove this, which may be due to the insufficient sample size collected in this study and further research is needed to verify this.

4.2 Focus on the self-efficacy of the elderly population and assist in screening for nutritional literacy

The nutritional literacy of the elderly population varies not only due to their different baseline characteristics but also as a result of their psychological state (11). Correlation analysis in research results has shown a strong positive correlation between self-efficacy and nutritional literacy among the elderly, and multiple studies abroad have also demonstrated a strong correlation between self-efficacy and nutritional literacy (46, 47). Therefore, self-efficacy, as a positive psychological resource, can be used to assess the confidence of the elderly in their ability to obtain nutrition. Relevant studies have already confirmed that the self-efficacy of elderly people in rural China is relatively low and significantly different from that of elderly people in urban areas (48). So focusing on the self-efficacy of rural elderly populations will be an important measure to improve their nutritional literacy.

Self-efficacy theory is an important component of psychologist Bandura's social learning theory, which emphasizes the mediating role of self-efficacy in behavior (21). Based on this theory, the present research results show that self-efficacy, as a moderating variable, affects the predictive effect of age and the number of chronic diseases on the nutritional literacy of the elderly. A survey on adult health literacy in Germany obtained results similar to those of this study (20), showing that the effect size of sociodemographic variables on nutritional literacy changed after self-efficacy was added to the regression model. Therefore, these studies suggest that when considering the impact of baseline characteristics on the nutritional literacy of the elderly, the position and role of self-efficacy in the model should be considered. Based on the Johnson-Neyman plot, the present research results show that when the self-efficacy of the surveyed elderly population is poor, age has a negative effect on nutritional literacy, that is, the nutritional literacy of the elderly decreases with age. Therefore, by using the self-efficacy score of rural elderly populations as a basis and dividing them into low self-efficacy score groups and other groups, the overall literacy level of rural elderly populations can be improved by implementing interventions to improve their nutritional literacy, especially for older elderly people. Similarly, it can be seen from the Johnson-Neyman plot that when self-efficacy is low, the number of chronic diseases also has a negative effect on nutritional literacy. Therefore, elderly people with chronic diseases in the low self-efficacy group can be screened out for targeted nutrition education and interventions (49). Therefore, this study suggests that when assessing the nutritional literacy of rural elderly populations, a general self-efficacy assessment scale can be used for auxiliary screening. On the one hand, self-efficacy itself has a positive predictive effect on nutritional literacy. And on the other hand, targeted interventions for elderly people with low self-efficacy scores who are older or have chronic diseases can significantly improve the overall nutritional literacy level. Additionally, the general self-efficacy assessment scale is simple and easy to evaluate (27), which is more convenient and effective for investigating rural elderly populations.

In summary, this article suggests that when providing elderly people with nutritional knowledge and other interventions, changes their psychological state should be considered in addition to the sociodemographic differences in the elderly population. The local authorities can strengthen the promotion of nutritional literacy, enhance the elderly's confidence in obtaining nutrition, and comprehensively improve the nutritional literacy level of the elderly population.

5 Conclusion

When conducting a nutritional literacy screening among rural elderly people, attention should be paid to the baseline characteristics of the elderly population: older age, elderly women, divorced or widowed, lower level of education, lower monthly living expenses, dental problems, and elderly people with chronic diseases tend to have lower nutritional literacy scores. Elderly people with low self-efficacy show a decline in nutritional literacy as they age, and those with multiple chronic diseases and low self-efficacy have lower nutritional literacy. Therefore, effective intervention measures should be taken for these key groups to promote a widespread improvement in nutritional literacy among the elderly population in rural western China.

6 Limitations

This study is the first to examine the nutritional status of elderly people in rural areas of northern Sichuan, and the sample

size is limited based on the local rural elderly population. However, according to Kendall's sample calculation method (50), the sample size of 264 cases meets the requirements by taking 5–10 times the number of entries in the most entries of the scale and considering a 20% sample loss rate. Furthermore, it is well known that people from different regions and cultural backgrounds have different health needs, which can lead to differences in nutritional status. The scale used in this study by Professor Zhang was selected to minimize the bias caused by geographic and cultural differences. Secondly, dietary habits and lifestyle are the basis for the development of nutritional status, and their nutritional status will ultimately move toward a direction favorable to chronic diseases. Since this study is a cross-sectional survey, it did not investigate the pre-nutrient status and course of chronic diseases of elderly people with these diseases, so more longitudinal studies are needed to explore the effect of chronic diseases on nutrient status. Finally, this study focused on rural elderly people in northern Sichuan, and the results cannot be generalized to other regions. Therefore, further research should expand the study population to comprehensively promote the improvement of nutritional status among rural elderly people.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Ethics Committee of Jinzhou Medical University (NO: JZMULL2022108). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

SL: Conceptualization, Data curation, Investigation, Methodology, Project administration, Software, Writing – original draft. XF: Data curation, Supervision, Writing – review & editing. LJ: Investigation, Methodology, Writing – review & editing. TL: Formal analysis, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnut.2023.1335008/full#supplementary-material

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Prevalence and predictive factors associated with stunting in preschool children in a governorate of Iraq: a community-based cross-sectional study

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Introduction: The prevalence and risk factors of stunting in various geographical regions have been well investigated. However, not enough data exists regarding the communities in Iraq. This study investigated the prevalence and risk factors of stunting in preschool children in Halabja governorate.

Methods: The required data for the study was collected through a structured questionnaire form from the children's parents. Then, the height and weight of the children were measured. According to the World Health Organization Child Growth Standards and using the WHO Anthro Survey Analyser software, children were classified as "stunted" when their height-for-age z-score was below two standard deviations.

Results: A total of 646 children were included, of which 310 (48%) were male and 336 (52%) were female. The gestational age of 556 (86%) children was 9 months, while 84 (13%) were born between 7–9 months, and 6 (1%) were born in 7 months. Regarding feeding during the first 2 years of life, 229 children (35.4%) were exclusively breastfed, 93 (14.4%) were bottle-fed, and 324 (50.2%) had mixed feeding. The prevalence of stunting was 7.9% in the sample pool, with 4.6% of females and 3.3% of males. Among stunted children, 6.35% were term babies, and 1.55% were preterm babies. None of the studied factors had a significant association with stunting.

Conclusion: The prevalence of stunting in the studied population was 7.9%. However, we could not find any significant association between the studied factors and stunting. Thus, the factors that may significantly affect stunting in our area of study, especially the historical chemical warfare side effects, need to be more extensively investigated in future studies.

KEYWORDS

child health care, growth retardation, malnutrition, nutritional status, stunting, survey

Introduction

The future prospects of infants and young children critically hinge on their optimal growth and development during the early stages of life. Stunting is a growth defect in which children have a lower height relative to their age and constitutes a serious health problem among children under the age of five in numerous low- and middle-income countries (1, 2). Stunting in children under the age of five can cause compromised physical development and may have an enduring effect on cognitive development, educational attainment, maternal reproductive outcomes, and economic productivity during adulthood (1, 2). As per United Nations estimates, one in eight Iraqi children dies before reaching 5 years of age. Nearly 30% experience malnutrition, a quarter are born underweight, and an additional 25% lack access to safe water (3).

The prevalence and risk factors of stunting in various geographical regions have been well investigated (1, 2, 4–6). However, not enough data exists regarding the communities in Iraq (3, 7, 8). The ongoing instability in Iraq since 2003 continues to have a profound impact on the physical and mental health of its residents (8). In a study conducted by Gabriela Guerrero-Serdan in Iraq to assess the effects of war on nutrition and health, it was hypothesized that those born after the war in high-intensity conflict areas were found to have lower height-for-age z-scores compared to those born in less violent areas (9).

This cross-sectional study explores the prevalence and risk factors of stunting in children aged four to five in the governorate of Halabja, which experienced chemical warfare in 1988.

Method

Study location and population

The study covered the urban areas in the Halabja Governorate of the Kurdistan Region, Iraq, with a total population of 121,793 people based on the Kurdistan Region Statistics Office.[1] The study was specific to the kindergartens located inside the city.

Study design

This was a survey-based cross-sectional study that enrolled kindergarten children aged 4 and 5 years old in Halabja governorate. The study lasted one year, from July 2022 to June 2023, and was ethically approved. Written informed consent was obtained from the parents or families of the children.

Setting and data collection

A multistage cluster sampling method was employed to collect the study sample. The city's geography was categorized into four distinct regions: north, south, east, and west. Within each of these regions, a total of 2–3 kindergartens were selected, resulting in a comprehensive selection of 10 kindergartens representing the entirety of the city. The required data for the study was collected through a structured questionnaire form from the children's parents including the following questions: demographics of children and parents, gestational age, type of feeding during the first two years of life, complementary feeding time, educational level of parents, family size, and socio-economic status. The questionnaire was distributed among families of children in all public and private kindergartens. We implemented quality control measures and adhered to best practices, which included training our data collection team, conducting pre-tests on processes and materials, and closely monitoring data collection in the field. To determine the necessary sample size for the population, we utilized the following equation from OpenEpi (Version 3), an open-source calculator: $n = [DEFF*Np\ (1-p)]/\ [(d2/Z21-\alpha/2*(N-1)+p*(1-p)]$. According to that calculation, a sample size of 383 individuals was needed at a confidence level of 95%. However, we collected a larger sample size than this requirement to ensure greater accuracy.

Anthropometric measurements

The height and weight of the children were measured. An electronic body scale (TCS-200-RT) was used for measuring the height. The children were taught to stand on the baseboard with their feet slightly apart. The back of the head, shoulder blades, buttocks, calves, and heels all touched the vertical board. This alignment was impossible for obese children, so they were helped to stand on the board with one or more contact points touching the board. The headboard was placed on the highest point of the head with enough strength to compress the hair. Anthropometric measurements were acquired in duplicate by the research team, with the final measurements being calculated as the mean between the two readings based on the protocols advised by WHO (10). According to the WHO Child Growth Standards and using the WHO Anthro Survey Analyser software, children were classified as "stunted" when their height-for-age z-score was below two standard deviations from the median of the same age and sex group (11).

Eligibility criteria

Children aged 4 to 5 years old in public and private kindergartens in Halabja governorate were included. Children with skeletal deformities, genetic diseases like achondroplasia, growth hormone deficiency, and familial short stature were excluded. Additionally, children whose parents were unable to complete the questionnaire or did not complete it properly were also excluded.

Statistical analysis

The data was collected and encoded using Microsoft Excel (2019), and then it was analyzed using the Statistical Package for Social Sciences (SPSS Version 22). Frequencies and percentages were calculated for categorical variables. The binary logistic regression test was used to compare proportions and show the possible association between stunting and the studied factors. The significant level was considered at a p-value < 0.05.

1 https://krso.gkrd/en/indicator

Resource assessment

For assessing the available resources, all cited studies have been checked for credibility (fully peer-reviewed) (12).

Results

Social demographics of the children

There were 646 children in the study. Of these, 310 (48%) were boys, and 336 (52%) were girls. Most participants (87.9%) were 5 years old, while the remaining 12.1% were 4 years old. Overall, 86% were born at 9 months of gestational age, 13% were born between 7–9 months, and 1% were born at 7 months. Regarding feeding during the first 2 years of life, 35.4% of children were exclusively breastfed, 14.4% were bottle-fed, and 50.2% had mixed feeding. Also, 20% of children started complementary feeding before 6 months, while 80% started it after 6 months (Table 1).

TABLE 1 The baseline characteristics of the participants.

Variables	No. cases/frequency
Demographics	
Age	
4 years	78 (12.1%)
5 years	568 (87.9%)
Sex	
Male	310 (48.0%)
Female	336 (52.0%)
Gestational age	
9 months	556 (86.0%)
>7–<9 months	84 (13.0%)
7 months	6 (1.0%)
Type of feeding	
Breastfeeding	229 (35.4%)
Bottle feeding	93 (14.4%)
Mixed feeding	324 (50.2%)
Complementary feeding	
Before 6 months	129 (20.0%)
After 6 months	517 (80.0%)
Stunting statue	
Yes	51 (7.9%)
Male	21 (3.3%)
Female	30 (4.6%)
No	595 (92.1%)
Mothers' age group	
15–24	20 (3.1%)
24–35	360 (55.7%)
35–45	234 (36.2%)
≥45	32 (5.0%)
Mothers' education	
Illiterate	39 (6.0%)
Primary and Secondary school	281 (43.5%)
Diploma	167 (25.9%)
Bachelor	152 (23.5%)
Higher education	7 (1.1%)
Fathers' education	
Illiterate	12 (1.9%)
Primary and Secondary school	341 (52.8%)
Diploma	128 (19.8%)
Bachelor	149 (23.0%)
Higher education	16 (2.5%)
Mothers' occupation	
Housewife	436 (67.5%)
Employee	200 (31.0%)
Unknown	10 (1.5%)
Family size	
3–5 person	516 (79.9%)
6–9 person	129 (20.0%)
≥9 person	1 (0.1%)
Family socio-economic status	
Low	111 (17.2%)
Medium	373 (57.7%)
High	162 (25.1%)

No., number.

Stunting and children-related factors

In the sample pool, the stunting prevalence was 7.9%, with 4.6% of females and 3.3% of males. Most stunted children were 5 years old (7.6%). Among stunted children, 3.6% were breastfed, 3.1% were mixed-fed, and 1.2% were bottle-fed. The majority of stunted children (6.7%) started complementary feeding after 6 months, while 1.2% started before that. Stunting affected 6.35% of term babies and 1.55% of preterm babies. When comparing age, gender, type of feeding, complementary feeding, and gestational age with stunting, no statistically significant correlation was found (p-value > 0.05) (Table 2).

Stunting and parent-related factors

Children whose parents completed primary and secondary school had a higher likelihood of being affected by stunting (3.7% for mothers and 3.4% for fathers), followed by those with bachelor's degrees (2% for mothers and 2.2% for fathers) and diplomas (1.7%). However, this wasn't statistically confirmed (p-value > 0.05). No significant association was found between stunting and age, occupation of mothers, family size, or family socioeconomic status (p-value > 0.05) (Table 3).

Discussion

Stunting is an indicative factor for potential risks, as it reflects the comprehensive state of development marked by impoverished conditions, low socioeconomic status, and the incidence of chronic disorders (13). According to data compiled by the United Nations Children's Fund (UNICEF) and WHO in 2018, approximately 149 million children under the age of 5 experienced stunting (14). This nutrition problem primarily impacts developing countries, and the highest rates of stunting in preschool children were observed in Eastern (45%), Middle (39%), and Western Africa (38%) (15).

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TABLE 2 Association between nutritional status (assessed by HAZ) and gender, age groups, type of feeding, complementary feeding, and gestational age.

Variables	HAZ*			
	Stunting	Normal	Total	*p*-value
	No. (%)	No. (%)	No. (%)	
Gender				
Male	21 (3.3)	289 (44.7)	310 (48)	1.00
Female	30 (4.6)	306 (47.4)	336 (52)	
Total	51 (7.9)	595 (92.1)	646 (100)	
Children age group				
4 years	2 (0.3)	76 (11.8)	78 (12.1)	1.00
5 years	49 (7.6)	519 (80.3)	568 (87.9)	
Total	51 (7.9)	595 (92.1)	646 (100)	
Type of feeding				
Breastfeeding	23 (3.6)	206 (31.9)	229 (35.4)	0.491
Bottle feeding	8 (1.2)	85 (13.2)	93 (14.4)	
Mixed feeding	20 (3.1)	304 (47)	324 (50.2)	
Total	51 (7.9)	595 (92.1)	646 (100)	
Complementary feeding				
Before 6 months	8 (1.2)	121 (18.7)	129 (20)	0.715
After 6 months	43 (6.7)	474 (73.4)	517 (80)	
Total	51 (7.9)	595 (92.1)	646 (100)	
Gestational age				
9 months	41 (6.35)	515 (79.7)	556 (86.1)	0.266
>7–<9 months	10 (1.55)	74 (11.5)	84 (13)	
7 months	0 (0)	6 (0.9)	6 (0.9)	
Total	51 (7.9)	595 (92.1)	646 (100)	

*HAZ, height-age-Z score.

Iraq, as a developing country, confronts challenges pertaining to economic and social development. Moreover, it contends with a multitude of environmental factors that impede the physical growth of children prior to puberty, including diseases, inadequate sanitation facilities, poor hygiene practices, limited access to adequate healthcare coverage and resources, and deficient food consumption. According to estimates from United Nations agencies, one out of eight Iraqi children die before reaching the age of five. Almost one-third of the children may suffer from malnutrition, and one-quarter are born underweight. In addition, another one-quarter lack access to safe water (3). This study was set out with the aim of assessing the risk factors and prevalence of stunting among preschool children in the Halabja governorate. The results showed that the prevalence of stunting among 646 children was 7.9%, indicating a high rate. Overall, the rate of stunting was higher than that found in Kosovo (16), yet considerably lower than in previous local studies from Baghdad (3, 8) and China (14), Nigeria (1), and Indonesia (2). The stunting prevalence in this study was similar to that of Brazil (9.9%), Vietnam (9.53%), Ethiopia (8.9%), and Iran (8.2%) (3–6).

Regarding the role of gender in stunting, there have been different outcomes (1–3, 17). Agho et al. reported that gender was a robust predictor of stunting in children aged 0–23 and 0–59 months. During infancy and childhood, girls were found to be less susceptible to stunting and severe stunting compared to boys (2). In contrast, another study revealed that, despite not being statistically confirmed, girls were more susceptible to stunting than boys, indicating that girl's growth might be more influenced by environmental factors like infectious diseases (3). A lack of gender roles in stunting has also been reported (17). Our study supported the latter assumption.

In the literature, numerous factors associated with stunting have been discussed, including environmental factors, number of family meals per day, age, gender, socioeconomic status, parental occupation, parental education, perceived birth size, diarrhea, breastfeeding duration, complementary feeding, maternal body mass index, family size, and residency (1–3, 18–20). Akombi et al. found a significant association between the duration of breastfeeding and stunting. Children breastfed for more than 12 months were found to have a higher likelihood of experiencing stunting and severe stunting compared to those breastfed for less than 12 months. They claimed that this outcome could be attributed to various factors, including cultural influences, exclusive breastfeeding practices, socioeconomic conditions, the time of initiating complementary feeding, the quality of complementary foods, and the educational status of the mothers (1). In the present study, there was no statistically significant association between stunting and age. The highest percentage of stunted children were breastfed children

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TABLE 3 Association between nutritional status (assessed by HAZ) and parents' level of education, mothers' occupation, mothers' age, family size, and family socio-economic status.

Variables	HAZ*			
	Stunting	Normal	Total	*p*-value
	No. (%)	No. (%)	No. (%)	
Mothers' education				
Illiterate	3 (0.5)	36 (5.6)	39 (6)	
Primary and secondary school	24 (3.7)	257 (39.8)	281 (43.5)	
Diploma	11 (1.7)	156 (24.1)	167 (25.9)	1.00
Bachelor	13 (2)	139 (21.5)	152 (23.5)	
Higher education	0 (0)	7 (1.1)	7 (1.1)	
Total	51 (7.9)	595 (92.1)	646 (100)	
Fathers' education				
Illiterate	3 (0.5)	9 (1.4)	12 (1.9)	
Primary and secondary school	22 (3.4)	319 (49.4)	341 (52.8)	
Diploma	11 (1.7)	117 (18.1)	128 (19.8)	1.00
Bachelor	14 (2.2)	135 (20.9)	149 (23)	
Higher education	1 (0.1)	15 (2.3)	16 (2.5)	
Total	51 (7.9)	595 (92.1)	646 (100)	
Mothers' occupation				
Housewife	37 (5.7)	399 (61.8)	436 (67.5)	
Employee	14 (2.2)	186 (28.8)	200 (31)	1.00
Unknown	0 (0)	10 (1.5)	10 (1.5)	
Total	51 (7.9)	595 (92.1)	646 (100)	
Mothers' age group				
15–24	1 (0.1)	19 (2.94)	20 (3.1)	
24–35	27 (4.2)	333 (51.55)	360 (55.7)	
35–45	20 (3.1)	214 (33.1)	234 (36.2)	1.00
≥45	3 (0.5)	29 (4.5)	32 (5)	
Total	51 (7.9)	595 (92.1)	646 (100)	
Family size				
3–5 person	37 (5.7)	479 (74.1)	516 (79.9)	
6–9 person	13 (2)	116 (18)	129 (20)	1.00
≥9 person	1 (0.2)	0 (0)	1 (0.1)	
Total	51 (7.9)	595 (92.1)	646 (100)	
Family socio-economic status				
Low	11 (1.7)	100 (15.5)	111 (17.2)	
Medium	27 (4.2)	346 (53.5)	373 (57.7)	1.00
High	13 (2)	149 (23.1)	162 (25.1)	
Total	51 (7.9)	595 (92.1)	646 (100)	

*HAZ, height-age-Z score.

(3.3%). Stunting is a reflection of chronic malnutrition, so this finding may be explained by improper nutrition of the mother during pregnancy and the lactation period. Additionally, the high percentage of stunting in those who started complementary feeding after 6 months may be due to the malpractice of giving food, as the family thought it was time to give everything to their child, but this may be a misconception, consequently leading to stunting. Moreover, this study showed that children born at full term had a higher percentage of stunting than those born prematurely; this is in contrast to the study of Sullivan et al. (21). The explanation for this in our study may be that families of preterm babies took care of their babies more seriously than those of full-term babies and more carefully followed the pediatrician's advice because of the babies' condition.

It has also been found that infants who were perceived by their mothers as being of smaller or average size at birth displayed a greater propensity for experiencing stunted and severely stunted growth in comparison to larger newborns. This diminished birth size may be attributed to inadequate maternal nutrition during the gestational period. Throughout this critical period, the child is entirely reliant on the mother for nourishment through the placenta. Consequently, any deprivation of nutrition by the mother can have detrimental effects on the child's growth and optimal development (1). Furthermore, the study presented a significant association between the mother's BMI and stunting in children under 5 years old. Mothers with a BMI below 18.5 kg/m^2 were more prone to have stunted children when compared to mothers with a BMI of 25 kg/m^2 or higher (1). Unfortunately, in this study, we could not represent any data regarding that, but another reason for such a higher incidence in full-term babies might be due to the dual mentioned factors.

Akombi et al., in a study on the Nigerian population, found that children from economically disadvantaged households faced a higher risk of stunting compared to children from more affluent households. This phenomenon could be attributed to the limited financial resources available to poorer families, resulting in inadequate spending on proper nutrition and making them more vulnerable to infectious diseases due to not reaching basic health care services (1). Comparable findings were derived from cross-sectional studies conducted in Iran (7) and Nepal (18). However, Sarma et al. demonstrated that children of rich families may also be affected by stunting (20).

Offspring of educated fathers have shown a reduced likelihood of experiencing stunting in comparison to children born to fathers with limited education. Moreover, children born to educated mothers who were breastfed demonstrated a decreased probability of severe stunting in contrast to children born to uneducated mothers who were not breastfed. These findings underscore a positive correlation between breastfeeding and parental education in fostering the development of their children (1, 18, 22). Another study showed that children whose mothers had bachelor's degrees were less likely to be affected by stunting compared to those whose mothers had diplomas or lower educational attainment. They explained that mothers with higher levels of education had greater knowledge about their children's health and nutrition, leading to improved childcare practices, increased utilization of health services, and better attention to hygiene and sanitation (7). Despite all of that, other studies have found that fathers' education was not correlated with being affected by stunting or not (7, 23). In addition, it has been reported that children with educated mothers showed a higher likelihood of being stunted than those whose mothers had no formal education. This was explained by the possibility that educated mothers were more likely to be employed, which might have led to reduced time available for childcare responsibilities (5). Giao et al. also revealed that housewife mothers and mothers with seller occupations were less likely to have stunted children than mothers employed in the public sector (6). Regarding the relationship between stunting and family education, this study showed a high prevalence of stunting in children whose mothers completed primary and secondary school, followed by those with bachelor's degrees and diplomas. These results may be explained by the fact that illiterate mothers in our community easily follow the instructions and advice given by experts in the field compared to those who have access to getting steps by themselves. In our study, the father's education played a reverse role in comparison to the previously mentioned studies (1, 18, 22). This may be related to the fact that families with illiterate fathers still have traditional feeding practices and easily follow instructions.

Our findings showed that a high percentage of the mothers of stunted children were housewives, although this may be due to the fact that most mothers in our region were housewives or families with employed mothers were economically more stable. The mothers of the stunted children were mostly young, similar to the study by Giao et al. (6). Children from middle-income families had a higher incidence than those from high- and low-income families. This finding might be due to the inaccuracy of the information given about family income in our sample data.

The major limitations of this study can be attributed to the nature of the study design, which is subjected to bias by respondents providing inaccurate data, and the collection of data in a small geographical area. However, this study can be a starting point for further studies with larger samples occupying a wider geographical area to accurately point out the factors and prevalence of the disease in the Iraqi population. Research to examine whether the historical chemical warfare has enduring effects on growth in both recent and future generations could be intriguing.

Conclusion

The prevalence of stunting in the studied population was 7.9%. However, we could not find any significant association between the studied factors and stunting. Thus, the factors that may significantly affect stunting in our area of study, especially the historical chemical warfare side effects, need to be more extensively investigated in future studies.

Data availability statement

The datasets presented in this article are not readily available because if needed, after that, it will be uploaded. Requests to access the datasets should be directed to fahmi.hussein@univsul.edu.iq.

Ethics statement

The study involved humans and was approved by the University of Halabja, Halabja, Kurdistan, Iraq. The study was conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' parents.

Author contributions

HM: Data curation, Investigation, Writing – review & editing. ZN: Conceptualization, Formal analysis, Writing – original draft. KHH: Methodology, Validation, Visualization, Writing – review & editing. DH: Data curation, Investigation, Validation, Writing – review & editing. HA: Conceptualization, Validation, Visualization, Writing – original draft, Writing – review & editing. KMH:

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Conflict of interest

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A 30-year trend of dairy consumption and its determinants among income groups in Iranian households

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Introduction: Milk and dairy products provide essential nutrients and have the potential to prevent chronic diseases, thus reducing healthcare costs. However, there is a lack of consistent and updated data on dairy consumption trends in Iran. This study aims to analyze the trends in dairy consumption among Iranian households from 1991 to 2021, focusing on household-level determinants across different expense groups.

Methods: The study uses data from the Iranian Household Expenditure and Income Survey conducted annually from 1991 to 2021 to analyze households' dairy consumption. The data includes values and expenses of food and non-food items purchased in the previous month, as well as demographic characteristics of household members. The households were categorized into 10 deciles based on their gross expense. The econometric model used weighted mean *per capita* milk, yogurt, cheese, and total dairy consumption based on milk equivalent for each decile. The model takes into account changes in income, prices, household composition, education level, occupation, and residency area using panel data. Data preparation and model estimation were performed using RStudio and STATA17 software.

Results: Based on the findings, in 1991, *per capita* milk, yogurt, and cheese consumption were 26.77 kg, 16.63 kg, and 2.42 kg, respectively. By 2021, these figures changed to 22.68 kg, 11.06 kg, and 3.79 kg, reflecting a decrease in milk and yogurt consumption but an increase in cheese consumption. Family size was positively correlated with yogurt consumption and head of the household spouse's job score were positively correlated with milk, yogurt and cheese consumption. Also, the presence of under five-year-old children and older adults members (over the age of 60) in the household was inversely related with yogurt and cheese consumption. Female-headed households tended to purchase more cheese, while their milk purchase level was significantly lower. Residing in urban areas was negatively related to milk, while cheese and total dairy consumption was higher in urban areas.

Discussion: The findings highlight the importance of targeted dairy subsidy interventions and educational programs to improve dairy consumption in Iranian households, especially among vulnerable groups. This will require urging policymakers and food system stakeholders for effective strategies that address macro-level factors to promote dairy consumption.

KEYWORDS

dairy consumption, household, determinants, policy, sanction, *per capita*, panel analysis

1 Introduction

Over the past 8,000 years, milk and fermented dairy products have been an integral part of the human diet, with their consumption deeply rooted in animal domestication (1, 2). Dairy products are rich sources of essential proteins and minerals, including calcium, potassium, zinc, and phosphorus, providing more micronutrients per kilocalorie than any other natural food in human diets (3, 4). In low and lower-middle-income countries where access to animal-source foods is limited, milk and dairy products play a vital role in meeting the community's nutritional needs. Despite the challenge of determining the precise impact of each dairy product on human health, current dietary guidelines emphasize daily consumption of milk and dairy products as part of a healthy and balanced diet (5). Furthermore, this food group can potentially reduce the burden of prevalent chronic diseases and significantly lower the medical costs for the community (6).

As global data is insufficient to provide a universal recommendation for milk and dairy product consumption; countries should develop their own guidelines, taking into account various factors, including physical access, price, nutritional status, and food habits of their community. The first (2006) and second (2015) Iranian food-based Dietary Guidelines, recommend consuming 2–3 servings per day of milk or dairy products, with each serving equivalent to 250 cc of milk or yogurt or 45–60 grams of cheese and based on these guidelines, an individual requires 500 to 750 milliliters of milk or its equivalent which amounts to 182.5 to 273.75 kilograms, annually. The average dairy and milk requirement is approximately 228 kilograms per year. Additionally, the "Desirable Food Basket for the Iranian Population" recommends the daily consumption of 250 grams of dairy products (91 kilograms per year) (7). Two national surveys conducted in Iran in 1993 and 2004 provide insight into household food consumption and nutritional status. In 1993, the average *per capita* consumption of milk, yogurt, and cheese was 34 ± 3.7 g/day, 72 ± 4.5 g/day, and 11 ± 1 g/day, respectively. The *per capita* consumption of dairy products in urban and rural areas was 120 ± 8.4 g/day and 147 ± 13.7 g/day, respectively, with a national average of 131 ± 7.9 g/day (equivalent to approximately 47.8 kg of dairy products per year) (8). According to FAO data this year, Iran's milk equivalent supply (excluding butter) was 58.84 kg/capita/year, compared to the world average of 74.03 kg/capita/year. In 2004, the average *per capita* consumption of milk, yogurt, and cheese increased slightly to 38 ± 1 g/day, 73 ± 1 g/day, and 15 ± 1 g/day, respectively. The *per capita* consumption of dairy products in urban areas (142 ± 1.8 g/day) was higher than in rural areas (134 ± 2.7 g/day) and the national average was 139 ± 1.5 g/day (equivalent to approximately 50 kg of dairy products per year) (9). At this time, FAO reported the *per capita* supply of milk as milk equivalent in Iran and the world as 63.95 kg/capita/year and 81.83 kg/capita/year, respectively.

A study conducted in 2014, using the Household Expenditure and Income Survey data revealed that *per capita* milk consumption, as the most commonly consumed dairy product, was 28.95 and 38.44 kilograms in urban and rural areas, respectively, falling far short of the recommended amounts (10). The available data shows that the consumption of dairy products in Iran is significantly lower than the recommended levels, particularly among lower socioeconomic groups. As it has been demonstrated that the intake of protein and calcium in the lowest tertile of socioeconomic status was significantly lower than in the highest socioeconomic status group (11).

Dairy consumption has the potential to reduce the burden of common chronic diseases in the population and significantly reduce healthcare costs for the community. In a study conducted by Javanbakht et al., the cost of medical expenses resulting from preventing type 2 diabetes and cardiovascular diseases can be avoided through daily consumption of 3 servings of dairy in the entire population of Iran has been estimated. The estimated costs for time intervals of 1, 5, 10, and 20 years are as follows: 83.33 million dollars, 31.661 million dollars, 21.138 million dollars, and 63.14934 million dollars, respectively (12). Thus, reducing dairy consumption may lead to increased costs related to the treatment of diseases, disability and care for patients and the older adults, and costs for lost years. For example, in Iran, the average hospitalization costs for older adult patients with osteoporosis in 2017 were estimated to be $3794.13, which should also account for the costs of disability, care for patients and costs for lost years (13). Additionally, it is important to consider dairy alternative foods in the diets of individuals who decide to reduce dairy intake, as this will involve substituting food and nutrients. For instance, replacing Saturated Fatty Acids (SFAs) in the diet with refined carbohydrates such as sugars and starches may increase the risk of Coronary Heart Disease (CHD) (14). Meanwhile, a study analyzing Iranian food intakes based on the desired food basket indicates that the quality of the Iranian diet has decreased in the past decade, resulting in decreased *per capita* consumption of milk and dairy products, meats (except for poultry and eggs), legumes, and vegetables in 2017 compared to 2011. In both periods, *per capita* consumption was less than the recommended amounts of the desired food basket (15). In such circumstances, the consumption of dairy products as an important source of valuable protein and calcium becomes doubly important.

Several factors, including demographic, social, cultural, and environmental factors, influence food choices and dietary patterns, including milk and dairy consumption. At the individual level, factors such as age, sex, education level, income, health status, nutritional knowledge, and psychological aspects, including attitudes toward foods and health, motivations, and values, affect milk and dairy consumption (16). Appendix 1, provides a brief overview of several studies that have examined the individual factors influencing dairy consumption. Beyond the individual level, social and cultural determinants such as lifestyle, societal and family norms, social pressure, social class, social network, and race/ethnicity also influence food choice behavior. Moreover, the local environment, including marketing and advertising pressures, plays a significant role in shaping

the entire milk and dairy products system from production to consumption (16). Studies have shown that subjective norms and social groups, including family, relatives, co-workers/colleagues, and other individuals with whom consumers associate, played a crucial role in influencing Iranian consumers' choice of dairy products (17, 18). It is important to note that Iran's economy has undergone several years of double-digit inflation and economic shocks, which are likely to have had an impact on food prices and household consumption, particularly among lower socioeconomic level households. However, the exact magnitude and severity of these changes remain unclear due to the lack of valid and up-to-date data. For this purpose, various data sources such as Food Balance Sheets, Household Budget Surveys (HBS), or Individual Dietary Surveys (IDS) may be utilized, each with its own advantages and limitations. Typically, national statistical offices conduct HBS to gather nationally representative data on household expenditure, including food, primarily to construct cost-of-living indicators. While HBS data includes information on the quantities of different types of food purchased and their consumption, it represents the food provided at the household level and is often used as a proxy to estimate household food consumption (19). Given that studies on dairy consumption in Iran are generally cross-sectional and have limited sample sizes, the objective of this study is to assess the trends in dairy consumption among Iranian households from 1991 to 2021 and explore household-level determinants. In addition to understanding the current situation, identifying these determinants is necessary to develop and implement appropriate, evidence-based policies and programs aimed at reversing the declining trend in dairy consumption.

2 Materials and methods

2.1 Data preparation

This panel study utilized data derived from the Iranian Household Expenditure and Income Survey which is conducted annually between 1991 and 2021 by the Statistical Center of Iran. The data include households' food and non-food expenses in urban and rural areas of Iran. The food expenses database contains information on 223 food items purchased by households during the previous month, including their amounts, prices, and expenses. Additionally, demographic characteristics, including age, gender, education level, occupation, and marital status of household members are also collected.

To determine households' total dairy consumption as the dependent variable, data was extracted from households that had consumed at least one dairy item each year. The dairy items included in this study were pasteurized and non-pasteurized milk, dried milk, cream, pasteurized and non-pasteurized yogurt, non-pasteurized doogh (yogurt drink), pasteurized and non-pasteurized cheese, and keshk until 2013. From 2014 onwards, some changes were applied to the questionnaires, and other types of milk, pasteurized cream, mixed yogurt, pizza cheese, and mixed cheese were added to the survey. Butter and ice cream were excluded since butter is regarded as fat from a nutrition perspective, and for ice cream only expense data was available. All monthly amounts of dairy items purchased were converted to kilograms per year by multiplying by 12. To calculate the total amount of dairy consumed, it is not sufficient to simply sum up the values of different dairy products. Instead, we employed a conversion method that involved determining the average milk equivalents for each dairy item. This conversion represents the amount of milk required to produce a given dairy product. To establish accurate conversion coefficients for dairy products into milk, we considered the variability in production coefficients based on factors such as the characteristics of the milk consumed and the technology employed in production. To ensure the reliability of these coefficients, we sought the expertise of both our research team and a panel of experts from the Iranian Dairy Association Society. The resulting conversion coefficients, which account for these factors, are presented in Table 1. Non-consumer households were assigned a value of zero for their dairy consumption. Family size for each household was also extracted, and *per capita* consumption was calculated by dividing the consumption value by the family size. Total household expenses were calculated by summing all expense categories, and households were categorized into 10 deciles each year based on their gross expenses. The weight of each household in the sample was provided by the Statistical Center of Iran relative to the population each year. Finally, the weighted mean *per capita* milk, yogurt, cheese, and total dairy consumption for each decile was calculated and entered into the model. All data extraction and preparation were performed using Rstudio software, version 3.5.1.

2.2 Econometric model

The present study applies consumer demand theory to identify factors that influence the demand for dairy foods among Iranian households. The theory implies that changes in food demand result from changes in income and prices, which can be influenced by policies (20). In Iran, due to the increasing inflation rate, prices of food and non-food commodities have been continuously raised (21), and household real income is also affected by several exchange rate shocks (22). As a result, households' food demand has changed considerably; depending on the household expense deciles. For example, *per capita* dairy consumption in the 10th decile of household expenditure has been 3.7 and 2.7 times more than the first decile in 2010 and 2011, respectively (23).

Studies have also shown that Iranian consumers prefer milk, yogurt, and cheese to other dairy items, and these items have the highest consumption among the dairy food group (9, 24). However since the same items show different price elasticity (25, 26), separate equations were used to estimate for household per-capita milk, yogurt, cheese, and total dairy intakes.

Family structure and composition, i.e., age and gender of family members, can also affect their dairy food preferences and consumption. Additionally, household size, occupation, and education

TABLE 1 Conversion coefficients of dairy products into milk.

Product	Coefficient	Product	Coefficient
Pasteurized milk	1.01	UF cheese	5.5
Dried milk	11	Mixed cheese	5.5
Yogurt	1.11	Pizza cheese	4.5
Mixed yogurt	0.9	Doogh	0.5
Brine cheese	7.5	Keshk	2

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are considered some of the other determinants of food choice at the household level (24, 27–31). The variables that entered the model and their definitions are shown in Table 2.

This study used panel data to estimate the econometrics model for assessing dairy demand function. To avoid false regression in estimating the model, the stationarity test of Levin, Lin & Chui (LLC) was used (32) and it was confirmed that some variables are integrated in the first level. Therefore, no risk of false regression was seen in the variables used in this model.

The baseline regression model is as follows:

$$Yit = \beta 0 + \beta 1\, C_{it} + \beta 2 D_{it} + \beta 3 E_{it} + \beta 4\, U_{it} + \beta 5 P_{it} + \varepsilon_{it}$$

In the above equation, Y indicates the weighted mean of *per capita* milk, yogurt, cheese, and total dairy consumption in household expense decile of *i* in year *t*, C*it* is a vector of family composition, D_{it} is other demographic characteristics of households, E*it* is households' economic characteristics, U is urban residence P_{it} is the price of the product and ε_{it} is residual. Regressions were estimated by STATA17 software.

2.3 Ethical considerations

This study protocol was approved by the ethics committee of the National Nutrition and Food Technology Research Institute (No IR.SBMU.nnftri.Rec.1400.059).

3 Results

This study analyzed data on dairy food group consumption of Iranian households from 1991 to 2021. Figures 1–4 show weighted means of *per capita* milk, yogurt, cheese, and total dairy consumption, among Iranian households over thirty years. For clarity and a better understanding of the trends, findings are presented in tertiles instead of deciles.

TABLE 2 The variables entered the model as determinants of household dairy consumption and their definition.

Variable	Definition
Price	Weighted mean of milk, yogurt, and cheese prices
Sex of Household's head	As the weighted ratio of women-headed households
Presence of children under 5 years old in the family	As the weighted ratio of households with children under 5 years old
Presence of adults over 60 years old in the family	As the weighted ratio of households with adults over years old
Household education score	Weighted mean of education scores of adult members. Education scores were: 0 = illiterate, 6 = elementary school, 11 = high school and diploma, 14 = under-graduation university degrees, and 18 = graduate degrees
Mothers' occupation	Weighted mean of mothers' job scores. Scores were: 0 = housewives, 5 = unemployed but have income and 10 = employed
Residency area	The weighted ratio of the urban population

According to Figure 1, higher-income households consume more milk and dairy products than lower-income households. There has been an overall decreasing trend in milk consumption across all tertile groups over time, although the rate of decrease varies somewhat between the income groups. In 2021, the mean milk consumption for the 3rd tertile was 27.05 kg *per capita*, as opposed to 16.50 kg *per capita* in the 1st tertile in the same year. There have also been some fluctuations in mean milk consumption; for instance, there was a slight increase in consumption in the early 2000s followed by a sharp decrease in the late 2000s and another decrease in 2010. The increasing slope of the 3rd tertile was more pronounced between 2000–2005, and the decreasing slope of consumption was slower in the 3rd tertile around 2012 compared to the other two tertiles. However, the decreasing trend in milk consumption has accelerated in both the 2nd and 3rd tertiles since 2018.

Figure 2, depicts a declining trend in yogurt consumption across all income groups, with the weighted mean of yogurt consumption dropping from 16.63 kg *per capita* in 1991 to 11.06 kg *per capita* in 2021. In terms of yogurt consumption, there was a decreasing trend until 1996, followed by a slight increase up to 2004 in the 1st and 2nd tertiles and up to 2005 in the 3rd tertile. However, there is a drop in consumption again, reaching the lowest level for the first three deciles in 2009, with a lower slope in the 3rd tertile. There has been an increasing trend since then, until 2012, when a decrease started and has continued since then.

Higher-income households tend to consume more yogurt than lower-income. Over time, the gap between the mean yogurt consumption for the 1st and 3rd tertiles has increased somewhat, from a mean difference of 2.9 kg in 1991 to 4.79 kg in 2021.

Based on Figure 3, despite the decreasing trend in *per capita* cheese consumption since 2012 for the 2nd and 3rd tertiles and 2014 for the 1st tertile, which has continued until 2021, *per capita* cheese consumption has increased over time across all tertiles of households' expense. For example, in 1991, the *per capita* cheese consumption for the 1st tertile was 1.96, while in 2021, it increased to 3.08. Similarly, the *per capita* cheese consumption for the 3rd tertile was 4.05 in 1991 and 4.25 in 2021.

In terms of differences in cheese consumption across different tertiles, the data indicate that higher-income households tend to consume more cheese than their lower-income counterparts. For example, the 10th decile had the highest *per capita* cheese consumption in most years, while the 1st decile had the lowest *per capita* cheese consumption. The increasing trend of cheese consumption shows a higher slope in the 1st and 2nd tertiles from 1996 to 2004. Additionally, the decreasing slope of consumption since 2014 in the 1st tertile is lower compared to the 3rd tertile. The gap between the 1st and 3rd tertiles of households' expenses has decreased (from 2.09 kg in 1991 to 1.17 kg in 2021).

Figure 4, illustrates an overall increasing trend in dairy consumption across all tertiles until 2005, followed by a decrease with two sharp drops. The first drop occurred in all tertiles since 2011, with the most significant decrease in the 3rd tertile. The second drop was observed around 2018, which had a steeper slope in the 2nd and 3rd tertiles. For instance, the total dairy consumption for the 1st tertile decreased from 59.64 kg in 1991 to 49.04 kg in 2021, while the total dairy consumption for the 3rd tertile decreased from 84.88 kg in 1991 to 81.74 kg in 2021. The weighted mean of *per*

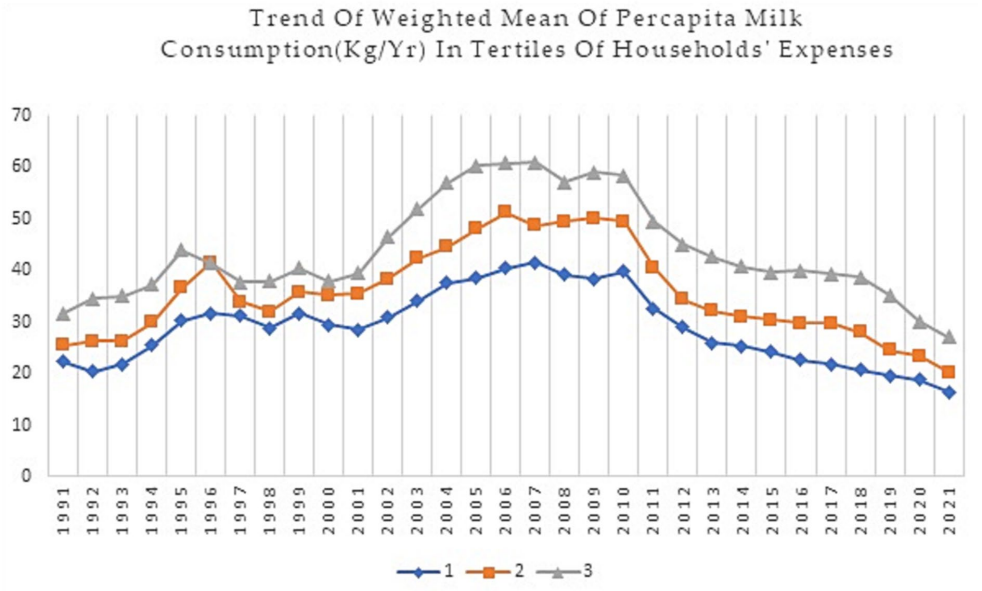

FIGURE 1
Trend of weighted mean *per capita* consumption (Kg/Yr) of milk in households' expenses tertiles during 1991–2021.

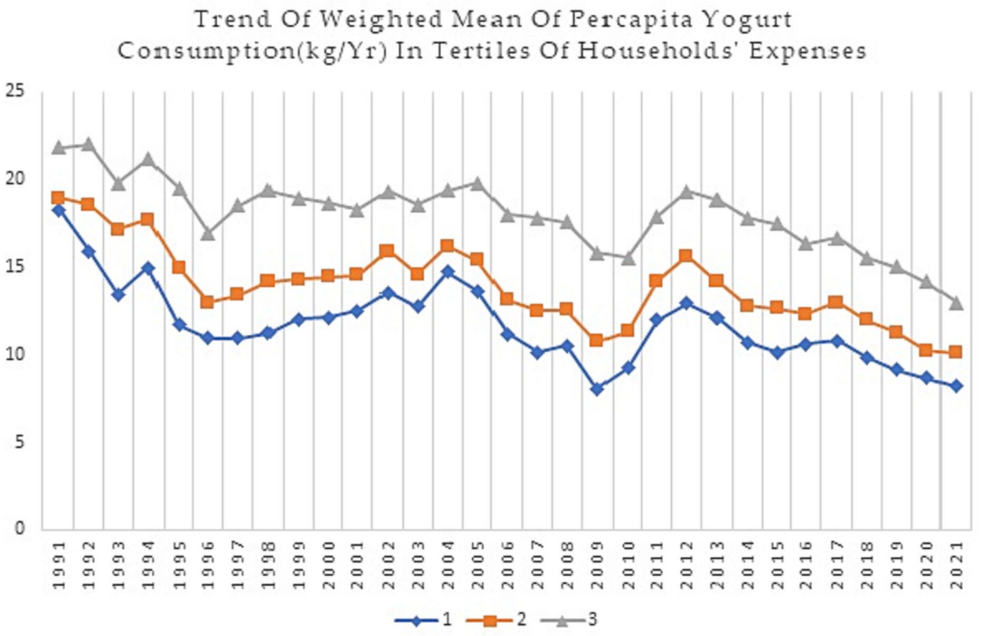

FIGURE 2
Trend of weighted mean *per capita* yogurt consumption (Kg/Yr) in tertiles of households' expenses during 1991–2021.

capita total dairy consumption increased from 63.39 in 1991 to 68.34 kg in 2021.

As shown in Figure 5, the mean *per capita* consumption of milk and yogurt has decreased and cheese has increased over time, from 26.77 kg, 16.63 kg, and 2.42 kg in 1991 to 22.68 kg, 11.06 kg, and 3.79 kg in 2021, respectively. It is also apparent that up to 2015, yogurt has been a substitute for milk in most years, and its consumption increased while milk consumption decreased. However, since then, yogurt consumption has also been on a decreasing trend, similar to milk. On the other hand, cheese consumption shows a similar trend to milk, except that, unlike milk, its overall trend is still increasing.

Findings of the estimated demand function for milk, yogurt, cheese, and total dairy consumption based on milk equivalent are presented in Table 3. This highlights that household expense was positively associated with the amount of all types of dairy

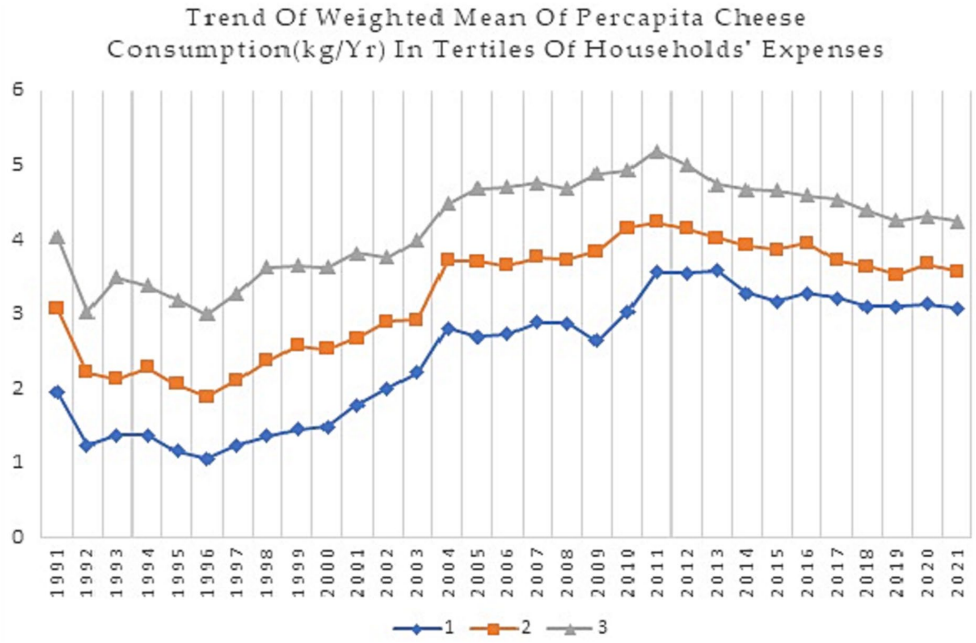

FIGURE 3
Trend of weighted mean *per capita* cheese consumption (Kg/Yr) in tertiles of households' expenses during 1991–2021.

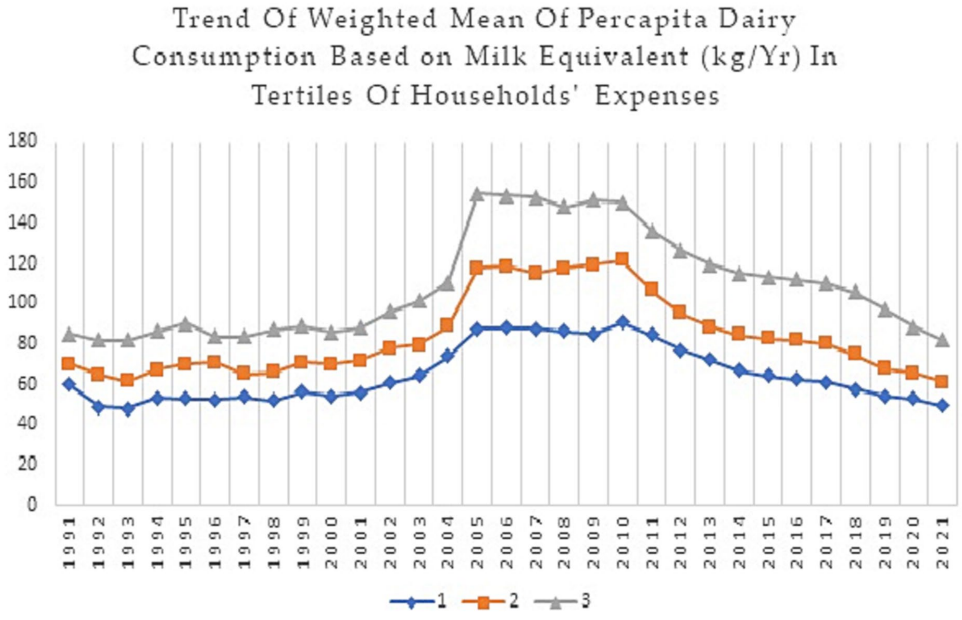

FIGURE 4
Trend of the weighted mean of *per capita* dairy consumption based on milk equivalent (Kg/Yr) in tertiles of households' expenses during 1991–2021.

consumption, while product price had a negative association. Family size showed a positive relationship between yogurt and total dairy consumption but a negative relationship with cheese consumption. Family education score had a significant positive relationship with milk, but a negative association with cheese and total dairy consumption. Housewives' job scores showed a statistically significant positive relationship with milk and cheese consumption. The share of families with children under 5 years old had a significant negative relationship with all dairy items, but not with total dairy, while the share of families with older adults members (over 60 years old) had an inverse relationship with yogurt and cheese, and total dairy consumption. Living in urban areas was negatively associated with milk consumption but positively associated with cheese and total dairy consumption.

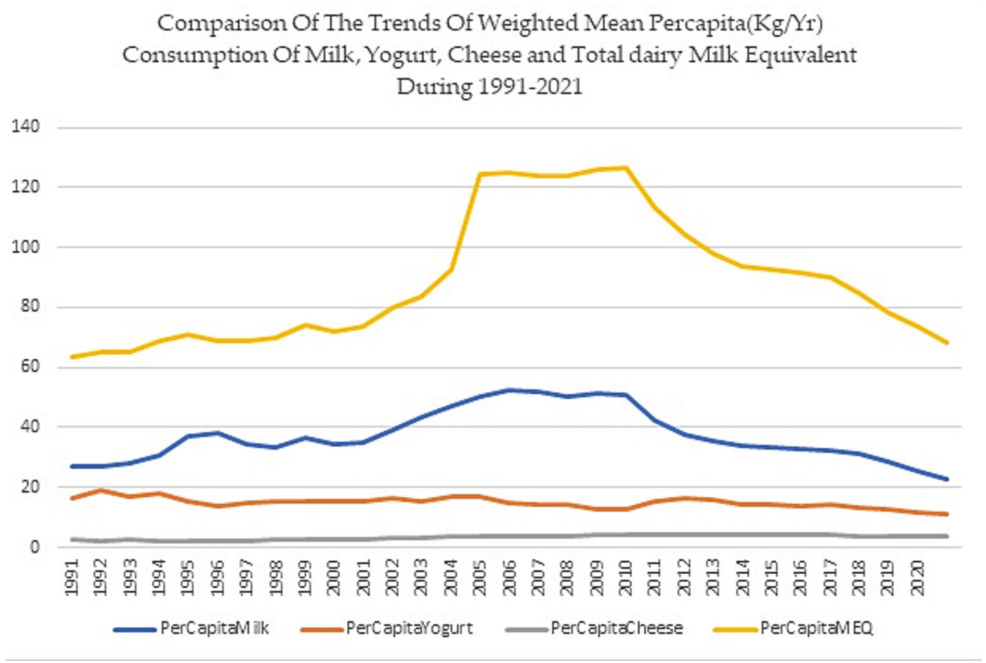

FIGURE 5
Comparison of the trends of weighted mean *per capita* consumption of milk, yogurt, cheese and total dairy based on milk equivalent during 1991–2021.

4 Discussion

The present study showed that despite an increasing trend in dairy consumption from 1997 to 2005 overall dairy consumption among Iranian households had a declining trend, with two significant drops in 2011 and 2019. There is also obvious that all tertiles have decreased their consumption since 2007, but 2nd and 3rd tertiles are less affected at least till 2018.

As shown in Figure 6, Iran began subsidizing pasteurized milk in (33). After the revolution, with the start of the Iraq war, the government introduced a voucher system to provide some main food items such as cheese. By the end of the war, due to the adoption of expansionary policies for the prosperity of production, the inflation rate increased and reached a peak of 50% (34). Despite the US imposing economic sanctions at that time (35, 36), the inflation rate began to decline. Meanwhile, the government implemented policies such as the guaranteed purchase of raw milk (37) and the school milk program (38) to safeguard producers and consumers, contributing to an uptrend in dairy consumption until 2005. However, with the change of government in 2005 and Iran's nuclear program's escalation, leading to its referral to the Security Council in 2006 inflation and sanctions intensified (34). The government implemented price stabilization measures (39), to counter inflation's effects while termination of the household cheese voucher program. But a slight reduction in dairy consumption is obvious. In 2010, the United Nations Security Council (UNSC) approved resolution number (40), further intensifying previous sanctions. Meanwhile, at the beginning of 2011, following government economic reforms and the Targeted Subsidies Law (41), subsidies were removed for goods such as gasoline, oil, water, and milk, substantially increasing milk and dairy prices during five years, and the inflation rate starts its ascending trend. The government distributed some of its revenue to the public as cash transfers to combat price hikes, but this led to significant inflation. This is the first considerable drop in dairy consumption. The trend of declining dairy consumption slowed after 2014, coinciding with a decrease in inflation rates and the JCPOA's approval in 2015. However, the US's withdrawal from the JCPOA in 2018, coupled with the COVID-19 pandemic in 2019, led to a second drop in dairy consumption due to an increase in inflation rates. Despite the government's efforts to control dairy prices by granting preferential exchange rates for livestock feed imports, dairy consumption continued to decline.

Other cross-sectional and longitudinal studies also mention the low consumption of milk and dairy products among Iranians and its decreasing trend (42–44) despite the increase in dairy production (45). For example, in a cross-sectional study on a subsample of a population-based cohort study of the "Tehran Lipid and Glucose Study" with 827 subjects (357 men and 470 women) aged 18–74 years, the mean (±SD) consumption of milk, yogurt, and cheese was 0.7 ± 0.2, 1.06 ± 0.6, and 0.9 ± 0.3 servings/day, respectively (46). The Iran National Comprehensive Study on Household Food Consumption Pattern and Nutritional Status 2001–2003 also showed that the *per capita* means daily consumption of milk and dairy groups in urban and rural households was 142.3 ± 1.8 and 134.1 ± 2.7 grams/day, respectively, with a total of 139.6 ± 1.5 grams/day (around 51 kg/year) (11) which is lower than the amount reported in the present study at that. This could be because the Household Expenditure and Income Survey used in the present study is a reliable proxy for household food consumption but does not consider food loss, waste, or food used for other reasons such as guests (19).

The findings of the study also showed that household expenses (as a proxy of income) have a positive relation and food price shows a

TABLE 3 Results of estimating milk, yogurt, cheese, and total dairy demand function.

	Milk		Yogurt		Cheese		Total dairy (Milk equivalent)	
	β	*t*	*β*	*t*	*B*	*t*	*β*	*t*
Family size	−1.873	−1.360	2.345***	3.740	−0.422***	−3.530	15.07**	2.340
Family education score	1.452*	2.030	−0.355	−0.850	−0.176**	−2.080	−7.22**	−2.190
Housewife job score	12.607***	9.060	−0.466	−0.940	0.297**	3.100	−27.89**	−2.630
Share of pasteurized milk	47.167***	16.270						
Household expense	6.83E-09*	1.870	4.54E-09**	2.590	2.14E-09***	6.270	2.58E-08*	1.760
Product price	−0.051***	−6.140	−0.001*	1.860	−1.23E-04**	−2.880	−2.46E-04**	−2.120
Share of women-headed households	−60.036**	−4.130			9.754***	8.520	−76.366**	−5.10
Share of families with children under 5 yr	−14.267**	−4.910	−7.282**	−3.130	−3.966***	−8.120	−28.79	−0.860
Share of families with members more than 60 yr	3.247	0.140	−19.307***	−4.170	−11.303***	−8.550	−223.43**	−2.450
Urban living	−55.220***	−5.890	2.924	0.920	1.176 *	1.900	80.98*	1.850
Intercepts	41.604	3.170	10.167*	1.770	7.226***	6.630	87.198*	1.850
F	237.220**		41.26**		−0.639**		47.99**	
R^2	0.891		0.531		0.865		0.012	
F- limer	5.17	*p*-value: 0.00	6.720***	*p*-value: 0.000	4.540***	*p*-value: 0.000	13.01***	*p*-value: 0.001
Hausman test	43.05	*p*-value: 0.00	51.310***	*p*-value: 0.000	33.040***	*p*-value: 0.000	259.69***	*p*-value: 0.089

*, **, *** are significance levels of 90, 95, and 99 percent, respectively. Results of the Fixed effect model for milk, yogurt, and cheese and the random effect model for Total dairy are presented.

significant inverse relation with milk, yogurt, and cheese consumption, although, among them, cheese seems less affected while milk was the most affected dairy items. Additionally, these studies show higher amounts of yogurt consumption, while milk consumption purchase is higher in the present study. This is probably due to the culture of home yogurt making, mainly in rural areas, e.g., in Turkey, where consumers of non-pasteurized milk, buy milk to make yogurt (47).

Iran's economic sanctions have resulted in austerity policies causing inflation, stagnation, and recession, resulting in lower household incomes and rising commodity prices, and likely leading to a sharp decline in dairy consumption (17). Targeting subsidies also led to a significant increase in milk and dairy prices, as production costs rose due to the elimination of subsidies as well as removing milk subsidy and high inflation due to the adoption of this policy. From 2010 to 2014, the price of milk increased by approximately four times based on the author's calculation.

As mentioned before, inflation reduces household real income, while studies indicate that economic factors such as price and income affect dairy consumption (48–51). For example, Maitah and Smutka noted an increase of about 68% in milk consumption in the Middle East and North Africa during 1990–2008, with country- level *per capita* income being the most significant factor for this rise (52). Bousbia identifies income level and price as major factors impacting the variation of dairy product consumption (53). In Brazil, the cost of dairy products has been an important factor related to their low intake (54). It is worth noting that all income groups are not affected by increasing the price or inflation in the same value. Low-income groups are more sensitive to income and price fluctuations as allocate a larger share of their income to food than higher-income households (55, 56). On the other hand, low consumption levels respondents are more responsive to changes in income (57). As household income increases, the possibility of consuming dairy products increases. In other words, a more diversified diet using more expensive animal food sources like milk and dairy products is possible with increasing household income or decreasing the prices of these products.

However, the effect of income is not uniform on all dairy products. The findings show that although cheese consumption (mainly white cheese) has a slower decreasing trend, its overall trend indicates an increase. Most Iranians consume cheese with bread for breakfast, making cheese consumption a part of their food culture (58). This could justify the slower decreasing trend, and the study's findings align with those of other studies (58, 25). In 2019, another drop in dairy consumption was observed, mainly in the 2nd and 3rd tertiles of income, which could be attributed to the COVID-19 pandemic and high inflation rates of 31.2, 41.2, and 47.1% during 2019–2021. A nationwide cross-sectional survey by Nikooyeh et al. found a significant decrease in dairy product consumption, particularly milk, and yogurt, in a high proportion of households during the COVID-19 epidemic lockdown (58). A similar decreasing trend in dairy consumption due to COVID-19 has also been reported for other countries such as China mainly due to the price increases, income loss, and insufficient savings combination (59). However, some others reported increasing dairy products consumption in the same period compared with that before the COVID-19 outbreak due to consumer health concerns (60).

The present study demonstrated that factors such as household composition and size have an impact on total dairy consumption. It seems that larger families tend to prefer yogurt consumption to cheese. Yekta et al., reported that household size has a positive and statistically important effect on yogurt consumption and large families

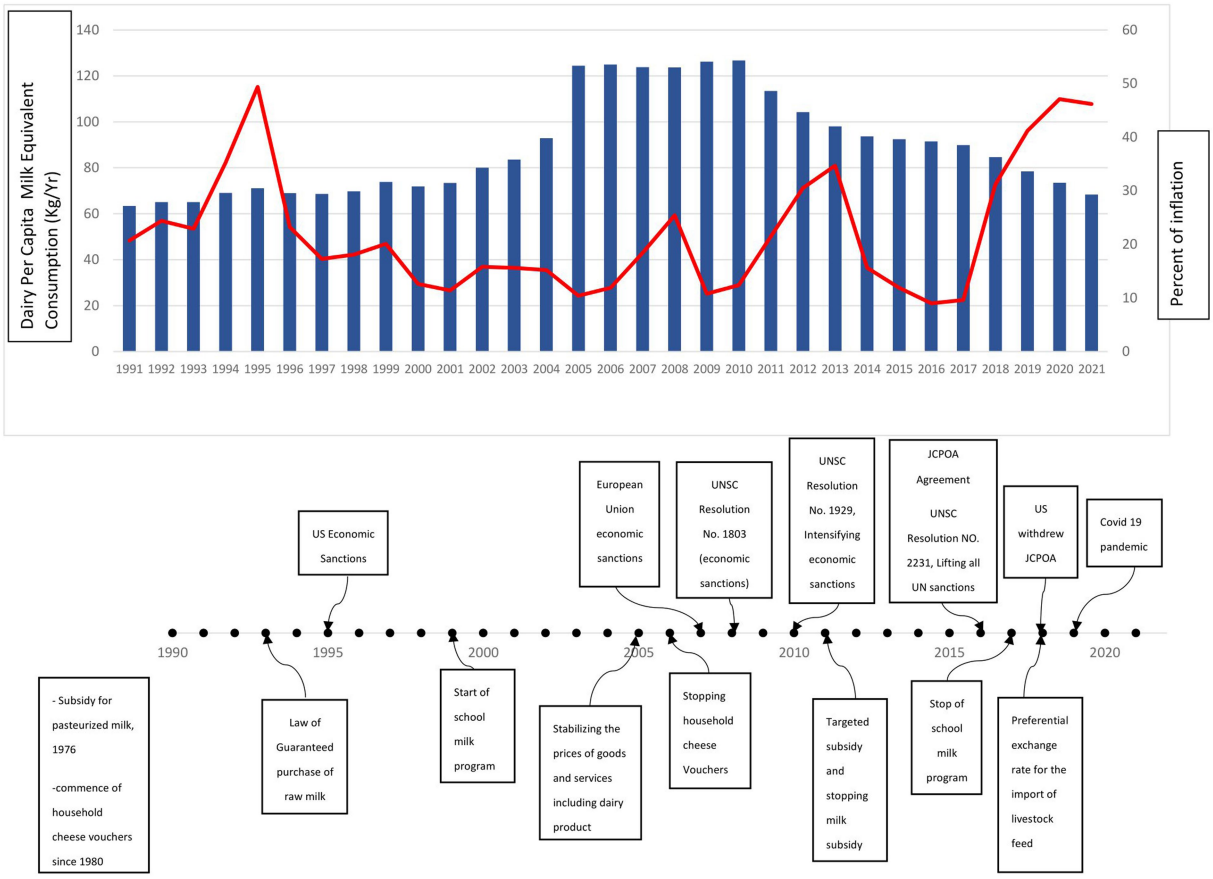

FIGURE 6
Total dairy consumption trend based on milk equivalent in comparison with inflation trend and timeline of major dairy food system and contextual events.

consume more yogurt than small families. Other studies have also found a positive association between household size and yogurt consumption (47). It seems that family size exerts its effect on dairy consumption in two ways. As Phuong et al. (61) concluded, family size has a positive effect on milk product buying decisions, as families perceive dairy as part of their children's diet (62); however, it has a negative effect on household's dairy expenditure on a *per capita* basis. Radam et al., also showed that consumers from households with four or more people, including children, tended to be more price-sensitive and less likely to pay for expensive food (63). Hagh et al., found that households in the lowest-income groups consumed significantly lower amounts of livestock and dairy food items as the family size increased (64). Also, Hannan et al. reported that as the family size increases, the budget shares for milk will decrease (65). Based on the Iranian cultural preference for yogurt consumption (66) and the perceived health benefits associated with yogurt, it can be concluded that family size has a significant impact on dairy consumption, particularly yogurt.

Family education score was negatively related to yogurt, cheese and total dairy consumption. Vakili et al., also showed that People with a high school diploma and lower levels of education consumed substantially more dairy products than more educated ones (67). Contrary to these findings, some other cross-sectional studies in Iran (66), indicated that higher education level increases the probability of choosing dairy products. Streeter and colleagues also showed that in China, better-educated respondents favor lower-calorie diets with more animal foods, fruit, and dairy but less cereals (57). Similar results were observed in Turkey where dairy product consumption was higher in those with a higher level of education (68). In recent years, there has been an international discourse about the potential association between high dairy consumption and an increased risk of certain non-communicable diseases (69, 70). As educated individuals often have greater access to information (71), they may be more aware of such concerns, which could have influenced their consumption patterns. Furthermore, there has been significant negative publicity surrounding the Iranian processed dairy industry, such as the unauthorized use of palm oil by the dairy industry being brought to the media's attention by the Minister of Health in 2015, or the discussion on aflatoxin contamination of milk on a national television show by an expert. However, it is important to note that there is also evidence highlighting safety concerns related to dairy consumption (72), as well. Considering that individuals with higher education often exhibit more sustainable and conscious eating behaviors (73), these factors may influence their dairy consumption.

Our study revealed a positive correlation between the job score of mothers and consumption of milk and cheese, while showed a negative correlation with overall dairy consumption. These findings

align with the research conducted by Kaheni et al., who also demonstrated a positive relationship ($p = 0.03$) between maternal employment and milk consumption among children aged 6–11 in Birjand (74), Iran. Another study by Widodo et al. (75) reported higher dairy consumption in Indonesian children whose mothers had permanent jobs (75). However, these findings contrast with Afrin et al.'s systematic review, which indicated that maternal employment tends to have more adverse effects than favorable on children's dietary patterns. The review concluded that in dual-income families, maternal employment may provide the financial means to afford healthier food options. Nevertheless, it also highlighted that employment can impose time constraints that affect meal-related behaviors (76). Therefore, the increased consumption of milk and cheese observed in our study could be attributed to greater resources provided by working women. However, the lower overall dairy consumption might be a result of time constraints, reduced supervision, and less caregiving by these women toward their families and possibly themselves. Interestingly, our study also revealed that female-headed households tend to consume more cheese and total dairy while have lower milk consumption. This finding is in contrast with other studies that have shown female-headed households have lower dairy consumption (58, 77) probably due to their limited resources. However, our study also found a positive relationship between female-headed households and cheese consumption. This may be due to the role of cheese in Iranian food culture, where cheese and bread can serve as a meal and may also be seen as a valuable source of protein for the households. Due to cheese's substantial weight in converting to milk equivalent, it is probable that it also influences overall dairy consumption.

We found a significant negative relationship with having under 5 age children and all dairy items but not total dairy. In contrast to the present study, several studies indicated that the presence of young children in the household positively affects household dairy consumption (78–81). Radam et al. showed that households with children less than 12 years of age were generally less concerned about price and more interested in purchasing safe and wholesome food (63). It may be rooted in economic issues as studies show there is a well-established relationship between household poverty and having children under the age of five. In general, households living in poverty are more likely to have young children. This is because poverty is often associated with a lack of access to education, healthcare, and family planning services, which can lead to higher fertility rates (82, 83).

The present study demonstrated that the presence of family members over 60 years in households was also inversely related to yogurt, cheese and total dairy consumption. In contrast, Possa et al. (54) showed that older adults subjects had the highest total dairy intake, milk, and cheese in Brazil (54). In another study on global, national, and regional estimates of milk and dairy beverage consumption, higher values were reported for the older adults (84). Align with the present study, a study in Switzerland reported that adults and the older adults did not consume the recommended number of dairy products per day. Besides, 25.0% of the individuals reduced dairy consumption to decrease fat or cholesterol intake (85). Although the amount of consumption is much less than in this study in Iran, geriatric health concerns may also affect older adults dairy consumption. For example, traditional Iranian medicine considers dairy food as cold temperament foods that exacerbate bone and joint pains that should be avoided (86). On the other hand, medical costs, in particular, can be a significant burden for older adults, particularly those who have chronic health conditions or require long-term care which may result in inappropriate economic conditions which affect their consumption as well (87).

The present study showed that residing in urban areas was negatively related to milk and positively related to cheese and total dairy consumption. In contrast with these findings, several studies showed that dairy product consumption among urban households is much more than in rural ones (57, 61, 79, 88). The difference is due to the different methodologies. In other words, these studies evaluate consumption while Household Expenditure and Income Survey studies assess household purchases. It seems that in rural areas people mainly buy milk and using home processing convert it to dairy products while urban people purchase less milk and instead, buy and consume more cheese. This difference may be attributed to rural households' access to raw milk as well as market and dairy products. A study in rural Ethiopia demonstrated that household cow ownership increases children's milk consumption and this ownership is less important where there is good access to local markets (89). Moreover, regarding the urban–rural income gap (90, 91), the economic situation may also negatively affect cheese consumption among rural households (77).

Strengths of the current study included the use of panel data to consider crosses effects (expenditure deciles) in addition to time series to draw a picture of Iranian dairy consumption using recent and large nationally representative data. Assessing the role of demographic and socio-economic factors in dairy consumption allows for deep problem identification and adoption of appropriate policy interventions unique to these households. It is also important to consider the limitations of the Household Expenditure and Income Survey analysis. One of the most important is the lack of information about the food allocation within the family. Also, the present study did not consider other determinants of dairy consumption such as the role of habits, nutritional knowledge, perceptions, and hedonic attributes of dairy products.

5 Conclusion

In conclusion, this study provides insight into the trends and determinants of dairy consumption in Iranian households. It also showed that the determinants of consumption vary for different dairy items, and it is more appropriate to evaluate them individually rather than as a group. This is particularly evident when converting dairy to milk equivalent, as the consumption pattern sometimes follows the trend of cheese due to its high weight in the conversion process. Therefore, using milk equivalent as a method to evaluate overall dairy consumption may not be a perfect approach. The findings indicate a declining trend in overall dairy consumption, with household income and product price showing significant positive and inverse relationships with milk, yogurt, and cheese consumption. Family size, family education score, and head of the HH spouse's job score were found to be positively correlated with dairy consumption, while the presence of children under the age of five and older adult members (over the age of 60) had inverse relationships with yogurt and cheese consumption. Female-headed households tend to purchase

more cheese, while their milk consumption is significantly lower. Residing in urban areas was negatively related to milk consumption, while cheese consumption was higher in urban areas. Based on the findings, it is necessary for policymakers to adopt appropriate economic policies at the macro level and take necessary measures to improve the economic situation of the society. Additionally, implementing supportive policies and allocating subsidies to promote dairy consumption can be achieved through interventions such as food support programs for female-headed households or the older adults. Furthermore, implementing suitable educational programs at the community level, along with supportive programs to enhance knowledge and attitudes toward dairy consumption, can also help to improve the consumption of this food group. However, further research is needed to explore the role of other determinants of dairy consumption, such as dietary habits, nutritional knowledge, and perceptions of dairy products.

Data availability statement

The data presented in this study is not publicly available due to privacy restrictions. Requests to view these datasets should be directed to the corresponding author.

Author contributions

RR: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Writing – original draft, Writing – review & editing. HE-Z: Conceptualization, Methodology, Supervision, Writing – review & editing. DG: Data curation, Formal analysis, Methodology, Writing – review & editing. EM: Data curation, Formal analysis, Investigation, Software, Writing – review & editing. NO: Formal analysis, Writing – review & editing. HH: Formal analysis, Writing – review & editing. SH: Data curation, Software, Writing – review & editing. HR: Conceptualization, Methodology, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1261293/full#supplementary-material

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Public food procurement as a tool of sustainable food and nutrition policy—fat products

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Introduction: Ensuring a sustainable and responsible diet, particularly in the procurement of fatty products, holds paramount importance for early childhood development. Dietary fats significantly influence children's growth and well-being, both in the short and long term. Schools and kindergartens play a pivotal role in shaping children's dietary habits. This study aims to quantitatively and qualitatively analyze public procurement orders conducted by educational institutions.

Materials and methods: Out of 1,126 public procurement orders, 197 met inclusion criteria, leading to the identification of 1,248 products categorized as sources of fats in children's diets. The study conducted both quantitative and qualitative analyses on the identified products.

Results: Criteria commonly employed by purchasers were derived from product descriptions. While product composition, especially fat content and the absence of certain additives, received due attention, organoleptic characteristics criteria were frequently overlooked. Sustainable procurement criteria were given the least consideration. The study highlights a notable reliance on vegetable oils, predominantly rapeseed oil. However, it reveals a worrisome prevalence of animal-derived fats, including butter, mayonnaise, pork belly, and lard. Although plant-based fats constitute around 52.77% of total orders, the substantial presence of animal fats poses challenges to maintaining a balanced and healthy diet for children.

Conclusion: The study underscores the necessity of establishing specific criteria for evaluating the quality of delivered products, especially fatty items, in educational settings. Standardized guidelines are crucial to promote healthier food choices, encourage sustainable diets, and ultimately enhance the overall health and well-being of children.

KEYWORDS

public food procurement, food policy, fat products, schools and kindergartens, nutrition policy, sustainability

Introduction

Rational nutrition is defined as systematically providing the body with an optimal amount of energy and all necessary nutrients, including proteins, carbohydrates, fats, vitamins, and minerals. A healthy nutritious provides beneficial nutrients (e.g., vitamins, minerals, essential amino acids, essential fatty acids, dietary fibre) and minimizes potentially harmful elements (e.g., sugars, saturated fats, anti-nutrients, quantities of sodium). Consuming these macronutrients and micronutrients in appropriate proportions, according to the body's needs, enables normal functioning and significantly influences one's health. Proper nutrition ensures proper growth and development in children. On the other hand, unhealthy nutrition leads to numerous lifestyle diseases. Both excess and deficiency of nutrients can cause serious health disorders, such as obesity or malnutrition (Neufeld et al., 2021).

It is crucial to create an environment in schools that promotes the development of healthy habits, including dietary habits, in a proper and supportive manner during children's education. Incorporating appropriate child nutrition into a healthy lifestyle is essential for ensuring proper development, preventing childhood diseases, and reducing the risk of diet-related illnesses in later stages of life. The reported obesity prevalence data pertains specifically to children aged 1–3 years old. Currently, approximately 10% of this age group is identified as overweight or obese, while 18.4% are deemed at risk of excessive body weight. The issue of overweight and obesity also affects nearly one in three 8-year-olds. Among adolescents aged 10–16 years old, one in five children is affected by excessive body weight. The significant increase in the prevalence of obesity among children and adolescents in Poland is very important as a problem of public health. Research shows that over a span of 30 years in Warsaw, the prevalence of obesity among boys aged 11–15 years old has tripled, while among girls of the same age group, it has increased tenfold (National Institute of Food and Nutrition, 2023a,b).

According to Polish recommendations for the nutrition of children and adolescents, a daily diet should provide proteins, fats, carbohydrates, as well as vitamins and minerals in appropriate proportions (National Center for Health Education, n.d.). The diet should include a small amount of plant-based fats (vegetable oils and products such as nuts, seeds, or kernels). It is important for health to limit the consumption of products such as cookies, candy bars, salty snacks, and fast food, as they contain harmful trans fats in addition to high amounts of salt or sugar. Excessive intake of animal fats, which contain saturated fatty acids, is a cause of many diseases, especially cardiovascular diseases and certain types of cancer. On the other hand, vegetable oils are the richest source of mono- and polyunsaturated fatty acids, which protect against these diseases. Therefore, it is recommended to replace animal fats with vegetable oils, with the exception of coconut and palm oil. The best choice is rapeseed oil, which has the most favorable fatty acid composition. It is important to note that cold-pressed oils should only be consumed raw, as an excellent addition to salads and raw vegetable dishes. For frying, it is best to use refined rapeseed oil or olive oil (however, it is advisable to limit the consumption of fried foods) (Food Pyramid for Children, 2022).

One of the effective tools for promoting proper dietary choices and proper patterns in schools and kindergartens are public food procurement, on which the entire mass catering system in educational units is based. Either ready meals or products and semi-finished products are ordered, from which dishes are made on site. It is important that the products used for school nutrition meet certain requirements and are of the highest quality, and on the other hand, they fit into a sustainable diet.

In Poland, public procurement of food is not subject to any special regulations, and the regulation on nutrition in schools focuses more on products available for sale, vending machines and menu composition rules (Regulation of the Minister of Health, 2016). This type of gap, on the one hand, leaves a lot of freedom to the stewards, but on the other hand, it can lead to the selection of inferior products if the only criterion is price.

All Polish public procurements are collected in the Public Procurement Bulletin (in the form of an application), from which documents are removed 3 months after the end of the procedure (only general information remains).

Aim of the study

The aim of the study was to evaluate the use of public procurement as an investment in health promotion and a tool for sustainable and responsible food/nutrition policy. For this purpose, a quantitative and qualitative analysis of food products classified as sources of fats in children's nutrition was carried out and qualitative criteria for product composition, organoleptic characteristics and sustainable public procurement were defined and verified.

Materials and methods

In Poland, the E-procurement Platform has been in operation since 2022. Each entity performing public procurement must log in and enter all relevant documents.

An integral part of the E-Procurement Platform is the Public Procurement Bulletin, which allows you to search for and obtain information about a specific public procurement. In accordance with the rules of operation of the E-Procurement Platform, all documents related to a specific public procurement are deleted within 3 months of its completion.

According to Polish legislation, educational units (kindergartens, primary schools and preschool teams) are obliged to provide at least one hot meal during the day. They can fulfill this obligation in two ways – by providing a catering service or preparing meals. In order to collect information on public tenders carried out by educational units for food products ordered for 2023, data collection was carried out between 15 November 2022 and 15 March 2023.

In order to obtain information on tenders concerning the purchase of food products, the resources of the database were searched on the basis of CPV codes (15000000–8–Food, beverages, tobacco and related products and all fats related to it, a detailed list is included in Annex 1).

On this basis, a database was created covering 1,126 items – public procurement, which in a given period were processed by the above-mentioned educational units in the scope of the indicated CPV codes.

The final criterion for inclusion in the analysis was the first procurement (those in which part of the procedure was repeated due to the invalidity of one of the parts was excluded) and the availability

of full documentation to guarantee the reliability of the analysis carried out.

In the end, 197 public contracts were extracted, which together met the following criteria:

- have been processed by an educational unit (kindergarten, primary school or school-preschool complex),
- were processed for the first time (covered the full commodity demand of individual units),
- had complete documentation of public procurement process.

A comprehensive database of 1,248 ordered products from the group of animal or vegetable fats was created based on the collected documentation. This group encompasses various fats such as: oil, olive oil, frying grease, butter, margarine, lard, pork fat, pork belly, bacon, and dewlap. This group also includes mayonnaise, avocados, and nuts, which are primary sources of fat in the diet. Subsequently, a quantitative analysis was carried out for each product.

Quantitative data were supplemented with a qualitative analysis – taking into account the criteria that are given by the Purchaser for individual food products classified in this group.

Based on the preliminary review of the collected descriptions of individual products, the following quality criteria were identified:

- in terms of product composition:

  o fat content, monounsaturated fatty acids [JNKT] and polyunsaturated fatty acids [WNKT],
  o without artificial colours, flavour enhancers and flavourings,
  o without preservatives,
  o without thickeners and stabilizers,
  o without added salt/sugar,
  o without the addition of palm oil,
  o free of antioxidants;

- in terms of organoleptic characteristics:

  o taste,
  o smell,
  o colour,
  o appearance/consistency;

- in the field of sustainable public procurement:

  o locality of products,
  o organic products,
  o GMO-free products.

To the best of the authors' knowledge, this is the first detailed and comprehensive analysis of public procurement of a specific group of food products.

Results

Based on the analysis of the volume of ordered fats, they were divided into 13 subgroups (Table 1):

TABLE 1 Type and quantity of ordered fats for schools and kindergartens in 2023 (according to forecasts).

Type of fats	Number of products		Order volume	
	Number of products (*n*)	% of all products	Order volume [kg]	% of order volume
Oil	239	19.15%	21,442,851,32 [l]	99.73%
Olive oil	94	7.53%	1516.50 [l]	0.01%
Frying grease	4	0.32%	130.50 [l]	0.00%
Avocados	37	2.96%	401.29	0.00%
Nuts	194	15.54%	2086.34	0.01%
Mayonnaise	156	12.50%	4511.50	0.02%
Butter	228	18.27%	36577.70	0.17%
Margarine	91	7.29%	2,826.65	0.01%
Lard	20	1.60%	219.95	0.00%
Pork fat	27	2.16%	511.00	0.00%
Pork belly	149	11.94%	9254.40	0.04%
Bacon	2	0.16%	20.00	0.00%
Dewlap	7	0.56%	167.00	0.00%
Total	1,248	100.00%	21,501,074,14	100.00%

The main source of fat in products ordered by educational institutions was oil (21442851.32 L, 99.73%). It should be noted that subsequent places were occupied by animal fats: butter (36577.70 kg, 0.17%) and pork belly (9254.40 kg, 0.04%).

In terms of the number of products, butter (228 products, 18.27%), oil (239 products, 19.15%) and nuts (194 products, 15.54%) were ordered the most.

Detailed analysis of each of the groups is presented below.

Vegetable fats—vegetable oil

239 products were classified into the oil category, of which the most numerous group was rapeseed oil. A detailed summary is presented in the Table 2.

The ordering pattern indicated a predominant preference for rapeseed oil, with 194 products (81.17% of vegetable oils) and a substantial volume of 21,433,247.66 liters (99.96% of vegetable oils). The second large group consisted of products categorized under the general name "oil," because the Purchaser did not specify in any way what type of product it expects. The least frequently ordered oils were coconut oil (1 product, 0.42%) and sesame oil (1 product, 0.42%).

The Purchaser mainly chose refined oil (113 products, 47.28%), virgin oil (132 products, 55.23%) and cold filtered oil (91 products, 38.08%). In the description of 100 products (41.84%), the contracting authority also specified the expected content of monounsaturated fatty acids (minimum 50%), and in the description of 96 products (40.17%) also polyunsaturated fatty acids (less than 40%). For 12 products (5.02%), specific proportions of fat content in 10 g were determined:

saturated fatty acids—0.7 g, monounsaturated fatty acids 6.5 g, polyunsaturated acids 2.8 g, cholesterol 0 mg.

In the case of 62 products (25.94%), it was indicated that the ordered oil was suitable for both frying and salads. In addition, according to the description, 61 products (25.52%) classified in the group of oils should not contain preservatives, artificial dyes and flavour enhancers in their composition, and 2 products (0.84%) should be zero-erucic.

No criteria on the composition or characteristics of the oil were taken into account for 64 products (26.78%). Organoleptic features have not been described with any product.

Other vegetable fats

Olive oil

The educational units ordered only olive oil (94 products, 7.53%). This oil should be virgin (40 products, 42.55%), free of preservatives, flavour enhancers and artificial colours (3 products, 3.19%), and cold-pressed (2 products, 2.13%).

No quality criteria were defined for 50 products (53.19%). Organoleptic features have not been described with any product.

Frying grease

The frying grease was ordered only by 4 educational units (4 products, 0.00%) in the amount of 130.5 L (0.00%). The temperature of smoking was expected to be at least 232°C.

Avocados

Avocados were ordered 37 times (2.96%), of which in 3 cases (8.10%) it was indicated that a variety of hass was desirable. The only criteria indicated in this product group concerned organoleptic characteristics. The ordered avocado should be ripe and without damage (14 products, 37.83%), without signs of rotting and mold (13 products, 35.14%), without stains (12 products, 32.43%) and fresh (10 products, 27.03%), firm (6 products, 16.22%), healthy (5 products, 13.51%) and green (4 products, 10.81%).

Nuts

Nuts, although in terms of quantity they constitute a small part of the ordered fats (2086.34 kg, 0.01%), it is necessary to pay attention to their wide volume in public procurement of educational units (Table 3).

The most frequently ordered are almonds (56 products, 28.87%) and walnuts (52 products, 26.80%), while the least frequently ordered are peanuts (3 products, 1.55%), pistachios (1.03%) and Brazil nuts (1 product, 0.52%) and nut cream (1 product, 0.52%).

In the largest quantities, walnuts, hazelnuts and cashews are ordered. In total, they account for 71.44% of all ordered nuts (1490.4 kg). The Purchaser expects these nuts to be husked (40 products, 20.62%), without the addition of salt (34 products, 17.53%) and/or without the addition of sugar (33 products, 17.01%).

Nuts should also not contain preservatives, artificial colors and flavor enhancers, as well as palm oil (27 products, 13.92%).

In addition, the description of 2 products indicates that these products should be marked with the bio symbol, and in the case of the next two, that they should come from the European Union.

For 147 products (75.77%) no quality criteria were defined.

TABLE 2 Type and quantity of oil ordered for schools and kindergartens in 2023 (according to forecasts).

Type of oil	Number of products		Order volume	
	Number of products (*n*)	% of all products	Order volume [l]	% of order volume
Oil	18	7.53%	9030.65	0.04%
Coconut oil	1	0.42%	8	0.00%
Flaxseed oil	9	3.77%	150	0.00%
Rice oil	2	0.84%	104	0.00%
Rapeseed oil	194	81.17%	21433247.66	99.96%
Sesame oil	1	0.42%	2.5	0.00%
Sunflower oil	3	1.26%	178	0.00%
Pumpkin seed oil	2	0.84%	4	0.00%
Grape seed oil	9	3.77%	115.5	0.00%
Total	239	100.00%	21,442,840,31	100.00%

TABLE 3 Type and quantity of nuts ordered for schools and kindergartens in 2023 (according to forecasts).

Type of nuts	Number of products		Order volume	
	Number of products (*n*)	% of all products	Order volume [kg]	% of order volume
Coconut	25	12.89%	96.8	4.64%
Nut cream	1	0.52%	2	0.10%
Peanut butter	11	5.67%	61.92	2.97%
Almonds	56	28.87%	390.22	18.70%
Brazil nuts	1	0.52%	30	1.44%
Hazelnuts	26	13.40%	495.04	23.73%
Cashew nuts	17	8.76%	470.2	22.54%
Walnuts	52	26.80%	525.16	25.17%
Peanuts	3	1.55%	11.5	0.55%
Pistachios	2	1.03%	3.5	0.17%
Total	194	100.00%	2086.34	100.00%

In terms of organoleptic characteristics, the main focus was on the shape and texture (softness/hardness) of nuts (9 products, 4.64%).

Mayonnaise

Mayonnaise was ordered 156 times (12.50%) by educational institutions in the amount of 4,511.50 kg (0.02%). The description of

15 products (9.62%) indicated that it was decorative mayonnaise, and the description of 9 products (5.77%) indicated that it was salad mayonnaise.

For every fifth product (31 products, 19.87%), the desired fat content was defined (at a minimum of 70%), and for 20 products (12.82%), the expected egg content was determined (at a minimum of 4%) or specifically egg yolk (38 products, 24.36%, at a minimum of 6%).

Mayonnaise was most commonly expected to be free of preservatives (85 products, 54.49%), stabilizers (62 products, 39.74%), artificial colors (62 products, 39.74%), antioxidants (50 products, 32.05%), and flavor enhancers (59 products, 37.82%). In addition, its composition should not include the addition of citric acid (26 products, 16.67%), as well as sugar (6 products, 3.85%), sweeteners (5 products, 3.21%) and salt (1 product, 0.64%).

For every third mayonnaise ordered (48 products, 30.77%), a specific permissible composition is given in the description. There were also individual specific records, such as without E385 (EDTA), starch, phosphoric acid (E338), powdered eggs, xanthan gum or glucose-fructose syrup.

In terms of organoleptic characteristics, the consistency was specified, which should be dense (3 products, 1.92%) or creamy (1 product, 0.64%), color and taste (1 product, 0.64%).

In the case of 6 products (3.85%), it was indicated that mayonnaise should be produced using free-range eggs.

For 58 products (37.18%) no criteria were defined (neither in terms of composition nor in terms of organoleptic characteristics).

Hydrogenated vegetable fats—margarine

A specific type of fat and a semi-synthetic product of plant origin is margarine. It was ordered 91 times to schools and kindergartens (7.29%) (Table 4).

Among margarines, vegetable butter (27 products, 29.67%) is the most frequently ordered, while soft margarine (12 products, 13.19%) and milk margarine (7 products, 7.69%) are the least frequently ordered. For 27 products (29.67%), the expected fat content was determined (at the level of a minimum of 60%).

Margarines should be free of preservatives (22 products, 24.18%), flavor enhancers (21 products, 23.08%), artificial colors (18 products, 19.78%) antioxidants (10 products, 10.99%) and stabilizers (2 products, 2.2%).

In addition, they should also be free of genetically modified organisms (6 products, 6.59%) and the addition of palm fat (1 product, 1.1%).

None of the descriptions referred to the organoleptic characteristics of margarine.

No criteria were identified for 59 products (64.84%).

Animal fats—butter

Butter is the product of the fat group that was ordered most often (228 products, 18.27%) (Table 5).

Traditional butter was most often ordered, the so-called "extra butter" (168 products, 73.68%), and one in ten butter ordered by educational units was clarified butter (25 products, 1.96%). In 13 cases (5.70%) schools and kindergartens also ordered lactose-free butter.

For 179 products (78.5%), the expected fat content was specified (for cream butter it was at least 60%, and for traditional butter it was 82% /although for 2 products it was 73%/). In addition, butter should be without vegetable additives (56 products, 24.56%) and without salt (34 products). Butter should also not include preservatives (42 products, 18.42%), artificial colors (38 products, 16.67%) and antioxidants (11 products, 4.82%) and stabilizers (11 products, 4.82%). In relation to 12 products (5.26%), the Ordering Party specified the specific required composition.

In terms of organoleptic characteristics for the Purchasers, the most important was the consistency, which should be: uniform, compact and lubricating and slightly hard or slightly greasy (30 products, 13.16%), carefully formed (27 products, 11.84%) with a smooth surface (17 products, 74.56%). The smell should

TABLE 4 Type and quantity of ordered margarine for schools and kindergartens in 2023 (according to forecasts).

Type of margarine	Number of products		Order volume	
	Number of products (*n*)	% of all products	Order volume [kg]	% of order volume
Margarine	26	28.57%	616.5	21.81%
Soft margarine	12	13.19%	244.15	8.64%
Milk margarine	7	7.69%	410	14.50%
Hard margarine	19	20.88%	411.25	14.55%
Vegetable butter	27	29.67%	1,144.75	40.50%
Grand total	91	100.00%	2,826.65	100.00%

TABLE 5 Type and quantity of butter ordered for schools and kindergartens in 2023 (according to forecasts).

Type of butter	Number of products		Order volume	
	Number of products (*n*)	% of all products	Order volume [kg]	% of order volume
Butter	168	73.68%	33475.90	91.52%
Lactose-free butter	13	5.70%	164.50	0.45%
Clarified butter	25	10.96%	798.00	2.18%
Butter mix	1	0.44%	90.00	0.25%
Pat of butter	6	2.63%	614.90	1.68%
Cream butter	15	6.58%	1434.40	3.92%
Grand Total	228	100.00%	36577.70	100.00%

be characteristic of butter (16 products, 7.02%), slightly sour taste with a specific taste of pasteurization (19 products, 8.33%), and the color should be uniform and golden (16 products, 7.02%).

47 products (20.61%) had no defined quality or organoleptic criteria.

Other animal fats

Lard

Lard for schools and kindergartens was ordered 20 times (1.60%) in the amount of 219.95 kg. Only for 1 product (5.00%) it was indicated that it should consist of 100% bacon, without the addition of preservatives and without foreign smells.

Pork fat

Of the analysed products, 27 (2.16%) were pork fat. In the case of 4 products (14.81%), the Purchaser indicated that it should be raw, and in the case of 3 products (11.11%), that it should be smoked. This pork fat is supposed to be fresh (6 products, 22.22%) and unfrozen (2 products, 7.41%), but can be minced (2 products, 7.41%). In addition, it should be without skin (4 products, 14.81%) and without bone shards (1 product, 3.7%) and without any additives (2 products, 7.41%). It should have a thickness of 2–4 cm (2 products, 7.41%), a white to light cream color (2 products, 7.41%) and a specific smell (1 product, 3.7%).

Pork belly

Pork belly was included in public procurement of educational units 149 times (11.94%). The most frequently ordered pork belly smoked (115 products, 77.18%) or steamed (43 products, 37.39%), less raw (27 products, 18.12%), fresh (23 products, 15.44%), unfrozen (4 products, 2.68%) or cooked (2 products, 1.34%).

The description of 12 products (8.05%) specifies the expected meat content in the product (above 70%), and for 2 products (1.34%) the expected fat content (below 30%).

These products should be free of ribs (48 products, 32.21%), skin (37 products, 24.83%) and bones (14 products, 9.4%). They should not contain preservatives (9 products, 6.04%), flavor enhancers (9 products, 6.04%), emulsifiers (5 products, 3.36%), antioxidants (3 products, 2.01%), stabilizers (3 products, 2.01%), acidity regulators (3 products, 2.01%), protein additives (3 products, 2.01%) and artificial flavors (3 products, 2.01%).

The taste (24 products, 16.11%) and smell (28 products, 18.79%) should be characteristic for a given product type, and the color (17 products, 11.41%) should be pale pink to red. The consistency (19 products, 12.75%) should be moist and soft, but at the same time firm and elastic.

With regard to 2 products (1.34%), it was indicated that they were of Polish origin.

68 products (45.64%) did not have any criteria.

Bacon

These were only 2 products (0.16%), smoked, with no specific criteria for composition or organoleptic characteristics.

Dewlap

Dewlap schools and kindergartens ordered 7 times (0.56%). It was supposed to be a fresh, unfrozen, smoked and skinless product.

Collective sheet

The matrix summarizing the occurrence of the identified criteria in the descriptions of individual groups of products from the fat group is presented below.

The most frequently taken into account criteria are those for the composition of the product (taking into account the specific fat content and the absence of the addition of preservatives, artificial colours and flavour enhancers). The criteria for organoleptic characteristics are quite often overlooked and the criteria for sustainable public procurement are the least taken into account.

The group of products that is described in the most detail (the largest number of products has specific criteria) is butter, mayonnaise and oil.

A detailed summary is presented in the Table 6.

Discussion

Dietary fats are all lipids present in plant and animal tissues that are consumed as food. They primarily serve as a source of energy necessary for proper growth and maintenance of the body's vital functions. Additionally, they provide essential unsaturated fatty acids and serve as a source of fat-soluble vitamins. Fats play various important roles in the human body. To maintain good health, it is crucial to ensure the intake of fats of appropriate quality. Excessive fat intake in the diet increases the risk of developing overweight, obesity, and other metabolic disorders and nutrition-related diseases. It is important for maintaining good health to consume an appropriate level of total fat while reducing the intake of Saturated Fatty Acids (SFA) and Trans Fatty Acid isomer (TFA). Saturated fatty acids contribute to an increase in total cholesterol and LDL cholesterol levels in the blood serum and are risk factors for the development of cardiovascular diseases. They also increase the risk of developing diseases such as colorectal cancer and breast cancer. Saturated fatty acids have prothrombotic effects, increasing the risk of strokes. The consumption of trans fatty acid isomers should be limited as they are primarily formed during the industrial partial hydrogenation of vegetable oils. They lead to an elevation of LDL cholesterol levels in the blood serum, decrease HDL cholesterol levels, and are recognized risk factors for cardiovascular diseases, stroke, and type 2 diabetes. Replacing saturated fatty acids with polyunsaturated fatty acids (PUFAs) reduces the risk of ischemic heart disease. Monounsaturated fatty acids (MUFAs) can play a protective role in the prevention of atherosclerosis and heart disease when they replace saturated fats as a component of the diet [g]. Based on Polish recommendation percentage of fat in total daily energy for children and adolescents aged 4–18 years is 20–35%. Intake of Saturated Fatty Acid and Trans Fatty Acid in daily diet should be as lower as is possible for healthy and balanced diet (but not more than 10% among 1–9 years group and 5–6% among adolescents aged 10–18 years) (Jarosz et al., 2020).

According to Polish observation (2007–2011) among children and adolescents there has been a shift in the structure of its sources in favor of plant-based fats. However, the consumption of animal fats remains too high. Among animal fats, butter dominates and is used both as a spread on bread and as an addition to dishes. Cream is also frequently added. Other animal fats such as lard and bacon are also found in the diets of children and adolescents, although they should practically be eliminated from the diet. High consumption of total fats

TABLE 6 Summary of the number of fat products for which a given feature is specified.

		Oil	Olive oil	Frying grease	Avocado	Nuts	Mayonnaise	Margarine	Butter	Lard	Pork fat	Pork belly
Product composition	Fat content	100 (41,84%)					31 (19,87%)	27 (29,67%)	179 (78,51%)	1 (0,05%)		2 (1,34%)
	Without artificial colours	61 (25,52%)	3 (3,19%)			27 (13,92%)	62 (39,74%)	18 (19,78%)	38 (7,89%)			
	No preservatives	61 (25,52%)	3 (3,19%)	1 (25%)		27 (13,92%)	85 (54,59%)	22 (24,18%)	42 (18,42%)	1 (0,05%)		9 (6,04%)
	Without flavor and aroma enhancers	61 (25,52%)	3 (3,19%)			27 (13,92%)	59 (37,82%)	21 (23,08%)				3 (2,01%)
	Without stabilizers						62 (39,74%)	2 (2,2%)	11 (4,82%)			3 (2,01%)
	Without added sugar					33 (17,01%)	6 (3,85%)					
	Without added salt					34 (17,53%)	1 (0,64%)		34 (14,91%)			
	Without antioxidants						50 (32,05%)	10 (10,99%)	11 (4,82%)			3 (2,01%)
	Without palm fat					27 (13,92%)		1 (1,1%)				
Sustainability characteristics	Non-GMO							6 (6,59%)				
	Bio/eco					2 (1,03%)						
	Origin					2 (1,03%)						2 (1,34%)
	Use of sustainable ingredients						6 (3,85%)					
Organoleptic characteristics	Taste								16 (7,02%)			24 (16,11%)
	Smell								19 (8,33%)	2 (0,1%)	1 (3,7%)	28 (18,79%)
	Colour				4 (1,08%)				16 (7,02%)		2 (7,4%)	17 (11,41%)
	Consistency				6 (16,22%)		3 (1,92%)		30			19 (12,75%)

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in the diet of young individuals and the continued high intake of animal fats make saturated fatty acids a significant source of energy, while the contribution of polyunsaturated fatty acids is lower. The dietary patterns of this population also show a low intake of n-3 fatty acids, which is not only due to an improper fat consumption structure but also inadequate fish intake (Rychlik and Jarosz, 2008). Mean intake of total fat among Polish children aged 1–9 was 30.9 ± 7.8% and among 13–18 aged group 34.2 ± 7.2%. Respectively mean intake of SFA was 11.6 ± 3.7% and 11.4 ± 3.8% and mean intake of MUFA was 12.9 ± 3.9% and 14.6 ± 3.9%. Mean intake of PUFA among Polish children aged 1–9 was 4.1 ± 2.3% and among 13–18 aged group 5.1 ± 2.7% (Harika et al., 2011).

Animal products and animal fats are the main sources of saturated fatty acids in the diet. Among plant-based fats, as mentioned earlier, coconut oil (over 80%) and palm oil (over 40%) are characterized by high levels of saturated fatty acids. Monounsaturated fatty acids (MUFA) are widely present in food. The main sources of MUFA are plant oils, including rapeseed oil and olive oil, which are important sources of oleic acid, beneficial for health. Sources of polyunsaturated fatty acids (PUFA) include plant oils (such as sunflower oil, flaxseed oil, and others), nuts, seeds, and fatty fish. Trans isomers are in partially hydrogenated oils and fats, including products such as margarine (Jarosz et al., 2020).

Based on the conducted study, a positive observation is the significant presence of plant oils and olive oil in the overall pool of public procurement in the fats category for schools (26.68% of all products and 99.73% of order volume). Very positive results were also observed in orders for avocados and nuts (2.96 and 15.54% of all products, respectively). These products provide beneficial MUFA and PUFA which are advantageous for health. Unfortunately, in the diet of children and adolescents in school institutions, there is still a significant presence of animal-derived fats, such as butter (18.27%) mayonnaise (12.50%), pork belly (11.94%), pork fat (2.16%), and lard (1.60%). These products are a source of unfavorable saturated fatty acids, which are not beneficial for health. It should be emphasized that plant fats accounted for only 52.77% of the total order (unfortunately, including 7.29% of margarines that may contain trans isomers), which is a significantly low proportion. This indicates that animal fats constitute as much as 47.21% of the overall pool of fats being provided to children for consumption.

Public procurement of fat products is a frequent element of the process of supplying public institutions with food. These include different types of fats such as oil, olive, butter, margarine, lard, etc. Since fats are characterized by the highest energy density among nutrients (1 g is 9 kcal), not only their quantity, but above all their quality is very important. Public procurement procedures for fats are usually governed by the applicable public procurement law in the country or region in question. According to the review carried out as part of the Best Re-MaP Project, there are European countries that have very detailed regulations and criteria in this area (such as the Scandinavian countries), but there are also countries that are at the beginning of this road (such as Poland or Bosnia and Herzegovina) (Report Best Re-MaP, n.d.).

In Poland, there are no specific regulations regarding the purchase of this type of products for educational units. The regulation regulating nutrition in schools only stipulates that no more than two portions of fried food should be served from Monday to Friday, while refined vegetable oil with a monounsaturated acid content of over 50% and a polyunsaturated acid content of less than 40% was used for frying. The oil ordered is the most (99.73%) and according to the order specification it meets these requirements.

However, the remaining products of the fat group do not have any criteria specified either in the regulations or by the Purchasers. A large volume of cured margarines, which previously could contain a large amount of pro-inflammatory trans fats, could raise doubts (National Center for Health Education, 2022). However, in 2021, a regulation came into force that prohibits the placing on the market of products of plant origin exceeding the industrial trans fat content of 2 g per 100 grams of fat (2%). While previously in the tests the samples reached even 22% of trans fats in products available on the Polish market – currently such values would make it impossible to place the product on the market [Commission Regulation (EU), 2019]. However, it is worth noting that there are countries that go a step further in these regulations—they prohibit the use of margarines and bakery fats or all products with trans fats in schools (New Dehli Act, 2006).

The specific disorder of the criteria, which can be seen on the example of lard, can also be alarming. Purchasers often emphasized its organoleptic features, but only a fraction of them focused on key quality issues, such as the meat or fat content of the product.

None of the Purchasers referred to the criteria of sustainable public procurement. Only nuts and margarine (a total of 28 products) were required to be palm oil-free. In the case of fatty products, it is important to implement not only locality criteria, but also sustainable sourcing of raw materials that are popular and successfully used in European countries (Neto, 2020).

Public procurement criteria, when strategically designed and implemented, have the potential to become a powerful instrument in shaping broader food policies. By establishing specific guidelines for the sourcing and delivery of food products, particularly those consumed by children, policymakers can influence dietary patterns on a large scale. Incorporating criteria that prioritize nutritional value, sustainability, and health outcomes in public procurement not only supports the immediate goal of providing healthier options for children but also contributes to the larger framework of promoting public health. Through these measures, public institutions can set precedents for the food industry, encouraging the adoption of sustainable and health-conscious practices. In essence, public procurement emerges as a tangible tool through which governments can actively contribute to the development and implementation of comprehensive food policies that prioritize the well-being of their citizens.

Conclusion

The findings of the study reveal a critical insight into the composition of fats procured for schools and kindergartens in Poland. The predominant reliance on plant-based oils, avocados, and nuts indicates a positive trend towards healthier sources of fats rich in monounsaturated and polyunsaturated fatty acids. However, a substantial portion of the procurement comprises animal-derived fats, such as butter, pork belly, and mayonnaise, which contribute to the intake of less favorable saturated fatty acids.

The absence of specific regulations for the procurement of fats in educational institutions, except for refined vegetable oil used for frying, raises concerns about the overall quality of fats supplied. While

the study identifies an encouraging shift in the procurement of healthier fats, particularly in oils, there is a need for comprehensive guidelines to ensure a balanced and health-conscious approach to dietary fat intake among children.

Furthermore, the lack of emphasis on sustainable public procurement criteria is noteworthy. Only a fraction of the products, such as nuts and margarine, were required to be palm oil-free. Integrating sustainable practices into public procurement can enhance the overall impact of nutritional policies, contributing not only to the health of individuals but also to environmental and social well-being.

In conclusion, addressing the identified gaps in procurement regulations, promoting the consumption of healthier fats, and incorporating sustainability criteria can collectively contribute to fostering better dietary habits and overall well-being among schoolchildren in Poland. These insights provide a foundation for future policy adjustments and interventions aimed at promoting optimal nutrition and a sustainable food system in educational settings.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

KB: Conceptualization, Data curation, Formal analysis, Methodology, Resources, Visualization, Writing – original draft. JN: Conceptualization, Methodology, Writing – original draft. AP: Data curation, Formal analysis, Writing – review & editing. NF: Conceptualization, Writing – review & editing. PO: Conceptualization, Writing – review & editing. OK: Conceptualization, Writing – review & editing. MB: Conceptualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2024.1265745/full#supplementary-material

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Effectiveness of mangrove sword bean food bar addressed to older people of landslide disaster victims

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Background: Older people require extra attention due to their reduced ability to prepare for disasters, as they adequately possess distinct needs. These groups necessitate uncomplicated, readily consumable, and palatable food options that fulfill their micronutrient needs. The objective of this research was to assess the effects of a snack bar enriched with *api-api* mangrove (*Avicennia marina*) and sword bean (*Canavalia ensiformis*) on the body weight and Body Mass Index (BMI) of older people individuals afflicted by a landslide event.

Methods: A non-randomized pre-post-intervention study was undertaken, involving 31 senior participants. The intervention group consisted of 15 seniors who were provided with a mangrove sword bean snack bar, while the control group comprised 16 seniors who received a sword bean food bar during 15 days. All study participants received education on maintaining a balanced diet for older people individuals. The data analysis involved using univariate and bivariate analyses, explicitly applying the independent *t*-test and dependent *t*-test.

Results: In the hedonic evaluation, the mangrove sword bean food bar had superior average attributes in terms of scent, flavor, texture, and color compared to the sword bean food bar. The consumption of snack bars made from mangrove sword beans resulted in a significant rise in weight (0.2 kg), energy intake (240.8 kcal), protein content (5.8 g), carbohydrate content (40.06 g), and fat content (4.4 g). Carbohydrate can significantly increase weight in the treatment subjects. Furthermore, the provision of comprehensive nutrition education has the potential to enhance the post-study knowledge score, as seen by the observed increase of 40.6. A significant disparity was observed between the mean carbohydrate consumption and understanding of balanced nutrition among the intervention and control groups.

Conclusion: *Api-api* mangrove sword bean snack bars have been identified as a viable and efficient substitute for emergency food provisions, particularly in disaster-stricken communities. These food bars have demonstrated a significant capacity to contribute to the weight gain of individuals within such groups, thus addressing the nutritional needs of impacted populations in the aftermath of natural calamities. Subsequent investigations may include employing pregnant women as participants to explore the issue above.

Clinical Trial Registration: Clinicaltrials.gov, identifier: NCT05897892.

KEYWORDS

older people, landslide, disaster, weight, mangrove-sword bean food bar

Introduction

Post-hydrometeorological disasters present a substantial problem in meeting the dietary requirements of vulnerable groups, particularly older people. To solve this matter, it is recommended that Complete Emergency Food Products (EFP) be made readily accessible for immediate consumption as the principal means of sustenance for 15 days, starting from the moment of evacuation (1, 2). In Indonesia, emergency food formulations include food bars created from a combination of brand and maize flours (3), cookies prepared with Moringa leaf flour (4), cookies made from sweet potato flour, banana flour, and mung bean flour (5), as well as a snack bar consisting of soybean, broccoli, and mangrove fruit (6).

The exploration of utilizing *api-api* mangrove (*Avicennia marina*) in producing food bars has yet to be previously investigated, despite its potential as a suitable alternative to rice and wheat flour. Based on a study conducted by researchers (7), it has been shown that the *api-api* mangrove demonstrates a greater energy density in comparison to rice and corn. The api-api mangrove is more energy-dense (371 kcal) than wheat flour (365 kcal) (7), rice (360 kcal), and corn (307 kcal) (8, 9). Api-api mangrove is commonly found in coastal tropical countries, including Indonesia. It is a plant species that is widely distributed throughout Indonesia and is abundant from Sabang to Merauke. *Avicennia marina* is a type of mangrove that can thrive in environments with minimal light and temperature, in brackish areas with high salinity levels, and is commonly found in coastal and mangrove habitats. They can also be found in freshwater swamps and muddy coastal areas with high salt content (10, 11).

Food bars produced from this specific wheat variety require additional lipids, carbohydrates, proteins, zinc, and vitamin C. *Canavalia ensiformis* (sword bean) flour has been selected to enhance geriatric nutrition. The snack bar has characteristics that render it a viable choice for dissemination among individuals affected by calamities. The compact and sturdy design facilitates convenient portability and manipulation. Furthermore, the creation of this product can be customized to include a wide variety of locally sourced food items, hence increasing its versatility and accessibility in various geographical areas. Furthermore, this substance can be ingested orally without needing any pre-treatment, and it exhibits a significant quantity of carbs and proteins. Similarly, when comparing food bars to cookies or pastries, it is essential to note that they can withstand higher amounts of pressure due to their partially dry composition (8). A comparative analysis was conducted in 2020 to assess the suitability of lindur fruit (*Bruguiera gymnorrhiza*) flour, broccoli flour, and soy flour as potential ingredients in a bar snack. During 15 days, a total of 33 older people who were relocated due to flooding in Depok City ingested the snack bars provided to them. During this particular time frame, it was noted that the average weight of the aforementioned retired individuals rose by 0.2% (6).

The primary objective of this study was to analyze a specific type of edible film-forming product (EFP) in the form of snack bars. The EFP was composed of *api-api* mangrove flour and sword bean. The *api-api* mangrove was chosen for examination due to its few studies compared to the lindur mangrove. Carbohydrates are present in this specific type of mangroves, albeit at a lower concentration (9). The nutritional makeup of 100 g of *api-api* mangrove is as follows: the liquid sample is composed of 21.43 g of carbohydrates, 10.4 g of protein, 0.043 g of fat, and 22.24 mg of vitamin C per milliliter (12). The study conducted by mangrove sword bean food bars reveals that their product has 55 g of carbohydrates, 24 g of protein, and 3 g of fat per 100 g (13). Food bars that utilize *api-api* mangrove flour have the potential to be a feasible and nourishing alternative to wheat flour (7). However, incorporating *api-api* mangrove flour in producing baked goods such as cookies and biscuits is not commonly practiced. The daily caloric needs of older women and men, total 1,900 kcal, were met by consuming four snack bars of a specific type, each weighing 100 g resulting in a total caloric intake of 2,000 kcal.

This research aimed to examine the possible impact of a snack bar made from *api-api* mangrove (*A. marina*) and sword bean (*C. ensiformis*) on the weight and Body Mass Index (BMI) of older people afflicted by landslides. The snack bars can also be used as emergency food in case of various other types of natural disasters such as floods, earthquakes, volcanic eruptions, etc. Several research have been conducted to investigate emergency food formulations in Indonesia. Numerous research investigations have been conducted in Indonesia to investigate emergency food compositions. These investigations had examined the feasibility of utilizing various ingredients, such as white millet and red bean flour, in producing food bars (8). Researchers have also explored the potential of incorporating moringa flour into cookies (14) and investigated the viability of combining sweet potato flour, banana flour, and mung bean flour in emergency food formulations (5). Nevertheless, the combination of *api-api* mangrove flour and *koro pedang* bean flour has yet to be utilized thus far in developing food bars. However, the *api-api* mangrove flour has been recognized as a prospective alternative to rice and wheat flour in manufacturing biscuits. This is attributed to its elevated energy content surpassing rice and maize. The inclusion of *koro* sword nut flour results in an elevation in the levels of lipid content, carbs, protein, zinc, and vitamin C. The inclusion of koro sword nut flour results in an elevation of lipid content, carbs, protein, zinc, and vitamin C levels. The potential impact of snack bars comprising a combination of *api-api* mangrove flour and *koro pedang* bean flour on the nutritional wellbeing of young children and older people affected by landslides remains unexplored in existing research. The potential effectiveness of snack bars is composed of a combination of *api-api*.

Materials and methods

Research design

A non-randomized pre-post intervention study was conducted, involving a sample of 31 older individuals who were divided into treatment and control groups. These participants were affected by the landslide catastrophe (15). Ethical approval (No. 089/KEPPKSTIKSC/VII/2022) was obtained by the Health Research and Development Ethics Committee (KEPPK) of Sint Carolus, College of Health Sciences, Jakarta. Before commencing the 2-week study period from August 10 to August 25, 2022. The intervention lasted only 2 weeks because emergency food is

provided for refugees or victims of natural disasters for 15 days from the time a disaster is experienced (16). All eligible participants provided their informed consent by signing a formal document at the onset of August 2022. The signing event occurred as part of the introductory activities of the study, and the *posbindu* cadres and the research team witnessed it.

Subject and population

The study sample comprised older people impacted by the landslide calamity in Cihanjuang Village, Cimanggung Subdistrict, Sumedang District, West Java Province, Indonesia. The geographical location of this village falls within the administrative boundaries of the West Java Province in Indonesia. The present study utilized the following criteria to determine the eligibility of older persons for inclusion: the study's inclusion criteria encompassed individuals aged 60 years or older, of both genders, who lived in Cihanjuang Village, who were directly affected by the landslide incident, and who exhibited normal, under, or over-nutrition statuses. To be eligible for the study, individuals were required to have no pre-existing chronic or degenerative disorders and demonstrate a desire to abstain from snacks other than snack bars and plain water.

The researchers employed the formula for the hypothesis test of paired mean difference (17) to determine the minimum required sample size. The above conclusion was deduced based on an observed augmentation in body weight of 0.2 kg within the older demographic, accompanied by a standard deviation of 0.1 (6). A significance level of 0.05 was selected for conducting bilateral hypothesis testing during this inquiry. Therefore, to attain a statistical power of 90%, it was essential to possess a sample size (n) of 15. The nutritional status of all eligible participants, who were older persons, was evaluated based on the established inclusion criteria. An anthropometric assessment was conducted from August 2 to August 6, 2022. These assessments encompassed the measurement of weight and height, as well as the application of the Mini Nutritional Assessment (MNA) tool. Food bars were supplied to all participants for 2 weeks (18), specifically from August 10 to August 25, 2022. The assignment of individuals to treatment and control groups was chosen based on the residential neighborhoods they inhabit.

Instrument

At the initiation of the inquiry, the investigators assessed the participants' weight, height, and Mid-Upper Arm Circumference (MUAC). A digital scale with a precision of 0.1 kg was utilized for the three weigh-ins at the beginning, week 1, and week 2 of the study. At the onset of the investigation, a solitary height measurement was acquired utilizing a microtoise device possessing a precision level of 0.1 cm. Mid-upper arm circumference (MUAC) was measured at the baseline using a midline tape, with a single measurement being acquired. The researchers assessed the subjects' malnutrition likelihood using the Mini Nutritional Assessment (MNA) (19). The evaluation of an individual's degree of autonomy can be enhanced by employing various instruments, such as the Basic Activity Daily Living (BADL) and Instrument Activity Daily Living (IADL) scales (20). A Mini-Mental State Examination (MMSE) was employed as a standardized screening technique to determine the existence of dementia or possible cognitive decline (21). During the preliminary stage of the research project, data was gathered on the participants' levels of autonomy, vulnerability to malnourishment, and degree of cognitive decline. The research team created instructional resources, including a brochure and flipchart, to disseminate information regarding a well-balanced diet.

Subject selection

During the study, a cohort of 31 older people actively participated. The study included 31 senior participants who completed the study, with 16 persons assigned to the control group and 15 individuals assigned to the intervention group with a non-random method. The intervention group comprised of older people from three neighborhoods: 1, 2, and 3. The control group consisted of older people from the neighborhoods 4, 5, and 6. At the initiation of the research endeavor, there existed a total of 34 individuals classified as seniors in each of the two groups who satisfied the stipulated criteria for inclusion in the study. However, three participants of advanced age withdrew from the study due to sore throat disease, a modification in the coloration of their feces to a dark shade, and experiencing nausea after consuming the snack bars (Figure 1)—the aforementioned adverse effects manifested after the ingestion of the snack bars by the individuals. The list of older people who perished in the landslides was obtained from the leader of the integrated health program for older people, *posbindu*. Anthropometric measurements were conducted at various *posbindu* sites to obtain preliminary data regarding the nutritional status of the subjects. The prospective participant was also invited to attend the study's inaugural event 15 days before their intended involvement.

Nutritional intervention and monitoring

For the 15-day study period, individuals assigned to the intervention group consumed mangrove sword bean food bars, whereas those in the control group consumed sword bean food bars (Figure 2). Due to the provision of emergency food assistance to victims of natural disasters and refugees for 15 days following the occurrence (18), the intervention time was limited to 2 weeks. As a component of this experimental study, it is anticipated that each participant within every group will be required to regularly ingest a snack bar with a weight of 50 g. Based on the data presented in Table 1, it can be observed that a 50-g mangrove sword bean snack bar contains a total of 234.2 calories, 24.7 g of carbohydrates, 5.8 g of protein, and 12.5 g of fat. The enumerators used the baseline questionnaire to interview all older people individuals to understand their sociodemographic characteristics comprehensively. These characteristics encompassed age, marital

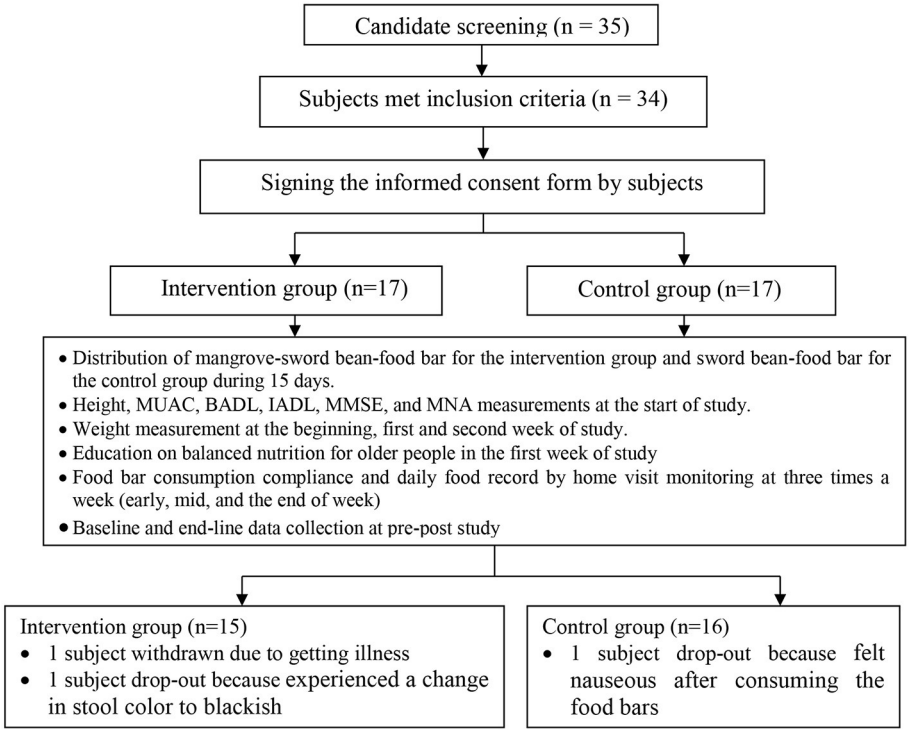

FIGURE 1
Research scheme of older people.

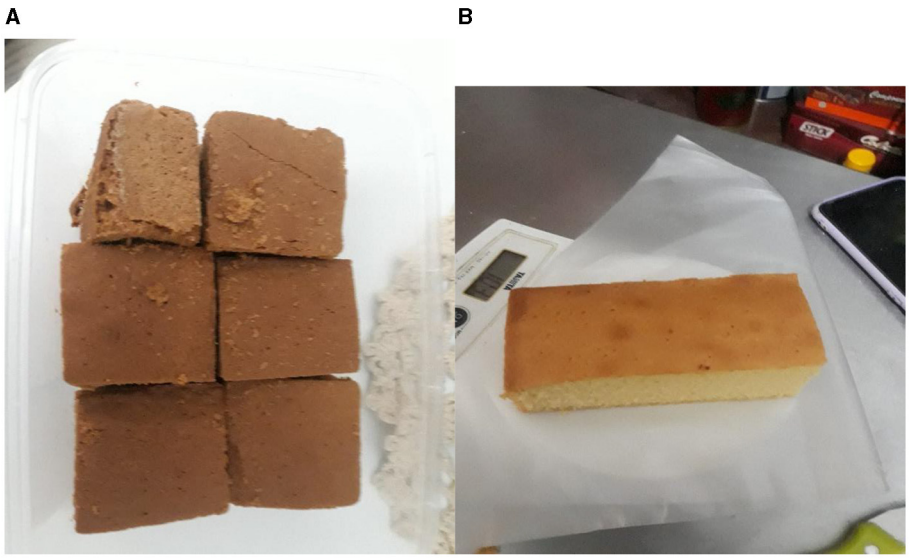

FIGURE 2
Mangrove sword bean food bar **(A)** and sword bean food bar **(B)**.

status, educational attainment, occupation, and cohabitation arrangements within their households.

Furthermore, the survey assessed the participant's understanding of balanced nutrition, encompassing topics such as a selection of nutritious foods, the advantages of carbohydrates, proteins, vitamins, and minerals, the definition of healthy food, the concept of balanced nutrition, the importance of weight measurement, the purpose of stable or reduced weight, including its underlying causes and consequences, and strategies aimed at weight gain. The participants in a group received balanced nutrition education twice for 30 min in the first and second weeks of the study. Because practically all of the participants did not

TABLE 1 Nutrient content per 50 g of food bar.

Type of food bar	Energy (kcal)	Carbohydrate (g)	Protein (g)	Fat (g)
Mangrove-sword bean	234.2	24.7	5.8	12.5
Sword bean	230.4	26.5	3.9	12.1

Nutritional content for results in Table 1 were examined at the Saraswanti Laboratory, Bogor City.

understand the Indonesian language, the nutrition education materials that were presented to the Sundanese population by the local enumerators, except the questionnaire, MNA, and MMSE tools.

The data collected at the endpoint of the study were acquired after the administration of instructional interventions to assess the extent to which modifications in balanced nutrition and macronutrient intake had occurred before selecting the mangrove-sword bean-food bar as the Emergency-Friendly Product (EFP) for older people, a hedonic assessment was conducted. The objective of the experiment was to ascertain the relative popularity of different combinations of *api-api* mangrove and sword bean in food bars. To complete the organoleptic test, a cohort of 20 individuals of advanced age, lacking any specialized expertise, was selected from diverse geographical locations and assigned to designated study sites. Ten to 20 people is the ideal number of panelists for a panel that is not informed (21). Due to the inherent possibility of bias, specific panelists with less training declined to participate in the study. The many attributes of the snack bar, such as its color, aroma, flavor, and texture, might impact individuals' compliance with and adoption of the food. The smell, texture, color, and taste of a snack bar were assessed using a four-point hedonic scale, with ratings ranging from 1 (indicating great hate) to 4 (displaying strong liking) (21, 22).

Monitoring for adherence to consumption regulations in food bars

During the duration of the research, the dietary habits of older people were monitored through regular home visits and anthropometric measures (weight) taken at *posbindu* every week during the study. Weight gain over 2 weeks was used as an indicator of adherence to consuming snack bars. During each household visit, detailed records were documented about the consumption of food items, the allocation of cookies, the remaining quantity of cookies, and the consequences following the consumption of cookies. At the onset, one older people individual expressed experiencing a headache due to consuming cookies, while another older people individual reported experiencing difficulties in bowel movements after consuming cookies. These remarks were made regarding the adverse effects associated with the consumption of cookies. Subsequently, the enumerators proceeded to elucidate to the participants that the detrimental repercussions observed in the initial stages were indicative of an early adaptation.

Furthermore, the adverse effects will diminish after the body has acclimated to the medicine. During food bar distribution, proficient enumerators conducted household visits to collect data on individuals' food intake records. The frequency of these visits was scheduled at a rate of three times each week. Anthropometric data was collected during the initial and subsequent weeks of the study to check compliance with food bar intake among the older people participants. Furthermore, food recalls were documented weekly, namely at intervals of 24 h, 3 days, and 7 days.

Food bar preparation technique

The food bar known as the *api-api* mangrove sword bean bar is composed of *api-api* mangrove flour and sword bean flour, melted butter, poultry eggs, refined white sugar, a modest quantity of wheat, and chocolate, strawberry or orange paste. The food bar was fabricated employing a digital oven, a mixer, a 20 cm × 15 cm alumunium brownie mold, a digital scale, a food bar dough-cutting equipment, and a dough mill. The following are the prescribed protocols for preparing food bars: the process involves the combination of melted butter and white refined sugar. The dough underwent mixing using a mechanical device for 5 min, resulting in a state of uniformity. Incorporate the *api-api* mangrove flour into the mixture, and afterward, add the sword bean flour, egg yolks, and pasta. Combine the dough with a sizable wooden spatula until it achieves a consistent and homogeneous texture. Transfer the batter onto a rectangular baking dish designed for brownies and cook it in a digitally controlled oven for 30 min, maintaining a temperature of 180°C.

Data analysis

To analyze the frequency distribution of the food bar organoleptic test, a univariate analysis was conducted using SPSS Version 22. The socio-demographic attributes considered in this analysis included age, gender, marital status, most recent education level, most recent position, living arrangement of family status, nutritional status, and knowledge of balanced nutrition among older people. The MNA, BADL, IADL, MMSE, and MUAC are all administered in a manner that is similar to the previously stated method. The Nutri Survey Program was employed to analyze the data acquired on food consumption for 2 weeks. The data analysis aimed to compare the consumption amounts for the four macronutrients (energy, carbohydrate, fat, and protein) before and after the study using 3 days of 24 food recall (at the first, middle, and end of weeks). Bivariate analysis, and paired *t*-tests were employed to assess the alterations in mean weight, BMI, macronutrient consumption (specifically energy, carbohydrate, protein, and fat), and comprehension of balanced nutrition throughout the study. In all investigations involving two opposing perspectives, a *p*-value of 0.01 was deemed statistically significant.

Results

The color, aroma, taste, and texture were the four factors that were considered in the study to determine whether the mangrove-sword bean food bar was preferred. In comparison to

TABLE 2 Organoleptic test of mangrove-sword bean and sword-bean food bars by older people.

Parameter	Mangrove-sword bean food bar	Sword bean food bar
Color	3.7 ± 0.7 (like)	3.0 ± 0.6 (like)
Aroma	3.5 ± 0.8 (like)	2.2 ± 0.1 (dislike)
Taste	3.5 ± 0.7 (like)	2.0 ± 0.5 (dislike)
Texture	3.0 ± 0.7 (like)	2.1 ± 0.4 (dislike)

1 = very dislike; 2 = dislike; 3 = likes; 4 = very like.

the sword bean food bar, the mangrove-sword bean food bar produced a significantly higher mean score for color, scent, taste, and texture when evaluated by older individuals (Table 2). Table 3 shows the socio-demographic parameters, nutritional status, level of independence, and cognitive function of older people. The study participants in the intervention group were mostly men, while the women in the control group were mostly married. The intervention group's mean age was slightly older than the control group. Almost all participants in the two groups had a low level of formal education, lived with their children and grandkids, and had retired. The majority of people in both groups had normal nutrition status (62.4% in the control group and 66.7% in the intervention group), normal MUAC (more than 23.0 cm), independence level for basic daily and instrumental activities, and normal cognitive performance. However, there were members in both groups who had cognitive impairment and, most likely, cognitive decline (Table 3).

Body Mass Index (BMI) was used to determine the nutritional status of older people. The intervention group's older participants experienced a slightly larger average weight gain than the control group. During the 15-day intervention, the BMI indicator revealed identical results. Positive significant differences in post-study weight and BMI were identified within the intervention group, but not between groups (Table 4). Table 5 displays the variations in energy, carbohydrate, protein, and fat consumed by older people before and after the study. The mangrove-sword bean food bar consumption was associated with increased macronutrient consumption, specifically carbohydrates, in the intervention group (p 0.02). In contrast, the groups had no significant difference regarding the average amounts of energy, protein, and fat. Balanced nutrition knowledge rose after the study ($p = 0.001$), and there were variations between pre-and post-test scores among the older people.

Discussion

The objective of research was to investigate the potential effects of a snack bar composed of api-api mangrove (*A. marina*) and sword bean (*C. ensiformis*) on the weight and BMI of older people affected by landslides. Despite its potential as a suitable alternative to rice and wheat flour, the possibility of utilizing api-api mangrove (*A. marina*) to produce food bars has yet to be previously investigated. According to a study by researchers (7), api-api mangrove has a greater energy density than rice and corn. Older people are prone to moderate to high risk during a crisis due to sensory abnormalities, physical restrictions, and degenerative disorders (23). The likelihood of surviving a natural disaster is influenced by various factors, including physical mobility, hearing impairment, limited physical mobility, poor vision, and memory deficits (24, 25). The issue of insufficient provision of sustenance for individuals affected by disasters should be considered. The nutritional status of individuals may experience deterioration after a natural catastrophe due to many factors, such as reduced access to health services, disruptions in food delivery routes, and insufficient sanitation (26). It is confident that there will be a heightened demand for healthcare and sustenance in regions impacted by disasters. Hence, all relevant parties must prioritize the effective administration of response strategies, particularly those that address the nutritional wellbeing of individuals affected by disasters. The unmet nutritional needs of older people at post-disaster are susceptible to infectious diseases and malnutrition (27). Following a devastating event, the issue of restricted availability of healthcare services and enough nourishment arises. In contrast, older people must have a diet rich in essential nutrients to fulfill their daily nutritional requirements and carry out their daily tasks.

Many individuals exhibit a typical nutritional status at the commencement, while a subset presents with excessive weight or obesity. The average MUAC of both groups exceeded 21 cm, a widely accepted value within the normal range (28). During instances of emergency, such as natural catastrophes, the use of Mid-Upper Arm Circumference (MUAC) proves to be an appropriate screening tool for evaluating the nutritional condition of older people adults. According to the MNA findings, the vast majority of individuals in both groups had a normative nutritional status. MNA has been widely employed as a convenient method for assessing the nutritional status of older people (28, 29).

Upon the study's conclusion, it was observed that the intervention group exhibited a slightly higher degree of weight gain and BMI alteration than the control group. Mangrove sword bean food bars in the diet impacted the development of nutritional indicators due to carbohydrates in these food bars (8, 9). The intervention group exhibited a higher mean consumption of these food bars than the control group. Carbohydrates are classified as a macronutrient that facilitates energy production, leading to an elevation in calorie intake and BMI (30). Approximately 11% of older people can meet their daily carbohydrate requirements by regularly consuming 50 g of mangrove sword bean snack. According to a study (31), the *api-api* mangrove flour has a fat content of 0.04 percent, protein content of 10.4 percent, and carbohydrate content of 21.4 percent per 100 g. The findings of the current study on the weight gain experienced by older people align with those observed in a similar study conducted on older people flood victims in Depok City (6).

According to the study conducted by Fatmah et al. (6), there was a recorded weight gain of 0.2 kg for 15 days following the intervention. The investigation findings are corroborated by a study on food and nutrition assistance for older people after an earthquake disaster (32). Upon the study's conclusion, it was observed that there existed a notable disparity in the level of knowledge of balanced nutrition among the senior participants of each respective group. The study's outcomes suggest that the nutritional knowledge of aged persons was statistically consistent with previous research, which indicated that their

TABLE 3 Socio-demographic characteristics, nutritional status, independence level, and cognitive performance of older people subjects.

Indicator	Control		Intervention		Total	
	n	%	*n*	%	*n*	%
Sex						
Male	7	43.7	8	53.3	15	48.4
Female	9	56.3	7	46.7	16	51.6
Marital status						
Married	8	50.0	9	60.0	17	54.8
Widow/widower	8	50.0	6	40.0	14	45.2
Age (y.o)						
Mean ± DS	65.3 ± 5.4		70.2 ± 9.2		67.7 ± 7.8	
60–65	10	62.5	8	53.4	18	58.0
66–74	4	25.0	2	13.3	6	19.4
≥75	2	12.5	5	33.3	7	22.6
Final education level						
Low	15	93.7	13	86.6	28	90.3
Moderate	1	6.3	2	13.4	3	9.7
Staying at home						
Alone	1	6.3	3	20.0	4	12.9
Husband/wife	1	6.3	2	13.3	3	9.7
Spouse/children/grandchild	3	18.7	5	33.3	8	25.8
Children/grandchild	11	68.7	5	33.4	16	51.6
Working type						
Laborer	4	25.0	4	26.7	8	25.8
Private	1	6.3	1	6.7	2	6.5
No Job	11	68.7	10	66.6	21	67.7
Body mass index (BMI) kg/m^2						
Underweight (<18.5 kg/m^2)	0	0.0	1	6.7	1	3.2
Normal (18.5–24.9 kg/m^2)	10	62.4	10	66.7	20	64.5
Overweight (25.0–29.9 kg/m^2)	3	18.8	3	20.0	6	19.4
Obesity (≥30.0 kg/m^2)	3	18.8	1	6.7	4	12.9
Mean ± DS	25.2 ± 4.1		22.9 ± 4.5		24.1 ± 4.4	
Mid upper arm circumference (MUAC)						
Mean ± DS	26.3 ± 2.8		25.2 ± 3.5		25.8 ± 3.1	
Independence level						
Basic activity daily living (BADL)						
Independently	15	93.8	15	100.0	30	96.8
Light dependence	1	6.2	0	0.0	1	3.2
Instrumental activity daily living (IADL)						
Independently	13	87.5	12	80.0	25	80.6
Need help now and then	3	12.5	3	20.0	6	19.4
Need help all the time	0	0.0	0	0.0	0	0.0
Mini nutritional assessment (MNA)						

(Continued)

TABLE 3 (Continued)

Indicator	Control		Intervention		Total	
	n	%	*n*	%	*n*	%
Normal	16	100.0	14	93.3	30	96.7
At risk malnourished	0	0.0	1	6.7	1	3.3
Mini mental state examination (MMSE)						
Normal	8	50.0	10	66.7	18	58.1
Probably cognitive deterioration	5	31.3	3	20.0	8	25.8
Cognitive deterioration	3	18.7	2	13.3	5	16.1

DS, deviation standard.

TABLE 4 The mean difference of weight and BMI of older people at pre-post study.

Indicator	Intervention		Control		Different	#*p*
	Mean	DS	Mean	DS		
Weight (kg)						
At 1st week	57.2	9.5	52.6	9.1	4.6	0.177
At 2nd week	57.4	9.4	52.7	9.1	4.7	0.167
Difference	0.3	0.4	0.2	0.4	0.1	0.505
95% CI of different	(0.0 to 0.5)		(−0.0 to 0.4)			
*p**	0.03**		0.150			
BMI (kg/m^2)						
At 1st week	25.1	4.1	22.9	4.5	2.2	0.155
At 2nd week	25.2	4.1	22.9	4.5	2.3	0.147
Different	0.1	0.2	0.1	0.1	0.1	0.408
95% CI of different	(0.0 to 0.2)		(−0.0 to 0.2)			
*p**	0.022**		0.152			

#*p*, Independen t-test.
**p*, Dependent t-test.
***p* < 0.05 at significant level.
CI, confidence interval; DS, deviation standard.

overall understanding of a balanced diet improved following nutrition education (33). In the aftermath of a disaster, nutrition management activities are implemented during rebuilding and rehabilitation to enhance and sustain the nutritional wellbeing of those affected by the event (34). The unique nutritional requirements that mean the need for energy decreases, but the need for protein remains of older people in the aftermath of a disaster have not been well addressed.

The provision of nourishing food and nutrition education has the potential to effectively mitigate malnutrition among older people individuals in the aftermath of natural calamities while also alleviating food insecurity. Food insecurity can be alleviated through emergency food assistance programs. The enhancement and preservation of the nutritional and health condition of individuals affected by a disaster can be achieved by implementing nutrition management strategies. These strategies encompass surveillance measures such as anthropometric assessment of older people and nutrition awareness initiatives involving nutrition education and the utilization of snack bars. These activities respond to and build upon the information gathered from public health service endeavors. The ability of individuals and institutions to cultivate a localized safety culture can enhance resilience in the aftermath of a disaster. Maintaining a constant state of readiness involves planning to ensure individuals, families, and communities are prepared for all types of disasters that may impact the community. The steps include preparing for emergencies, creating a disaster plan, and staying informed about potential threats using traditional local wisdom such as poetry, fairy tales, and construction of house on stilts (35). Integrating food security into post-disaster recovery initiatives is crucial to uphold the nutritional and health wellbeing of populations particularly susceptible to the impacts of disasters, such as older people. The Sendai Framework emphasizes the mitigation of catastrophe risk within people of older individuals (36). The post-disaster recovery process is impacted by heightened community engagement by observing emergency food consumption protocols.

TABLE 5 Comparison of mean macronutrient intake and nutrition knowledge of older people.

Indicator	Intervention	Control	*p*
	Mean ± DS	Mean ± DS	
Energy (kcal)			
At 1st week	1,173.9 ± 5,20.7	1,162.8 ± 370.1	0.946
At 2nd week	1478.3 ± 629.9	1,403.6 ± 529.3	0.724
*p**	0.072**	0.112	
Carbohydrate (g)			
At 1st week	179.2 ± 80.9	188.7 ± 56.7	0.709
At 2nd week	238.9 ± 100.6	229.8 ± 94.5	0.797
*p**	0.020**	0.071	
Protein (g)			
At 1st week	38.6 ± 18.5	36.4 ± 14.4	0.728
At 2nd week	41.3 ± 24.1	42.2 ± 16.3	0.905
*p**	0.645	0.283	
Fat (g)			
At 1st week	35.1 ± 22.8	30.5 ± 20.0	0.562
At 2nd week	39.9 ± 23.5	34.9 ± 17.3	0.502
*p**	0.601	0.503	
Total consumption of food bar (g)	643.8 ± 25	640.0 ± 38.7	0.749
Balanced nutrition knowledge			
Pre-study	30.6 ± 16.1	26.6 ± 14.6	<0.001**
Post-study	64.2 ± 14.3	67.2 ± 13.9	<0.001**

#p, independent t-test.
*p, dependent t-test.
**p < 0.05 at significant level.
DS, deviation standard.

Conclusion

Following a natural disaster, older individuals were provided with a dietary supplement in the form of a snack bar containing mangrove sword beans for 15 days. As a result, these individuals saw a modest increase in body weight, with an average gain of 0.2 kg. Consumption of carbohydrates in mangrove sword bean snack bars directly impacts weight when used as a dietary supplement. While the BMI of older individuals did not exhibit a noteworthy rise, a notable disparity in weight was observed following the consumption of the *api-api* mangrove and sword bean snack bar compared to their pre-bar weight. Due to its nutritional composition and structural attributes, the snack bar remains a viable choice for emergency sustenance options during and following a crisis. Education regarding appropriate nutrition is crucial in disaster relief initiatives, particularly when considering particularly susceptible demographics such as older people and children underfive.

Further investigation utilizing a more expansive cohort and an extended temporal scope is imperative to generate empirical data on the effects of emergency sustenance, such as snack bars, on the nutritional wellbeing of displaced individuals in the aftermath of catastrophic events. This assertion holds particular significance for populations that are considered vulnerable, such as older people, children below the age of five, lactating women, and expectant mothers. The present research endeavors to comprehensively address various nutritional statuses observed in the older people population, including persons who are underweight, of average weight, overweight, and obese. In addition, Law 24 of 2007 on Disaster Management in Indonesia is a suitable legal reference for disaster management in Indonesia. However, it does not adequately protect older people group prone to disasters. Therefore, it is recommended that specific provisions for older people for disaster management be included in the draft of the Older People Law. Government policy to conduct rapid nutrition and health assessments of older people to identify nutritional problems during emergencies and post-disasters.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the Ethics Commission for Health Research and Development (KEPPK) of the Sint Carolus, College of Health Sciences, Jakarta (No.089/KEPPKSTIKSC/VII/2022). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

FF: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Investigating the role of women producers in alternative food networks implementing organic farming in Berlin Brandenburg

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Introduction: This study sheds light on the challenges faced by women in alternative food networks (AFNs) applying organic farming in Berlin Brandenburg. They engage in AFNs as producers, consumers, and prosumers (producer-consumers). Literature indicates that individuals in farming face obstacles such as limited ownership, traditional gender roles, undervalued contributions, disparities in recognition and compensation, and barriers to leadership. The objective of this research is to understand the realities, self-perceptions, and conditions experienced by individuals in AFNs and organic farming. This study examines contextual factors, participation levels, decision-making processes, leadership dynamics, and impacts related to these participants.

Method: Using qualitative content analysis, interviews were conducted with active female respondents in three types of AFN: community-supported agriculture (CSA), food cooperatives (FCs), and self-harvest gardens (SHG).

Results: The interviewees expressed optimism about their involvement but emphasized the need for increased governmental support and community engagement. Participants in CSAs and FCs reported stronger producer-consumer connections and community building, while self-harvest gardeners sought personal growth and access to garden spaces.

Conclusion: Interview data highlighted demands for gender equality improvements and support mechanisms. Addressing these challenges and promoting equal status for them can enhance their contributions to community building and localized food production. Recognizing their efforts fosters societal inclusiveness and progress. Understanding and supporting individuals in organic farming AFNs, we can move towards a future where their contributions are properly acknowledged.

KEYWORDS

agriculture, feminist farming, female empowerment, consumer-producer networks, gender, alternative food network, prosumers

Introduction

Women are playing an increasingly important role in food production, accounting for 43% of the worldwide agricultural workforce (Alston et al., 2018). Agricultural industries in the developed world operate in a policy, media and industry environment that is predominantly masculine, and rarely acknowledges the significance of their input to successful farm production (Dahm, 2022a).

The current share of female farm managers in Germany is approximately 11%. On top of that, only one in five of the people set to inherit or otherwise take over farms are female (Davier et al., 2023). However, they face more difficult conditions than men, due to male-dominated systems

of access to land, knowledge, networks, roles, recognition and market (Davier et al., 2023). Participants frequently copy male roles and do not often develop their own unique leadership. They often adopt male behaviors due to societal and systemic pressures within male-dominated agricultural environments. These pressures include the need to conform to established norms to gain acceptance and recognition. Such systemic constraints hinder them from fully developing their potential as they navigate structural barriers and gender biases. This perspective aligns with the findings of Annes et al. (2021), who discuss how French female farmers challenge hegemonic femininity in agriculture (Annes et al., 2021). Nevertheless, more than 50% of the graduates of agricultural and nutritional sciences courses have been women for more than a decade in Germany (Zoll et al., 2018). About 36% of workers in Germany's agriculture sector are female, yet, this figure may not directly correspond to the proportion receiving financial support (Dahm, 2022b).

Our understanding of the distinction between consumption and production in recent times, and especially in alternative food networks (AFNs), has undergone an intriguing shift. What was once a clear-cut division has now become more fluid and nuanced (Stephens and Barbier, 2021). Several factors have contributed to this change, including advancements in technology, evolving roles of consumers, and the power of individual choices to influence public life and cultural values through consumption. As a result, a new term has emerged: the "prosumer," describing those who exist in the middle ground between consumers and producers in today's AFNs (European Union, 2018; Alberio and Moralli, 2021). This hybridization of food production and consumption is unfolding especially within the organic farming area, where growing, distributing and consuming intersect. When using the term "prosumers," the division of responsibilities, roles and practices is not a strict one, as AFNs are cooperative networks with the participation of professional farmers/gardeners, on the one hand, and consumers, on the other, sharing (or not sharing) labor practices in the fields of cultivation, care, harvesting and distribution to varying degrees and extents.

This term, "hybridization," describes the mixing of roles that were formerly distinguished between producers and consumers, resulting in "prosumers" who take part in both the production and consumption of food. This integration showcases the interconnectedness of production and consumption and its influence on food behaviors, access, and policy, emphasizing the importance of household-level activities and unpaid care work in food systems (Brückner and Sardadvar, 2023).

Within the food industry, new forms of collective action have emerged as a result of the rise of alternative food networks, such as short food supply chains and collaborative farmer stores (Kessari et al., 2020). As consumer behavior and corporate sustainability change, these networks become even more important for tackling sustainability concerns in the global food chain (Navrátilová et al., 2020). Though there are differences based on the kind of organization and degree of responsibility, these networks have a hierarchy of decision-making and accountability (Kessari et al., 2020)The selection of sustainability indicators is a critical factor in ensuring that decisions about production and consumption are taken into account in an integrated and global context (Rohmer et al., 2019). The roles of each participant and socioeconomic factors influence the perceptions of organizers, producers, and consumers in these networks, which also vary (Escobar-López et al., 2021).

The practices, narratives and decisions of both producers and consumers involved in food production are considered, playing a pioneering role in reshaping the entire landscape (Alberio and Moralli, 2021). Participants in AFNs exemplify this evolution as they engage as consumers, producers and processors (Nigh and González Cabañas, 2015). Conversely, urban consumers are increasingly drawn to AFNs for various reasons (Zoll et al., 2018). It is crucial to acknowledge that consumers are not passive bystanders but active contributors, who help shape the range of options available to them (Randelli and Rocchi, 2017).

Research has shed light on a range of motivations behind participants' engagement, including the search for ecologically sustainable modes of production, certified food quality, food safety consciousness in general or food hazards, health and nutrition concerns, as well as sympathy with social and political causes (Zoll et al., 2018). Furthermore, AFNs bear the potential of gradually redirecting the food system toward a more sustainable orientation (Zoll et al., 2021).

Nevertheless, gender inequalities persist in food provisioning in AFNs, with women often bearing the primary responsibility for this role (Som Castellano, 2015), which underscores the need for further investigation and up-front dedication to redistributing gender inequities within AFNs. This research, thus, seeks to shed light on female farm managers and active participants in AFNs, focusing on the Berlin-Brandenburg region of Germany. The research was conducted with the support of a broader research team, aligning with the journal's interdisciplinary perspective and that this is why sometimes the term 'we' is used.

We do not know enough currently about women producers/prosumers in AFNs working with organic farming practices in this geographical area. We address this gap in order to better understand the obstacles and opportunities that are specific to experiences in this domain. Our understanding of the roles to be played by these producers/prosumers within sustainable agriculture and alternative food systems in Berlin-Brandenburg will be beneficial to them, farmers, and the members of AFNs. Understanding the roles of female producers/prosumers in sustainable agriculture and alternative food systems in Berlin-Brandenburg will empower them to take on leadership roles, drive the adoption of sustainable practices, and strengthen community ties through initiatives like CSA and food cooperatives. A more inclusive, equitable, and sustainable food system that benefits all stakeholders can result from using this knowledge to guide supporting policies, generate employment opportunities, and prioritize health and nutrition.

Alternative food networks

The aim of AFNs is to establish connections between food producers and consumers (Barnett et al., 2016; Zoll et al., 2021). The primary objective of these alternative approaches is to promote both environmental and social sustainability. Various examples of AFNs in Germany include community-supported agriculture (Medici et al., 2023), food coops, farmers' markets, self-harvest gardening, animal sponsorship, urban gardening, pick-your-own farms and food assemblies.[1]

1 Food assemblies" typically refer to a model or platform that connects local farmers, producers and consumers in a community. These assemblies provide an online marketplace where consumers can purchase fresh, locally produced food items directly from farmers and producers in their area. This concept

AFNs aim to use resources sustainably. They represent a movement focused on transforming economic power structures to tackle diverse food system challenges, such as consumer health and environmental impacts (Brinkley, 2018).

Women producers/prosumers who prioritize local food systems in AFNs tend to be responsible predominantly for and spend more time in food provisioning, and engage in more food production and gardening (Meena et al., 2019).

These initiatives foster collaboration between consumers and agricultural producers allowing them to work together, form mutual agreements, and exchange knowledge (Brinkley, 2018). In Baltimore County, Maryland, such initiatives are evident where 110 farms and 224 markets participate in a closely-knit alternative food network aimed at addressing food system challenges through direct consumer engagement producers (Brinkley, 2018).

Similarly, in various regions of Germany, including urban and peri-urban areas, Community Supported Agriculture (CSA), food cooperatives, and self-harvest gardens have emerged as significant models of AFNs. These initiatives create meaningful bonds between producers and consumers through a shared commitment to environmental and societal goals, facilitating direct engagement and cooperative use of resources and land (Zoll et al., 2021).

In the United States, alternative food networks create a unique bond between producers and consumers, not just through the exchange of crops but also through the sharing of information and resources. Their study focuses on the regional context of various AFNs across the US, emphasizing the importance of local engagement and mutual support (Bruce and Som Castellano, 2017).

Incorporating these regional contexts, it becomes evident that the success and impact of AFNs are deeply influenced by their specific geographical and socio-economic settings, enhancing the overall understanding of how these networks function and thrive in different areas. Within European AFNs, individuals make up a large portion of producers and distributors and are thus key to the networks' formations and transformations. Participants engage in many traditional roles, but they also undertake substantial work that is usually not counted as part of their family's or household's production, taking on activities that occur most often in nondomestic spaces. These activities have both challenged and reinforced gender roles within AFN spaces (Blumberg, 2022).

Participating in community-supported agriculture (CSA) allows them to shatter commonplace gender norms. Not only that, but obtaining these enfranchised roles in CSA farming seems to have a positive impact on the social, economic, and environmental conditions of the communities themselves. They are the pathfinders for community resilience and sustainability (Jarosz, 2011).

Moreover, in Germany those in rural areas are systemically important, but, at the same time, are often not very visible when it comes to finances. In 2022, 83% of the individuals in agriculture work on the family farm, while almost three-quarters are involved in strategic business decisions (Davier et al., 2023). Measures to increase access to assets and services for them and empowerment of female farm successors by education and extension providers, as well as mentoring programs to pave the way for more to become farm managers and decision-makers are urgently necessary (Davier et al., 2023).

Gender relationships are fundamental worldwide to the way in which farm work is organized, assets, such as land, labor, seeds and machinery, are managed, and farm decisions are made.

In order to offer a new perspective, we apply a social analytical framework to examine the involvement of participants as producers and/or prosumers in AFNs applying organic farming. Our research seeks to specifically address the following inquiries:

- What factors influence women to be producers and/or prosumers in AFNs?
- To what extent and in what ways are participants involved in decision-making and leadership in AFNs?
- What is the impact of their participation in AFNs?

We created an analytical framework to examine the participation of these individuals in AFNs.

Analytical framework

The analytical framework we use for taking an inventory of our understanding has been thoroughly described, bearing in mind the empirical studies about the female prosumers' role on organic farming and AFNs. This comprehensive structure holds together four main sections, and their respective subsections, as it is shown below in Figure 1.

Contextual factors

The role of participants in AFNs is influenced by contextual factors, which include social, economic (Bruce and Som Castellano, 2017), environmental (Darnhofer et al., 2005) and political considerations (Karipidis and Karypidou, 2021). The sets and subsets of factors that impact farmers' decisions related to the conversion of conventional farming activities to organic activities incorporated in the farm business decision framework are categorized as those located in the external farm business environment and those located in the internal environment (Karipidis and Karypidou, 2021). We gain profound insights into the way these elements mold and influence the position held by individuals within the realm of alternative food network through a comprehensive exploration of social factors, such as cultural mores, financial aspects, for example, market entry points, and governmental influences pertinent to motivations and certifications.

Participation and engagement

The participation and engagement of individuals are central to the analytical framework aiming to comprehend the part that they play within AFNs. This framework not only acknowledges the different types of activities in which the interviewee engages but also considers the obstacles they encounter and the motivations propelling their participation.

aims to strengthen local food systems, promote sustainable agriculture, reduce the environmental impact of food transportation, and foster a sense of community by encouraging direct relationships between producers and consumers. The term is often associated with the movement toward more transparent and localized food supply chains.

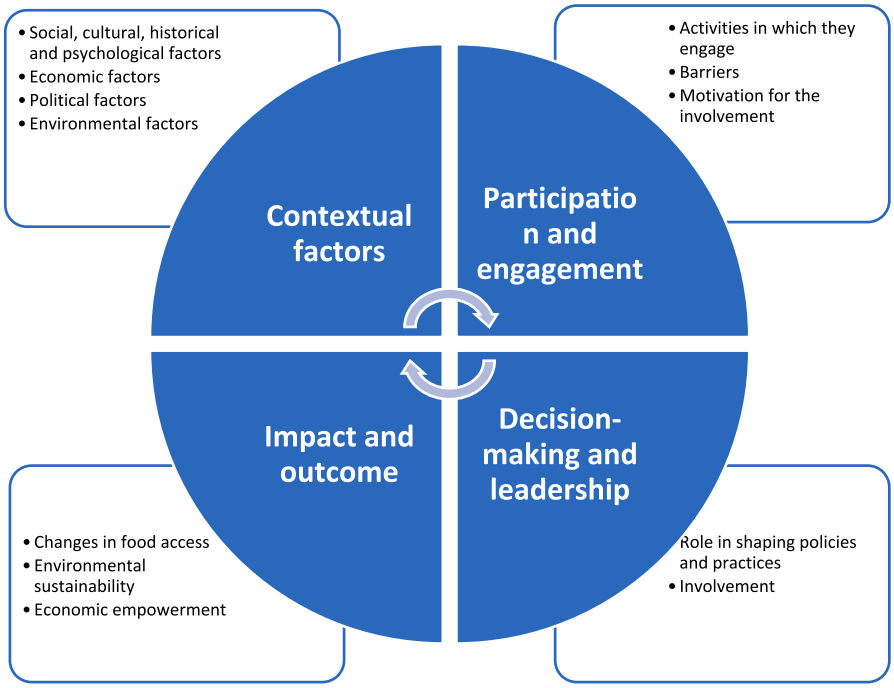

FIGURE 1
Analytical framework.

Those involved as producers/prosumers in these networks carry out diverse tasks, ranging from cultivation and production to distribution, alongside active networking (Bruce and Som Castellano, 2017). Female producers also display versatile capacities in rural settings, taking on farm management roles, among other responsibilities (Davier et al., 2023). We stand better positioned toward gauging these activities' actual influence upon food systems, both at micro and macro levels, by examining them more closely.

In spite of these obstacles, individuals exhibit an eagerness to participate in alternative food systems due to various incentives. Some are driven intrinsically by noble intentions revolving around environmental and social fairness; others by the desire to connect with local communities and positively influence local economics (Bruce and Som Castellano, 2017). Having knowledge about what calls participants to action in these alternative food spaces will equip us with useful tactics to support them further.

In summary, the participation and engagement of them in AFNs is a critical aspect of the analytical framework for understanding the role of female producers/prosumers in these networks. This framework considers the activities in which they engage, the barriers they face and the motivations that drive their involvement. We can better understand the contributions individuals make to AFNs and develop plans for fostering female leadership and participation by looking at these elements.

Decision-making and leadership

The exploration of women's decision-making and leadership skills plays an important role in the analytical framework seeking to comprehend their contributions as producers/prosumers within AFNs. This framework investigates how their involvement influences practices and procedures within the food system. The insights and experiences of individuals in AFNs can inform policy recommendations and support advocacy efforts, particularly when they engage with political networks and community organizations (Dhal et al., 2020; Malapit et al., 2020).

Engaging female participants in these deliberative sessions gain access to various perspectives and priorities which eventually foster impartial and sustainable measures (Metcalf et al., 2012; Nigh and González Cabañas, 2015). We can enhance our understanding of their impact on culinary provisions by examining particular processes where they lead or make choices. Those active within decision-making engagements contribute toward crafting more ecologically sound policies that aid both society and natural surroundings (Aguilar et al., 2015).

Studying the involvement of participants in administrative roles or decision-making within AFNs enhances our understanding of policy interventions in contemporary food systems. This knowledge helps us to identify strategies supporting and empowering individuals, while progressing towards impartial and environmentally sustainable food governance.

Impact and outcome

Participants' involvement in entrepreneurial activities revolving around organic food networks holds considerable significance for examining how their influence shapes the system. Regarding such alternatives, emphasis is placed on analyzing both the fallout and result of the increased active role of them in AFNs. This study encompasses diverse shifts attributable to their participation, such as

improvements in access to food, environmental sustainability and economic empowerment.

The participation of female in AFNs in United States has a significant positive effect on environmental sustainability (Bruce and Som Castellano, 2017). Those in East London, specifically the Tower Hamlets area in these networks frequently place a higher priority on environmentally friendly methods of producing food and farming, such as organic farming, regenerative agriculture and waste-free initiatives (Metcalf et al., 2012).

One of the key impacts of their participation in AFNs is an increase in food access for communities that have been traditionally marginalized (Fourat et al., 2020). Individuals in AFNs often prioritize the production and distribution of locally grown and culturally appropriate foods, which can contextualize with food awareness, healthy nutrition, food waste avoidance, access to organic food to marginalized groups, and education (Canal Vieira et al., 2021).

The involvement of female in AFNs can also contribute to their financial freedom (Canal Vieira et al., 2021). Those in these networks frequently launch small businesses and engage in entrepreneurship, for example, by starting farmer's markets or CSA programs (Aguilar et al., 2015). This can open up employment opportunities and help local economies become more sustainable and egalitarian.

In conclusion, one important part of the framework for understanding the role of women in these networks is the impact and results of their participation in AFNs. This approach takes into account the benefits of food access, environmental sustainability and economic empowerment that producers/prosumers bring to the food system through their engagement and participation in the AFNs.

Materials and methods

In order to answer our research questions, we conducted extensive research, which centered on interviewing female producers and consumers, specifically hybrid actors that we call "prosumers" (individuals) actively involved in organic farms within AFNs. We utilized a snowball sampling technique to ensure a deliberate selection of participants with diverse involvement in both organic farming and the AFNs. We managed to engage a total of seven interviewees for this study, all of whom had active affiliations with various agricultural communities, such as CSA, food cooperatives (FCs), and self-harvest gardens (SHGs). Each segment was represented by two participants, apart from CSA which contributed three interviewees. Explicit informed consent was sought from participants for the purposes of recording, transcription and potential publication in order to gain ethical clearance for this study. This demonstrates an ethical commitment to transparency, confidentiality and good practice throughout the research.

The existing literature describes roles among women concerning engagement in AFNs as producers (female farmers or farm workers), consumers, and those who link both domains – commonly termed as prosumers (consumers engaged in agricultural practices and/or distribution). Our focus in this study centered on individuals actively engaged in both production and consumption processes (prosumers) and those who have a clear focus in their professional role on production (producers). Hence, we deliberately selected our interviewees from this specific demographic identified as producers/prosumers, a term we will consistently employ throughout this article to refer to this dynamic group. To initiate the interview recruitment process, we reached out to potential participants by contacting them directly and inquiring about their willingness to contribute to our study. With this sample size, the participants expressed genuine interest in the topic. In this study the insights gained from participants contribute valuable qualitative data to the existing body of knowledge.

The study was carried out in the Berlin-Brandenburg region, which is known for its varied agricultural environment that includes both large-scale commercial farms and smaller organic and community-supported agricultural projects. This area is notable for the high degree of contact between the urban and rural areas and the growing interest in locally sourced and sustainable food systems. With its vast agricultural lands, Brandenburg serves as the production basis for organic produce, while Berlin, the capital city, offers a sizable market for it. Rich urban customers and rural farmers make up the socioeconomic landscape, which fosters a dynamic environment for AFNs. Agricultural collectivism in the area before reunification and the shift to market-based farming add levels of complexity to contemporary farming methods and community projects. It is important to comprehend this background since it affects women's roles and participation in AFNs, affecting the opportunities and difficulties they encounter in this field.

The qualitative research methodology followed here involved conducting semi-structured interviews with 17 open-ended questions using a Zoom platform, except for three interviews which were conducted face-to-face. The manuscripts contain 39,509 words and each interview lasted between 50 min and an hour. Although this approach made it easier to reach individuals in diverse places, there were drawbacks as well, like the possibility of technological difficulties and a lack of face-to-face interaction. But Zoom's utilization made it easier for participants to participate and reached a wider audience, which enhanced the quality of the data gathered.

Prior consent was obtained from the participants before recording their conversations to ensure consistency in the language used during the analysis. The primary focus in the interviews was on posing questions to the participants regarding their involvement in (AFNs) and their experiences with organic farming. The key areas explored included the challenges they encountered in these pursuits and the limited engagement of female participants observed in both production and consumption aspects. Another major area of inquiry focused on assessing the decision-making capabilities within the framework of farming practices. The demographic section captured critical information, such as age, gender and involvement in organic farming activities. Analysis of the transcripts revealed three main ideas: participation, community, and leadership. Women's participation in AFNs and their motivations, the impact of their involvement on community building, and the leadership roles they take on and the challenges they face were the primary focus areas explored in the research. We expected to uncover the specific challenges related to gender roles, recognition, and compensation within AFNs. The following table provides details regarding the research focus and correspondent expectations (see Table 1).

What we aimed to do in these interviews was twofold: firstly, to carefully understand the roles in terms of the woman themselves. Subsequently, actually exploring with the other participants the way they also saw these issues and what processes they are going through in their own work. Secondly, the participants gave us valuable insights by sharing their stories during the interview research, and what

TABLE 1 Research focus and anticipated insights.

Key area	Questions	Expectation
Contextual factors	What social, economic, and environmental factors influence women's roles in AFNs?	Identify key barriers and enablers related to contextual factors
Participation and engagement	How do women participate in AFNs, and what motivates their engagement?	Understand motivations and the nature of participation
Decision making and leadership	What are the leadership roles women take on in AFNs, and what challenges do they face?	Explore leadership dynamics and decision-making processes
Impact and outcome	How does women's participation in AFNs impact food systems and community dynamics?	Assess the broader impact of women's involvement on food systems and communities

TABLE 2 Demographic distribution of participants.

Participants	Code	Age	Engagement in AFN	Relative frequency (%)
1	CSA1	25–30	Community-supported agriculture	42.85
2	CSA2	30–35	Community-supported agriculture	
3	CSA3	35–40	Community-supported agriculture	
4	FC1	30–35	Food coops	28.57
5	FC2	20–25	Food coops	
6	SHG1	35–40	Self-harvest garden	28.57
7	SHG2	30–35	Self-harvest garden	

we have been able to uncover were perspectives that are derived from not only the path of their lives but also from their observations of people who are benefiting from the things that they are doing. Therefore, the first level of analysis, having collected the interview data, was to go through the interviews we recorded and transcribe them word-for-word. That became our basic data in conjunction with the analytical framework we developed. We then systematically identified the key parts of the transcript, identifying themes and elements and matched them up against the different sections of the analytics template.

The process of analysis was descriptive in nature and conducted manually. This was done to gain a comprehensive understanding of the participants' viewpoints and narratives. It is important to mention that this study went through a very thorough content analysis process to make sure that it was able to provide as accurate data as possible by capturing emerging themes, patterns and subtle nuances within participants' responses (Lindgren et al., 2020). We have carefully selected specific quotes from the interviews as references to provide clarity and support in order to articulate our findings. It is critical to consider that these quotes were used as references from each interview without changing the interviewee's words or context. Using these precise quotations, this study has maintained a very strong sense of integrity and authenticity for the readers to fully understand the participants' true perspectives.

Certain actions were undertaken to ascertain the trustworthiness and soundness of the qualitative analysis. During our careful and detailed analysis of the interview data, we coded the responses by systematically reviewing and sorting them into categories. We employed a series of coding procedures to ensure the reliability and quality of our analysis, implemented specific coding procedures and put rigorous quality assurance measures in place. This included cross-checking among coders to verify consistency and addressing any discrepancies through discussion and resolution.

To sum up, the participants in this research were carefully chosen. We undertook qualitative interviews with an extremely precise transcription technique, and analysis was done manually to the highest standard. We adopted this systematic methodology to thoroughly capture multifaceted views from female farmers who are particularly part of the organic farming in AFNs. We benefitted from this methodology, as the paper is filled with rich findings relating to the research questions.

Results

The findings underscore the significance of every factor that influences the participation of these producers/prosumers in the AFNs across these three initiatives. However, distinctions and commonalities come to light among these instances upon delving deeper into the analysis. This section explores the key elements of these deviations in greater detail. The following table provides sociodemographic details regarding those who were interviewed (see Table 2).

Contextual factor

The participation of individuals in AFNs and organic farming is shaped by various contextual factors, such as income, education, employment and health, family structure, farm structure and duration of organic farming practice. These factors significantly impact the role of female participants within AFNs. Those who have higher levels of income and better education are more inclined to engage in these

activities to the fullest. Moreover, the existence of stable agricultural institutions and supporting family structures can help them participate. Additionally, individuals who have been involved in organic farming for a long time are more likely to make significant contributions to the development of a sustainable food system. They are empowered and given opportunities to advance sustainable agriculture methods when these social influences are taken into account.

> *"So, I think, if women really want, they have all the access they need but I believe that they will always have to work a little bit harder than men, to get, like, when even, when they have the knowledge to get access to markets and everything. I think it requires just more effort than it is for men because everything is, so male-dominated."* (FCI)

This highlights the additional effort women need to exert face in male-dominated sectors, requiring them to exert more effort than their male counterparts.

> "I think it's also kind of, how women are socialized, or how they're taught to be as well as it's men and how they're taught to be, for example, like I try to make sure that I don't just employ men, but if only men apply, obviously, I, I only have male applicants that it's only going to be men doing the job. But I think that's not necessarily because we scare off women, but because women sometimes feel they're being told by the world that they're not good enough for physical jobs or they're not good enough for, I mean, one of the things that we write in our application is that job posting is that you have to drive a tractor, a small tractor, but it doesn't matter if you don't have any knowledge of this. We're going to teach you, and I didn't know how to drive. But I think it's this thing where a lot of women think, oh, I, I can't do that because they've been taught by the world that they don't fit jobs like that or they can't do jobs like that. So I think that's one part, but it's also, obviously things like, it's also bigger societal problems. I'd say, I think its physical jobs are often taught to men and so like it's this whole circle". CSA2

The perceptions of these producers/prosumers regarding sustainable organic farming encompass various attributes, including educational attainment, active engagement in social activities, economic incentives, yearly income level, availability of information sources, involvement with extension personnel, willingness to embrace innovation and readiness to embrace risk (FC 2.1). The influence of social factors on engaged individuals' roles within the AFNs and organic farming is evident.

> *"I think the main thing is that women have to form these spaces themselves. They have to fight for these spaces and like this, like a women's gardening collective, they have to found this, shape this and work for this to be a safe feminist space that's very aware and very like. And I think that there could be in all agricultural areas, it could be more work done from the men themselves as well. So, I feel like men could work more to form safe spaces for women or could maybe start the communication more or work with things. I mean, do workshops or whatever. There's a lot to come from male-dominated companies as well, I'd say."* CSA3

Economic factors are another aspect shaping the role of women in AFNs and organic farming. The participants showed the economic shift of farming and nuanced understanding of this dynamic. Acknowledging the lessening of agriculture in economic effectiveness compared to the past, one participant outlines that making a living out of agriculture nowadays is a hard task, especially for them. The phrase "at the border somewhere" shows this sense of marginalization from the current economic system. Asking for governmental incentives and more assistance show this need for policy changes and the economic financing that the agricultural population deems necessary.

> "Because farming is no longer such a big part of the economic world. It was different 50 years ago. So we just don't do it. And other than that, there could also be government incentives. I mean, there can also always be funding projects maybe or like, yeah, I think there, there could always be more support from the government or more money from the government." SGH2

Moreover, the interviewee highlights the unequal treatment of small-scale farmers who do not have access to government support rather than the government not having enough money to fund both. This participant notices how the extensive paperwork is the same whether the farm is large or small-scale. Twenty-six pages of standardized paperwork emphasizes how there needs to be a procedure in place regarding to the size of the operation. It relates to systemic equality and supporting the needs of farmers of various scales.

> *"It would be great to have support from the government. I think the normal government's wish is not to have these small-scale farms. They want to have the big farms. And yeah, I think this is more the way. It would be great to have more support also for like in big farms, like all, all our neighbors have 2000 hectares. We have all the women in in the office doing all the paperwork and the smaller farms, we have to do the same amount of paperwork or where we have only one third of the land of them. But we have the same work because the papers have the same. It's 26 pages. And, yeah, it would be good to have, a good access for, having paperwork, helping with bookkeeping stuff, taxes."* SHG2

The female participation in AFNs is important and should be supported by local politics and the government.

> *"I think it starts with the state, like the local politics, especially the agriculture departments. They can offer services for women, like information and workshops and but it, it is also down to the consumers. They can support women-owned businesses and farms. And not always looking at the, at the price of the food but, buying, for example, community-supported agriculture and supporting the whole farm and not just the product, so, that it's like the best vegetables, the one that's cheapest, that's not always the best. And but also for other farmers and like to support the women around them and make it easier for them [the women] to establish a business."* (SHG1)

Participation and engagement

The AFN greatly values participation and engagement, recognizing the important role played by female participants in its various activities. In fact, there are instances where they show even higher levels of engagement compared to men (FC2). They contribute actively across multiple domains, including both administration and fieldwork. Especially when it comes to the latter, the interviewees display remarkable enthusiasm for participating in CSA, FCs and SHG activities. Their strong commitment to sustainability motivates them to participate eagerly in work in the field and show their willingness to operate machines.

> *"So, at our farm it's very obvious that we have more women working in the administration and doing like office work. I mean, obviously the farm work is really hard work. I did it a few seasons and its super exhausting and like even the tools that we use, they are made for strong people, like some of the tools I couldn't use because some often I was too weak to move things around and that makes everything extra hard. When the infrastructure around you is just not designed for you. And so, we had other women working at the farm. And they couldn't do it for more than one season. And like many of them, they changed to a different farm. I still feel that, most men are more interested in machines and technical things. I mean, it's also because, these are the stereotypes that we grew up with and, they became true for us that men are more the cars themselves and women are doing the office work. And, I mean, now we start, rethinking these patterns and these stereotypes but they are still the reality that we live with. And, it just takes time for, for this to change, to have women being more comfortable to work with machines and everything. But then also the machines need to be designed that anybody can work with them."* (CSA2)

Engaging with an AFN can greatly influence these producers/prosumers' understanding of the social and environmental aspects of local food systems. This is because a considerable number of those involved choose to prioritize organic, nourishing foods for themselves and their children. Consequently, those who actively participate in AFNs are more inclined to support the sustainability of the food system.

> *"From my point of view, I noticed women being more interested in, local sustainable food systems. I think that there's a very high potential in, in women to support these local networks and to support like transformation for more sustainable food systems, but also in other areas of society that that's really great. I feel women are more concerned about the environment and also social aspects because we are community-supported agriculture."* (SCA3)

The engagement of female producers/prosumers in AFNs is closely linked to their individual values. Those who are involved in the production and consumption of food in Berlin Brandenburg tend to place a high priority on health and organic aspects. They also recognize the significance of sustainability and the impact of food on the environment and climate. Consequently, these producers/prosumers in the region value purchasing from farmers or producers who prioritize sustainable practices. This reflects a strong appreciation for sustainable approaches and environmental responsibility among them in Berlin Brandenburg, as pointed out by SHG 2 and SHG1.

In addition to their preference for organic food, engaged producers/prosumers are also involved in various activities within the AFN. They participate in CSA, farmers' markets and community gardens, and they often play a key role in organizing these activities. They are also involved in food cooperatives, where they work together to purchase organic food in bulk, which helps to reduce the cost of organic food for everyone involved.

> *"I feel a lot of women I know personally are more interested in climate activism and sustainability and are more invested in, where does their food come from? And I think maybe it's also this thing where a lot of women are also often societally pressured to be like very healthy. And I think maybe those two things connect with each other, and then there's this thing that women are interested in sustainability. But then they're also like very knowledgeable about regional produce and unhealthy vegetables and then these kind of intersect and then they get into organic produce."* SHG2

Furthermore, these producers/prosumers are also involved in the education and advocacy of organic farming and AFNs. They often organize workshops and training programs to teach others about organic farming, sustainable agriculture and the importance of supporting local food systems. Involved female producers/prosumers are also involved in policy advocacy, lobbying for policies that support organic farming and AFNs (FC2).

Participants play a pivotal role in various activities within the AFN. They actively contribute to administration, field work, sales and other areas. However, certain obstacles still hinder their full participation, such as household chores and childcare responsibilities. In addition, the design of certain machinery and equipment used in the field often cater solely to male users, making it challenging for them to engage in fieldwork. Despite these challenges, they continue to excel in diverse roles within the AFN.

> *"I think there is sometimes prejudice that women's bodies are weaker than men. I have sometimes noticed that there's like some work where my coworkers prefer to do with men because they are stronger. That's one of these fake reasons to not employ women or to not really do work with women where it's like, I consider myself pretty strong. And when I've worked with this women's gardening collective in Berlin, I felt like they were all incredibly, like, physically able and had a very good stamina. And they do more physical work than we do. So, they were fitter than the men that I work with, I would say. So, I think that there's this biological prejudice that's kind of a problem in, in jobs that are physical."* (FC2)

In spite of the potential benefits AFNs offer, producers/prosumers encounter substantial barriers when it comes to participating and holding leadership roles within such networks. The persistence of gender stereotypes and discrimination poses one primary obstacle for their involvement in AFNs. These producers/prosumers, often perceived as caregivers and homemakers rather than leaders or entrepreneurs within the food system, may struggle to be taken seriously or obtain access to crucial resources and networks that are necessary for success in AFNs.

> *"Well, politics are also very male-dominated. So, they may not think of things that women need. I don't think they do it on purpose that there are not really any differences, but maybe there should be more differences in how they support men and women because, as I mentioned, like the whole infrastructure is, is just not designed for women to work in agriculture."* (SHG2)

One more aspect to consider is that these individuals frequently encounter considerable time limitations and caregiving obligations. These factors can pose challenges when attempting to engage in the demanding, erratic timeframes often associated with various AFNs (CSA1). Moreover, they are more prone to experiencing harassment within their professional environment, especially in male-dominated fields such as agriculture and the food production sector (CSA2).

Each female producer/prosumer has a distinctive motivation to join AFNs and preference for organic crops. Overall, consumers seem to be drawn towards sustenance yielded by sustainable practices. They very often cite family health, particularly that of their children, as a crucial factor influencing their participation in AFNs. Their presence in different aspects of these networks is pronounced, with data suggesting more females on our food cooperative team compared to males.

It is important to note that while there is no clear data on whether they are more involved in the AFN than men, it is clear that women have made significant contributions to the growth and development of this movement. Many of the key players in the AFN, including farmers, organizers and advocates, are participants. Additionally, they have been instrumental in making the AFN more accessible and inclusive, particularly for marginalized communities (CSA2).

Recognizing the substantial contributions of these individuals within the AFN is crucial. Those in administrative positions bring important skill sets and views. These roles are essential for maintaining the organization and operation of many different projects. Particularly attending to the details, being able to communicate effectively and having the ability to multitask makes a great deal of difference in the success of administrative functions. Coordinating events, managing budgets and making collaborative meetings effective are examples of the types of tasks they are able to engage in successfully.

Furthermore, female producers/prosumers actively participate in field activities within the AFN. They play an essential role in cultivating, harvesting and processing food, as well as engaging in activities related to sustainable agriculture and organic farming. Their expertise in areas such as permaculture, crop rotation and agroforestry help to foster environmentally friendly practices within the network. Additionally, they contribute to CSA programs, farmers' markets and food cooperatives, fostering local food systems and promoting access to nutritious and sustainable food (SHG2, FC1.2).

Impact and outcome

Female participants have a great potential in AFNs and organic farming. Their community engagement, organic preference, education and leadership are the skills that they bring with them to add value to the AFN.

In terms of environmentally friendly farming practices, young female farmers exhibit a greater level of concern than their male counterparts.

> *"I believe that women work more and think more about future generations and children and environment protection because we are more conscious about this fragile environment."* CSA3

The change towards climate action, sustainability, and food justice necessitates the active participation of women in agricultural growth and empowerment. Their involvement can make a big difference in promoting sustainable practices, guaranteeing a just and equitable food system, and reducing the effects of climate change.

> "Women involvement in agriculture development and liberation is I think really important for achieving transformation towards the climate action, sustainability and food justice. Yeah, which can help to mitigate the effects of climate change." CSA1

These producers/prosumers display a stronger inclination towards environmental activities. A case in point is the significantly higher degree of adoption of organic horticulture technologies among female farmers than male farmers. Furthermore, female farmers are more dominant in sustainable and organic farm operations than in industrial farming, and also demonstrate greater involvement in alternative agriculture initiatives. Additionally, organic farmers tend to be younger and more often women than conventional farmers (CSA1). Due to their multitasking responsibilities, these farmers need to balance family, childcare and farm work activities (Unay-Gailhard and Bojnec, 2021).

Decision-making and leadership

It is essential to acknowledge the significant role that participants play in influencing practices and informing policies. Despite the progress made, they continue to strive for visibility and actively contribute to shaping a better future for themselves.

> *"I feel a lot of women are very sustainable, like, very socially aware and very aware of many different political aspects because they themselves are political. Yeah, we still have many feminist fights. So, I think, there's a large involvement definitely and I think we need generally more help from all sides but there's already a large involvement."* CSA2

Individuals play an important role in AFNs and organic farming. Their contribution is essential to the success of the transformation of the food system. These producers/prosumers are involved in various aspects of AFNs and organic farming. They may, for instance, participate in seed-saving, food processing and preservation, market gardening or CSA. Participants have a deep understanding of local food systems and are responsible for preserving traditional food practices and knowledge.

> *"It's my claim that we are more conscious about this fragile environment and that we have to and keep it balanced and we can't take more out than we put in. I think this is normal that we just notice when we raise children and it's the same when I raise calves and when I raise I, or when I let it grow, I don't raise it, then I have to pull on it. And I think this is very transformative. Women are*

> *talking to each other more and we, and the knowledge exchange is faster."* (SHG1)

Innovation is another area where women in AFNs and organic farming excel. Women are often at the forefront of innovation (CSA2), experimenting with new techniques for soil conservation, developing new marketing strategies for their products and trying new approaches to growing food. Women-led cooperatives and collectives are becoming more common, providing a platform for women to collaborate and share resources (SHG1, CSA2).

The share of these members in the workforce of AFNs and organic farming is significant. They often take on the role of primary producers and prosumers, working long hours in the fields or food processing facilities. They are also involved in other aspects of the industry, such as research or policy development. However, women's contributions are often undervalued and underpaid, and they may face discrimination and exclusion from decision-making processes.

> "I feel like there's just not a lot happening on a government level because I feel like the government's priority is different subjects. I think it's kind of like this whole, there's of talk about land, about funding, about rules and lawmaking and policies in organic farming. And it's also a lot about fair wages. And then like this whole like gender equality thing always feels kind of like an afterthought to me. It's always like listed when we, when we do the demonstration with all the other tractors and people who do agriculture here. Then that's always one of the parts on the agenda, but it's always like a very small part if you know. So I think that the government has other priorities definitely.
>
> *And certainly, I think there's having more women in leadership does bring new leadership styles. What I see in our cooperation is there's quite or importance placed on communication, for example, having a clear feedback routine to make sure we're actively learning with and from each other. I see a lot of potential just in terms of leadership styles and where emphasis is placed. Again, this is, you know, it's my bias, my experience, but around inclusivity and equity simply."* (CSA1)

Discussion

This study aimed to address three research questions mentioned above. The findings presented here contribute to gaining a more comprehensive understanding of women's roles in these types of initiatives.

Factors influencing the roles of female producers/prosumers in AFNs

Research indicates various factors influencing their participation in agriculture in Germany, particularly in pursuing farm manager or higher positions. Two key reasons are identified regarding this aspect: They anticipate fewer personal rewards from these roles and feel less confident in meeting job requirements due to cultural expectations, lack of role models, and challenges in balancing work and family responsibilities. Additionally, gender bias, limited access to resources and training, and differences in educational and professional experiences contribute to this lack of confidence. These factors collectively discourage them from seeking higher positions in agriculture, necessitating targeted interventions to promote gender equality and support their career advancement in this sector (Lehberger and Hirschauer, 2016).

The literature suggests that policymakers should prioritize enhancing women's access to resources, education, training and credit facilities. This highlights the existing low demand and supply for participants involvement in the agricultural sector (Chebet, 2023). However, engagement in AFNs is fueled by diverse motivations, encompassing a quest for quality food, health considerations, and political or environmental awareness (Som Castellano, 2015). In contrast to traditional agricultural contexts, they have greater access to leadership roles in Alternative Food Networks (AFNs) due to cultural differences. AFNs promote inclusive and encouraging environments by putting a strong emphasis on teamwork, community involvement, and social justice. Community-supported agriculture (CSA) and food cooperatives, for instance, frequently feature democratic decision-making procedures and offer networking and mentorship opportunities, enabling women to assume leadership positions. On the other hand, they find it more difficult to progress in traditional agricultural environments because of the prevalence of hierarchical structures and gender biases. Consequently, AFN cultural norms and values give them greater chances to take on leadership roles and receive acknowledgement for their accomplishments.

Moreover, a notable increase in female participation in AFNs has been observed. This shift can be attributed to various factors, including the importance placed on family health, childcare, sustainability and environmental friendliness. Despite challenges in traditional agriculture, these initiatives showcase a positive trend in fostering a greater female engagement.

Research indicated a higher frequency of females participating in self-harvest gardening in Germany (Gauder et al., 2019). However, we observed that although there are a considerable number of women involved in this initiative, it was only acknowledged by the participants, and mentioned that it seems that recognizing the role of female in AFNs may not have been emphasized as an important topic.

The research explores various interrelated factors in Germany's Alternative Food Networks (AFNs) that contribute to gender dynamics, such as the division of labor, access to resources, social recognition, and economic opportunities. It emphasizes that female producer/prosumers often handle the majority of the workload but struggle to gain the same level of recognition and support as men (Čajić et al., 2022). Our research supports these conclusions by presenting particular instances of individuals engaging in various AFN activities, such community service, and by emphasizing the additional difficulties and prejudices they encounter. The fact that they frequently have to put in more effort to receive the same recognition as men despite their great achievements highlights the need for institutional adjustments to encourage gender equality in AFNs.

Furthermore, economic factors significantly influence the role of women in shaping alternative food networks in Germany (Marks-Bielska, 2019). Our research produces similar results and it would be worth government exploring and implementing supportive policies, including streamlined paperwork processes and financial

incentives for smaller-scale farms. Their participation, including the dissemination of information, workshops and financial aid programs, should be supported. Consumers also play a pivotal role by consciously choosing to support female-owned businesses and farms, fostering an environment where they can establish and sustain successful ventures in AFNs and organic farming.

As the consumer helps to blur the boundaries between traditional consumer and producer roles, the consumer plays a critical part in Alternative Food Networks (AFNs), helping to create the concept of "prosumers." Through labor, decision-making, and distribution activities, consumers in AFNs actively participate in production processes including food cooperatives and community-supported agriculture (CSA). Individuals are empowered to directly impact the food system by their active engagement, which also supports sustainable practices.

Initiatives should challenge embedded gender stereotypes, providing opportunities for women to thrive in traditionally male-dominated sectors. Proactive measures are essential to create safe spaces for them, both through their own initiatives and with support from men in agricultural settings. Addressing dominant male norms and behaviors in agriculture is crucial for fighting gender inequalities. Our findings, highlighted the interviewees, emphasized the importance of recognizing and challenging these norms to promote gender equality. Focusing on gender relations and the impact of societal norms, this approach offers a broader understanding of the dynamics at play. It shifts the focus from solely female experiences to the interactions between genders, providing a more comprehensive strategy to combat gender inequalities in the agri-food sector.

Women's roles in decision-making and leadership within AFNs and organic farming

Our study identifies specific criteria facilitating their participation as prosumers in AFNs. falling within a particular income bracket, coupled with significant maternal responsibilities and a commitment to organic and nutritious dietary habits, represent a notable segment. However, challenges emerge, particularly for low-income working mothers facing overwhelming physical, mental and emotional demands (Bruce and Som Castellano, 2017). Participation in AFNs demands resources, time and dedication, underscoring the importance of accommodating diverse circumstances (Fourat et al., 2020).

Addressing infrastructural barriers and promoting environmental awareness, the literature shows that women are leaders in AFNs in Germany (Antal and Krebsbach-Gnath, 1993), and our study observed active involvement of them in AFNs. Still, they are facing some limitations that makes them unable to take more of a leadership part and decision-making as often.

The difficulties they encounter in achieving top leadership roles is partly based on the way tasks related to providing food are divided between genders, especially in AFNs (Som Castellano, 2016). There is a major barrier that prevents the full participation of women in AFNs, which lies in the limitations of infrastructures, with machinery and tools often constructed without any considerations of diverse physical abilities. Improvements to individual capacities and intra-household relationships are critical to supporting their participation and leadership in producer organizations (Kaaria et al., 2016). In order to overcome this, actions should involve the redesign of agricultural tools to be more inclusive, since targeted training is inadequate to encourage female participants' confidence in interacting with machinery.

In addition, the AFNs can support informal caregivers by adopting flexible work practices by providing shorter, more intensive bursts of work as and when required and creating arrangements allowing workers to coordinate tasks with broader family responsibilities. These practices help in reducing the impact of time poverty, reflecting an understanding of the labor burden shouldered by them. As such, the prescriptive measures proffered here present a composite strategy designed to ensure their full and robust participation in AFNs. These measures respond to key findings which have consistently shown that women consumers want to do more rather than less in the AFN context. However, they are extremely aware of the very precise bounds within which they are required to operate. Achieving this participation requires a reassertion of the social contract between public and private provisioning. In the absence of this, we are left with seeking more localized and community-supported agricultural solutions.

differ from conventional gardening techniques or cultural symbolic activities historically linked to men (Metcalf et al., 2012). The particularities of the Berlin-Brandenburg area, especially the prevalence of large-scale farming, display barriers to female participants who endeavor to enter farming and establish their own farms. Issues such as poor soil and intense competition in the land market intensify these challenges. In comparison, in regions where family businesses dominate farming toil, women might bridge into these families and this way of farming more smoothly.

In order to gain a deeper understanding, it would be advisable to carry out a more expansive study which specifies factors such as gender within network structures, local food systems and CSA in AFNs as separate entrepreneurial expressions. This approach will contribute significantly to adopting a systematic perspective. Alternatively, exploring the dynamics in a different geographical location may yield valuable insights.

Impact of women's participation in AFNs

The results of this research demonstrate some of the multiple effects that female engagement in AFNs have that go beyond only economic outcomes. Participants can improve local connections, community expansion and social cohesion. Some of the obstacles that they encounter include the possibility of over idealizing alternative strategies and restrictions in reaching alternative food products (Bruce and Som Castellano, 2017). Instead, their dedication to sustainable approaches helps to preserve health ecosystems and more sustainable food systems (Fourat et al., 2020).

It is essential to help participants to build strong community engagement and leadership capacities to make sure that they play a maximum role in community-engaged and leadership roles in AFNs and organic farming. Supporting individuals in their participation in the decision-making processes and leadership roles of AFNs is to strengthen not only resilience but also diversify perspectives that are crucial for sustainability. Making it easy for them to preference organic farming by creating educational initiatives and targeting resources will also make them become more capable of promoting the environmentally friendly practices, future-building and inclusiveness of AFNs.

Understanding the challenges of participants, such as balancing family responsibilities with farm work, is critical. To help them succeed, AFNs and organic farming need to introduce measures that proactively address these issues. That includes everything from flexible time schedules, daycare, and compensation that reflects farmers' contributions. When we empower them in these sectors, their ability to lead profound change is increased. They will drive new environmentally resilient, community-focused agricultural practices.

To sum up, what this research found was the complicated nature of influences on participants' roles in AFNs and organic farming. But the potential for change when they come together to shape more sustainable and more equal food systems also came through. Their contributions should never be taken for granted; they should be actively supported.

Conclusion

We employed a comprehensive analytical framework in our study to explore the integration of these prosumers into AFNs. What sets this study apart is its unique analytical framework, which thoroughly considers the varied positions of women in Berlin and Brandenburg. It becomes apparent that female prosumers confront distinct obstacles and gender-related issues, particularly when it comes to AFNs. Their participation in AFNs gains numerous advantages for the sustainability and well-being of agriculture. Their contributions extend beyond ecological aspects and encompass social elements, including fostering community connections and facilitating knowledge exchange.

Furthermore, their preference for organic produce and roles as mothers who advocate for healthier food choices underscore the importance of their involvement. In order to establish a more equitable and sustainable food system, it is crucial to address the hurdles faced by female prosumers in obtaining land, forming networks and accessing resources in organic farming. Governmental assistance must be tailored to accommodate small-scale farmers, especially women, by building upon their communities' stabilizing capabilities. A collaborative approach with supportive networks can significantly mitigate these challenges while amplifying the voices of prosumers. Additionally, financial aid while instilling trust should be facilitated alongside customized regulations aligned to their particular needs.

Efforts in different initiatives demonstrate the potential for positive change and empowerment of female prosumers in AFNs. Promoting visibility, networking and providing resources, these initiatives contribute to a more inclusive and supportive environment for women prosumers in AFNs and organic farming. The interview subjects stressed the value of having more women in executive roles in the AFN value chains. They think that varied leadership may foster inclusivity and bring forward fresh viewpoints.

It is also crucial to put government policies and incentives to work in the AFN to advance gender equality. They think that by enacting these policies, more women will be inspired to succeed. Creating networks of support and promoting cooperation among them in agriculture and the AFN are essential. The growth and success of female participants in various fields can be facilitated by these networks, which can offer a forum for exchanging experiences, information and resources. It is essential to increase their access to resources such as land and finance. The respondents highlighted that in order to provide equitable possibilities, access barriers, such as a lack of knowledge, financial limitations and discriminatory practices, must be addressed.

It was also made clear that there is a need to confront and eliminate the prejudice and discrimination that individuals experience in agriculture and AFNs. This can be accomplished through educational initiatives and inclusive practices that support the equality of opportunity and treatment. Women in organic farming and the AFN can improve their knowledge, self-confidence and ability to thrive by developing mentorship programs and offering skill-building opportunities. The significance of encouraging to start their own businesses and develop new ideas in organic farming and the alternative food industry is crucial. They can create their own businesses and contribute to the growth and development if they are given access to capital, business training and mentorship.

It was stressed how important it is to develop markets for these prosumers in organic farming and AFNs. This can be accomplished by supporting female-owned businesses, local and sustainable produce, and collaborations with businesses and customers who value inclusion and gender equality. The interviewees proposed the development of specialized financial goods and services, such as cheap loans, grants and investment opportunities, suited to the requirements of women working in these sectors.

The interviewees talked about how vital it is to spread knowledge of the contributions and difficulties faced by women prosumers in the alternative food industry. They think that altering attitudes and beliefs about the functions and skills of these individuals will foster a more welcoming and inclusive environment for them in these fields. Taking these steps, the cooperative's operations will be improved, issues experienced by women will be addressed, and inclusion, sustainability and resource access will be promoted. These activities also aim to address the underrepresentation of female prosumers in leadership roles.

This study is important because it explores new and unexamined aspects. It sheds light on the unique needs and challenges faced by women in the AFN, an area that has been overlooked in previous research. This study stands out as one of the few that has delved into the initiatives within the AFN. It underscores a crucial point – the gender perspective, particularly that of women, has been inadequately acknowledged both in academic studies and real-life scenarios.

The findings reveal a prevailing oversight in AFN initiatives, where the involvement and engagement of these individuals have not been recognized as significant issues. Historically, the focus has been on the tasks to be accomplished rather than considering who could contribute more effectively. A limitation of this study is the scarcity of literature on gender in AFNs in Germany. Expanding research in this area is essential to gain specific insights into the situations, needs and challenges faced by women in AFNs. Such an expansion could contribute to a more comprehensive understanding of the gender dynamics within the AFN and inform future policies and research endeavors.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation. https://doi.org/10.4228/zalf-6qrj-sw78.

Ethics statement

Written informed consent was not obtained from the individual(s) for the publication of any potentially identifiable images or data

included in this article because All the interviewees provided oral consent, understanding that this research would present their responses anonymously.

Author contributions

FD: Conceptualization, Formal analysis, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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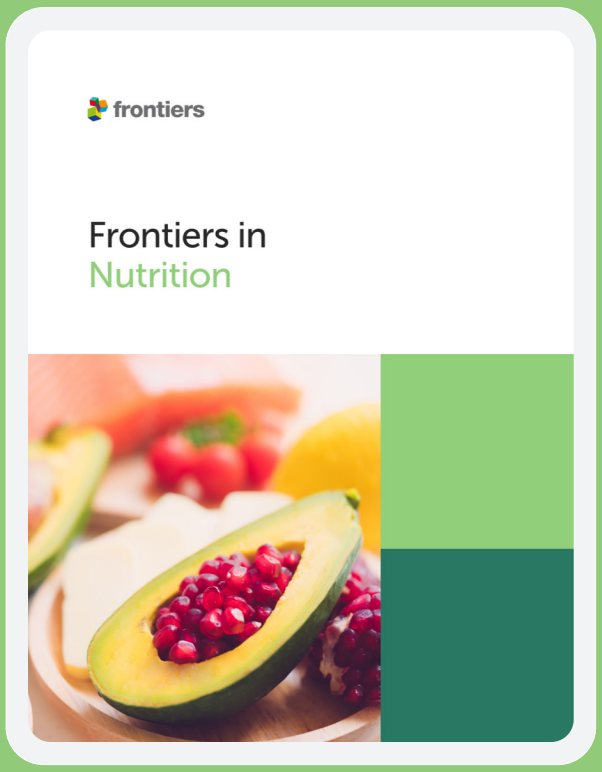

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