

A Web-Based Gamification Program to Improve Nutrition Literacy in Families of 3- to 5-Year-Old Children: The *Nutriscience Project*

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ABSTRACT

Objective: Assess the impact of a web-based gamification program on nutrition literacy of families and explore differences in impact by socioeconomic status.

Design: Quasi-experimental.

Setting: Thirty-seven kindergartens from Portugal.

Participants: Eight hundred seventy-seven families.

Intervention: Web-based social network of participants' interactions, educational materials, apps and nutritional challenges, focused on fruit, vegetables, sugar, and salt.

Main Outcome Measures: Parental nutrition literacy (self-reported survey – 4 dimensions: Nutrients, Food portions, Portuguese food wheel groups, Food labeling).

Analysis: General linear model – Repeated measures was used to analyze the effect on the nutrition literacy score.

Results: Families uploaded 1267 items (recipes, photographs of challenges) and educators uploaded 327 items (photographs, videos) onto the interactive platform. For the intervention group (n = 106), the final mean (SD) score of nutrition literacy was significantly higher than the baseline: 78.8% (15.6) vs 72.7% (16.2); $P < .001$, regardless of parental education and perceived income status. No significant differences in the scores of the control group (n = 83) were observed (final 67.8% [16.1] vs initial 66.4% [15.6]; $P = .364$).

Conclusions and Implications: Gamified digital interactive platform seems to be a useful, easily adapted educational tool for the healthy eating learning process. Future implementations of the program will benefit from longer time intervention and assessment of the eating habits of families before and after intervention.

Key Words: nutrition literacy, families, kindergarten children, gamification (*J Nutr Educ Behav.* 2018;000:1–9.)

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INTRODUCTION

Noncommunicable diseases (NCD) are the main cause of mortality worldwide, responsible for two thirds of all deaths in 2015.¹ Unhealthy diet is

considered one the most important lifestyle risk factors for NCD and is associated with frequent metabolic/physiologic changes such as high blood pressure, high fasting blood glucose, high blood lipids, and

overweight/obesity.² Social inequalities persist regarding the distribution of risk factors for NCD, putting the disadvantaged social classes at higher risk. In Portugal, according to a recent national food and physical activity survey, 25% of children (under 10 years of age) are overweight.³ Moreover, unhealthy dietary patterns seem to be the leading cause of the total number of years of healthy life lost (19%) in the Portuguese population.⁴ In addition, inequalities in energy-balance-related behaviors in children are well documented, reflected by a higher prevalence of obesity among children whose parents have a low education level.³

Evidence shows a strong correlation between nutritional knowledge and healthy eating.⁵ In fact, understanding the importance of nutrition

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seems to be a determinant for prevention and management of different global health concerns. However, while nutrition knowledge is an important enabling factor, it might not be enough to change behavior. In recent years, the ecological model has thus been used to explain and develop interventions to change eating behaviors.⁶ Ecological models are based on the premise that an individual's behavior is shaped by a dynamic interaction with the social and physical environment, which includes influences at the interpersonal, organizational, and community levels and employs a variety of disciplines and perspectives to understand and address complex public health problems.^{7,8} However, the application of the social ecological model has had limited success in changing dietary behaviors.⁹

The combination of traditional ecological systemic approaches with the acknowledgment that in modern life, health and well-being strongly depend on the individual's health behaviors opened new horizons to use motivation as the core concept of a new generation of health communication interventions. This raises the immediate question; what kind of interventions are best positioned to intrinsically motivate health behavior change?

Gamification a New Model?

A main rationale for using gamification designs in health is that they are systems purpose-built for motivation. Systematic literature review shows that, compared to traditional persuasive approaches, gamification offers several advantages for motivating behavior change for health and well-being.^{10,11} Gamification strategies have already gained recognition for fostering desirable health-related behaviors through motivational reinforcement, personalized teaching approaches, and social networking.¹² Gamification is a concept that makes use of social mechanisms such as social influence or interaction by applying game mechanics (action points, feedback, competition).¹³ Various studies indicate that specific messages based on group behavior could have the power to influence

health-related intentions,¹⁴ and that individuals use information about how others behave as a guide to appropriate behavior in a given context, especially in uncertain situations.¹⁵

In short, the main reasons to consider gamification as relevant to health behavior change include:

Intrinsic motivation. The ability to intrinsically motivate the initiation and continued performance of health and well-being behaviors,^{11,16–19} and the well-established advantages of intrinsic over extrinsic motivation with regard to health behaviors.^{20,21}

Broad appeal across audiences. The psychology of familiarity may explain the broad appeal of game design language. Game experience is now so entrenched in our culture that games elements and game design become approachable and appeal to wider populations.¹⁷

Everyday life fit. Gamified systems are typically in line with already-ongoing everyday behaviors facilitating interventions efficacy.

Supporting well-being. Gamified interventions offer a wide range of possibilities for generating positive experiences of task accomplishment and social relationships, as well as other elements of well-being, like positive emotions.¹⁰

This study aimed to assess the impact of a web-based gamification program delivered through classrooms on nutrition literacy of families with children 3–5 years old and explore differences in impact by socioeconomic status.

METHODS

The *Nutriscience Project* is a prospective follow-up program implemented in 2016 that aimed to improve nutrition literacy in families of 3–5-year-old children after a web-based intervention using a gamified multiplatform strategy. The main topics addressed in this project were promotion of fruit and vegetable consumption and decreasing sugar and salt intake, according to the priorities of the World Health Organization.²² The evaluation study was performed

during 3 months with intervention and control groups.

Participants and Procedures

A convenience nonrandom sample of 37 kindergartens (59 classrooms and 877 families) were invited to participate in the program; from those, 32 were allocated to the intervention group and 5 to the control group, targeting a minimum of 1 kindergarten from each administrative region of Portugal. All the families with 3–5-year-old children were invited to participate in this project through the participating classrooms. From the invited families, 63% agreed to participate. However, only 106 families from the intervention group and 83 from the control group completed pre and post questionnaires. Explanations on how to participate in the project and access the platform were provided in 3 regional meetings with educators and school directors. In addition, an introductory video and a PowerPoint presentation (Microsoft Corporation, Redmond, WA) was given to educators to present at parent meetings, and a pamphlet was distributed to all the eligible parents through the classrooms. Families from both intervention and control groups completed a questionnaire assessing nutrition literacy at the beginning and at the end of the intervention period (3-month period). After the second assessment, families from the control group were invited to access the platform and all the contents.

Intervention Model Design

The model behind *Nutriscience* (Figure) is structured around 3 main interconnected strategies aimed at promoting nutrition literacy: (1) parents' level of intervention; (2) children's level of intervention; (3) educators' level of intervention. The children's level was based on contents like comics and a serious game app (*TuttiNutriScience*) promoting healthy food choices. The educators' level was based on a Massive Open Online Course on Nutrition (10 modules) and lasted for 5 weeks. Each module includes learning objectives, video, and activity sheets to be developed for children in the classroom. The Massive Open Online Course

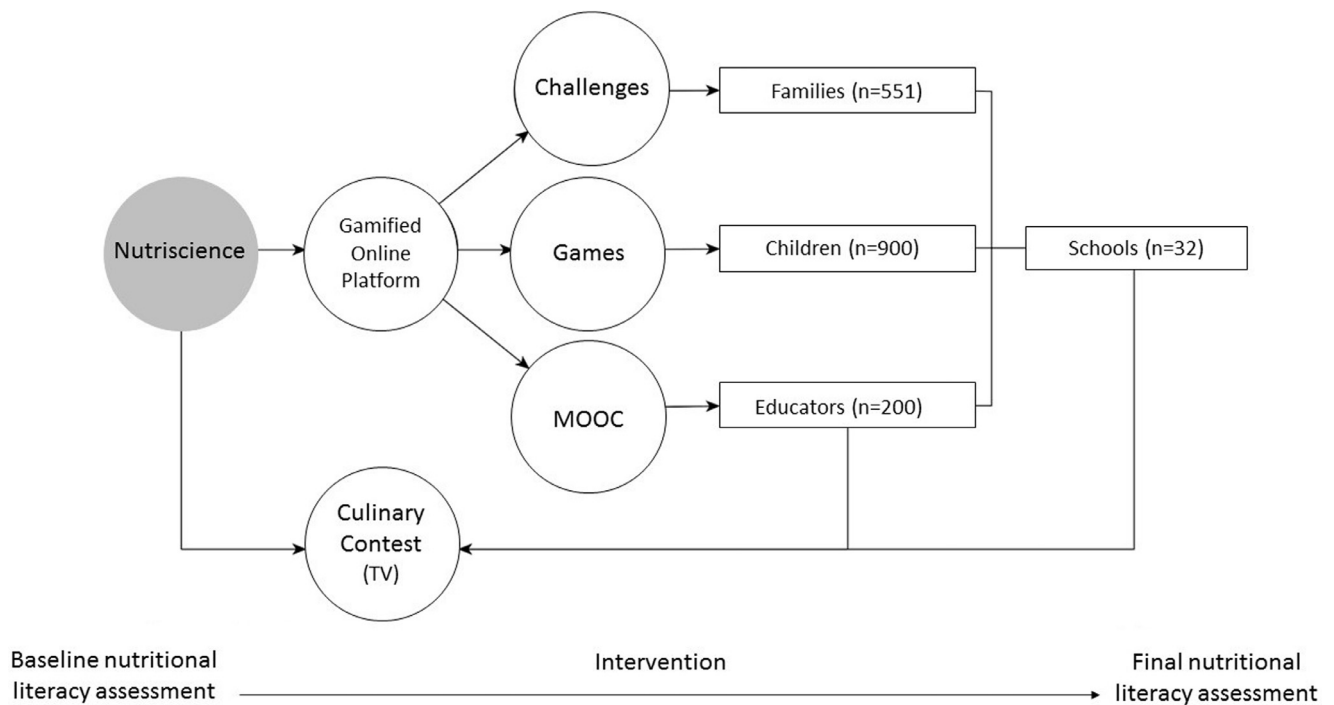


Figure. The *Nutriscience* intervention model: a web-based intervention using a gamified multiplatform strategy. MOOC indicates massive open online course.

was certified by the board of continuous training of teachers and educators (0.4 credits). This paper will focus on the parents' level of the intervention, which is described in more detail below.

The platform was developed as a social network environment where schools and families signed up for membership. Families accessed the interactive platform through a code, creating a "Family Page" with the name and photo (optional). The platform provides different layers of information: nutritional informative contents (videos, recipes, food "identity cards"), weekly challenges launched by the project team (related to the 3 intervention topics), news about events in the network, and an interactive space (forum and visualization/comments of other members' participation).

Weekly nutritional challenges (Table 1) were launched in the platform and were the main driver of interaction, encouraging family involvement in real life with a sharing online, for example, (a) recipes preparation (a vegetable soup with pulses and no added salt, a Mediterranean Diet main dish, low sugar dessert, etc); (b) analyzing food labeling (compare the amount of sugar in 2

different yogurts, find the amount of salt of a processed food); (c) food-related activities (planting aromatic herbs). The platform allowed the participants to visualize their performance through bar of completion and to get a badge for each of the 3 topics when all 3 challenges for that topic are completed. In each topic there was a challenge related to a recipe. Uploaded recipes received feedback on their nutritional quality and were ranked based on nutritional quality, creativity, and cultural relevance. In total, 30 recipes were chosen to be performed by a chef at a national TV channel and to be included in a cookbook based on the ranking and representativeness of regional diversity (north/south, coast/inland).

In classrooms, educators accessed the platform through an institutional code, and had 3 weekly nutritional challenges about healthy eating related to arts, music, and drama to complete in class with children and to share through the platform. All the participating classrooms also had access to educational contents available in the platform. The involvement of the classroom community (educators and other professionals) was considered fundamental, since

the intervention had a holistic approach and the educators–families relation was essentially a motivational strategy for participation.

In addition, an open Facebook page for the *Nutriscience Project* was created in order to increase its visibility.

Nutrition Literacy Assessment

To assess changes in parents' nutrition literacy, a parental self-reported questionnaire was applied, which was filled out on the *Nutriscience* online platform. For the control group, a paper-based version of the questionnaire was handed out and returned through the classrooms.

The questionnaires were administered before and after the intervention, assessing (1) sociodemographic characteristics (respondent's age and degree of kinship; number of household members; household classification; number of household children; gender and age of participant child; educational level, job situation, and type of work institution of respondent and his/her spouse, and perceived income status),²³ and (2) food and nutrition literacy.

Educational level was recoded into the following categories (more than

Table 1. *Nutriscience*^a Families Intervention Challenges

	Topic	Date	Challenge	Answer
October 3 to October 23, 2016	Fruit and vegetables	October 3 to October 9	Development and preparation of a soup recipe with legumes	To submit the soup photo- graph and its recipe
		October 10 to October 16	Development and preparation of a dessert only with fruit (using seasonal fruit)	To submit the dessert photo- graph and its recipe
		October 17 to October 23	Development and preparation of a Mediterranean recipe—main dish	To submit the main dish photo- graph and its recipe
October 24 to November 13, 2016	Salt	October 24 to October 30	Creation a small herbs' plan- tation in the kitchen	To submit the herbs' planta- tion photograph
		October 31 to November 6	Development and preparation of a traditional dish of fami- lies' region with less salt	To submit the dish photo- graph and its recipe
		November 7 to November 13	Find out how much salt there is in food from its label (choose 2 options): 1) ham 2) pizza 3) culinary broth	To submit a document or a photograph with salt content comparison between products
November 21 to December 13, 2016	Sugar	November 21 to November 27	Preparation of a breakfast or a lunchbox with low sugar content	To submit the photograph and the description of the meal content
		November 28 to December 4	Compare 2 labels of one type of product (choose one) 1) 2 different types of cookies 2) 2 different types of yogurts	To submit a document or a photograph with sugar con- tent of the selected products
		December 5 to December 13	Preparation of a traditional Christmas dessert (chosen by each family)	To submit the dessert photo- graph and its recipe

^a*Nutriscience* is a gamification approach to improving nutrition literacy by challenging family participation.

12 years of schooling – ‘high educational level’; 12 years of schooling or less – ‘low educational level’. The Nutrition Literacy questionnaire was based on the Nutrition Literacy Assessment Instrument (NLAI), published by the Centers for Disease Control and Prevention.²⁴ The NLAI has 5 different sections regarding nutrition and health, macronutrients, household food measurement, food labels and numeracy, and food groups.^{24,25}

The Nutrition literacy questions were adapted to the Portuguese setting, regarding Portuguese food habits and the 3 major topics of the project (promoting the consumption of fruit and vegetables; reducing the intake of sugar and salt), resulting in 20 questions covering 4 different dimensions: Nutrients (6 items), Food Portions (3 items), Portuguese Food Wheel Guide Groups (7 items), and Food Labeling (4 items). Two

important modifications were introduced to NLAI: disease-related questions were removed from the NLAI questionnaire, taking into account the objectives of the project, focusing on a health promotion approach rather than focusing on the relationship between diet and disease. Regarding food portions, the changes were culturally induced, they were adapted to the food recommendations in the Portuguese food guide. The objective was to assess the knowledge of participants regarding the adequate amount of food for a meal – portions – and the proportion between portions of vegetables, as well as protein and carbohydrate food sources in the plate of a main meal. Particular emphasis was given to the portion of vegetables in line with one of the central objectives of the project – the increase of its consumption.

Therefore, it was decided to include 3 examples of main meals in which vegetables are usually consumed according to Portuguese dietary habits, showing different proportions of the 3 main components of a Portuguese main meal (meat/fish, starchy food, and vegetables). A pretest was conducted in a sample of 10 families with 3–5-year-old children, to help refine the wording and layout of the questionnaire and evaluate the time taken to fill it out, and the eventual misunderstanding of the questions. Informed by the results of pretest, minor changes were made to improve the clarity of the questionnaire.

The nutrition literacy score was obtained through the proportion of right answers (number of right answers, divided by the total number of questions and multiplied by 100). The project was approved by the

Ethics Committee of University of Porto and National Commission for Data Protection. Informed consent indicating agreement of the parents to participate in this study was also requested before inclusion.

Statistical Analysis

Descriptive statistics included mean (SD) and proportions. General linear models (GLM) with repeated-measures analysis were used to analyze change in the nutrition literacy score over the *Nutriscience* intervention and to test 3 hypotheses: (1) the main effects on repeated measures of between-subjects (grouping) factor A (in this case, education or income); (2) the main effects of within-subjects (conditions) factor B (in this case, the *Nutriscience Project*); (3) interaction effect between factors.

The repeated-measures GLM procedure is “conceptually an extension of the ubiquitous ANOVA.”²⁶ The biggest advantage of this method is its conceptual simplicity and the way it deals with possible clustering of data. “Earlier (first-generation) studies

probably over-estimating school effects because they treated the school variable as one among several characteristics of individuals.”²⁷ A review indicates that “for the future, multi-level studies are the empirical approach of choice,” since it takes account of the hierarchical structure of the data.²⁸ In this study, the effects of school- and individual-level factors could be estimated simultaneously using the intraclass correlation coefficient (ICC) as a preliminary analysis to determine the most appropriate model-to-data agreement. The ICC assesses the degree of clustering or dependency among subsets of cases in nested data. When the ICC is close to 0, as happened in this study, clustering is not present in the data and simple GLM is the most statistically appropriate procedure to implement. Otherwise, mixed models should be used.

RESULTS

Sociodemographic characteristics are described in [Table 2](#) and did not differ significantly between the intervention and control groups ([Table 2](#)).

Indicators of Family Engagement With the Platform

During the *Nutriscience Program*, a total of 1267 uploads from families (including recipes and photographs of challenges) were recorded on the interactive platform. There was a total of 512 answers for ‘fruit and vegetables’ challenges (1st group of challenges), 412 to ‘salt’ challenges (2nd group of challenges), and 343 to ‘sugar’ challenges (3rd group of challenges) by the families. Considering the 3-week challenges for classrooms, 27 ‘*Nutriscience* mascots’ (1st challenge), 25 ‘*Nutriscience* hymn/chorography’ (2nd challenge), and 14 ‘*Nutriscience* children theatre’s plays (3rd challenge) were developed.

Impact of the *Nutriscience Project* on Nutrition Literacy

For the intervention group, the final mean (SD) score was significantly higher than the baseline one: 78.8% (15.6) vs 72.7% (16.2); ($P < .001$) ([Table 3](#)). The significant P -value for *Nutriscience* intervention shows an

Table 2. Sociodemographic Characteristics of the Participants^a (Intervention Group, n = 106; Control Group, n = 83)

	Intervention Group n (%)		Control Group n (%)		Significance Value	
Educational level (years)					.194	
< 10	10 (9.3)		8 (9.6)			
10–12	27 (25.5)		31 (37.3)			
> 12	69 (65.1)		44 (53.0)			
Income perception					.486	
Live comfortable	18 (17)		9 (10.8)			
Can live	66 (62.3)		55 (66.3)			
Live with difficulties	22 (20.8)		19 (22.9)			
Household classification					.979	
Mother or father with children	7 (6.6)		6 (7.2)			
Couple with children	93 (87.7)		72 (86.7)			
Couple with children and other	6 (5.7)		5 (6.0)			
Number of children					.708	
1	55 (51.9)		38 (46.3)			
2	44 (41.5)		39 (47.6)			
≥ 3	7 (6.6)		5 (6.1)			
Job situation					.406	
Employed/paid internship	94 (88.7)		73 (88.0)			
Unemployed	5 (4.7)		7 (8.4)			
Other ^b	7 (6.4)		3 (3.6)			
	Median	Minimum	Maximum	Median	Minimum	Maximum
Age (parent)	36	24	51	37	19	47

^aParticipants were families with 3–5-year-old children (106 families in intervention group and 83 families in control group). $P < .05$;

^bStudent, retired, disable, military/community work, domestic, another inactivity situation.

Table 3. Nutrition Literacy Over Time^a Using General Linear Models (GLM) With Repeated Measures

	Mean Score (SD) Baseline	Mean Score (SD) Final	Mean Difference	Within-Subjects (<i>P</i> -Value)
Intervention group	72.7 (16.2) %	78.8 (15.6) %	6.1	< .001
Control group	66.4 (15.6) %	67.8 (16.1) %	1.4	.364

^aParticipants were families with 3–5-year-old children (106 families in intervention group and 83 families in control group). *P* < .05.

effect on the nutritional scores – a within-subjects effect reflected by the repeated measures. In the control group, no significant difference between the final and initial scores was observed [67.8% (16.1) vs 66.4% (15.6)] (*P* = .364) (Table 3). It could also be possible that nutritional literacy scores are confounded by conditions such as income and education. Nevertheless, according to Table 4, there is a nonsignificant interaction between time and education (*P* = .324), and between time and income (*P* = .338). Therefore, *Nutriscience* intervention is the only statistically significant variable affecting literacy scores. Also worth noting is the between-subjects effects, which determine if respondents differ on scores, depending on their group. In this case, according to Table 4, nutritional scores are statistically different according to education level (*P* = .003) and income (*P* = .026). However, since this study was not powered, any nonsignificant results should be cautionary since a lack of significant results could be caused by too few participants.

DISCUSSION

The implementation of a gamified web-based intervention as an alternative to face-to-face approaches highlights a potentially fruitful line of research. The significant improvement of the nutrition literacy of the participant families regardless of parental education and perceived

income status was particularly relevant. Previous studies have failed on engaging individuals from lower socioeconomic levels in this kind of intervention on healthy eating promotion.^{29,30} Despite advancements, questions remain mainly around the issues of assessing literacy and mechanisms of change.

First, little attention has been paid to establishing valid instruments for measuring nutrition literacy.³¹ Some of the available questionnaires were focused mainly on global health,^{32–37} and there were few related to nutrition literacy.^{25,38–40} The field landscape is therefore characterized by a certain confusion of concepts. Articles were found using terms like food literacy, nutrition literacy or functional literacy, interactive literacy, critical literacy (all applied to nutrition), and health literacy, apparently referring to similar issues.^{25,32,41} Two food and nutrition literacy questionnaires validated for Portuguese population were found,^{42,43} but required a high baseline literacy by the target population. Those questionnaires were focused, respectively, on labels reading and calculation³⁸; and nutrition topics like antioxidants, micronutrients, and nutritional therapy for diseases³⁹; as the *Nutriscience Project* aimed to reach the whole spectrum of social socioeconomic status, these questionnaires were not appropriate. Secondly, an important point to discuss is the underlying mechanisms of change for intervention.

It is not possible to separate the effect of the various components of such a comprehensive ecological intervention. Providing the nutritional intervention to the whole educational community *per se* was certainly a key aspect of the success of the intervention. Nevertheless, a number of other dimensions (experiential learning; social norms through benchmarking against others and professionally set standards/recommendations; role modeling/vicarious learning) are likely to have contributed to improve nutrition literacy.

Nutrition literacy is not just about information, but also requires other skills related to what people actually do with the knowledge being communicated. Effective communication does not happen by pushing messages on to people. It only happens when the receivers understand and make meaning of those messages.^{44–47} Families were challenged to develop tasks and to train practical skills such as preparing a vegetable soup with pulses, cooking a traditional recipe with reduced salt content, and selecting healthy foods while purchasing or planting culinary herbs (“kitchen garden”). Experiential learning strategies have been considered the most effective to promote healthy eating.⁴⁸ Therefore, the impact of involving the family in the preparation of healthy meals through active cooking is expected to be higher than other strategies such as passively transmitting knowledge from a purely theoretical point of view.

Table 4. Impact of Intervention Program in Nutrition Literacy in Families According to Education and Income Perception^a

	Significance Value	
	Between-Subjects	Interaction
Education level	.003	.324
Income perception	.026	.338

^a*P* values calculated through general linear model for repeated measures.

The gamification design allowed the diffusion of sustainable nutritional behavior within the community by activating perceived social norms. (The forum allowed participants to interact and share experiences. Participants could also see recipes from other families, comment, and add to their favorites). A large number of people don't know what to think about nutrition, with all the media mixed messages bombarding them.⁴⁹ It is therefore important that choosing healthy meals is made visible so as to activate the desired norm.⁵⁰ For instance, the introduction of a points system (often used in gamified applications) based on schools' participation displayed in a leader board and ranked schools against each other. Such a ranking is often used in gamified applications, thereby allowing people to compare their ranking against others. As Bandura⁵¹ points out, vicarious experiences provided by social models are one of the main sources that influence an individual's perceived self-efficacy. This means that a gamification strategy may involve peer modeling activating and increasing self-efficacy by raising beliefs of being capable of mastering activities.

This study has several limitations that should be pointed out. This study uses a nonrandom sampling method, and the sample size of the control group was small in comparison with the intervention group. An online questionnaire was used, which might reduce the response rate of certain demographic groups. The short duration time presents another limitation.

This intervention was focused on specific nutrition objectives, which led to a more accurate intervention. Secondly, parents were used as the main agents to be involved in this intervention. Further, this project was focused on enhancing motivation for participation and learning process. Finally, educators were also involved in this intervention to facilitate the environmental changes in schools.

It is demanding for health researchers to think about the different ways people acquire new behaviors so they can be successful at

population-level changes with respect to nutrition literacy.⁵² Gamification could be a promising approach in helping to bridge the intention-behavior gap for a potentially large group of individuals.

IMPLICATIONS FOR RESEARCH AND PRACTICE

The *Nutriscience Project* provided families and classroom staff with significant information (booklets, online comments, and other written information) about what are considered the best practices for intervention in families and schools. Using a digital and entertaining interactive platform seems to be a useful, easily adapted and disseminated education tool for a healthy eating learning process. However, future implementations of the *Nutriscience Project* will benefit from a longer time intervention, at least 5 months duration,⁵³ along with an assessment of the eating habits of families and school communities before and after the intervention period. Markers of the interaction with the platform, such as the time that participants are exposed, could also be further explored. Further research is needed to determine the effectiveness of gamification in the health and well-being domain. Particularly, more well-designed studies comparing gamified and nongamified interventions, gamification approaches with and without ecological designs, and other relevant comparisons with long-term follow-up assessments of outcomes are welcomed. In addition, in future research, social interaction phenomena, within the family, between families, and between families and schools, could be assessed, as well as their impact on participants' nutrition literacy.

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