Exploring children's knowledge of healthy eating, digital media use and caregivers perspectives: Design and contextual considerations for game-based interventions in schools for low-income families in Lima, Peru.

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Abstract

Background: The prevalence of overweight and obesity in school children is increasing in Peru. Given the increased use of digital media, there is potential to develop effective digital health interventions to promote healthy eating practices at schools. This study investigates needs of schoolchildren in relation to healthy eating and the potential role of digital media to inform the design of game-based nutritional interventions.

Objective: To explore schoolchildren's knowledge about healthy eating, use and preferences of digital media to inform the future development of a serious game to promote healthy eating.

Methods: A survey was conducted in 17 schools in metropolitan Lima, capital of Peru. The information was collected virtually with specific questions for the schoolchild and their caregiver; during October and November 2021 and following the COVID-19 public health restrictions. Questions on nutritional knowledge, preferences and use of digital media were included. In the descriptive analysis, the percentages of the variables of interest were calculated.

Results: A total of 3937 validated responses were received from caregivers and schoolchildren. The schoolchildren were aged between 8 and 15 years (55.8% girls). Eighty-three percent of the caregivers were mothers, 56.5% of whom had secondary education. Only 5.2% of schoolchildren's homes did not have internet access; such access was through WiFi (54.6%) and mobile internet (33.4%). 95.3% of schoolchildren's homes had a mobile phone; 31.3% had computers. In relation to children's knowledge on healthy eating, 42.2% of schoolchildren do not know the recommendation to consume at least 5 servings of fruits and vegetables daily. 46.7% of schoolchildren do not identify the front-of-package warning (FOPWL) labels and 63.9% did not relate the presence of FOPWL with dietary risk. The majority of schoolchildren (78.7%) prefer to use the mobile phone, only 38% indicated that they prefer the computer. In addition, 47.9% of caregivers consider that the Internet helps in the education of schoolchildren; 82.7% of caregivers give permission for schoolchildren to play games with digital devices; furthermore 38% of caregivers consider that traditional digital games for children are inadequate.

Conclusions: The results suggest that knowledge about nutrition in Peruvian schoolchildren has limitations. Most schoolchildren have access to the Internet, with the mobile phone being the device of greatest availability and preference. Caregivers' perspectives on games and schoolchildren greater interest in using digital games provide opportunities for the design and development of serious games to improve schoolchildren's nutritional knowledge in Peru. Thus, future research is needed to explore the potential of serious games to promote healthy eating that are tailored to the needs and preferences of both schoolchildren and their caregivers in Peru.

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Exploring children's knowledge of healthy eating, digital media use and caregivers perspectives: Design and contextual considerations for game-based interventions in schools for low-income families in Lima, Peru.

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Keywords: Child; adolescent; schoolchildren; formative research; digital media; digital games; serious game; nutrition; obesity; overweight; mhealth; caregivers' perspectives

INTRODUCTION

Food intake not only provides energy, but also a variety of nutrients that play a crucial role in human health. The diversity and properties of these nutrients continue to be the subject of study to date [1]. Importantly, certain dietary patterns are critical in preventing and addressing the development of chronic noncommunicable diseases, such as cardiovascular disease, cancer, stroke, and diabetes[2] , as well as contributing significantly to the obesity and overweight epidemic[3]. Risks associated with diet, such as low intake of fruits, vegetables and whole grains, as well as excessive consumption of red meat, processed meats and sugar-sweetened beverages, are major contributors to global mortality rates[4]. In contrast, a healthy diet not only promotes general well-being, but also plays an essential role in the prevention of the diseases mentioned above[5]. Despite the widely recognized benefits of healthy eating for children's health and optimal development, it is concerning to note that many do not meet the established recommendations for fruit and vegetable consumption[6]. Instead, they tend to over-consume sugars and fats, which represents a significant challenge for the promotion of appropriate eating habits in this population[7].

The COVID-19 pandemic accelerated the growing trend of digital media use, especially among children and adolescent[8,9]. Consequently, there has been an increasing interest in exploring the use of digital resources to address the global epidemic of overweight, as different studies have reported positive effects on weight reduction in children and adolescents especially in developed countries [10,11]. Indeed, Health promotion interventions to prevent obesity that seek to engage children through for example the use playful strategies (e.g.,games) can take advantage of the predisposition for entertainment and learning so that the player can make choices or decisions through the game challenges [12]. In contrast, traditional interventions (e.g., weight control in children's centers) may not be appropriate for certain populations with limited mobility, time, or money, especially in low- and middle-income countries (LMICs)[10].

One type of intervention for children using digital media are digital games for educational purposes, also called serious games, which seek to entertain while supporting serious purposes such as education, training, as well as improving health [13]. Compared to traditional digital games, which mostly prioritize fun and entertainment, health-related serious games are intentionally created for learning about topics such as nutrition, or to support health prevention, rehabilitation, among others, so that the participant can aid motivation and subsequently achieve a healthy target behavior[14]. In the context of changing eating-related behaviors some systematic reviews have shown that most studies using serious games had positive results and are suitable to accompany strategies for the prevention and treatment of childhood overweight[15,16]. In recent years, serious games for health promotion, in particular for healthy eating[17], can be an appropriate alternative for an audience that is increasingly indifferent to television or printed advertisements; even the cost is comparatively

lower [18].

Currently there are several models for the development of digital game interventions, these models offer guidance in each part of the development cycle, from the exploration of the user's needs to the implementation of the intervention. Several researchers point out that one of the main barriers to the development of digital health interventions in LMICs is the still lack of evidence regarding contextual issues; such as some specific socioeconomic and infrastructural factors, as well as the use and preferences of digital devices and media of the target population [19–22]. Inclusion of the target audience is recommended for the development of effective interventions[23]. In that sense, it is important to explore certain characteristics of children and adolescents to identify specific requirements of their context, as well as to establish the learning objectives of the intervention[24]. For this reason, it is necessary to conduct formative research to engage with participants to better understand their needs and the personal relevance of the messages and activities contributing to better informed serious game interventions[14].

Formative research is a necessary step before developing an intervention because it allows for understanding the complexity of implementation projects, analyzing aspects of responses to change, adaptations and context [25]. However, not all interventions are developed under a step-by-step implementation scheme. While effectiveness trials or impact evaluations are required, it is also necessary to publish formative research that serves as a basis to gather design requirements for the development of an intervention [24]. Especially in LMICs such as Peru, where there is less evidence on the context and problems of schoolchildren, which makes it difficult to transform pilot programs into sustainable and scalable interventions [26,27].

Given the potential use of game-based approaches with Peruvian schoolchildren to develop health promotion interventions and prevent overweight/obesity, the present formative research aims to explore the knowledge about healthy eating of primary schoolchildren, as well as the acess, use patterns and preferences of digital media. This information will elucidate design elements and considerations to inform the future development of health interventions such as serious games to promote healthy eating in schoolchildren, in the Peruvian context.

METHODS

Design

Cross-sectional exploratory study; information was collected through online surveys for primary schoolchildren and only one of their caregivers. The father, mother or other relative in charge of the schoolchild at home was considered as "Caregiver". Based on the last census, public schools in Metropolitan Lima located in districts with higher population density were invited to participate.

Population and sample

In coordination with the “Regional Directorate of Education of Metropolitan Lima” (RDEML), school children and their caregivers from 4th, 5th and 6th grade of primary school from 17 public schools were invited to participate. A total of 6396 officially registered schoolchildren were invited in 2021.The invitation was sent through WhatsApp groups where teachers shared the link to the digital questionnaire and a 2-minute informative video to the caregivers. The video presented the study and showed key guidelines for the correct completion of the questionnaire. The data collection took place between October and November 2021.

Research context

Data collection occurredduring 2021 school year that were entirely remote, and following the Covid-19 public health restrictions. Communication between teachers and caregivers of schoolchildren took place using online means through WhatsApp groups and/or emails. Metropolitan Lima is the capital

of the country with approximately 11 million citizens, representing 30% of the national population[28]. Despite the economic development of the country in recent years, even in urban areas, there is a large number of the population with social vulnerability and scarce economic resources; this population generally uses public schools for the education of their children. The food environment of school children is disproportionately composed of availability of ultra-processed foods compared to healthy options[29].

Questionnaire: Development and Design

The first version of the questionnaire was elaborated by the researchers, trying to incorporate the necessary questions for the study variables. The study variables were informed by a literature review. Subsequently, the questionnaire was submitted for content validation by 8 peruvian experts from public and private academic institutions with expertise in nutrition, psychology, teaching, engineering and digital game development. For the content evaluation, Aiken's V coefficient was calculated for each section of the questionnaire, and values > 0.7 were obtained, indicating an adequate consensus of the experts[30] Likewise, modifications were made to the questionnaire in view of the suggestions made by the experts and considered pertinent by the research team. For the form validation, three mothers and their children were interviewed through synchronous video calls via Google Meet; in this phase, the caregivers and children were asked if the questions were understandable and if the categories corresponded adequately to their answers. Based on the feedback from these stages, modifications were made to the questionnaire. Subsequently, the questionnaire was digitized using the SurveyMonkey® web platform, and informed consent was added at the beginning of the digital questionnaire. Finally, a pilot was carried out with schoolchildren from one school other than the 17 schools selected for the research, where the link was sent to a group of 30 schoolchildren to fill out the questionnaire, in order to validate the process of entering and storing information, and to calculate the time it takes to answer the questionnaire (average: 20 minutes; minimum time: 16 minutes). These responses were excluded from the final analysis.

The questionnaire was designed to be answered by the schoolchildren and their main caregiver at the same time. It was divided into questions for the child and then for the caregiver. The introduction of the two sections presented the informed consent for the caregiver and the informed assent for the schoolchild, which included information about the research, voluntary participation, and data protection. The first part of the survey was for the schoolchild with questions on nutritional knowledge (21 items), digital media preferences and serious games (24 items). Most questions for schoolchildren included reference images to improve their understanding. The second part of the questionnaire was intended for the caregiver with questions about eating habits at home related to the schoolchild (36 items), perceptions of school children's use of digital media (12 items). All questions were closed-ended with multiple or single response options. The questions were short and easy to understand. The questions on nutritional knowledge included the option "I do not know" to prevent incorrect answers. the information gathered throught thesequestions was used to construct the indicators of nutritional knowledge presented in the results (its construction is detailed in supplementary material).

Statistical analysis

Initially, 5331 records were downloaded (surveys responses submitted to the Survey Monkey® platform). Subsequently a quality control was performed on the downloaded database based on a systematic process[31]. 338 duplicate questionnaires were excluded from the analysis, their identification was achieved by the similarity of the names of the children and caregivers provided during the informed consent. After this procedure the data was anonymised. Subsequently, 345 questionnaires were excluded if they were completed in less than the minimum time estimated in the

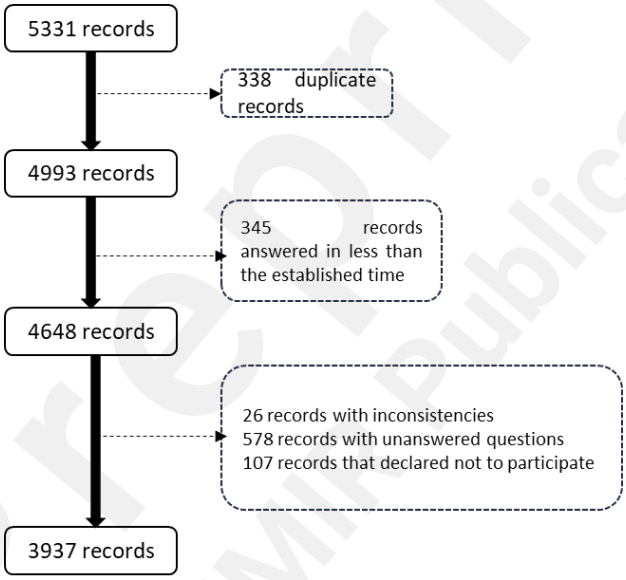
pilot (16 minutes). In addition, 26 questionnaires with inconsistencies and 578 with unanswered questions were discarded. The responses of the pilot participants were also excluded from the analysis. In addition, 107 questionnaires that had not accepted caregiver informed consent or informed assent for the schoolchild were excluded. At the end, 3937 questionnaires were included in the analysis (Figure 1).

Descriptive analysis was performed focusing on variables related to the development of serious play: knowledge about nutrition, caregivers' perceptions about the use of schoolchildren's digital media, and schoolchildren's preferences for a digital intervention. Frequencies and percentages were calculated using Microsoft Excel 365 (Microsoft Corp) and SPSS version 25 (IBM Corp).

Ethics

The research protocol was approved by the Institutional Research Ethics Committee of the National Institute of Health (Code OI-002-21). Coordination was made with the RDEML for the implementation of the research in all the selected schools. The digital questionnaire included informed consent for the caregiver and informed assent for the child. Participation was completely voluntary and could be stopped at any time; there was no compensation.

Figure 1: flowchart of quality control of records prior to descriptive analysis



RESULTS:

Table 1 shows an overview of the characteristics of our participants. The schoolchildren had a mean age of 10.8 years; 51.6% were female. Most of the caregivers who responded to the survey were the schoolchildren's mothers (3267/3937, 83%) with a mean age of 38.4 years; 56.5% (2223/3937) of the schoolchildren's mothers had a high school education. During the study period most of the households had mobile phones (3753/3937, 95.3%) and their own WiFi internet connection (2151/3937, 54.6%).

Table 1: Characteristics of among schoolchildren in 17 public schools in Metropolitan Lima, Perú, 2021

Variable	n (%)
Age of schoolchild [a]	
8-10 years	1647 (41.8)
11-12 years	2198 (55.8)
≥13 years	92 (2.3)

Sex of schoolchild	
Male	1907 (48.4)
Female	2030 (51.6)
Role of the caregiver surveyed	
Father	474 (12)
Mother	3267 (83)
Relative (Uncles, grandparents, siblings)	181 (4.6)
No immediate family	15 (0.4)
Age of caregiver surveyed[b]	
18-30 years	577 (14.7)
31-50 years	3113 (79.1)
≥51 years	247 (6.3)
Mother's instruction [c]	
No education	44 (1.1)
Initial	12 (0.3)
Primary	651 (16.5)
Secondary	2223 (56.5)
Higher Education (University or Institute)	939 (23.9)
Do not know	24 (0.6)
The child does not live with the mother	44 (1.1)
Devices available in the home [d]	
Computer	1233 (31.3)
Laptop	793 (20.1)
Mobile phone	3753 (95.3)
Tablet	635 (16.1)
Type of Internet access [d]	
WiFi inside the home	2151 (54.6)
Family or neighbor's WiFi	603 (15.3)
Mobile Internet (mobile phone)	1314 (33.4)
No Internet access at home	203 (5.2)

[a] Age of schoolchildren in years: mean 10.8 (SD 1.03); minimum 8, maximum 15
[b] Caregiver: mean 38.4 (SD 7.53); minimum 18, maximum 78
[c] The question referred exclusively to the schoolboy's mother
[d] The variables were collected independently for each category, the participant could choose more than one option.

In Table 2, we present an overview of schoolchildren's knowledge about healthy eating from our study. 90.8% (3574/3937) of schoolchildren participants were able to distinguish on three occasions the best food options for a healthy lunchbox and 42.2% (1663/3937) did not know the recommendation to consume at least 5 servings of fruits and vegetables per day. With respect to the questions asking schoolchildren to identify the foods with the highest sugar and fat content, 18.3% (720/3937) of the participants could not identify the solid food with the highest sugar content; 10.8% (x/3937) did not identify the beverage with the highest sugar content; while 8% (426/3937) did not identify the food with the highest fat content. In addition, 53.3% (2100/3937) of schoolchildren did not identify the front-of-package warning labels (FOPWL) on the food images displayed. Furthermore, 36.1% (1423/3937) of schoolchildren did not relate the presence of FOPWL with the consequences they would suffer if they consumed these products in excess. Finally, 95.5% (3755/3937) of schoolchildren indicated that their parents are the ones who teach them about healthy eating. (All questions are shown in the supplementary material.)

Table 2. Knowledge about healthy eating among schoolchildren in 17 public schools in Metropolitan Lima, Perú, 2021

Variable	Boys n (%)	Girls n (%)	All n (%)
Assembled a healthy lunch box [a]			
Achieved	167 (8.8)	196 (9.7)	363 (9.2)
Not Achieved	1740 (91.2)	1834 (90.3)	3574 (90.8)
Know the recommendation of at least 5 servings of fruits and vegetables a day.			
Meet	1098 (57.6)	1176 (57.9)	2274 (57.8)
Not known	809 (42.4)	854 (42.1)	1663 (42.2)
Identifies the solid food with the highest sugar content [b]			
Identified	389 (20.4)	331 (16.3)	720 (18.3)
Not identified	1518 (79.6)	1699 (83.7)	3217 (81.7)
Identifies the beverage with the highest sugar content [c]			
Identified	237 (12.4)	189 (9.3)	426 (10.8)
Not identified	1670 (87.6)	1841 (90.7)	3511 (89.2)
Identifies the food with the highest fat content [d]			
Identified	152 (8.0)	164 (8.1)	316 (8.0)
Not identified	1755 (92.0)	1866 (91.9)	3621 (92.0)
Identifies FOPWL on food labels [e]			
Identified	1024 (53.7)	1076 (53.0)	2100 (53.3)
Not identified	883 (46.3)	954 (47.0)	1837 (46.7)
Relates unhealthy foods to the presence of FOPWL [f]			
Yes	710 (37.2)	713 (35.1)	1423 (36.1)
No	1197 (62.8)	1317 (64.9)	2514 (63.9)
Provider of food information [g h]			
My teachers	608 (31.9)	693 (34.1)	1301 (33.0)
My parents	1813 (95.1)	1942 (95.7)	3755 (95.4)
My friends	32 (1.7)	50 (2.5)	82 (2.1)
Health personnel	350 (18.4)	363 (17.9)	713 (18.1)
I do not remember	19 (1.0)	16 (0.8)	35 (0.9)

[a]"Achieved" if the schoolchild chose three appropriate options: cookie vs apple; Home-produced traditional drink vs Soda; chicken sandwich vs chocolate cake. [b] "Identified" if the schoolchild chose the chocolate cake instead of the banana or cookies. [c]"Identified" if the schoolchild chose the glass of soda instead of the glass of water or lemonade. [d] "Identified" whether the schoolchild chose potato chips with sauces instead of boiled potato or potato chips alone[e] "Identified" whether the schoolchild selected foods with nutritional FOPWL twice. [f] "Yes" if the schoolchild associated the most harmful food with the one that had FOPWL twice. [g] Who teaches you to eat healthy? [h]The categories were collected independently for each category (Yes/No).

In Table 3, we present an overview of caregiver's perceptions about their children's use of digital media. Parents reported that the most used device by schoolchildren to distract themselves was the mobile phone (2514/3937, 63.9%); likewise, the websites with the highest use were YouTube (1178/3937, 29.9%) and Tik-Tok (723/3937, 18.4%). Regarding the perception of internet use in the education of their children, most caregivers (1885/3937, 47.9%) maintain a cautious position by selecting the option "It helps, but it can be harmful". Regarding the attitude towards the use of devices for entertainment, very few caregivers indicated that they would not give permission for any reason (243/3937, 6.2%). Regarding parental control, many caregivers say that a time limit can be set (2611/3937, 66.3%). Finally, many caregivers (1495/3937, 38%) consider that the use of digital games may be inappropriate for their children.

Table 3. Perceptions of caregivers about the schoolchildren's digital media use in Metropolitan Lima,

Perú, 2021

Variable	Caregivers of boy n (%)	Caregivers of girls n (%)	All Caregivers n (%)
Children's most preferred device for distraction [a]			
Computer	237 (12.4)	203 (10.0)	440 (11.2)
Laptop	98 (5.1)	103 (5.1)	201 (5.1)
Mobile phone	1188 (62.3)	1326 (65.3)	2514 (63.9)
Tablet	162 (8.5)	183 (9.0)	345 (8.8)
Nintendo, Playstation	58 (3.0)	10 (0.5)	68 (1.7)
Other (tv, gameboy)	164 (8.6)	205 (10.1)	369 (9.4)
Your children's favorite digital media for distraction [b]			
Facebook, Instagram	39 (2.0)	57 (2.8)	96 (2.4)
YouTube	586 (30.7)	592 (29.2)	1178 (29.9)
Tik-Tok	143 (7.5)	580 (28.6)	723 (18.4)
WhatsApp	157 (8.2)	194 (9.6)	351 (8.9)
Mobile games	677 (35.5)	360 (17.7)	1037 (26.3)
Computer games	141 (7.4)	82 (4.0)	223 (5.7)
Google	76 (4.0)	90 (4.4)	166 (4.2)
I do not know	88 (4.6)	75 (3.7)	163 (4.1)
Perception of the Internet in their children's education [c]			
Helps a lot	552 (28.9)	579 (28.5)	1131 (28.7)
Sometimes it helps	389 (20.4)	461 (22.7)	850 (21.6)
Helps, but can be harmful	934 (49.0)	951 (46.8)	1885 (47.9)
Does not help	20 (1.0)	25 (1.2)	45 (1.1)
No clear opinion	12 (0.6)	14 (0.7)	26 (0.7)
Attitude towards the use of digital devices for entertainment [d]			
I always give him/her permission	94 (4.9)	86 (4.2)	180 (4.6)
I hardly notice when he/she plays	133 (7.0)	127 (6.3)	260 (6.6)
I can give him/her permission, it depends on	1566 (82.1)	1688 (83.2)	3254 (82.7)
I do not give him/her permission	114 (6.0)	129 (6.4)	243 (6.2)
Parental control of the use of digital devices for entertainment purposes [e]			
Yes, he/she always obeys me	1235 (64.8)	1376 (67.8)	2611 (66.3)
Regular	484 (25.4)	493 (24.3)	977 (24.8)
Difficult	69 (3.6)	59 (2.9)	128 (3.3)
No, it is very difficult	119 (6.2)	102 (5.0)	221 (5.6)
Perception of the use of digital games for schoolchildren [f]			
Very Adequate	37 (1.9)	56 (2.8)	93 (2.4)
Suitable	265 (13.9)	292 (14.4)	557 (14.1)
I have no problem using it	553 (29.0)	585 (28.8)	1138 (28.9)
Inadequate	737 (38.6)	758 (37.3)	1495 (38.0)
Very inadequate	315 (16.5)	339 (16.7)	654 (16.6)

[a] According to your perception, which device does your child prefer to be distracted by? [b] When your child is out of school hours and connects to the Internet, what type of site does he/she visit or prefer the most? [c] At present, what is your perception of the Internet in your child's education? [d] When your child wants to use the devices for entertainment, what is your attitude? [e] When your child is entertained using the devices, can you set a time limit?[f] What is your perception of digital games used by children?

In Table 4, we present the schoolchildren's source of distraction and preferences in relation to digital games. Most schoolchildren are distracted by mobile phone use (3100/3937, 78.7%). Schoolchildren report using digital games when they are bored (2211/3937, 56.2%) or when they feel like it (1308/3937, 33.2%). Most schoolgirls are interested in using a serious game that teaches them about food (3280/3937, 83.8%). Regarding the digital game character, 31.8% (636/2030) of girls preferred animated animals, while 42.4% (798/1907) of boys preferred superheroes. Regarding the environment of the digital game, many schoolchildren (1715/3937, 44%) preferred a nature environment.

Table 4. Preference of schoolchildren related to a digital game in 17 public schools in Metropolitan Lima, Perú, 2021

Variables	Boys n (%)	Girls n (%)	All n (%)
They are distracted using PCs [a]	768 (40.3)	741 (36.5)	1509 (38.3)
They get distracted using mobile phones [b]	1494 (78.3)	1606 (79.1)	3100 (78.7)
They are distracted using Tablet [c]	434 (22.8)	429 (21.1)	863 (21.9)
Moment when using digital games [d e]			
When I feel like it	644 (33.8)	664 (32.7)	1308 (33.2)
When I am happy	162 (8.5)	182 (9.0)	344 (8.7)
When I am sad	84 (4.4)	105 (5.2)	189 (4.8)
When I'm bored	1073 (56.3)	1138 (56.1)	2211 (56.2)
When I am with friends	395 (20.7)	289 (14.2)	684 (17.4)
When I am alone at home	364 (19.1)	389 (19.2)	753 (19.1)
I do not play	170 (8.9)	311 (15.3)	481 (12.2)
I do not know	59 (3.1)	54 (2.7)	113 (2.9)
Interest in a digital nutritional game [f]			
I am interested	1559 (82.3)	1721 (85.3)	3280 (83.8)
I have little interest	218 (11.5)	180 (8.9)	398 (10.2)
I do not know	74 (3.9)	65 (3.2)	139 (3.6)
I am not interested	44 (2.3)	52 (2.6)	96 (2.5)
Preference of digital game characters [g]			
Animated animals	503 (26.7)	636 (31.8)	1139 (29.3)
Superheroes	798 (42.4)	426 (21.3)	1224 (31.5)
Fantastic animals	124 (6.6)	191 (9.5)	315 (8.1)
Children	214 (11.4)	309 (15.4)	523 (13.5)
Teenagers	245 (13.0)	440 (22.0)	685 (17.6)
Digital game environment preference [h]			
Magical	422 (22.4)	664 (33.0)	1086 (27.9)
Nature	803 (42.5)	912 (45.4)	1715 (44.0)
Universe	353 (18.7)	108 (5.4)	461 (11.8)
City	310 (16.4)	326 (16.2)	636 (16.3)

[a] When you want to be distracted, do you use the computer? [b] When you want to be distracted, do you use your mobile phone? [c] When you want to be distracted, do you use the tablet?[d] At what time do you play on the computer or mobile phone or tablet? [e] The categories were collected independently for each category, the participant could choose more than one option[f] Would you like to try a digital game that teaches you how to eat well like in the previous figure?[g] What kind of character would you like to have in a digital game?[h] What kind of environment would you like a digital game to have?

DISCUSSION:

Nutritional knowledge of school children: Challenges to Promote Healthy Eating

The results suggest that primary school children have limited knowledge about nutrition. Although most of the schoolchildren from our study knew how to put together a healthy lunch box and identified high-calorie foods, only 42.5% of them knew the recommendation to consume at least 5 portions of fruits and vegetables per day. The "5 a day" message is part of an international campaign recommended by the WHO for healthy eating[32]. Our results show that, although this recommendation is shared by public and private institutions in Peru, through health promotion campaigns, information leaflets at schools and TV advertisements, this message has not yet improved the knowledge of schoolchildren. Our results are very similar to an educational intervention study in Chilean children where Gonzales et al. showed that at baseline in 2018 only 45.6% were aware of this message[33].

Another aspect evaluated was related to the healthy eating policy, which has been implemented in Peru since 2019 [34], which requires that processed foods carry front-of-package warning labels (FOPWL). Our study shows that 53.3% of schoolchildren did not identify the FOPWL in the 2 images of ultra-processed foods presented. The FOPWL system is a type of front-of-package (FOP) labeling, which aims to make product nutritional information more understandable to consumers[35] and encourage healthier food choices[36]. The fact that school children do not recognize FOPWL means that they have not received sufficient information about nutrition labeling in their schools nor in their homes even though they are able to identify them. It has been shown that children aged 7 to 13 years understand nutrition information and can use it to classify healthy and unhealthy foods[37,38]. FOPWL focus on helping consumers to make better-informed food related choices aiming to potentially discourage the purchasing and consumption of ultra-processed foods by highlighting the unhealthy aspects of products by pointing out their health risks (e.g., "High in saturated fats"). According to our results, 36.1% of schoolchildren participants did not associate the presence of FOPWL with unhealthy foods. These results are similar to a study with Brazilian schoolchildren where the FOPWL was the most accepted type of FOP compared to the GDA and the nutritional traffic light, but it did not play the expected dissuasive role[39]. Reducing the intake of ultra-processed foods is a key factor in the prevention of excess weight and various metabolic diseases[40] and various metabolic diseases[41]. Different studies point out that PUFs contain high caloric density, high concentration of free sugars, sodium, saturated fats; as well as, low concentrations of fiber and micronutrients, compared to natural or minimally processed foods[42,43]. In the present study, the majority of school children (95%) indicated that parents teach them about healthy eating. Children's eating habits are closely related to behaviors at home, specifically to the parenting and eating styles of the parents[44]. For this reason, it is noted that interventions that can be targeted toparents or involving them could offer many opportunities in enhancing healthy eating practices in children, such as increasing the consumption of fruits and vegetables[45].

Opportunities for Serious games: Digital Game’s Preferences of schoolchildren

Almost all schoolchildren (83.8%) affirmed their interest in trying a digital game that teaches them healthy eating. This result relates to the wide acceptability of children and adolescents with digital games, which could influence the use of serious games for health and nutrition. Children’s game acceptability is key to develop an effective and better-informed interventions as the enjoyment and participation of children increases the chances of achieving a change in eating behavior[46]. Most schoolchildren in our study preferred to play when they are bored (56.2%) or when they are in the

mood to play (33.2%); these results are similar to the study by Holzmann et al. where German children and adolescents had a positive emotionally induced digital game experience for pleasure and boredom[47]. Thus, the fact that most schoolchildren use digital games in a good mood could be exploited to suport active learning in an entertaining way through serious games. Several authors have studied the use of serious games to improve children's nutritional knowledge[48,49]. In order to transmit knowledge using a game, several elements must be considered in the design, such as the character or the environment. In that sense, our study showed that most girls preferred animated animals (31.8%), while boys had a greater affinity for superheroes (42.4%). In relation to the environment of the digital game, the greatest preference of schoolchildren was a context with nature (44%). Formative studies prior to game development have investigated these preferences and found similar findings such as Holzmann et al., where the majority of schoolgirls preferred a heroic animated human character; or Kayali et al. where the majority of Austrian children aged 8 to 14 years preferred animals and a natural environment for the digital game[50]. This information is essential because children's preferences for characters influences their motivation to use serious games that can support learning about nutrition; as children remember nutritional information when they are presented with a sympathetic character[51].

The role of caregivers in the development of serious games

Taking a human-centered approach[52], our first step was to include caregivers in the survey because of their clear relevance in the education of schoolchildren[53]. We inquired about caregivers' perceptions and attitudes regarding the use of Internet and digital games by schoolchildren. Considering that during the COVID-19 pandemic the dependence on digital media at home increased[54]; this may have affected how parents mediated the use of this technology with their children. For example, caregivers usually share mobile phones with their children, therefore, they can give an informed opinion about certain behaviors of schoolchildren. Most caregivers (47.9%) from our study consider that the Internet helps in the education of schoolchildren, but they are aware that it can be harmful, the major concerns include risks such as cyberbullying or inappropriate content [55]. This concern often causes caregivers to apply restrictive measures such as setting rules of digital media use for their children. In our study, the majority of caregivers (82.7%) indicated that they give permission to the use of digital devices to their children for entertainment. In addition, the majority of caregivers noted that schoolchildren complied with the time limits they agree to for the use of digital devices for entertainment (66.3%). Parental mediation seeks for children to achieve self-regulation and digital skills that allow the child to limit the risks related to the use of digital media, and thus maximize the benefits they offer[56]. Therefore, the acceptability of a novel digital intervention by caregivers may be contingent on the serious game carefully consideration of the aforementioned risks.

In relation to digital games, 38% of caregivers perceived that the use of digital games for schoolchildren is inadequate. These results are related to a study of schoolchildren and parents in New Zealand[57], where parents were involved in the development of a serious game for nutrition education, where a major concern was the excessive screen time caused by digital games, increasing sedentary behavior. Recommendations such as the Canadian 24-hour Movement Guidelines state that children use less than 2 hours per day of screen time after school [58]. Thus, more research is needed to understand whether a digital game for health, such as a serious game, can be incorporated into recreational or educational screen time especially in LMICs. In addition, our results could be interpreted to mean that parents do not tend to give a positive rating to leisure time activities of 8- to 12-year-olds compared to early childhood[59]. Parents tend to pigeonhole the use of digital games to totally playful and interactivepurposes as serious games are not popular in Peruvian society and future research shall explore the potential value they could bring to support and improve children's health in the Peruvian context. If parents are involved and become aware of the potential

opportunities that serious games for health could offer[60] , their perceptions may change.

Implications for serious game design in the Peruvian Context

The results of the study indicate that the best device to deploy a serious game would be the mobile phone; since it is the device with the greatest access in households (95.5%) as well asit is also the device with the greatest use for distraction according to the schoolchildren themselves (78.7%) and their caregivers (63.9%). Due to the growing popularity of mobile phones and applications, several health applications have been developed aimed at modifiable risk factors such as children's diet[61]. Interventions based on the use of mobile phones are often effective in improving behavioral changes associated with obesity in children aged 8 to 12 years [62].

Likewise, our study highlights how feasible it could be to develop an online game in urban areas of Peru, since almost all participant households had internet at home (94.8%), and most participant households are connected to the internet through WiFi (69.9%), which generally has unlimited megabytes. These results are similar to those of the Residential Survey of Telecommunications Services [63], which indicates that 95% of households in metropolitan Lima have Internet access, the main source of Internet access was through WIFI (68.5%) and mobile phones (92.3%). The residential survey also reported that 94.6% of households have a Smartphone [63].

Our study suggest that serious games may be used as an educational tool to increase schoolchildren's knowledge about food and nutrition. To date, there are no large-scale interventions in Peru to improve the nutritional knowledge of schoolchildren. Also, educational content on nutrition in public schools is almost nonexistent, as it competes with other activities in the school curriculum.

Serious games are more cost-effective for reaching large numbers of participants than a traditional interventions, such those using human resources; LMICs generally have limited resources for training and transportation of intervention staff [64]. In addition, serious games may not disrupt classroom activities, or even fit harmoniously into school curricula, such as the 'Fitter Critters' serious game where children play in health classrooms for 1 week[65]. Finally, serious games can offer flexibility in relation to the location or time of play without negatively affecting the content of the intervention. Future research should further engage with caregivers and schoolchildren to explore the design, feasibility and acceptability of the games in the Peurivan context.

Importance of developing digital intervention to improve school children's nutrition:

Today's food environment is characterized by increased availability of cheap, tasty, energy-dense foods; coupled with wide-ranging and highly persuasive food marketing[66]. Most foods intended for children are generally excessive in sugars, fats and sodium[67,68]. In that sense, children and adolescents constitute a vulnerable group that deserves social protection, as they have limited nutritional knowledge, are unable to perceive the risks of their behaviors and their choices may be affected by the sociocultural environment such as the marketing of unhealthy foods.

Vulnerability also refers to the socioeconomic level of the students in this study; although a specific indicator was not evaluated to determine socioeconomic level, it is very likely that most students belong to a low socioeconomic stratum. Students in public schools are generally of low socioeconomic status; this is due to the fact that private schools in Peru enjoy better prestige and involve high expenses for families. In this sense, socioeconomic status is one of the main determinants in food choice and eating habits; households with lower incomes buy less healthy food[69,70]. For example, adolescents of low socioeconomic status often choose foods for their snacks with higher sugar content compared to their peers of higher socioeconomic status[71]. It should be noted that most successful experiences in improving nutrition in schoolchildren have been reported mainly in contexts other than LMIC[72]. It is essential that interventions such as serious games are aligned to promote children's health and development in a digital world. Establishing a

responsible and conscious use in front of the screen, as well as the participation of caregivers[73].

Strengths and Limitations

To our knowledge, our study is the first formative research carried out with primary schoolchildren in metropolitan Lima to support a future development of digital intervention to improve nutrition. Despite Peru's economic progress in recent years, the insufficient decentralization of the country has meant that metropolitan Lima represents 30% of the country's total population. For this reason, an attempt was made to cover the largest number of participants in the study (3,937 schoolchildren) and schools in the most densely populated districts were included. In addition, the questionnaire was developed by a multidisciplinary team with expertise in health sciences, education and informatics; disciplines relevant to the type of intervention to be developed. In order to achieve the best quality of responses, interviews and a pilot were conducted, the results of which not only served to improve the understanding and accuracy of the questions, but also to establish criteria for the quality control of the database.

There are some limitations that should be mentioned. The results may be prone to selection bias, since by using a digital survey, participation may have been limited to those with Internet access. Also, probability sampling was not used, so the results are not representative of metropolitan Lima. The questions on nutritional knowledge, although they took into account aspects of the food guide for the Peruvian population [74], these aspects are not yet considered in the official curriculum. There is no official school curriculum on nutrition in Peru. Finally, considering that a self-administered survey with many questions could fatigue participants and lead to decrease the quality of their answers, it was decided to prioritize the most relevant questions to answer the purpose of the research. This led to disregarding questions to better characterize the population, such as those related to socioeconomic status, also obvious open-ended questions. We believe that this type of information would be better addressed in future research with qualitative methodology. Another limitation of this study lies in the use of self-administered questionnaires, which implied reliance on self-reporting by the schoolchildren and their caregivers.

Conclusions

The results presented indicate that there is limited knowledge about nutrition in schoolchildren, specifically in the consumption of healthy food (fruits and vegetables), and the management of information on nutrition labels of ultra-processed products. Moreover, the results revealed that schoolchildren are interested in using serious games to improve nutrition education. While it seems feasible to develop an intervention using the Internet, since most households have access to this service, our results higlights the mobile pones as the most suitable device to develop a digital intervention, since it is the most available and preferred device by schoolchildren. Another aspect to consider for the development of a serious game intervention is to get the acceptance and trust of the caregivers, both in the type of content of the serious game as well as the time of use. Therefore, the development and implementation of a serious game is a feasible alternative for schools to increase nutrition knowledge and promote healthy eating in schoolchildren as long as all the different stakeholers are involved in the design process of the intervention.

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Abbreviations

WHO: World Health Organization
LMIC: Low- and middle-income countries
RDEML: Regional Directorate of Education of Metropolitan Lima
FOPWL: Front-of-package warning labels

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Supplementary Files

Multimedia Appendixes

Indicators of nutritional knowledge.
URL: http://asset.jmir.pub/assets/5c5f60aa349aff740644c4d49eafbf6a.docx