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RESEARCH

How does a storybook impact preschool children's willingness to try vegetables? An experimental study from the Veggies4myHeart project

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Abstract

Background Vegetable consumption among children is below recommended. Given the critical role of vegetable consumption in health, it is essential to identify effective strategies to promote this intake. This study aimed to test the efficacy of a superhero's storybook (SB) as a nutrition education strategy on the willingness to try (WTT) 10 different vegetables in preschool children and relate WTT with food neophobia, preferences, age, and body mass index.

Methods This is an experimental study conducted in three Portuguese preschools. The intervention consisted of 20-min educational sessions once a week for 5 weeks, using a SB for nutrition education, to 178 children aged 2 to 6 years. A baseline and a post-test were conducted to determine the impact of the nutrition education strategy on the WTT ten vegetables. WTT was assessed using the Farfan-Ramirez WTT (FR-WTT) scale. Kruskal–Wallis *H* test, Spearman correlation, and Wilcoxon test were used for statistical analysis.

Results The mean FR-WTT total score at baseline was significantly lower than the mean FR-WTT total score at post-test [M = 22.79 (S.D. = 11.85) versus M = 24.39 (S.D. = 11.77)], respectively. The intervention promoted a significant increase in the WTT of half of the vegetables offered and the total FR-WTT score.

Conclusion The storybook from the Veggies4myHeart project demonstrated positive results in increasing WTT vegetables. However, it is essential to understand the project's impact at home and in the long term. It is necessary to find valuable strategies to increase vegetable consumption in different contexts, including schools and at home.

Keywords Children · Food preferences · Food neophobia · Health education · Preschool · Vegetables

Background

In Portugal, the consumption of fruit and vegetables (FV) is inadequate, concerning the World Health Organization (WHO) recommendation of 400 g daily [1]. WHO recently advised the consumption of at least 350 g of FV per day in children between the ages of 6 and 9 years old. The consumption must be at least 250 g per day for preschool children [2]. Although FV consumption is associated with a lower risk of non-communicable chronic diseases [1, 3] 72% of Portuguese children under 9 years old do not comply with these recommendations [4]. In addition, the latest results released by the Childhood Obesity Surveillance Initiative (COSI) Portugal 2022 report indicate that there has been an increase in the prevalence of childhood overweight and obesity, regressing almost a decade, at all the progression achieved [5]. The prevention of childhood obesity can be helped by increasing the consumption of FV, and several studies report that this consumption can be stimulated by exposing children to these foods at a very young age [6]. This food group provides dietary fibre, vitamins, minerals, and non-nutritive phytochemicals (phenolic compounds, flavonoids, and bioactive peptides) essential for child growth, development, and better body functioning [7]. Nevertheless, children often reject vegetables due to their bitter taste [8]. Since eating habits established in early life are more likely to be maintained throughout adulthood, educating children about healthy eating patterns at an early age is crucial and

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can be implemented in different contexts, from family to school [9].

Previous studies have used several strategies to increase the willingness to try (WTT) and young children's acceptance of vegetables. One of the strategies is exposure to images, books, and games to increase the WTT of these foods [9]. One of the critical determinants of WTT and food intake is preferences, as the foods children report liking are strongly and positively correlated with their intake [10]. The food environment influences children's food preferences [11, 12] which is shaped by parents and can affect the liking and acceptance of vegetables due to the low variety offered and lack of repeated exposure to these foods. In addition, preschool staff are considered the second influencers of eating habits since children can consume up to five meals a week in this environment [13]. Through repeated exposure, the body learns that the food is safe to eat, which increases familiarity, reduces food neophobia, and promotes long-term consumption [14, 15] However, some studies report that parents often project their own preferences onto their children, offering only foods they themselves enjoy, assuming that their children share the same tastes [16, 17] Despite the recognized effectiveness of repeated exposure in increasing vegetable consumption by scientific literature, vegetables are usually presented less than five times before parents feel that their children do not like them [12]. There is little consensus, but most scientific literature suggests that young children need 8 to 15 exposures to recognize a new flavour of an unknown or previously rejected food [13].

On the other hand, a characteristic behaviour of children in this age group is food neophobia, which peaks mainly between 2 and 5 years of age, consisting of reluctance to consume new foods and avoidance of trying unfamiliar foods [18, 19] This rejection also applies to foods previously consumed but appear new when served or prepared differently than usual. This behaviour can result in nutritional deficits due to an unbalanced diet [17], and, in the case of severe long-term restriction, it can affect the nervous system, compromising cognitive and motor function [18]. Nevertheless, this behaviour proved malleable to dietary practices, particularly repeated food exposure [13].

In addition to repeated exposure, other educational strategies have shown promise in improving children's WTT vegetables. One such strategy is engaging storybooks (SB), which promote familiarity and positive attitudes towards vegetables in early childhood [20]. Some studies have shown that even simple interactions—such as looking at picture books of vegetables with a child for a few minutes daily—can significantly enhance the child's WTT and consume those vegetables. These effects were observed immediately after exposure and sustained for at least 3 months afterwards [20, 21].

The Veggies4myHeart project was developed to promote vegetable consumption in preschool children by creating and implementing pedagogical materials designed for this age group [22, 23] During the 2022/23 school year, the educational strategy selected was a SB featuring vegetable superheroes, aiming to evaluate and enhance children's WTT vegetables. This type of strategy has been identified in the scientific literature as effective in improving preschool children's knowledge, attitudes, and behaviours towards healthier eating—particularly in increasing their WTT unfamiliar vegetables [24, 25]

Despite the growing interest in storybook-based interventions, few studies have assessed their impact using validated tools in real-world preschool settings. To our knowledge, this is the first study to apply the FR-WTT scale before and after a Food Education Pedagogical Instrument (FEPI) intervention, providing a structured evaluation of both vegetable consumption and WTT.

This study aimed to assess the impact of the SB on both vegetable consumption and WTT. Additionally, we examined whether food neophobia and parents' perceptions of their children's vegetable preferences influenced WTT. Finally, we explored whether there was a relationship between children's body mass index (BMI) and their WTT vegetables.

Materials and methods

Veggies4myHeart project overview

The Veggies4myHeart project was created in 2018/2019 by a group of researchers of ciTechCare—Center for Innovative Care and Health Technology (Polytechnic University of Leiria), to address the lack of Food Education Pedagogical Instruments (FEPI) adapted for preschool children. In that same year, the project team and partners developed two FEPIs: a digital game (Veggies4myHeart) and a SB ("Who wants to go to the village market?"). Grounded in social modelling theory, which recognizes the influence of peers, parents, and educators on children's eating behaviours, the project promotes contact with various vegetables to increase familiarity and acceptance. Although both resources have been used previously in 25 preschools in Leiria's district through a partnership with the municipality of Leiria, this study focuses exclusively on the SB, used as the educational strategy during the 2022/2023 school year to promote preschool children's WTT vegetables. This study reflects a 5-week food education intervention involving the reading of a SB about five superheroes: tomato, carrot, red cabbage, cucumber, and lettuce. Before and after the intervention, the consumption of 10 vegetables (including the 5 represented

in the story) and the willingness to try (WTT) them were assessed.

Recruitment and participants

The Ethics Committee of the Polytechnic University of Leiria approved this study. The municipality of Leiria selected three public preschools based on internal data indicating low vegetable consumption among their preschool children, covering 179 children aged 2 to 6 years. The week before the baseline assessment, an informed non-consent form was sent to all parents. Children whose parents did not return this form were included ($n = 178$). Only those present on the days of assessment (November 2022–February 2023) were assessed. Children who refused to participate at the time of assessment were excluded. The vegetable tastings for assessments were scheduled during class at moments deemed least disruptive by educators.

Measures

Data collection relied on two sources: (1) a caregiver-completed questionnaire administered before the intervention and (2) direct observations of children during baseline and post-intervention assessments.

Questionnaire completed by caregivers

Parents completed a questionnaire including the following components:

Sociodemographic and anthropometric information

Information was collected on the child's and parent's age and gender, educational level, and number of household elements. Parents also reported their child's weight (kg) and height (m). These values, together with the child's date of birth and the date of questionnaire completion, were used to calculate the BMI *z*-score for age following the WHO growth standards. The Anthro software [26] was used for children under 5 years of age and Anthro Plus software for children aged 5 and above [27].

Vegetable preference scale

Parental perception of children's preferences for the ten selected vegetables was assessed through a 5-point Likert-type scale completed by the parents. The response options were as follows: 1 "Strongly Dislikes," 2 "Dislikes," 3 "Neither likes or dislikes," 4 "Likes," and 5 "Strongly Likes." If parents considered that their child had never been exposed to a particular vegetable before, they could select the 0 "Never tried" option. This tool, originally validated to assess the taste of FV, was adapted in this study to focus exclusively on vegetables [11].

Child food neophobia scale (CFNS)

To assess food neophobia, the Child Food Neophobia Scale (CFNS) was used. The parents completed this 10-item scale, adapted initially from the adult Food Neophobia Scale by Pliner and Hobden [28]. Responses were recorded on a 7-point Likert scale, ranging from 1 (strongly agree) to 7 (strongly disagree), resulting in total scores ranging from 10 to 70, with higher scores indicating higher levels of food neophobia [19]. The total score was categorized into three behavioural profiles: "Children with neophilic behaviour," "Children with neutral behaviour," and "Children with neophobic behaviour" [29]. The Portuguese version was validated by Gomes et al. [30].

Instruments used in observational assessment of children

Children's WTT and vegetable consumption were assessed during assessment sessions before and after the intervention.

Intake assessment procedure

The research team carried out the assessments (baseline and post-test), and student volunteers from the Dietetics and Nutrition ungraduated degree program at the School of Health Sciences of Polytechnic University of Leiria were trained in dedicated preparatory meetings. The training covered the proper use of assessment instruments, standardized procedures for offering the vegetables during the assessment sessions, and clear instructions to avoid influencing children's intake or WTT of the vegetables. Immediately before the assessment, verbal consent was obtained from each child.

Children were offered standardized portions of ten raw vegetables: five featured in the SB (tomato, purple cabbage, cucumber, carrot, and lettuce) and five additional vegetables (endive, spinach, radish, arugula, and red bell pepper). All ten vegetables were selected by the research team for their suitability to be consumed raw and were presented uncooked during the intake assessments. The five SB vegetables were selected based on their frequent inclusion in public preschool meals in Portugal. The additional five were chosen as a control group of vegetables not addressed in the intervention to evaluate whether changes in WTT were specific to the vegetables featured in the SB or extended to

others. The assessments were conducted in group settings, and the study design acknowledged the potential influence of peer modelling on children's behaviour. Each portion was standardized as follows: ¼ leaf of lettuce and endive, one 6-cm stick of carrot, cucumber and red bell pepper, one strip of grated purple cabbage, one leaf of spinach and arugula, one thin slice of radish, and one cherry tomato. Two rounds were conducted in the same order—lettuce, carrot, purple cabbage, endive, spinach, radish, arugula, cucumber, red bell pepper, and cherry tomato—offering one vegetable at a time. A researcher distributed the vegetables, while others observed and recorded the servings each child consumed for each vegetable. Educators were instructed not to influence children's responses through encouragement or praise.

Farfan-ramirez willingness to try scale (FR-WTT)

The FR-WTT scale, validated using baseline data from the FRESH study, assessed preschool children's WTT of the ten selected vegetables at baseline and post-test [31]. A researcher rated each child's interaction with each vegetable using a 5-point scale. The options were as follows: 0 "Did not remove vegetable from box," 1 "removed food, but did not bring to nose/mouth," 2 "removed food and brought to nose/mouth, but did not put food in mouth," 3 "put food in mouth, but did not swallow food (including taking a bite and spitting it out or licking an item)," and 4 "put food in mouth and swallowed" [32]. The total FR-WTT score (range 0–40) was calculated by summing the ratings across all vegetables.

Procedures

Study timeline and design

The intervention comprised five 20-min weekly sessions held in the classroom. Led by two trained researchers, each session explored one chapter of the SB "Who wants to go to the village market?" introducing a "vegetable superhero" (tomato, purple cabbage, cucumber, carrot, and lettuce). The sessions highlighted each vegetable's functions and characteristics using child-friendly language. These vegetables were chosen because they are commonly offered to children in Portuguese school canteens. After each reading, children discussed the vegetable's "superpowers," reinforcing the nutritional message in an age-appropriate way.

Baseline and post-intervention assessments

Baseline assessments were conducted before the first session, and post-intervention assessments occurred after the last intervention session. Both followed the intake procedure and WTT assessment outlined in the "Instruments used in observational assessment of children" section. Table 1 shows the intervention design.

Statistical analysis and treatment of data

Data were analysed using the Statistical Package for the Social Sciences (SPSS) version 28.0.0. The Shapiro–Wilk test was applied to assess the normality of distributions. Statistical significance was assumed at $p < 0.05$. The Kruskal–Wallis H test was used to compare the FR-WTT scores at baseline between CFNS cut-offs. Spearman's correlations were used to analyse the baseline relationship between children's vegetable preferences and FR-WTT. Furthermore, the Wilcoxon non-parametric test was used to analyse the changes in the WTT the vegetables offered between baseline and post-test.

Results

Study sample and demographic data

A total of 178 children and 138 parents were enrolled in the study. The sample was characterized by children's sex and age, parents' education level, number of household elements, children's and parents' mean age, and S.D. Most participants were girls (54.5%), and the child's mean age and S.D. at the time of data collection were 4.1 and 0.9, respectively. The mean age of parents was 35.6 years old, and the S.D. was 7.1 years. Most parents completed at least high school education (80.9%). Sample characterization can be observed in Table 2.

Table 1 Design of the Veggies4myHeart project

Condition	Baseline (1 week)	5-week intervention					Post-test (1 week)
		Target vegetable					
Storybook (SB)	Assessment of Willingness to Try (WTT) ten vegetables	Tomato	Purple cabbage	Cucumber	Carrot	Lettuce	Assessment of WTT ten vegetables
	Assessment of ten vegetable consumption						Assessment of ten vegetable consumption

Table 2 Characteristics of preschool-aged children and parents

	n	%
Children's sex (*n* = 178)		
Male	81	45.5
Female	97	54.5
Children's ages		
2	1	0.7
3	40	29.0
4	48	34.8
5	44	31.9
6	5	3.6
Children's BMI (*n* = 99)		
Underweight	8	8.1
Normal weight	74	74.7
Overweight	10	10.1
Obesity	7	7.1
Parent's educational level		
Basic education	26	19.1
High school education	62	45.6
University education	48	35.3
Household elements		
2	9	6.7
3	56	41.5
4	49	36.3
5 or more elements	21	15.5
Children's age (years)		
Mean	4,1	
S.D	0,9	
Parent's age (years)		
Mean	35.6	
S.D	7.1	

Veggies4myHeart project on WTT vegetables

The mean FR-WTT total score at baseline was 22.79 (S.D. = 11.85). In the post-test, the mean FR-W.T.T. total score was higher, assuming the value of 24.39 (S.D. = 11.77). The Veggies4myHeart intervention promoted a significant increase in WTT of half of the offered vegetables, specifically carrot ($p = 0.043$), purple cabbage ($p = 0.024$), arugula ($p < 0.001$), cucumber ($p < 0.001$), and red bell pepper ($p = 0.034$). The FR-WTT total score significantly increased between the two assessment moments ($p < 0.001$). Despite the small effect size in most vegetables (nine out of ten), it showed a negative direction, except for WTT radish (0.040), suggesting an increase in WTT even though they did not show statistical significance. Cucumber presented a moderate size effect (− 0.504). The total FR-WTT score increased significantly between baseline and post-test, with an effect size of − 0.378. Therefore, there was a general increase in the willingness to try all vegetables. These results are presented in Table 3.

CFNS and FR-WTT relationship

The mean and S.D. of the CFNS total score were calculated, corresponding to 41.52 and 9.572, respectively. We round to the most proximal whole number of the values obtained, and it allowed the categorization of the CFNS total score into three groups: "Children with neophilic behaviour," (10; 32); "Children with neutral behaviour," (32; 51) and "Children with neophobic behaviour," (51; 70). Our results showed 17 (13.2%) "Children with neophilic behaviour," 90 (69.8%) "Children with neutral behaviour," and 22 (17.1%) "Children with neophobic behaviour."

A significant difference was verified in the FR-WTT total score at baseline between "Children with neophilic behaviour" and "Children with neophobic behaviour" ($p = 0.009$) and between "Children with neutral behaviour" and "Children with neophobic behaviour" ($p = 0.027$), as presented in Table 4.

Vegetable preferences (parents report) and respective correlation with FR-WTT at baseline

Parents reported their children's vegetable preferences. The less preferred vegetables (answer 0 "Never tried" ≥ 15%) were purple cabbage, endive, radish, arugula, and red bell pepper. From the parent's point of view, the children's preferred vegetables (answers 4 "Likes" + 5 "Strongly likes" ≥ 50%) were lettuce, carrot, cucumber, and cherry tomato. Parents also pointed out spinach as one of the children's favourite vegetables (answers 4 "Likes" + 5 "Strongly likes" equal 42.3%). The absolute and relative frequencies are presented in Table 5.

After this descriptive analysis of vegetable preferences, we run Spearman's correlations with FR-WTT at baseline to determine its relationship with vegetable preferences. Seven correlations with statistical significance were observed: four at the 0.01 level (lettuce, purple cabbage, cucumber, and cherry tomato) and three at the 0.05 level (carrot, spinach, and arugula), and all were positive correlations. Lettuce presented a weak correlation (0.271), as well as carrot (0.209), purple cabbage (0.274), spinach (0.209), and arugula (0.208). We found two moderate correlations, one for cucumber (0.475) and the other for cherry tomato (0.444) (Table 6).

Sociodemographic variables (children's age and BMI), FR-WTT total score, and number of vegetable portions

We tested the correlation between children's BMI category (underweight, normal weight, overweight, and obesity),

Table 3 Preschool children's willingness to try the offered vegetables (baseline to post-test)

	n **(Baseline)**	***n*** **(Post-test)**	***p*****-value**	**Effect size (Cohen's *d*)**
FR-WTT lettuce = 4	86	98	0.539	− 0.041
FR-WTT lettuce = 0, 1, 2, 3	48	53		
FR-WTT carrot = 4	103	124	**0.043**	− 0.186
FR-WTT carrot = 0, 1, 2, 3	31	27		
FR-WTT purple cabbage = 4	61	77	**0.024**	− 0.218
FR-WTT purple cabbage = 0, 1, 2, 3	73	74		
FR-WTT endive = 4	30	43	0.529	− 0.057
FR-WTT endive = 0, 1, 2, 3	104	108		
FR-WTT spinach = 4	66	73	0.401	−0.087
FR-WTT spinach = 0, 1, 2, 3	66	78		
FR-WTT radish = 4	35	44	0.602	0.040
FR-WTT radish = 0, 1, 2, 3	97	106		
FR-WTT arugula = 4	36	46	**< 0.001**	–0.417
FR-WTT arugula = 0, 1, 2, 3	96	103		
FR-WTT cucumber = 4	59	88	**< 0.001**	–0.504
FR-WTT cucumber = 0, 1, 2, 3	73	61		
FR-WTT red bell pepper = 4	27	30	**0.034**	–0.189
FR-WTT red bell pepper = 0, 1, 2, 3	107	119		
FR-WTT cherry tomato = 4	68	82	0.102	–0.150
FR-WTT cherry tomato = 0, 1, 2, 3	66	67		
FR-WTT total score (mean)	22.79	24.39	**< 0.001**	–0.378
FR-WTT total score (S.D.)	11.85	11.77		

FR-WTT Farfan Ramirez-Willingness to Try scale. Bold denotes significant $p < 0.05$.

Table 4 Relationship between CFNS and FR-WTT scores

CFNS total score	
Mean	41.52
S.D	9.572
Categorization of the CFNS total score in three groups	
A	[10;32]
B	[32;51]
C	[51;70]
Children's distribution across three groups	
A	17 (13.2%)
B	90 (69.8%)
C	22 (17.1%)
Multiple comparisons	
A vs. B	0.366
A vs. C	**0.009**
B vs. C	**0.027**

Group A "Children with neophilic behaviour": [10; mean – S.D.]

Group B "Children with neutral behaviour": [mean − S.D.; mean + S.D.]

Group C "Children with neophobic behaviour": [mean + S.D.; 70].

CFNS Child Food Neophobia Scale.

Note: bold denotes significant $p < 0.05$.

FR-WTT total score, and the total vegetable portions consumed at baseline. There were no significant correlations between BMI *z*-score and these variables. We also checked if there was a correlation between children's age and FR-WTT total score at baseline, which was approximately zero.

Discussion

In this study, we tested the effectiveness of a FEPI, in this case, a children's SB, in increasing vegetable consumption. The results showed an increase in the WTT for both the vegetables covered in the SB and those not. Although there was statistical significance in some vegetables of each group, there was a global increase in the WTT, except for radish, which was often rejected.

While repeated exposure during the assessments may have contributed to this improvement, the inclusion of vegetables in the SB likely played a complementary and motivational role. Recent studies suggest that combining non-gustatory strategies—such as SB that introduces vegetables in a positive, engaging context—with tasting experiences can enhance familiarity, reduce food neophobia, and foster

Table 5 Vegetable preferences reported by the parents

		Frequencies																	
		Lettuce (n_{Total}=134)		**Carrot** (n_{Total}=136)		**Purple Cabbage** (n_{Total}=134)		**Endive** (n_{Total}=129)		**Spinach** (n_{Total}=137)		**Radish** (n_{Total}=133)		**Arugula** (n_{Total}=136)		**Cucumber** (n_{Total}=135)		**Red Bell Pepper** (n_{Total}=136)		**Cherry Tomato** (n_{Total}=137)	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Vegetable preferences	0 = Never Tried	6	4.5	2	1.5	28	20.9	83	64.3	9	6.6	64	48.1	41	30.2	8	5.9	21	15.4	4	2.9
	1 = Strongly Dislikes	6	4.5	1	0.7	8	6	3	2.3	5	3.7	7	5.3	9	6.6	4	3.0	11	8.1	3	2.2
	2 = Dislikes	27	20.1	8	5.9	45	33.6	18	14	25	18.2	32	24.1	43	31.6	30	22.2	48	35.3	24	17.5
	3 = Neither Likes or Dislikes	28	20.9	18	13.2	33	24.6	19	14.7	40	29.2	22	16.5	22	16.2	17	12.6	29	21.3	14	10.2
	4 = Likes	44	32.8	61	44.9	16	11.9	4	3.1	47	34.3	7	5.3	18	13.2	35	25.9	21	15.4	37	27.0
	5 = Strongly Likes	23	17.2	46	33.8	4	3	2	1.6	11	8	1	0.7	3	2.2	41	30.4	6	4.4	55	40.1

FR-WTT – Farfan Ramirez-Willingness to Try scale; **Note:** There may be a difference of ± 0.01% in the total relative percentage.

Table 6 Spearman's correlations: Vegetable preferences reported by the parents and FR-WTT at baseline

		FR-WTT at baseline									
		Lettuce	**Carrot**	**Purple Cabbage**	**Endive**	**Spinach**	**Radish**	**Arugula**	**Cucumber**	**Red Bell Pepper**	**Cherry Tomato**
Vegetable preferences	Lettuce	0.271 **									
	Carrot		0.209 *								
	Purple Cabbage			0.274 **							
	Endive				0.018						
	Spinach					0.209 *					
	Radish						0.124				
	Arugula							0.208 *			
	Cucumber								0.475 **		
	Red Bell Pepper									0.145	
	Cherry Tomato										0,444 **

FR-WTT – Farfan Ramirez-Willingness to Try scale; * Correlation is significant at the 0.05 level;** Correlation is significant at the 0.01 level.

positive attitudes towards vegetables in young children [20, 21, 33–35].

The increase observed in both groups of vegetables suggests that repeated exposure was a key driver of behavioural change. However, while gustatory exposure is considered essential for building acceptance, non-gustatory strategies can provide a necessary foundation [36, 37] Future studies should consider evaluating their independent and combined impact to understand the mechanisms behind improved vegetable acceptance better.

Regarding food neophobia, the results were similar to findings reported by other authors [34, 38] that verify a weak or inconsistent correlation between WTT vegetables, which may be mainly due to the small sample size. This study reinforces the theory that the FR-WTT total score can be used as an observational method to identify young children with food neophobia. Even so, we used the CFNS to categorize the children according to the total score obtained from the parent's answers. The methodology followed [29] allowed us to verify that the sample contained a slightly higher number of children with neophobic behaviour than children with neophilic behaviour. Several studies with samples aged between 4 and 9 years point to the prevalence of neophobic behaviours at percentages between 14 and 44% [39], values within which the prevalence of 17.1% found in our study fits. These findings also confirmed that parents correctly perceive their children's eating behaviour.

In the vegetable preferences reported by the parents, there was no statistical significance in the correlation of WTT, in baseline, with preferences for endive, radish, and red bell pepper, which are also three of the vegetables with the highest prevalence of children who had never tried them until the project intervention. It seems to indicate that this translates into a low perception of parents regarding children's taste for these three vegetables. Due to the scarce offer, both in school and family environments, neither parents nor children know whether they like a particular food, and, therefore, children may even surprise their parents by consuming them and even liking them. In this sense, parents should be made aware of the importance of offering a wide variety of foods, even if they do not like them or consider that the child does not like/will not like them. Social models, namely parents, preschool teachers, or peers, can influence children's eating behaviour, namely their food preferences, liking, intake, and degree of neophobia. Younger children are more influenced by social models than older ones [40]. Veggies4myHeart was an added value for the participants as it allowed children to come into contact with vegetables they had not yet tried. In addition, it made it possible to become familiar with new or less-known vegetables, promoting greater acceptance of these foods in the future, whether in a school or a family environment and a higher intake of

those already habitually consumed. Additionally, the children with a greater WTT and vegetable intake had a lower BMI *z*-score classification than those with less WTT and vegetable intake. In the literature, few studies examined the association between WTT or consuming vegetables and BMI status in children. The studies identified inverse associations between BMI *z*-score and vegetable consumption [41–43] indicating that children with a more suitable BMI status are more likely to accept new vegetables [44]. However, the correlation of these variables was not statistically significant in our study. One of the reasons that may justify these results is the reduced number of parents who completed anthropometric data in the parent's questionnaire, featuring a small sample size ($n = 74$). There are recognized limitations regarding anthropometric data reported by parents; therefore, the reported results should be interpreted with caution. As for the correlation between age and WTT, no other studies evaluated these variables. In this study, no correlation was found.

This study had several limitations that should be considered. Firstly, the delay in caregivers returning the questionnaires may have introduced response bias, including social desirability bias, as exposure to the intervention could have influenced how they reported their children's behaviours. The children's appetite was not assessed at baseline or post-test, and the evaluation sessions were conducted at times convenient for preschool staff. For this reason, not all sessions took place immediately before a meal (snack or lunch), which may have influenced the children's appetite. Additionally, due to seasonal illnesses, many children were absent during the baseline assessments, and some did not complete the sessions due to classroom interruptions.

Cultural diversity also presents a relevant factor. Given the growing number of immigrant families in Portuguese preschools, it is important to consider that the vegetables provided might not be the most suitable for the habits and cultures of these families. It would be valuable to understand how cultural background and food traditions shape children's WTT vegetables. Moreover, while peer influence may introduce bias, it can also positively impact outcomes in this context by increasing vegetable tasting.

Despite these limitations, this study provides relevant implications for practice. The Veggies4myheart project represents a practical and well-received tool for teachers and schools that integrates food education into daily activities without disrupting class routines. The availability of a vegetable-specific educational instrument is an asset for promoting healthy eating habits from an early age. For parents, exposure to vegetables through storytelling and repeated exposure may increase familiarity and help transfer positive attitudes towards vegetables into the home environment. For policymakers, the success of this initiative supports the inclusion of similar educational strategies in early childhood settings, reinforcing the importance of structured, playful, and evidence-based food education in promoting healthier dietary patterns.

Conclusion

The SB from the Veggies4myHeart project demonstrated positive results in increasing preschool children's WTT vegetables. These findings highlight the importance of using educational strategies tailored to early childhood to promote healthier eating behaviours. Understanding the impact of such interventions at home and in the long term is crucial, as food preferences are shaped in multiple environments and evolve.

In future work, we would like to implement the project in different regions and preschool settings to explore how cultural and contextual differences influence its effectiveness. Ultimately, we aim to develop an educational kit that integrates these strategies and can be easily implemented by preschool teachers in their daily routines to support vegetable acceptance among young children.

Abbreviations BMI: Body mass index; COSI: Childhood Obesity Surveillance Initiative; CFNS: Child Food Neophobia Scale; FEPI: Food Education Pedagogical Instruments; FR-WTT: Farfan Ramirez-Willingness To Try scale; FV: Fruit and vegetables; SB: Storybook; SPSS: Statistical Package for the Social Sciences; WHO: World Health Organization; WTT: Willingness To Try

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Author contribution M.B. and T.A.R. conducted the data collection, made the statistical analysis, and wrote the manuscript. R.N. and M.L. reviewed the manuscript. L.V. performed the data analysis. S.S.D. conducted data analysis and revised the manuscript. M.P.G. revised the manuscript. C.B.-P. formulated the research question, designed, carried out the study, and reviewed it.

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Data availability The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Ethical Committee of Polytechnic Institute of Leiria (CE/IPLEIRIA/11/2019). Written

informed consent was obtained from all the parents of children enrolled in the study and a verbal assent was obtained from all children.

Consent for publication Not applicable.

Competing interests The authors declare that they have no competing interests

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