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# Veggies4myHeart digital game: an educational tool to promote vegetable consumption in preschool children - a multicentre experimental study

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## Abstract

**Background** Vegetable consumption as part of a balanced and diversified dietary pattern is associated with a lower risk of cardiovascular disease, cancer, and all-cause mortality. Even though the scientific evidence for these benefits is strong, the consumption of vegetables remains far below recommendations, especially in early childhood. Despite existing literature, the evidence on how to increase vegetable consumption in preschool children remains limited and the development and validation of new strategies should be pursued in varied contexts. The study presented herein aimed to compare the impact of educational sessions based on the serious game Veggies4myHeart and repeated exposure to vegetables on preschool children's willingness to taste them and also their nutrition knowledge, measured at baseline and post-intervention, in Portuguese and Swiss preschool children.

**Methods** The intervention was carried out in preschools with 39 Portuguese and 45 Swiss children, from 3 to 6 years old, in their preschools, between May 2019 and February 2021. Children participated in weekly 20-minute educational sessions for 5 weeks, delivered by trained nutritionists and incorporating the Veggies4myHeart digital game. Willingness to taste was assessed by offering the five raw vegetables in standard portions and recording whether each child tasted them at baseline, throughout the intervention, and post-intervention. Nutrition knowledge was assessed using three questionnaires applied before and after the intervention. Data were analysed using IBM SPSS software and statistical significance was set at  $p$ -value  $< 0.05$ .

**Results** Comparing the results between the two countries post-intervention, statistically significant differences were found in the willingness to taste lettuce, carrot, and red cabbage, with Portuguese children showing more willingness to taste these vegetables than Swiss children ( $p < 0,05$ ). Improvements in nutrition knowledge, from baseline to post-intervention, were observed in both countries ( $p < 0,001$ ), but without statistically significant differences between countries ( $p = 0.114$ ).

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**Conclusions** Despite differences in context and eating habits of Portuguese and Swiss children, the intervention with the Veggies4myHeart digital game increased preschoolers' willingness to taste vegetables, supporting the value of repeated exposure combined with digital tools. Improvement in nutrition knowledge further reinforces the potential of serious games as comprehensive educational strategies for promoting healthy habits in young children.

**Keywords** Vegetables, Education, Serious games, Obesity prevention, Food preferences

## Background

The prevalence of childhood obesity is of increasing global concern. Overweight and obesity are known risk factors for several pathologies, including cardiovascular diseases, diabetes, musculoskeletal disorders, and some types of cancer [1]. In children and adolescents, overweight and obesity are also associated with depression [2–4], low self-esteem [2, 5], and poor quality of sleep [6, 7]. According to the World Health Organization (WHO) and UNICEF, from 1990 to 2022, the percentage of children and adolescents aged 5–19 years living with obesity increased fourfold from 2 to 8% globally. In 2022, 37 million children under the age of 5 were overweight [8]. In Portugal, data from the National Food and Physical Activity Survey reported that 25.0% of children under the age of 10 years, and 32.3% of adolescents aged between 10 and 18 years were overweight or obese in 2015–2016 [9]. In Switzerland, although data from Health Promotion Switzerland showed a lower prevalence of overweight and obesity among children and adolescents compared to Portugal, the numbers are still alarming. According to this report, 13.2% of children and adolescents were overweight at the time of the survey and 4.0% had obesity, which represents a total of 17.2% of children and adolescents with overweight or obesity in Switzerland [10].

Consumption of vegetables, as part of a balanced and diversified dietary pattern, is associated with a lower risk of cardiovascular disease, cancer, and all-cause mortality [11–16], as well as with a lower risk of developing obesity in childhood [17]. Even though the scientific evidence for these benefits is strong, the consumption of vegetables remains far below recommendations, especially in early childhood. The WHO European Childhood Obesity Surveillance Initiative (COSI) from 2021/2022 evidenced that Portugal is the country with the seventh highest consumption of vegetables in a group of 23 countries [18], but half of the children (55.5%) analysed consumes 1 to 2 portions of fruit and/or vegetables a day, with only 7.2% consuming 5 or more portions a day [19]. In Switzerland, 95.5% of the children between 5 and 12 years old were not meeting the Swiss dietary guidelines regarding vegetable consumption according to a study conducted in 2012 [20]. Therefore, it is extremely important to design and implement strategies to increase the consumption of vegetables among the youngest. Nekitsing et al. [21] performed a systematic review and meta-analysis to identify and assess the effectiveness of strategies aiming to

increase vegetable consumption in preschool children. Nine types of intervention strategies were identified: educational, repeated taste exposure, pairing/stealth, modification of food services, reward interventions, modelling, choice, variety and appealing visual presentation. Of these, the most effective strategies were those including taste exposures and rewards, and the less successful (but effective, too) were the nutrition education and the modification of food services [21]. The benchmarks for Nutrition in Child Care proposed by the Academy of Nutrition and Dietetics [22] recommend that child-care settings should use material resources (books, posters...) and sensory exploration of foods for nutrition education in classrooms.

With the rapid technological evolution of the 21st century, a growing number of innovative and differentiated pedagogical strategies are being used to increase children's motivation to learn and to engage them in classroom activities [23]. One of the strategies is the use of serious games in educational settings at a wide range of ages, even at early ages of development [24]. The term "serious games" is used to refer to games that are created with an educational and training purpose, being more than just for entertainment [25], and that have motivational and enjoyable characteristics [26]. Their application in food education is gaining in popularity and has shown some potential to increase children's knowledge about food and even to prevent childhood obesity [27]. Recent studies have shown that the use of gamification techniques and well-designed apps may increase the intake of vegetables and knowledge about this theme [28]. In addition, serious games are an effective entertainment tool designed to serve a useful purpose, such as changing eating behaviours and nutrition education [29, 30]. According to Thompson et al. [31], recent evidence suggests that serious theoretically based video games are effective in achieving dietary changes in youth, but most of these studies have been performed in school-aged children or adolescents. Despite existing literature, the evidence on how to effectively increase vegetable consumption in preschool children remains limited and the evaluation of new strategies should be pursued across different contexts. To the best of our knowledge, no studies have compared interventions aimed at promoting vegetable consumption and willingness to taste among Portuguese and Swiss preschool children.

Therefore, this study aimed to explore and compare the impact of educational sessions based on the Veggies4myHeart serious game and repeated exposure to vegetables on preschool children's willingness to taste vegetables (primary outcome) and nutrition knowledge (secondary outcome) in Portuguese and Swiss preschools.

## Materials and methods

### Recruitment and participants

This study was carried out with a convenience sample from a Portuguese school and a Swiss school. Participating children from Portugal were recruited by the city council of Leiria, which invited 4 preschools. One preschool accepted and a total of 50 children (2 classes) were assessed for eligibility. Of the 50 Portuguese parents invited to participate, 39 accepted. In Switzerland, two classes of one preschool in Geneva were invited to participate and a total of 45 children were assessed for eligibility. The only inclusion criteria was the age of the participants, namely 3 to 6 years old, and the exclusion criteria were oral motor difficulties that impaired chewing and food allergies. All agreed to participate in the study. Informed consent was signed by the parents who participated in the study and each child was asked if they wanted to participate. In this study, it was not possible to include a control group due to logistical constraints and the schools' poor compliance. This study was approved by the Ethics Committee of the Polytechnic of Leiria. No personal data were collected, so this pilot study did not fall under the Swiss Federal Human Research Act. However, it was submitted to and approved by the Service of Research in Education in Geneva, Switzerland (research number 584).

### Intervention

#### *Intervention sessions*

The intervention consisted of 20-minute educational sessions using the Veggies4myHeart serious game, conducted once a week for five consecutive weeks. Each week, children engaged with a different mini-game from the Veggies4myHeart digital game, each one focusing on a specific vegetable introduced by a superhero character (tomato, red cabbage, cucumber, carrot, and lettuce). After playing the mini-game of the week, children were invited to taste the five vegetables offered raw and in similarly sized portions. Sessions were held in preschool classrooms and delivered by trained nutritionists.

#### *Description and educational content of the digital game*

Veggies4myHeart is a serious game developed by undergraduate students and researchers at the Polytechnic Institute of Leiria, tested for its appropriateness for preschool children in pilot tests, and currently available in Portuguese and French on both the PlayStore and

AppStore. The game features five mini-games, each centred on a different vegetable superhero — tomato, red cabbage, cucumber, carrot, and lettuce. Animated characters represent each vegetable and are portrayed as superheroes, with their respective health benefits framed as superpowers to enhance engagement and understanding among the target age group. In each mini-game, the corresponding character introduces the featured vegetable and communicates its health benefits through age-appropriate, superhero-themed spoken messages. These audio messages were recorded by native French- and Portuguese-speaking children. The recording and implementation followed a protocol validated by researchers and nutritionists from both countries. As the player advances through the levels, the characters share the key messages referring to the benefits of their consumption. Examples of these spoken messages include: "Do you want a strong heart that gives you energy? Eat tomatoes whenever you can."; "Hi! I am Super Lettuce, and my superpower is to cleanse the intestines."; "Hi! I am Super Cucumber and I have the superpower of water." "Hi! I am Super Carrot and I have the superpower of sight."; "Hi! I am Super Red Cabbage, and my superpower is to protect."

#### *Gameplay and classroom implementation*

Educational sessions were conducted in the classrooms, and children played in pairs, sharing one tablet per duo, with pairs rotating weekly. Each child engaged with the mini-game corresponding to the vegetable of the day for approximately 10–15 min, based on the attention span typical for this age group and as recommended by preschool teachers. Sessions were conducted in a group setting within the classroom.

#### *Tasting protocol*

During the tasting phase, raw and plain vegetables were offered in small pieces, and the investigator recorded both the types and quantities of vegetables tasted by each child. The order of presentation was the same across the five weekly sessions, not randomized, to ensure protocol standardization. The portions included: one cherry tomato = 1 portion, one stick of cucumber = 1 portion, one stick of carrot = 1 portion, one piece of lettuce = 1 portion, five pieces of grated purple cabbage = 1 portion. All vegetables were prepared and provided by the research team. Importantly, classroom staff were instructed not to encourage or reward children for tasting, to avoid introducing extrinsic motivators. Compliance with this instruction was verified and monitored by the researchers present during the sessions.

#### *Instruments*

To assess willingness to taste, children were seated in groups in the room where school activities usually took

**Table 1** Characteristics of preschool-aged children from Portugal and Switzerland

	Portugal		Switzerland		Total	
	N	%	n	%	n	%
Sex						
Male	20	51.3	19	42.2	39	46.4
Female	19	48.7	26	57.8	45	53.6
Total	39	46.4	45	53.6	84	100%

place, and the nutritionist offered each of the vegetables to each child in raw form and similar portions. One vegetable at a time was presented, and children were free to choose whether to taste it or not. Researchers recorded whether each vegetable was tasted. Willingness to taste was assessed at baseline (week 0), after each educational session (weeks 1–5), and post-intervention (week 6). All measurements of willingness to taste were performed by researchers, and the time of the intake assessment procedure was agreed upon with the preschool staff. The primary outcome was willingness to taste and nutrition knowledge was the secondary outcome. The willingness to taste was measured by the difference in the number of vegetables consumed from baseline (week 0) to post-intervention (week 6) and the evolution of consumption during the educational sessions (weeks 1–5).

Nutrition knowledge was assessed through three questionnaires applied both before and after the intervention. The first questionnaire included photographs of 15 food items for children to identify; the second questionnaire included the same 15 food items, and children had to indicate which of those were vegetables. These 15 foods were Marie biscuit, sausages, candies, fish, bread, chocolate, ice-cream, banana, pizza, grapes and the five vegetables of the digital game. In these two questionnaires, the correct answers could vary between 0 and 15 (1 point-correct answer; 0 points – incorrect or missing answer). In the third questionnaire, children had to link the five specific vegetables of the digital game Veggies4myHeart - tomato, lettuce, cucumber, carrot, and red cabbage to their five health benefits, using an illustrated document (1 point- correct link; 0 point – incorrect or missing link). The nutrition knowledge was assessed by the difference in the number of correct answers from baseline (week 0) to post-intervention (week 6) by the researchers.

### Statistical analysis

Data were analysed using IBM SPSS software (version 26.0) and submitted to descriptive statistical analysis techniques (mean, medians and quartiles), dispersion and variability measures (standard deviation). To assess normal distribution Kolmogorov-Smirnov test was used, and to assess the homogeneity of variances Levene test was computed. T-Student tests and two-sample Z-test for proportions were computed to compare means when the variables had a normal distribution and homogeneity of

**Table 2** Comparison of willingness to taste vegetables and nutrition knowledge (food recognition, vegetables identification and vegetables health benefits) before and after the intervention in children from Portugal and Switzerland

	Portugal		Switzerland	
	Mean ± SD	p-value	Mean ± SD	p-value
<b>Willingness to taste (0–5)</b>				
Baseline	3.38 ± 1.39	0.083 <sup>‡</sup>	2.90 ± 1.80	0.063 <sup>‡</sup>
Post-intervention	3.59 ± 1.32		3.22 ± 1.64	
<b>Food recognition (0–15)</b>				
Baseline	12.90 ± 1.12	< 0.001 <sup>‡</sup>	13.12 ± 0.89	< 0.001 <sup>‡</sup>
Post-intervention	14.03 ± 1.09		14.16 ± 0.77	
<b>Vegetables identification (0 – 15)</b>				
Baseline	11.05 ± 2.66	0.737	13.02 ± 1.67	0.001 <sup>‡</sup>
Post-intervention	10.91 ± 3.47		14.13 ± 0.89	
<b>Vegetables' health benefits (0–1)</b>				
Baseline	0.25 ± 0.20	< 0.001 <sup>‡</sup>	0.16 ± 0.20	< 0.001 <sup>‡</sup>
Post-intervention	0.47 ± 0.29		0.46 ± 0.28	

<sup>‡</sup> T-test for paired samples

variances, and the Mann-Whitney U test was computed otherwise. Statistically significant differences before and after intervention and between Portugal and Switzerland were set at a *p*-value < 0.05.

### Results

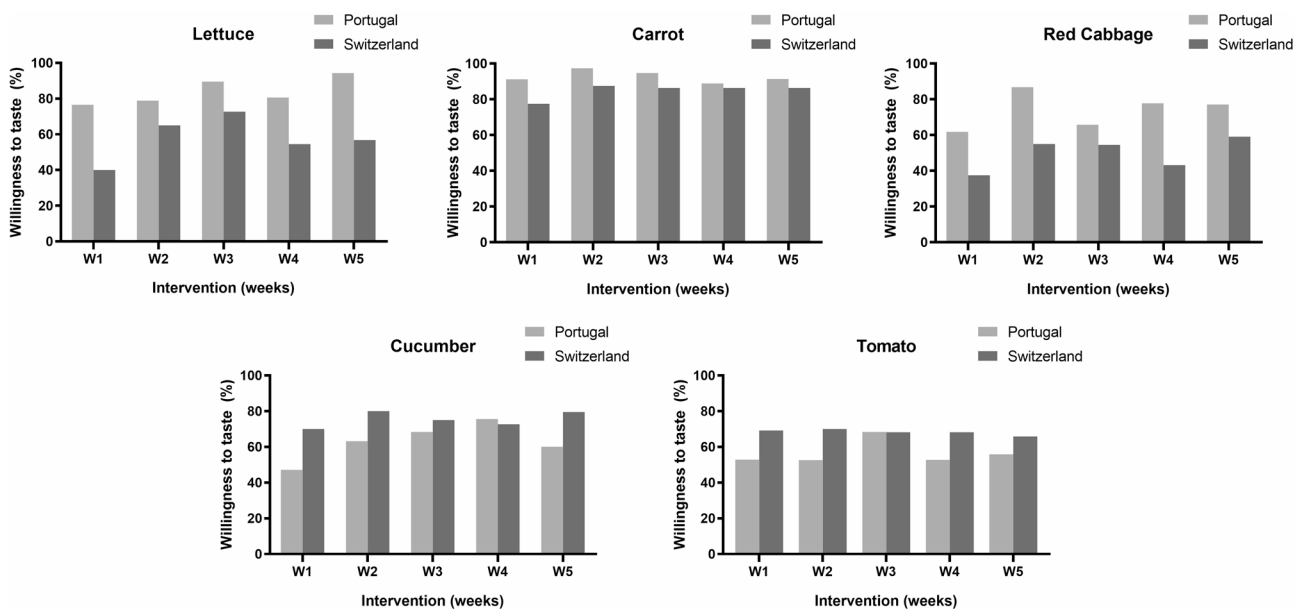
A total of 84 children participated in this study, including 39 (46.4%) from Portugal and 45 (53.6%) from Switzerland, with the majority being girls (53.6%). Table 1 presents the characteristics of the children who participated in the study.

Table 2 compares the difference in the proportion of children who tasted the vegetables between baseline and post-intervention in each country and the mean scores of correct answers in the three nutrition knowledge questionnaires. Regarding willingness to taste, there were no statistically significant differences between baseline and post-intervention in either country. There was a statistically significant increase from baseline to post-intervention in the number of correct answers of food recognition (first questionnaire) and vegetables health benefits (third questionnaire) in both countries. In Switzerland, there

**Table 3** Comparison of changes in willingness to taste the five vegetables and nutrition knowledge (food recognition, vegetable identification, and vegetable health benefits) from baseline to post-intervention between children from Portugal and Switzerland

		Portugal	Switzerland	p-value
<b>Δ Willingness to taste</b>	<b>Mean ± SD</b>	0.39 ± 1.20	0.44 ± 1.47	
Post-intervention – Baseline	<b>Median (Q<sub>3</sub>-Q<sub>1</sub>)</b>	1.000 [1.000–0.000]	0 [1.000–0.000]	0.567 <sup>#</sup>
<b>Δ Food recognition</b>	<b>Mean ± SD</b>	0.07 ± 0.08	0.06 ± 0.06	
Post-intervention – Baseline	<b>Median (Q<sub>3</sub>-Q<sub>1</sub>)</b>	0.07 [0.13–0.00]	0.07 [0.13–0.07]	0.747 <sup>#</sup>
<b>Δ Vegetables identification</b>	<b>Mean ± SD</b>	-0.01 ± 0.21	0.07 ± 0.13	
Post-intervention – Baseline	<b>Median (Q<sub>3</sub>-Q<sub>1</sub>)</b>	0.00 [0.13–0.18]	0.07 [0.17–0.00]	0.114 <sup>#</sup>
<b>Δ Vegetables' health benefits</b>	<b>Mean ± SD</b>	0.21 ± 0.27	0.31 ± 0.31	
Post-intervention – Baseline	<b>Median (Q<sub>3</sub>-Q<sub>1</sub>)</b>	0.20 [0.40–0.00]	0.30 [0.60–0.20]	0.114 <sup>#</sup>
<b>Δ Willingness to taste</b>	<b>Mean ± SD</b>	0.39 ± 1.20	0.44 ± 1.47	
Post-intervention – Baseline	<b>Median (Q<sub>3</sub>-Q<sub>1</sub>)</b>	1.000 [1.000–0.000]	0 [1.000–0.000]	0.567 <sup>#</sup>

SD, standard deviation; Δ – Difference between post-intervention and baseline; <sup>#</sup> between-group comparisons of the difference scores (post-intervention - baseline) using the Mann-Whitney U test

**Fig. 1** Evolution of willingness to taste the five vegetables included in the digital game Veggies4myHeart in Portugal and Switzerland. Legend: W1 – week 1; W2 – week 2; W3 – week 3; W4 – week 4; W5 – week 5

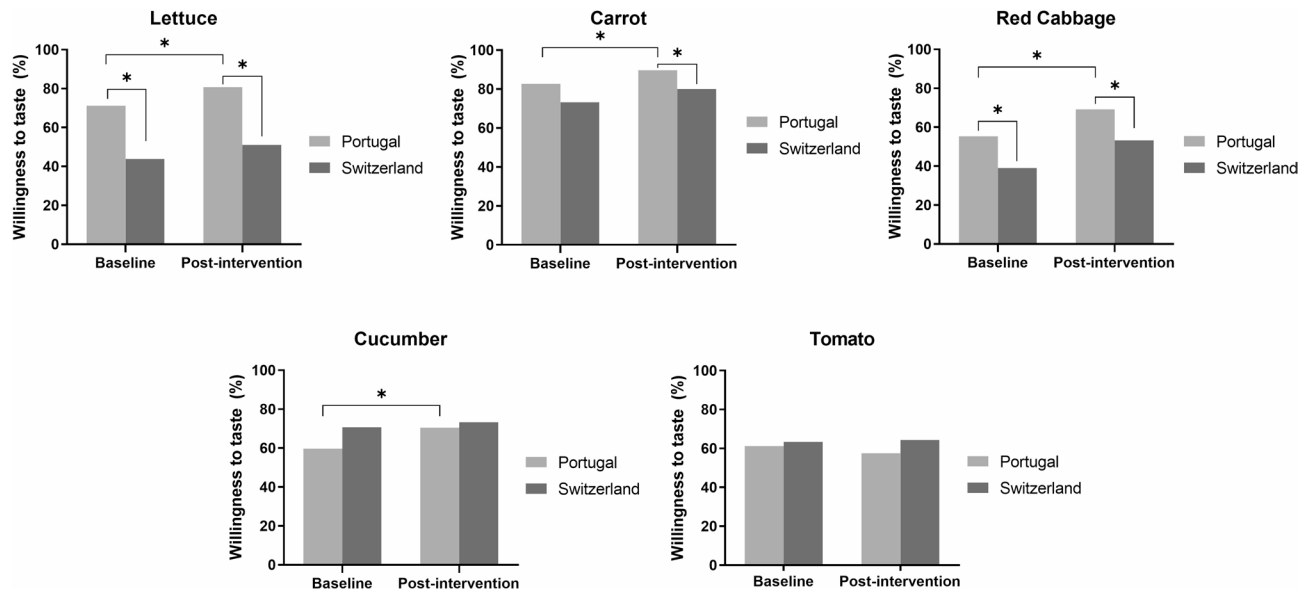
was also a significant increase in vegetable identification (second questionnaire).

Table 3 compares the change from baseline to post-intervention in willingness to taste vegetables and nutrition knowledge (food recognition, vegetable identification, and vegetable health benefits) between children from Portugal and Switzerland. There were no statistically significant differences in the progression of nutrition knowledge and willingness to taste vegetables between the two countries.

Figure 1 represents the evolution of the percentage of children present at each educational session who were willing to taste the five vegetables over time. Comparing the two countries, Portugal had a greater willingness to taste lettuce, carrot, and red cabbage in all the educational sessions. Switzerland had a greater willingness to taste carrot, cucumber and tomato, which was similar

during all sessions. The carrot was the vegetable that children were more willing to taste during all sessions in both countries, without great differences between Portugal and Switzerland.

Figure 2 depicts the differences between the two countries. Portugal had statistically significant differences in the willingness to taste between baseline and post-intervention for all the vegetables except for tomato. In Switzerland, there were no statistically significant differences in willingness to taste all the vegetables. The results showed that, at baseline, there were significant differences in willingness to taste between countries for the lettuce and red cabbage. Comparing the results between the two countries post-intervention, statistically significant differences were found in the willingness to taste lettuce, carrot, and red cabbage, with Portuguese children



**Fig. 2** Comparison of willingness to taste the five vegetables included in the digital game Veggies4myHeart at baseline and post-intervention in Portugal and Switzerland. Footnote: \*  $p$ -value of two-sample Z-test proportion  $< 0,05$ ;

showing more willingness to taste these vegetables than Swiss children.

## Discussion

This study demonstrated that the Veggies4myHeart intervention had a positive impact on the children's willingness to taste vegetables and nutrition knowledge in both Portugal and Switzerland, despite different cultural and dietary differences. These findings support the effectiveness of combining digital educational tools with repeated exposure to promote healthier eating behaviours in early childhood.

Regarding willingness to taste, the Veggies4myHeart and vegetable exposure intervention in Portuguese children showed significant improvements in four of the five vegetables offered, except for tomato, which slightly decreased without statistically significant differences. Swiss children also showed improvements, although these were not statistically significant overall. One possible explanation lies in the cultural familiarity and availability of the vegetables selected, which were chosen based on their prevalence in Portuguese preschool canteens. In Switzerland, some of these vegetables may be less commonly served or less familiar, which could have influenced children's openness to try them. Additionally, language, classroom dynamics and contextual factors such as teacher involvement or mealtime practices may have contributed to these differences.

In terms of nutrition knowledge, both groups showed improvements. Portuguese children showed progress in food recognition and vegetable–health benefit association, while Swiss children improved across all three

questionnaires, including food recognition, vegetable identification and vegetable health benefits, reinforcing that knowledge alone is insufficient to drive eating behaviour.

These findings align with previous studies highlighting the effectiveness of serious games, such as Veggies4myHeart, in enhancing children's knowledge about food and even preventing childhood obesity [27], as well as the well-established role of repeated exposure as a strategy to increase vegetable acceptance among young children [32]. Combining these two strategies, as in the Veggies4myHeart intervention, may offer a particularly effective means of promoting both behavioural change and nutrition education in early childhood.

Repeated exposure is a widely studied evidence-based strategy, known to increase both willingness to taste and actual consumption of vegetables among preschool children [33–35]. In this study, children were exposed to the five target vegetables a total of seven times, which is within the range suggested by studies indicating 6–10 exposures may be sufficient to influence short-term behavioural change [34]. However, evidence suggests that long-term integration into diet may require 10–15 exposures or more [21]. Further studies are needed to establish whether this number of exposures is efficient in the long term [34].

Importantly, the effectiveness of repeated exposure is not solely determined by the number of exposures. Social, cultural, and environmental contexts play a significant role in modulating children's responses. Chawner and Hetherington proposed a biopsychosocial model to explain how eating behaviours in infancy and childhood

are influenced by multiple interacting factors, including parental modelling, feeding practices (e.g., restriction, encouragement), parenting style, and the physical food environment (e.g., availability, preparation methods) [38]. In light of these influences, some variation in outcomes between Portuguese and Swiss children could be expected. Nonetheless, the consistently positive impact of the Veggies4myHeart intervention in both settings suggests that the tool is flexible and adaptable across diverse cultural and educational contexts, regardless of classroom dynamics or teaching styles. To strengthen future interventions, Veggies4myHeart could be complemented by additional educational tools that promote experiential learning. For instance, the use of live characters has proven effective in increasing children's willingness to try vegetable-based recipes in low-income populations [36]. Hands-on food activities [37], school gardening [38], picture and storybooks [39, 40], sensory play [40], e-books [41], and cooking workshops [42] may also be promising strategies for enhancing vegetable acceptance in early childhood.

In parallel with repeated exposure, serious games have also gained increasing attention as tools to support nutrition education and behaviour change in children. Furthermore, the positive influence of serious games on promoting healthier eating habits and improving nutrition-related knowledge in children by enhancing knowledge, encouraging food exploration, and reducing picky eating has been demonstrated in a recent systematic review [43], highlighting their potential as accessible and engaging tools.

To the best of our knowledge, few serious games focus specifically on promoting vegetable consumption in preschool-aged children. Other tools such as Squire's Quest! II and Mommio games have shown promising results in older age groups, suggesting that parent engagement and children's involvement in food preparation and offering accessible, appealing vegetable recipes may further support behavior change [29–31]. In this context, adding a new section to the Veggies4myHeart app with simple, child-friendly vegetable recipes and tasks could enhance parental involvement, foster sensory learning, and increase children's familiarity with different vegetables.

Despite the positive results, some limitations of the study must be acknowledged. The study relied on a convenience sample and lacked a control group, which limits the ability to isolate the effect of the serious game from repeated exposure. This was primarily due to logistical constraints, as only one school in each country agreed to participate, largely because of the timing of the school year when recruitment took place. The short duration of the intervention also prevented an assessment of long-term impact. Future studies should include follow-up measurements to evaluate whether behavioural

and cognitive changes are sustained over time. In addition, environmental factors such as sound volume during gameplay, classroom setting, and children's prior familiarity with digital devices may have influenced their engagement with the game. The family context and access to technology at home were not assessed, which may also have affected children's ability to interact with the digital tool. Another limitation of the study may be related to the fact that there was a statistically significant difference in the proportion of male and female children in the Swiss class. Some European studies indicate that female children are more likely to follow healthier eating patterns [44] and that girls consumed more fruit and vegetables than boys [45], which could be explained by different parenting styles according to gender, where girls are more encouraged to be healthier, or also by differences in innate food preferences. However, in more recent studies, the gender of the child is not indicated as a significant predictor of vegetable consumption [46, 47].

Finally, future studies should consider evaluating children's prior preferences and actual vegetable intake to better understand individual variability in outcomes. Additionally, involving parents may help reinforce behavioural changes and support habit formation at home.

## Conclusion

The intervention conducted in Portugal and Switzerland using the digital game Veggies4myHeart had a positive impact on preschool children's willingness to taste vegetables. Although the changes did not reach statistical significance, a positive trend was observed in both countries (Portugal:  $p=0.083$ ; Switzerland:  $p=0.063$ ). Improvements in nutrition knowledge, from baseline to post-intervention, were observed in both countries ( $p<0,001$ ), but without statistically significant differences between countries ( $p=0.114$ ). Despite differences in context and eating habits, the digital game was well accepted and successfully implemented in both countries. These findings highlight the importance of developing engaging educational tools and strategies to increase vegetable consumption and, hopefully, help reverse the current low consumption of this food group. Despite some limitations of the study, such as the lack of a control group and the lack of a later follow-up evaluation, and other contextual factors (e.g., sample characteristics and classroom dynamics), we believe that this study offers an important perspective on the use of a serious game to promote vegetable consumption in preschoolers, in diverse cultural and population contexts. Enhancing familiarity and delivering age-appropriate messages through digital games may help empower children across diverse contexts to make healthier food choices and prevent childhood overweight and obesity.

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## Author contributions

PF and NB wrote the manuscript; ML performed the data collection and wrote the manuscript; LV realized the data analysis; SSD realized the data analysis and reviewed the manuscript; MPG and SBDT reviewed the manuscript; CBP formulated the research question, designed, and carried out the study, and wrote the manuscript. All authors read and approved the final manuscript.

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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 and consent to participate

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. 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 no competing interests.

This study was approved by the Ethical Committee of Polytechnic Institute of Leiria (CE/IPLEIRIA/11/2019) and by the Service of Research in Education in Geneva, Switzerland (research number 584).

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