



Leveraging digital health platforms to enhance vegetable consumption among children: A parent-focused approach

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ABSTRACT

The intervention aimed to increase parents' awareness of their children's nutritional status through a customized digital nutrition education package (DNEP). A total of 328 parents of primary school children in Tbilisi, Georgia, participated in a 10-week DNEP intervention to educate parents about children's healthy food choices and dietary habits. To assess its effectiveness, the results from a semi-quantitative Food Frequency Questionnaire (FFQ) and a Knowledge, Attitudes and Practices (KAP) Questionnaire were compared before and after the intervention. After the intervention, daily breakfast consumption among children increased by 8.3% ($p = 0.010$), and vegetable intake increased significantly (up by 150%) from 77g to 116g per day. While the overall macronutrient ratio remained consistent ($p > 0.05$), average daily vegetable consumption surged by 192% in private schools and 131% in public schools. The DNEP effectively increased vegetable intake among school children and can potentially enhance their physical and cognitive development. Our findings highlight that a healthy home eating environment promotes balanced nutrition habits among families, making DNEP a viable strategy for addressing malnutrition in Tbilisi. The results of this study contribute to Georgia's national nutrition guidelines for children and align with UN Sustainable Development Goals (SDGs) (3, 4, 5, and 10).

1. Introduction

Insufficient and imbalanced nutrition is interrelated with health issues, especially malnutrition, which is a universal problem that hinders human development. Both the UN Decade of Action on Nutrition (2016–2025) (World Health Organization, 2022) and the UN Sustainable Development Goals (SDGs) are largely focused on health-associated matters (United Nations, 2015; Global Nutrition Report, 2019) to mobilize national and international efforts to solve the problem of malnutrition. However, even in the present day, malnutrition still has a significant negative impact on the population, particularly on children, affecting their physical and cognitive development.

In Georgia, there is a recognizable gap in nutritional education among parents to support children's healthy, optimal growth

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(Shengelia et al., 2018). This gap is related to an increased risk of nutrient deficiencies and diet-related illnesses. Additionally, language barriers and limited access to trusted nutritional education resources tailored to target audiences are among the problems that Georgian parents may face.

Georgia is a typical example of the double burden of disease, the coexistence of obesity and undernutrition within the same population. Overweight and obesity are significant among 7-year-old schoolchildren nationwide (22 % among girls and 26 % among boys) (Andguladze et al., 2020). In 2022, the country's nutritional profile has revealed that Georgia has shown limited progress toward achieving diet-related non-communicable disease (NCD) targets (Global Nutrition Report, 2023). However, no updated data are available to further examine the situation across various population groups.

In general, nutrition is a challenging topic that is significantly affected by social, cultural, economic and behavioural factors (Barros et al., 2010; Mayen et al., 2014). The formation and development of a child's dietary habits and practices largely depend on parental education and engagement. There is significant evidence suggesting that parental involvement in nutrition education interventions, particularly those linked to schools or communities, can positively influence children's eating habits and long-term health (Goldstein, 2013; Scaglioni et al., 2008). Additionally, parental nutritional knowledge and behaviours significantly influence children's risk of both undernutrition and overnutrition. As the study demonstrated, parental body mass index (BMI) and education level were correlated with child weight status (Kakutia et al., 2025).

Recently, innovative tools, including digital platforms, webinars, mobile apps, and online formats, have emerged for delivering nutrition education. Studies highlight the significant potential of digital interventions to enhance parents' nutrition literacy and promote healthier eating patterns in children (Wyse et al., 2011; Bleich et al., 2014; Zhao et al., 2016). Importantly, research has demonstrated that digital nutrition education can be highly effective, often corresponding to or even surpassing the effectiveness of traditional methods. A systematic evaluation by Drapeau et al. (2022) revealed that a family web-based intervention was successful at promoting healthy eating habits and significantly improved dairy consumption among parents (Group $\times$ Time, $p = 0.01$ to 0.03) and children (Group $\times$ Time, $p = 0.02$ to 0.03). In addition, a randomised controlled trial among Women, Infants, and Children (WIC) participants demonstrated that online nutrition education programmes delivered practical outcomes by contributing to increased consumption of fruits and vegetables ($p < 0.001$) (Bensley et al., 2014). Springvloed et al. (2015) argued that both versions of their tailor-made digital intervention delivered better outcomes than traditional nutrition programmes that provided information to individuals from higher-risk groups, regardless of their education level.

The integration of healthcare and digital technology, known as digital health, could provide a sustainable solution for nutritional education for parents. Digital technology offers new opportunities to reach parents without distance barriers and share digital materials to advise them about their children's nutritional requirements (Stotz, 2022). Digital platforms such as social media can effectively boost outreach to broader audiences by providing a digital educational package on nutrition (Uribe et al., 2023). This approach proved instrumental in low- and middle-income countries, such as Georgia, in modifying family diets and eating habits that affect children and other family members.

Leveraging digital platforms offers a powerful pathway to increase access to nutrition education and engagement across diverse communities. Central to this approach is the emphasis on co-creation and participatory design with key stakeholders, including parents, children, health professionals and nutritionists, ensuring that nutrition interventions are relevant and practical.

The literature review has identified a clear gap: there are currently no parent-focused digital nutrition education programmes in Georgia to promote healthy eating among children (Georgian Nutrition Society, 2022). The absence of such interventions leaves many families without accessible, reliable, evidence-based guidance on how to make healthier food choices (Georgian Nutrition Society, 2022). These findings highlight the need for a culturally adapted, practical and measurable digital intervention for parents in Georgia.

This study aimed to enhance children's vegetable consumption by raising nutritional awareness of parents concerning their children's nutrition through a tailored digital nutrition educational package. The study focused on improving parents' nutritional literacy and practices, including their cooking skills and eating behaviours. The study's findings highlight the importance and effectiveness of utilising digital health for public health objectives.

Considering the study objectives, the study focused on the following activities:

- a) Implementation of a baseline survey for parents to assess their nutritional knowledge and the dietary intake of their children;
- b) Development and optimisation of relevant digital nutritional educational materials for parents;
- c) Implementation of a 10-week intervention programme along with weekly online meetings;
- d) Evaluation of the effectiveness of digital nutritional education on children's dietary intake [Quality and quantity].

This is the first study of this kind in Georgia, focusing on a family-based approach to support and promote healthy eating and lifestyle through a nutritional education intervention for parents of primary school-age children. The intervention strategy aims to increase children's nutritional knowledge while developing healthy eating habits and practices. The DNEP represents a convergence of three distinct innovation dimensions. First, it constitutes a digital service innovation, leveraging freely accessible platforms (YouTube, Zoom, and email) to deliver culturally adapted nutrition education at scale within a resource-constrained healthcare system, an approach that aligns with emerging frameworks for digital health service delivery in low- and middle-income countries (Zhao et al., 2016; Uribe et al., 2023). Second, the programme embodies social innovation by addressing an institutional gap: in the absence of formal national nutrition education structures in Georgia, the DNEP bypasses systemic barriers to reach parents directly, thereby filling a service void that neither the healthcare nor education sector had previously covered (Georgian Nutrition Society, 2022; FAO, 2021). Third, the DNEP represents a scalable model for behaviour change in resource-constrained settings by designing content in the Georgian language that uses locally relevant foods and culturally familiar practices, making the programme replicable across diverse

socioeconomic contexts (Eyles et al., 2009). The innovation of the parents' education intervention strategy is further grounded in combining non-communicable disease prevention with the development of healthy practices for children, offering a dual-impact pathway seldom operationalised within a single low-cost digital framework in contexts such as Georgia. The tailored DNEP, as a nutritional education programme for parents, could be considered a potential long-term tool to ensure optimal health for children and their families. The study focused on improving parents' nutritional literacy and practices, including cooking skills and eating behaviours.

2. Methodology

The intervention was designed entirely online, using digital tools, to educate parents about children's nutritional needs in Georgia. The study was divided into three phases: preintervention, intervention and post-intervention to evaluate changes in parents' nutritional knowledge and children's dietary intake.

2.1. Participants

The participants in the study were parents of school-aged children (ages 6–12) based in Tbilisi, Georgia. Parents were recruited through schools selected at random. A total of 365 parents were recruited for this study, and 328 parents completed the post-intervention assessments (target sample size 325 parents). The sample size for the scale-up has been calculated based on the total number of students in primary schools in Tbilisi (Fig. 1). In 2022, the total number of relevant students in Tbilisi was 219,247. According to the National Statistics Office of Georgia (GEOSTAT), 2022, the population of Tbilisi was 1,201,769 (Population and Demography - National Statistics Office of Georgia (GEOSTAT), 2022). Therefore, the population proportion is $219,247/1,201,769 = 0.182437 - 18.24\%$. The total number of students in grades I–VI in Tbilisi is 99,888. Therefore, the population proportion is $99,888/1,201,769 = 0.0831 - 8.31\%$.

Sample Size Calculation Formula:

$$\text{Unlimited population : } n = \frac{z^2 \times \hat{p}(1 - \hat{p})}{\epsilon^2}$$

$$\text{Finite population : } n' = \frac{n}{1 + \frac{z^2 \times \hat{p}(1 - \hat{p})}{\epsilon^2 N}}$$

z score: 95 % - 0.95 - z = 1.96; 99 % - 0.99 - z = 2.58

ϵ – margin of error: $\epsilon = 3\%$

$N = 219,247$.

$\hat{p}$ – population proportion

In accordance with these criteria, this study focused on parents of private or public school-aged children (ages 6–12) in the capital city of Tbilisi who do not receive any nutritional training.

2.2. Developing a digital nutrition education package

To achieve the above-mentioned specific objectives, it was critical to develop nutritional materials in the Georgian (native) language, such as webinar videos and digital handouts for Georgian parents, including traditional, easily accessible Georgian foods (Table 1).

The digital nutrition education package for the 10-week intervention (March–May 2023) included information on food groups, portion sizes, recommendations to increase nutrient intake, widely held nutrition myths, and other important topics (the detailed syllabus of the webinars is described in Table 2).

Confidence Level:	95% ▼
Margin of Error:	3%
Population Proportion:	8.31%
Population Size:	99888
Sample Size	325

Fig. 1. Sample size calculation for scale-up (if the margin of error $\epsilon = 3\%$).

Table 1

Conceptual framework for developing digital nutritional educational materials in the Georgian language.

Phase	Description	Details
Step 1	Explore the nutritional information gaps according to the survey	Determine nutritional issues and find out the most consumed meals in families
Step 2	Literature review regarding the global practice of development of nutritional educational materials for parents	Find the best practice case according to the level of health literacy
Step 3	Create sustainable nutritional educational materials - a DNEP	Adjust materials and global practices to the Georgian case
Step 4	Develop DNEP materials with visual, easily understandable images, videos and voiceover explanations with multiple food examples	Create video presentations, E-brochure and organise weekly e-meetings
Step 5	Revise materials according to the outcomes of e-meetings	Get feedback from parents about educational materials
Step 6	Monitor and evaluate the changes related to dietary intake, nutritional status and habits of children and parents' nutritional awareness	Evaluate the impact of a DNEP

2.3. Intervention process

2.3.1. Pre-intervention phase

Before engaging, participants received full information about the study, including the Participant Information Sheet and the Consent Form. These documents described the purpose of the study, its objectives, procedures, the voluntary nature of participation, potential benefits, and the researcher's contact details.

The recruitment procedure was conducted in the selected schools identified through the randomisation process described earlier. The school administration provided assistance only at the initial stage by distributing study invitations via email to targeted parents of children aged 6–12 years. This email included:

- Participant Information Sheet.
- The online consent form, which had to be completed before participation.
- Two separate links to the questionnaires used in the study: the Food Frequency Questionnaire (FFQ) and the Knowledge, Attitudes and Practices (KAP) Questionnaire.

After completing both questionnaires, the parents confirmed their willingness to participate in the intervention. Once this was completed, the researcher started all direct communication with participants. This included weekly emails with webinar links, downloadable handouts, and invitations to join the follow-up Q&A sessions on Zoom. Participation was entirely voluntary, and parents could withdraw from the study at any stage without providing any explanation.

2.3.2. Intervention phase

A 10-week intervention phase was optimised and implemented to educate parents about children's nutrition using the DNEP. The DNEP included:

- Weekly Webinars—pre-recorded webinars focusing on the most important nutrition topics accessible only via a dedicated YouTube channel with a passworded link (10 webinars in total);
- Digital handouts—summarizing major highlights of the webinar shared via email with comprehensible visuals, like pictures and tables (10 digital handouts total).
- Weekly online meetings (30-min Zoom online meetings) followed by Q&A sessions for participants (10 online meetings in total).

Table 2

Title of webinars included in the nutrition educational intervention package.

Webinar	Title of the topic	YouTube links
Webinar 1	"What is a healthy and balanced diet?"	https://youtu.be/dbj74QCPLp8
Webinar 2	"Macronutrients: carbs"	https://youtu.be/v6KdiCJTsk
Webinar 3	"Macronutrients: Protein"	https://youtu.be/dw0vcgZxMCA
Webinar 4	"Macronutrients: fats"	https://youtu.be/y4jmQF6XMzs
Webinar 5	"Micronutrients necessary for child's growth and development"	https://youtu.be/9WV1SUBtvFA
Webinar 6	"Healthy breakfast ideas"	https://youtu.be/dOL0_4OAxo
Webinar 7	"Healthy snack ideas"	https://youtu.be/ijbHwVhCvVM
Webinar 8	"Healthy lunch ideas"	https://youtu.be/j_1_QBHkC3k
Webinar 9	"Healthy dinner ideas"	https://youtu.be/jxpC4mSy9PI
Webinar 10	"Small steps for big changes"	https://youtu.be/goq9YaFhJok

Note: All covered materials were aimed to enhance the nutrition status of children aged 6–12 by raising nutrition awareness among parents/caregivers.

2.3.3. Post-intervention phase

After the intervention, the participants completed two questionnaires (FFQ and KAP) for the second time to evaluate the effectiveness of the digital educational intervention. In total, 328 participants completed the intervention's final phase.

2.4. Statistical analysis

The data analysis was conducted using SPSS (Statistical Package for the Social Sciences) version 27 and Microsoft Excel (version 365). Different statistical tests (Table 3) were used to compare and find correlations among the variables.

2.5. Ethical considerations

The ethical clearances for the study were granted by the Ethics Committee of the University of Westminster (UoW; ETH2122-0424; Appendices 1, 2 and 3), London, UK, and the Tbilisi State Medical University (TSMU; N7-2021/91; Appendix 4), Tbilisi, Georgia.

3. Results

Table 4 shows the total number of participating parents recruited for the scale-up intervention; 365 schoolchildren participated (Girls, $N = 186$; Boys, $N = 179$), with each child represented by their parent.

According to the results of the Food Frequency Questionnaire (FFQ), Fig. 2 demonstrates the improvement of dietary macronutrient ratio (CHO, proteins and fats) of pre-compared to post-intervention (not significant ($p > 0.05$)). There is a slight improvement in the protein intake percentage (up by 0.5 %) and a reduction in total carbohydrates by 0.5 %. The proportion of fats remains unchanged throughout the intervention at 18.5 %. The quality of the carbohydrate group has been significantly enhanced with the massive increase in vegetable intake [from 77 g/day to 116 g/day, which is equivalent to more than 50 % increase (from baseline, reaching approximately 150 % of the initial intake)] post-intervention.

The pie chart in Fig. 3 represents the Acceptable Macronutrient Distribution, as recommended by Public Health England and the World Health Organization (Public Health England, 2016; World Health Organization, 2018).

Table 5 shows that the children's vegetable intake has significantly increased post-intervention. An independent-samples t -test has been used to describe changes across the different components of vegetables. The daily mean intake of vegetables (in private and public schools) before the intervention was 76.60 g, compared to 116.37 g after the intervention. The daily mean intake of vegetables increased by 39.8 g, representing a 150 % increase from the pre-intervention intake. However, there was no significant difference between the school types (private and public). The daily mean consumption of vegetables has increased by 192 % in children from private schools and by 131 % in children from public schools. Those values are based on who started and completed the intervention fully. To contextualise the practical significance of these findings beyond statistical significance, effect sizes were estimated. The absolute increase in vegetable intake of 39.8 g per day represents a meaningful shift in dietary behaviour when considered against the WHO recommendation of at least 400 g of fruits and vegetables per day (World Health Organization, 2015) and the approximately 200g–250 g daily vegetable target for school-aged children. Cohen's d for the change in vegetable intake was approximately 0.62, indicating a medium-to-large effect size and suggesting that the observed change is not only statistically detectable but also substantively meaningful in practice (Cohen, 1988). Readers are encouraged to weigh this practical magnitude alongside the p -values when interpreting the intervention's impact.

Based on the obtained results of the KAP Questionnaire, the number of children eating breakfast regularly increased after the intervention. According to the results of the chi-square test, the difference was statistically significant ($p = 0.010$) (Table 7). The

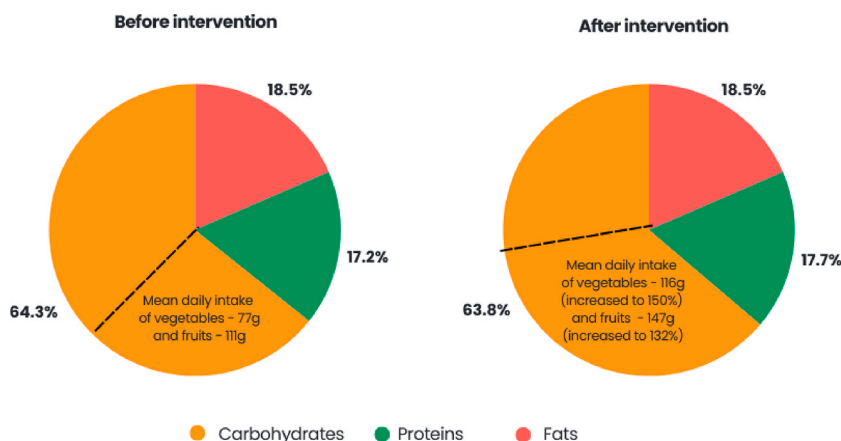
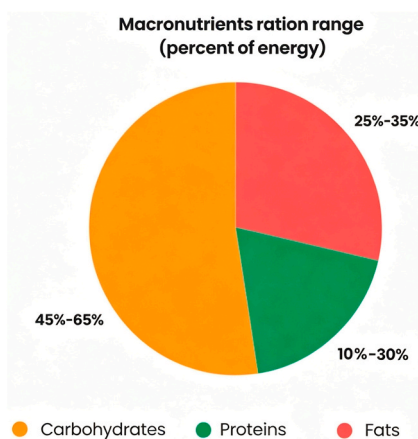
Table 3
Statistical analysis details.

Statistical test	Purpose and rationale	Usage
Chi-square test	For categorical variables, compare observed results with expected results to better recognise and interpret the relationship between two categorical variables.	To analyse dietary habits and knowledge changes (using results of the KAP questionnaire) before and after intervention.
Analysis of variance (ANOVA)	To analyse the difference between the means of more than two groups	To evaluate the mean total energy from the dietary intakes (using results of the FFQ).
Levene's Test for Equality of Variances	To evaluate whether the variances of two or more groups were statistically equivalent and to check the assumption of homogeneity of variances before applying certain statistical techniques.	To examine daily dietary intake (using results of the FFQ).
Multiple regression analysis - Stepwise exclusion method	Multiple regression analysis by the stepwise exclusion method is used to gradually remove the variables (independent variables), which contribute the least to finding out the main predictors of the outcome (dependent variable).	To explore different predictors of mean daily energy intake—calories of the children (using results of the FFQ and KAP).
The independent samples' T test	To assess the differences between the means of two separate and unrelated groups of samples.	To analyse dietary intake (like fruits and vegetables) in different groups of schools—private and public (using results of the FFQ questionnaire).

Table 4

Total number of parents recruited from the school children for the scale-up intervention.

Recruited participants	Duration (weeks)	Before (N)	After (N)	Public School (N)	Private School (N)	Total N (Percentage)
Girls	10	186	171	207	121	171 [92 %]
Boys		179	157			157 [88 %]
Total		365	328	207	121	328 [89 %]
Calculated Sample Size (N)	325					

**Fig. 2.** Carbohydrates/Proteins/Fats Ratio of dietary intake per day and mean daily intake of vegetables comparison (pre- and post-a 10-week intervention).**Fig. 3.** Daily recommended Carbohydrates/Proteins/Fats Ratio (Public Health England, 2016; World Health Organization, 2018).

percentage of parents who reported that their children are having breakfast daily increased by 8.3 % (Table 6). These values are based on the number of respondents who completed the KAP questionnaire fully.

4. Discussion

The outcomes of this digital nutrition educational intervention underscore the importance of dedicated online platforms for parents' education, utilising webinars, social media, and e-meetings to enhance their knowledge and raise awareness of the quality and quantity of macronutrients for their children. The intervention's greatest impact was on the quality of the children's diet, especially vegetable intake. The study's findings revealed an increase in daily vegetable portions among schoolchildren. As described in the pie chart (Fig. 2), the reduction in total carbohydrate intake (from 64.3 % to 63.8 %) is likely related to the decline in the intake of refined carbohydrates along with the consumption of more fibre-containing vegetables. The findings of the KAP questions indicated that the decrease in total carbohydrate intake is due to a change in behaviour, associated with a shift from consuming unhealthy, refined

Table 5

T-test of vegetable intake and its nutrients before and after the intervention in private and public schools.

Before Intervention									After Intervention								
Parameter	School	N	Mean	Mean (Private & Public schools)	SD	SE	t-test	P	Parameter	School	N	Mean	Mean (Private & Public schools)	SD	SE	t-test	P
Mean Daily Intake (MDI), g	Public	207	80.04	76.6	89.57	2.4	0.96	0.340*	Mean Daily Intake (MDI), g	Public	207	105.17	116.37	117.05	8.24	-2.16	0.032
	Private	121	70.72		84.34	7.43				Private	121	135.54		127.28	11.82		
Energy, kcal	Public	207		36.82	41.2	2.8	0.96	0.340*	Energy, kcal	Public	207	48.38		53.84	3.79	-2.16	0.032
	Private	121		32.53	38.79	3.42				Private	121	62.35		58.55	5.44		
Carbohydrates, g	Public	207		5.84	6.54	0.44	0.96	0.340*	Carbohydrates, g	Public	207	7.58		8.54	0.6	-2.16	0.032
	Private	121		5.16	6.16	0.54				Private	121	9.89		9.29	0.86		
Proteins, g	Public	207		2.24	2.51	0.17	0.96	0.340*	Proteins, g	Public	207	2.94		3.28	0.23	-2.16	0.032
	Private	121		1.98	2.36	0.21				Private	121	3.79		3.56	0.33		
Fats, g	Public	207		0.48	0.54	0.04	0.96	0.340*	Fats, g	Public	207	0.63		0.7	0.05	-2.16	0.032
	Private	121		0.42	0.51	0.04				Private	121	0.81		0.913	0.07		
Fiber, g	Public	207		3.12	3.49	0.24	0.96	0.340*	Fiber, g	Public	207	4.1		4.56	0.32	-2.16	0.032
	Private	121		2.76	3.29	0.29				Private	121	5.29		4.96	0.46		
Iron, mg	Public	207		3.12	3.49	0.24	0.96	0.340*	Iron, mg	Public	207	4.1		4.56	0.32	-2.16	0.032
	Private	121		3.12	3.49	0.24				Private	121	5.1		4.56	0.32		
Ca, mg	Public	207		3.12	3.49	0.24	0.96	0.340*	Ca, mg	Public	207	4.1		4.56	0.32	-2.16	0.032
	Private	121		3.1	3.49	0.24				Private	121	4.1		4.56	0.32		
Vitamin A, µg	Public	207		3.12	3.49	0.24	0.96	0.340*	Vitamin A, µg	Public	207	4.1		4.56	0.32	-2.16	0.032
	Private	121		3.12	3.49	0.24				Private	121	4.1		4.56	0.32		
Zn, mg	Public	207		3.12	3.49	0.24	0.96	0.340*	Zn, mg	Public	207	4.1		4.56	0.32	-2.16	0.032
	Private	121		3.12	3.49	0.24				Private	121	4.1		4.56	0.32		

Table 6

Regular breakfast eating habits before and after intervention.

Does your child eat breakfast regularly?					
Intervention		Never	Sometimes	Yes	Total
Before	count	65	21	274	360
	row %	18.06 %	5.83 %	76.11 %	100.00 %
After	count	43	7	271	321
	row %	13.40 %	2.18 %	84.42 %	100.00 %

Table 7

Chi-square tests for regular breakfast eating habits.

Statistic	Value	df	Asymp. Sig. (2-tailed)
Pearson Chi-Square	9.29	2	0.010
Likelihood Ratio	9.62	2	0.008
Linear-by-Linear Association	5.21	1	0.022
N of Valid Cases	681		

carbohydrates to more nutrient-dense fruits and vegetables. Carbohydrates are the primary source of energy, especially for Georgian children; however, the focus should be on the type of carbohydrates consumed. The simple and complex carbohydrates should be well identified, which is a key topic of educational webinars. The complex carbohydrates present in whole grains, fruits, vegetables, and beans provide steady energy to the body and contain a high amount of fibre and micronutrients (Rebello et al., 2014).

4.1. Interpretation of the findings and comparison with the literature

The intervention provided clear evidence that better parental nutritional awareness leads to improved children's diets, with increased consumption of key nutrients essential to children's growth and development. A cohort study in Canada targeting school-children revealed that children who consumed fruits and vegetables daily had higher academic performance than those who did not (Florence et al., 2008). Dietary factors may even be correlated with IQ scores, as explored in the Avon Longitudinal Study of Parents and Children (ALSPAC) (Northstone et al., 2023). According to the shared outcome, a diet rich in fruits and vegetables has been positively correlated to higher IQ scores among primary school children (Northstone et al., 2023). Many studies and guidelines indicate that a diet rich in plant-based foods, especially fruits and vegetables, is related to children's health improvement. According to the

WHO strategy, to effectively prevent malnutrition and other diseases in childhood, it is recommended to promote a diet rich in fruits and vegetables from an early age, while minimising added sugar (World Health Organization, 2015). Another study examined the relationship between fruit and vegetable consumption and body fat percentage in children. It confirms that a diet rich in fruits and vegetables helps to lower body fat in adolescents (Rasmussen et al., 2006).

This digital educational intervention, while helping parents increase their knowledge about the benefits of plant-based diets, such as those rich in fruits and vegetables, also aimed to influence children's dietary habits through DNE materials. Similar interventions worldwide were part of health campaigns, such as the "High 5 for Kids programme", aimed at expanding knowledge about the importance of fruits and vegetables and their benefits among parents of children between the ages of 2 and 5. Another initiative, the "5-a-Day" campaign in the UK, launched in 2003, promoted daily consumption of five portions of fruit and vegetables (Whitton et al., 2011). A study exploring the effectiveness of the "5-a-Day" campaign demonstrated a noticeable increase in awareness among the population. However, the consumption of fruits and vegetables still falls short of the recommended level, especially among parents (Upton et al., 2012). Strategies to increase fruit and vegetable intake among children were similarly part of the educational webinars. The relevant information was included in the handouts, which were emailed to parents weekly. The digital intervention with DNEP materials provided the perfect opportunity to create online, easily comprehensible visuals for the webinars and handouts on key topics, such as protein sources, seasonal vegetables, and snack ideas. Another digital intervention used online cooking classes as a webinar topic to educate parents in the US. Their findings showed an increase in vegetable consumption (Bensley et al., 2014). In modern times, relevant digital resources can provide parents with guidance on meal planning and offer healthy, balanced recipes. Another study showed that practical support is key to developing dietary habits and behaviour changes (Fallaize et al., 2019).

According to Scaglioni et al. (2008), parents serve as role models for children regarding eating habits. From that perspective, regular family meals tend to be healthier and richer in fruits and vegetables. This is a good example of how eating together can help shape healthy eating habits among children.

The DNEP for parents focused on learning more about a balanced diet and key nutrients, encouraging them to offer more fruits and vegetables to their children and providing practical recommendations to improve their diet. Online nutritional education for parents is a well-researched topic that suggests digital nutritional education could be an effective tool for developing healthy dietary habits among children and increasing the intake of nutrient-dense foods (Contento, 2016; Birch and Ventura, 2009). The outcomes of the intervention have consistently shown similar direct effects across studies, including Epstein et al. (2007), which confirmed that family-based interventions help shape long-lasting, healthy eating patterns in both children and parents. As a result, improved awareness of healthy eating supports better food choices, including reducing the consumption of unhealthy foods high in fat, sugar, and salt (Hesketh and Campbell, 2010).

One of the key nutrition-related habits reported in guidelines for children is having a regular breakfast (Alexy et al., 2010). A study (Abalkhail and Shawky, 2002) demonstrated that regularly skipping breakfast in primary school children was associated with poor academic performance. Another study, which examined children and adolescents aged 9–19 years, reported that regularly having breakfast was associated with higher intakes of calcium and fibre (Jackson, 2013). This educational intervention in Georgia showed that more children began having breakfast after the intervention than before. In addition, several epidemiological studies have demonstrated an association between skipping breakfast and obesity in children (Belanger-Ducharme and Tremblay, 2005; Dubois et al., 2009; Affenito et al., 2005). During the intervention's e-meetings, some parents reported that the main reason for skipping breakfast was a lack of time. To address this problem, practical, easy, and fast breakfast ideas (wraps, yoghurt with fruit) were suggested in our educational material. In addition, the quality of the breakfast and the use of nutrient-dense ingredients are critical. Some studies suggest that milk products at breakfast help achieve the daily recommended calcium intake (Ortega et al., 1998).

The main objective of this study was to develop and deliver DNEP materials to the Georgian parents in their native Georgian language (Table 3). A country like Georgia is renowned for its rich traditions and culture, including its distinctive cuisine (Goldstein, 2013). It was crucial to provide nutritional educational materials in the Georgian parents' native language. While developing



Fig. 4. Screenshot of the webinar about iron-rich nutrients and their sources, as well as tips to increase iron absorption in the Georgian language.

nutritional materials, it was essential to consider the background of the targeted audience, such as culture, language, and the accessibility of food and local cuisine (Eyles et al., 2009). The study revealed that language barriers and accessibility pose significant challenges for parents in obtaining reliable nutritional information. This problem was also highlighted during the 10-week intervention programme's online meetings. Participants in the questionnaires also explicitly mentioned that this study provided the first opportunity for Georgian parents to access materials in their native language. The mentioned linguistic challenges and lack of cultural competencies were identified as the primary barriers in some studies to promoting a healthy lifestyle (Greenberg et al., 2015).

Using visual materials, such as video presentations with photos of concrete food or meals, helped to memorise the new nutritional information (Contento, 2016). For example, a separate video presentation was created to explain nutrient deficiencies, featuring a narrated explanation and photos of iron-rich meals and products to aid memory (Fig. 4).

Notably, online nutritional education was the first comprehensive initiative to address the gap in parents' nutritional literacy in Georgia. All activities within the research framework, including online-accessible educational webinars, data collection, and examination, had one main objective: to support the sustainable, long-term improvement of children's health in Georgia. The DNEP was designed to support sustainable changes for long-term health benefits. The findings from the intervention showed that digitalised nutrition education for parents could be the first step toward promoting modifications in their children's eating habits. The outcomes of this study are sustainable (SDGs 3, 4, 5 and 10), and it will contribute to establishing the Georgian national nutrition guidelines for children (United Nations, 2015).

The design and development of the first Georgian nutritional materials, the DNEP, marks the first step in promoting a healthy lifestyle and enhancing nutritional literacy in Georgia. This intervention, along with its accompanying resources, is beneficial for both individual use and promoting a healthy lifestyle for entire families within the Georgian community (Table 1). Therefore, it is recommended that the outcomes of this study serve as a baseline to inform nutrition guidelines for Georgian schoolchildren (Fjeldstad et al., 2018). Several plausible mechanisms may explain the observed changes in dietary behaviour. The most likely proximal mechanism is an increase in parental nutritional knowledge and self-efficacy, which in turn influences food purchasing decisions and meal preparation at home. This pathway is consistent with social cognitive theory, which holds that knowledge acquisition, modelling, and reinforcement collectively promote behaviour change (Bandura, 1986; Contento, 2016). The use of weekly Zoom Q&A sessions likely facilitated social reinforcement and accountability among the participating parents, elements known to strengthen the translation of nutritional knowledge into sustained dietary practices (Michie et al., 2011). The culturally tailored content, featuring Georgian traditional foods and cooking methods, may have enhanced the perceived relevance and applicability of the educational messages, reduced attitudinal resistance and increased uptake (Eyles et al., 2009). However, it is also important to consider the conditions under which similar digital interventions might be less effective. Engagement quality likely played a critical mediating role: the voluntary nature of participation and the weekly interactive meetings probably attracted and retained parents who were already somewhat motivated to improve their children's diets. In populations with lower baseline motivation, lower digital literacy, or more precarious socioeconomic conditions, similar effects may not be replicated. Digital access and device availability also represent enabling conditions that are not universally present. The relatively high retention rate (89.8%) observed in this study may partly reflect the self-selected, motivated nature of the sample, suggesting that effect sizes in broader, less-engaged populations could be more modest. Regarding transferability, the findings offer cautious grounds for optimism about the replicability of this model in other low- and middle-income country (LMIC) contexts, particularly where there is a recognised gap in formal nutrition education infrastructure, where digital access is sufficient, and where co-designed, culturally adapted content can be developed (Springvloedt et al., 2015). However, the specific cultural, linguistic, and institutional characteristics of the Georgian context, including the country's food traditions, school administrative structures, and the absence of competing nutrition programmes, may have contributed to the observed success. Future replications in different settings should incorporate formative assessments of local context before adapting the DNEP model.

4.2. The study impacts

Georgia, as a middle-income developing country, is currently facing malnutrition challenges due to socioeconomic factors, cultural practices and regional disparities. This pioneering study, the first of its kind in the country, evaluated the effectiveness of a family-based nutrition intervention designed to improve healthy eating habits among schoolchildren in Tbilisi, the capital city. The study sought to educate parents about their children's nutritional needs. Parents' education was associated with greater awareness of a balanced diet and key nutrients vital to child growth and development. Nutritional education of parents is a well-researched topic that demonstrates the effectiveness of this approach in developing healthy dietary habits among children and increasing the intake of nutrient-dense foods (Contento, 2016; Birch and Ventura, 2009). The outcomes of the intervention demonstrated very similar results across studies, including Epstein et al. (2007), which confirmed that family-based interventions help shape long-lasting, healthy eating patterns in both children and parents. As a result, improved awareness of healthy eating supports better food choices, including reducing the consumption of unhealthy foods high in fat, sugar, and salt (Hesketh and Campbell, 2010).

4.3. Sustainability plan, implications and future work

Nutritional education needs to become an integral part of Georgia's health and education systems to sustain the intervention's positive impact and ensure its long-term sustainability. Support from education and health-related institutions, including relevant ministries, is crucial for developing a specialised curriculum for the nutritional education program. For this purpose, a dialogue was initiated with the Ministry of Internally Displaced Persons from the Occupied Territories, Labour, Health, and Social Affairs

(MOILHSA) and the Ministry of Education in Georgia to explore opportunities for establishing a special program in schools focused on healthy eating and wellbeing. These ministries are key stakeholders in the dialogue as policymakers, advancing the implementation of the above priorities. As required from the early stage, the Georgian Ministry of Education supported the research theme, including authorising access to public schools. Following the intervention in Tbilisi, a dialogue with relevant policymakers resumed on nationwide coverage, yielding a positive outcome. The MOILHSA expressed its readiness to review the findings of this research in “a working format, as strategies and specific implementation pathways to be undertaken in this area in the future”. At the same time, it is crucial to create a healthy environment that supports healthy food choices for both parents and children. In this regard, policy changes are fundamental to regulating access to more nutritious food for the Georgian population. For the sustainability of the intervention, it is essential to plan regular evaluations and monitoring to assess its effectiveness. For this process, it is crucial to use a framework to track the system and monitor the intervention’s progress and impact over a given period. Finally, the intervention concluded that nutrition education for parents is a powerful tool for improving children’s diets and dietary behaviours. Future research and actions are necessary, in collaboration with policymakers and stakeholders, to achieve sustainable results. It is important to distinguish between what has been empirically demonstrated in this study and what is theoretically anticipated based on prior literature. The present study provides evidence that a 10-week DNEP was associated with increased vegetable intake and improved breakfast habits in children of participating parents. Long-term health outcomes, such as reduced obesity prevalence, improved academic performance, or lower NCD burden, are theoretically plausible given the established literature linking diet quality to these outcomes (Florence et al., 2008; Northstone et al., 2023), but have not been measured in this study and cannot be directly inferred from the short-term findings. Any claims regarding lasting developmental benefits should therefore be understood as hypotheses grounded in existing evidence rather than conclusions drawn from this intervention’s data alone (Epstein et al., 2007).

4.4. Limitations of the current study

The study had several limitations that should be taken into consideration. Firstly, the questionnaires, especially the Food Frequency Questionnaire, about a child’s usual food intake over an extended period, are lengthy and laborious. This tiring and exhausting process might affect the accuracy of parents’ responses. Moreover, as parents answered food intake questions for their children, this did not necessarily reflect the child’s actual diet. The self-reported approach also contributes to other limitations, including recall bias, social desirability bias, and misinterpretation of certain questions. For example, without clear intentions, parents might under-report the intake of foods considered unhealthy or over-report foods believed to be healthy. All the above-mentioned factors could influence the accuracy of the findings. In addition, parents might not always have complete information about their child’s eating behaviours outside the home, especially during school time, which may lead to errors. As combining the FFQ and KAP provided a broader picture, these limitations of self-reporting must be carefully considered when interpreting the results. A further important methodological limitation concerns the absence of a control group. The pre-post single-arm design adopted in this study is appropriate for exploratory research and feasibility assessment and is consistent with early-phase intervention studies in this field (Craig et al., 2008). However, the lack of a comparator group means that observed changes cannot be unequivocally attributed to the DNEP itself. Several alternative explanations cannot be ruled out, including seasonal variation in vegetable availability, concurrent public health messaging, natural maturation, or regression to the mean. Accordingly, the findings should be interpreted as evidence of an association between intervention exposure and dietary change, rather than as proof of causal effectiveness. Future research employing randomised controlled trial designs, or at a minimum, quasi-experimental designs with matched controls, would be necessary to establish intervention efficacy with greater certainty (Bonell et al., 2011). Regarding measurement instruments, both the FFQ and KAP questionnaire were contextually adapted for use with Georgian parents, with culturally familiar foods incorporated and the materials translated into Georgian. Nevertheless, formal psychometric validation of these instruments within a Georgian population was not conducted. The FFQ used in this study was adapted from validated templates used in Eastern European nutritional surveillance contexts, informed by the principles outlined by Willett (2012). While such adaptations are standard practices in cross-cultural nutrition research, it is acknowledged that cultural specificity, interpretation of portion size, and food classification may vary across communities (Cade et al., 2002). Furthermore, the KAP questionnaire, though widely employed in nutrition behaviour research (Alkerwi, 2014), is inherently subject to social desirability bias, particularly in an intervention context where participants are aware of the study’s goals. These measurement constraints should be considered when interpreting the magnitude and direction of reported changes, and future studies should prioritise instrument validation alongside intervention evaluation.

5. Conclusion

The implemented nutritional education intervention for parents highlighted that the online nutrition education program is an effective tool for enhancing vegetable intake among school-aged children in Georgia. DNEP materials in Georgian, along with the organisation of regular webinars and Zoom meetings with parents, improved the quality of their children’s diet. This lifelong educational content was specially designed to support sustainable changes and long-term health benefits. The findings from this intervention showed that digital education for parents could be the first step in behaviour modification toward healthy eating habits for their children. It may also promote a healthy lifestyle, thereby decreasing the risk of developing health-related problems later in life. In this study, we utilised digital education as a tool to enhance parents’ nutritional literacy, practical knowledge, and skills while also motivating them to incorporate more vegetables into their children’s diets. Therefore, by focusing on transforming household and community food environments, these efforts can promote healthier and more sustainable lifestyles. Guided by evidence-based practices, collaboration, and adaptability, the digital transformation initiative can embody the principles of systemic food innovation,

fostering lasting change through integrated, inclusive solutions. It is crucial to create a healthy environment that supports healthy food choices for both parents and children. Policy changes are fundamental to regulating the accessibility of healthier food for the entire population in Georgia. Developing national nutrition guidelines for children, including strategies to reduce malnutrition cases and support healthy eating with a special DNE package, could be an effective way to improve child nutrition. The intervention was confirmed by the Ministry of Education in Georgia as part of the ethical clearance process on the Georgian side. However, now that we have finalised the intervention in Tbilisi, we are negotiating with them to collaborate on the next stage, covering the whole of Georgia, to achieve sustainable improvement in the population's health. Partnership opportunities could also include collaborations with Georgian NGOs or international organisations, such as the WHO or the UNICEF Georgian office, to support the sharing of nutritional educational materials and/or scaling up interventions.

Declaration of competing interest

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

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijis.2026.100204>.

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