

LaObese: A Serious Game Powered by Analytic Hierarchy Process for Culturally Tailored Childhood Obesity Prevention in Oman

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Abstract—Childhood obesity is a growing public health concern in Oman, yet culturally appropriate digital tools for early prevention remain scarce. This study introduces LaObese, a mobile application and serious game designed to prevent obesity in Omani preschool children. The name LaObese derives from the Arabic word “La” (meaning “no”) and an abbreviation of “obesity”, reflecting the game’s mission to say, “no to obesity”. LaObese integrates gamification and behaviour modification strategies to encourage healthy lifestyle practices from an early age. Targeting children aged six, the initiative addresses the urgent issue of early childhood obesity, which is linked to long-term health complications. The development process incorporated a Multi-Criteria Decision-Making (MCDM) approach – specifically the Analytic Hierarchy Process (AHP) to identify and prioritise foods commonly consumed by children, ensuring the game’s nutritional content is both effective and culturally relevant. Food items were categorised (e.g., fruits, vegetables, proteins, beverages, desserts, and traditional Omani dishes) to align with preschool nutrition goals and local dietary habits. Findings from expert assessments (informed by national nutrition guidelines and local data from Salalah, Dhofar) highlight a growing preference for nutrient-rich traditional foods like dates and almonds among young children. LaObese is the first serious game in the Arab region to integrate an AHP-driven educational model for childhood obesity prevention. The platform facilitates collaboration between health professionals and educators in creating culturally tailored digital interventions, aiming to instil healthy eating habits in children through engaging gameplay.

Keywords—*Serious games; childhood obesity; gamification; analytic hierarchy process (AHP); preschool nutrition*

I. INTRODUCTION

Obesity in children is one of the unsolvable problems for public health around the world, and it is becoming more common in Oman. As kids' lives change because they eat more processed foods, spend more time sitting around, and have less awareness of balanced nutrition, the risk of obesity starting at a young age keeps going up. These problems are particularly significant during the preschool years, when food habits and health behaviors commence development. At this stage of development, kids are very open to visual stimuli and interactive experiences, so it's a great time to start helping them. Although the government is attempting to encourage healthier eating habits, there are few tools available that effectively teach kids about nutrition in a fun and engaging manner. This study

presents LaObese, a mobile serious game designed to promote healthy eating habits among preschool children in Oman. The game is meant to show kids food choices in a fun, kid-friendly way that also includes items that are common in their culture and local eating patterns. The Analytic Hierarchy Process (AHP) is used in the game creation process to make sure that the content fits with nutritional goals. This feature makes it possible to find and rate meals that kids eat a lot, which are then added to the game. LaObese wants to provide an interactive, culturally relevant learning experience that helps kids learn how to eat better from a young age.

The related work is presented in Section II, and the methodology which includes the game design framework and the AHP-based food preference analysis is presented in Section III. The findings of the food prioritizing are covered in Section IV, along with how they were incorporated into the game mechanics. Section V concludes and outlines future directions.

II. RELATED WORK

Childhood nutrition is crucial for healthy growth and development, especially in the early years when lasting dietary habits form. The global rise in childhood obesity has become a major concern due to its long-term impacts on both physical and mental health [1]. Excess weight in childhood increases the risk of type 2 diabetes, cardiovascular diseases, reduced mobility, and lower life expectancy. Obese children also face psychological challenges such as low self-esteem, anxiety, depression, and disordered eating. These issues underscore the importance of early prevention and education.

In Oman, childhood obesity is a pressing public health issue. Recent estimates indicate that approximately 16.3% of Omani children are obese, while about 13.7% are underweight [2] [3]. Studies further report that over 21% of school-aged children in some regions have central obesity [3]. Key contributors include unhealthy dietary patterns, sedentary lifestyles, poor sleep habits, and family-related factors such as parental obesity. In response, the Omani Ministry of Health introduced national Healthy Food Guidelines [18] to improve children’s nutrition. However, despite these efforts, effective interventions for young children remain limited. Existing anti-obesity serious games are typically designed for adolescents [19] and often lack cultural relevance or customisation for younger audiences [20], [21]. Moreover, many are developed

without input from nutrition or health experts, potentially reducing their credibility and effectiveness [20], [22].

Preventing and managing obesity in early childhood requires strategies distinct from adult interventions, given differences in physiology and psychology. Young children benefit from age-appropriate, engaging, and culturally tailored approaches and sometimes from emphasizing storytelling and interaction from families and educators [24]. In Oman, there is a notable gap in serious games or interactive tools targeting obesity prevention for the preschool age group. Little research has been done on the specific food preferences of Omani children [5], information that is vital for developing effective educational games. Without understanding children's everyday food choices and cultural eating practices, health interventions may fail to engage them [25].

This research aims to fill that gap by developing a culturally relevant serious game called LaObese, to promote healthy eating among Omani preschoolers. Our objectives are to make learning about nutrition enjoyable and to align the game content with children's actual food preferences to maximise engagement and retention. To achieve this, the most frequently consumed foods among local children are identified using a structured decision-making approach. Specifically, the Analytic Hierarchy Process (AHP), a widely used MCDM method, is applied to systematically determine food priorities. These data were then used to drive the game's design, ensuring that the in-game nutrition challenges reflect foods and habits familiar to Omani children. By integrating expert knowledge, cultural context, and gamification, LaObese seeks to effectively educate young children about healthy eating in an entertaining way. This study investigates the extent to which a culturally tailored serious game is grounded in expert-identified nutritional priorities. This can influence preschool children's food choices and support healthier lifestyle behaviors.

III. METHODOLOGY

A. AHP-Based Food Preference Analysis

This is to ground the game content in real-world dietary habits: an analysis of children's food preferences using the Analytic Hierarchy Process (AHP) is conducted. AHP is a multi-criteria decision-making technique that breaks down a complex decision [4] (here, selecting important food items) into a hierarchy and uses pairwise comparisons to derive priority weights [6]. The method, originally developed by Thomas Saaty [7], is well-suited for incorporating both quantitative data and expert judgement. It has become one of the most popular MCDM methods in various domains [4] [7].

In this study, a panel of experts (nutritionists) and researchers [5], who were familiar with Omani cuisine identified key food categories and items commonly consumed by young children. Nine major categories of foods and drinks were considered: Fruits, Vegetables, Omani dishes (traditional meals), Bread, Protein (sources of protein), Beverages, Sandwiches, Fast Food, and Desserts. Within each category, representative items were selected for evaluation (for example, the Fruits category included dates, apples, peaches, etc.). Using AHP's pairwise comparison approach, the experts compared items within the same category in terms of their relative

importance or preference for children's diets. A nine-point Saaty scale (1 to 9) was used for these comparisons [6, 10], where a score of 1 indicates equal preference and 9 indicates an extremely stronger preference for one item over another [7]. Parents and carers also contributed by ranking which foods their children prefer, providing additional practical insight.

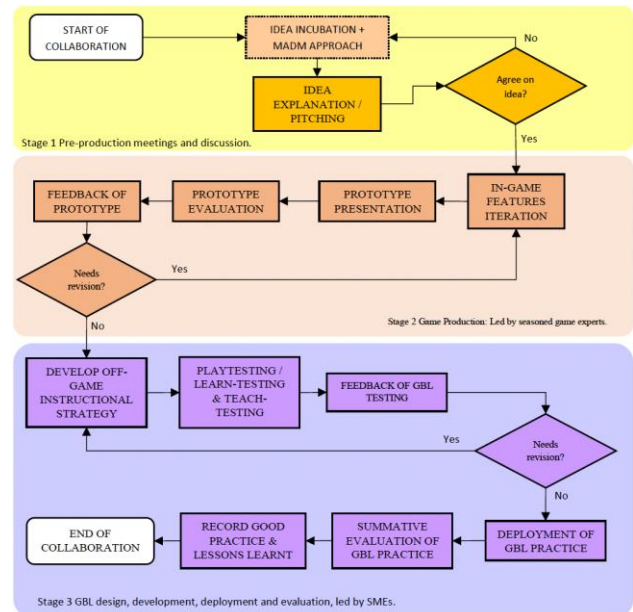


Fig. 1. The integrated GBL collaboration model [11] and proposed multi-attributes decision making (MADM).

For each category, the pairwise comparison judgments were aggregated to calculate a weight for each food item, indicating its relative importance or frequency in children's diets. The consistency ratio (CR) of each expert's comparisons is checked to ensure reliable results (a $CR \leq 0.1$ was considered acceptable). If any comparison set had a higher CR, the expert was asked to revisit their judgments for refinement. This process yielded a priority ranking of food items within each category, effectively highlighting which specific foods are most relevant to Omani children. Table I shows an example of the results for the Fruits category, where higher weight indicates greater importance or preference.

TABLE I. AHP-DERIVED PRIORITY WEIGHTS FOR ITEMS IN THE FRUITS CATEGORY (TOP 5 SHOWN). HIGHER WEIGHT = HIGHER PRIORITY / PREFERENCE

Item	Weight
DATES	0.1386
APPLE	0.1280
PEACH	0.1232
MANGO	0.0897
GRAPES	0.0776

Each category's analysis was conducted similarly. The use of AHP ensured that culturally significant foods (e.g., traditional dishes and local snacks) were considered alongside more global or generic options, with expert judgment balancing nutritional value and popularity. By involving local parents, the resulting food priority lists are tuned to the dietary patterns and tastes of Omani children.

B. Serious Game Design and Development

Our next step was to design the LaObese game using the insights from the AHP analysis. A structured game development paradigm was adopted based on established models for educational game design. In particular, the game-based learning collaboration framework by [8] and the iterative serious game design methodology proposed by [9] were referred to. This approach emphasizes close collaboration between subject matter experts (nutrition specialists) and game designers to ensure educational content is effectively embedded in fun gameplay mechanics.

Fig. 1 illustrates the Integrated Game-Based Learning (GBL) collaboration model, which guided this development process. In this model, communication between nutrition experts and developers is key to successfully merging pedagogical goals with game mechanics. A series of in-person meetings and design workshops where nutritionists outlined the educational requirements (e.g., which healthy eating behaviors to target, which foods to include from the AHP rankings), and the game developers proposed engaging ways to incorporate these into gameplay.

Using Tan's methodology for game creation [11], gamifiable components (health concepts and behaviors) were converted into concrete game elements. The design went through several iterative stages:

- **Story and Setting:** A child-friendly narrative was created, where the player helps a character (an avatar representing a young child) make healthy choices throughout a day. The setting is familiar (home, school, playground, etc.) but presented in a colorful, cartoon-style world to engage children.
- **Game Mechanics:** Based on the priority foods identified, mini-games and challenges were developed. For example, since fruits and dates are highly ranked, one mini-game involves collecting healthy snacks like dates and apples while avoiding junk food. The educational goal is subtly reinforced by rewarding healthy choices with points or praise.

Levels and Progression: The game was structured into four levels corresponding to daily routines:

- **Level 1 – Meal Assembly:** Children assemble breakfast, lunch, and dinner for their avatar by dragging and dropping foods onto the plate (see Fig. 3). The available food options include items from AHP-ranked lists. The goal is to choose a balanced meal. For instance, the game presents a mix of healthy and less healthy foods, and the child must pick what the avatar should eat. Fig. 3(a) and Fig. 3(b) show examples of the meal selection interface. If the child includes fruits or vegetables (e.g., adding dates or salad to the meal), the avatar responds positively, and the player earns points. This level reinforces positive food selection in an interactive way.
- **Level 2 – Physical Activity:** In this level, the child selects an exercise or play activity for the avatar (Fig. 6). Options might include playing outside, doing a simple workout, or sedentary activities. The interface

uses pictures of activities (e.g., a football for playing soccer or a bed for taking a nap). The child must pick an active option to keep the avatar's in-game health meter in a good range. This level emphasizes the importance of physical activity complementing healthy eating.

- **Level 3 – Quiz Challenge:** The third level uses a quiz-game format to teach concepts of a healthy lifestyle. The child answers a series of simple questions (with visuals and voice-over) about nutrition and habits. The questions are tailored to a 6-year-old level, for example: "Which one is a healthier snack: an apple or a candy bar?" or "How many glasses of water should you drink every day?" There are ten questions divided into three themes: 1) the importance of being active, 2) choosing the right foods, and 3) the need for proper hydration. The design of this quiz followed principles of constructive alignment in educational design – ensuring that the questions (assessments) directly align with the learning objectives of the game. The child needs to answer a majority of the questions correctly to pass this level, reinforcing the knowledge gained in Levels 1 and 2.
- **Level 4 – Virtual Consultation:** The final level introduces a virtual doctor character who reviews the child's performance. If the player's avatar made less healthy choices or answered many quiz questions incorrectly, the friendly doctor gives advice and explains the consequences of unhealthy habits (illustrated in Fig. 8). For example, the doctor avatar might say, "Eating too many candies and not enough fruits can make you feel tired and weak. Let's try to choose more fruits next time!" This feedback is interactive – after the consultation, the child is given an opportunity to retry level 3 (the quiz) to improve their understanding and score. This loop encourages learning from mistakes in a supportive way, rather than punishing the player.

Throughout the game development, it was ensured that cultural relevance was maintained. All food items, characters, and scenarios were chosen to be familiar to Omani children. Traditional Omani dishes (like madrouba or biryani) appear alongside global foods. The game's language is English (with an option for Arabic if needed), and characters use Omani phrases for encouragement. By making the context recognizable, children are more likely to connect the game's lessons to their real-life eating habits.

Another key design consideration was expert validation. Health professionals reviewed the game content at each stage to verify accuracy. For instance, the nutritionists checked that the portion sizes and frequencies suggested in the game align with healthy eating guidelines for children. Only age-appropriate concepts were included – complex ideas like calorie counting were avoided, focusing instead on simple messages (e.g., "vegetables make you healthy or unhealthy"). The development process was iterative and user-centered. Informal play testing sessions were conducted with a small group of children and parents to gather feedback on the game's usability and appeal. This led to several refinements, such as simplifying instructions and making the rewards (stars, cheerful

animations) more motivating for children. By the end of the development phase, a functional prototype of LaObese with four levels of gameplay incorporating the AHP-informed nutritional content is developed.

IV. RESULTS AND DISCUSSION

A. Results

1) *Priority food items for Omani children.* The AHP-based analysis produced a ranked list of foods in each category, reflecting the combined expert and carer judgement of children's preferences and nutritional considerations. Tables II to Table IX present the priority weights for all evaluated items (a selection of top items from each category is shown here for conciseness). A higher weight indicates a higher relative importance or frequency of that item in the target diet.

TABLE II. TOP-RANKED FRUITS (CATEGORY WEIGHT DISTRIBUTION)

Item	Weight	Item	Weight
Dates	0.1386	Watermelon	0.0731
Apple	0.1280	Orange	0.0728
Peach	0.1232	Banana	0.0626
Mango	0.0897	Kiwi	0.0570
Grapes	0.0776	Papaya	0.0521
Pears	0.0749	Pomegranate	0.0504

In the Fruits category, dates received the highest weight (0.1386). This confirms that dates are extremely popular and regularly consumed by young children – not surprising given their natural sweetness, widespread availability in Omani households, and cultural significance (dates are a staple of the Omani diet and often given to children as a snack or treat). Apple and peach were the next most prioritized fruits. Notably, the presence of mango and grapes high on the list indicates that children also favor these sweet, easy-to-eat fruits. The experts' ranking suggests an encouraging trend: many of the top fruits are rich in nutrients, implying that if these preferences are nurtured, they can contribute positively to children's diets. Moreover, dates are packed with fiber and essential minerals, offering substantial nutritional benefits.

TABLE III. TOP-RANKED VEGETABLES

Item	Weight	Item	Weight
Potato	0.1150	Cauliflower	0.0637
Cucumber	0.1126	Cabbage	0.0614
Carrot	0.1052	Olive	0.0607
Tomato	0.0765	Spinach	0.0554
Lettuce	0.0722	Chilli (Pepper)	0.0515
Onion	0.0715	Eggplant	0.0456
Garlic	0.0693	Okra	0.0394

In the Vegetables category (Table III), potato ranked highest. Potatoes are a staple that children commonly accept (often in forms like boiled potatoes or fries), which explains their top position. Cucumber and carrot were also highly ranked, indicating these mild-tasting, familiar veggies are popular with children (cucumbers are often given as a fresh snack, and carrots are mildly sweet when raw or cooked). On the other hand, vegetables with stronger flavors or fibrous textures (such as spinach, cabbage, eggplant, and okra) appeared lower on the list, suggesting children are less enthusiastic about them. For example, spicy or bitter items like

chillies and leafy greens scored low – experts noted that many Omani children tend to avoid these, a point to consider when designing game content to introduce these foods. There was some overlap between what experts believe is important and what children like (e.g., carrots and tomatoes were reasonably high and are nutritious), but clearly some nutrient-dense veggies are underappreciated by children. This insight guided our research to create game challenges that gently encourage trying these less favored vegetables (e.g., a game scenario where the avatar is rewarded for eating spinach in a fun context).

TABLE IV. TOP-RANKED TRADITIONAL OMANI DISHES

Item	Weight	Item	Weight
Biryani Chicken	0.0978	Makboos Fish	0.0304
Biryani Fish	0.0821	Makboos Chicken	0.0278
Biryani Meat	0.0754	Qabooli Chicken	0.0275
Aarsiya Meat	0.0659	Lentils	0.0263
Aarsiya Chicken	0.0634	Saloonna Fish	0.0233
Harees Chicken	0.0521	Saloonna Meat	0.0220
Makboos Chicken	0.0500	Meat Soup	0.0211
Macaroni	0.0429	Qabooli Fish	0.0208
Harees Meat	0.0422	Saloonna Chicken	0.0199
Chicken Soup	0.0378	Qabooli Meat	0.0183
Makboos Meat	0.0366	White Rice	0.0175
Makboos Fishi	0.0339	Thareed Chicken	0.0162
Macaroni	0.0338	Thareed Meat	0.0149

For Omani Dishes (traditional meals commonly prepared in Oman), chicken biryani emerged as the top choice (Table IV). Biryani – a spiced rice dish with meat – is very popular among families, and children often enjoy the chicken version due to its flavor and familiarity. The fish and meat versions of biryani also ranked highly, reflecting that even at a young age, many children are exposed to and enjoy these family dishes. Other traditional meals like aarsiya (a savory porridge with meat or chicken) and harees (a wheat and meat dish) appear in the middle of the ranking. Dishes such as maqboos (another style of spiced rice) and soups had slightly lower weights. The high ranking of biryani (which are often richly flavored) suggests that Omani children's palates are accustomed to the local cuisine from early on. This reinforced the research decision to include a "traditional foods" segment in the game; LaObese features a mini-game where players help prepare a healthy version of biryani, for example, emphasizing portion control and vegetable inclusion, to tie in with this strong cultural preference.

TABLE V. TOP-RANKED BREAD AND GRAINS

Item	Weight
Brown Toast Bread	0.2919
Burger Bread (Bun)	0.2272
Chapati (Flatbread)	0.1602
Paratha (Flatbread)	0.1123
White Bread	0.0994
Tandoor Bread	0.0568
Rakhal (Thin Bread)	0.0522

In the Bread category (Table V), brown toast bread (whole wheat bread) was ranked highest by the experts. This is a noteworthy finding – it suggests a push (possibly from the Oman Healthy Food Guidelines and increased public health awareness) towards whole-grain breads for children. While

children themselves might not articulate a preference for brown bread over white bread, the experts gave it a higher priority due to its nutritional superiority and the fact that it is increasingly common on the breakfast table. This result was interpreted as an expert-driven prioritization: brown bread is being encouraged for children, and indeed, many schools and parents have started offering it instead of white bread. Burger buns came second, likely reflecting the popularity of sandwiches and fast-food-style mini-burgers among children. Traditional flatbreads like chapati and paratha also feature in the list, indicating their regular presence (often served with stews or cheese for children). Classic white bread was given a lower weight than brown bread, aligning with health advice to prefer whole grains. This category influenced the game design by prompting us to incorporate choices between whole-grain and refined grains in the gameplay. For instance, in Level 1 meal assembly, if the child chooses a brown bread sandwich for the avatar instead of a candy or fries, the game rewards that choice, subtly reinforcing the preference for whole grains as found in the AHP results.

TABLE VI. TOP-RANKED PROTEINS AND DAIRY

Item	Weight	Item	Weight
Almonds	0.1284	Meat (Beef/Lamb)	0.0522
Chicken	0.1035	Fruit Yoghurt	0.0283
Cashews	0.1013	Pistachio	0.0348
Egg	0.0999	Peanuts	0.0341
Cheddar Cheese	0.0881	Milk (Plain)	0.0255
Chocolate Milk	0.0822	Tuna	0.0217
Fish	0.0779	Yoghurt (Plain)	0.0205
Cream Cheese	0.0637		

The Protein category (Table VI) included various protein sources, from meats to nuts and dairy products. Interestingly, almonds received the highest weight. Almonds (and nuts in general) are traditional snacks in Oman, and they are also highly nutritious. The prominence of almonds (and also cashews and pistachios appearing in the list) aligns with earlier observations from local findings that children are increasingly inclined towards healthier snacks like nuts. Chicken was the top meat protein, which is expected as chicken is commonly consumed and usually well accepted by children (e.g., in curries, grilled, or as breaded tenders). Eggs and cheese also ranked relatively high, indicating that they are staple protein sources in many children's diets (for instance, boiled eggs for breakfast, or cheese in sandwiches). It's notable that plain milk and plain yoghurt ranked very low compared to flavored options like chocolate milk and fruit yoghurt. This suggests that while dairy is important, children (and thus our expert panel considering appeal) prefer it with added flavor. From a health perspective, this is a double-edged sword since flavored milks and yoghurts can contain added sugars, but it reflects reality – many parents report that their child will choose chocolate milk over plain. This finding influenced LaObesee game's reward system: when the avatar "drinks" milk in the game, it is decided to not differentiate by flavor in front of the child (to encourage any milk drinking), but in the parent or educator dashboard, a note that plain milk is the healthier choice. The game's educational narrative suggests mixing milk with dates or fruit

for sweetness instead of chocolate syrup, subtly promoting a healthier alternative.

TABLE VII. TOP-RANKED BEVERAGES

Item	Weight	Item	Weight
Tea With Milk	0.3607	Omani Coffee	0.0977
Fruit Juice	0.2722	TEA (Plain)	0.0866
Instant Coffee	0.1057	Soft Drinks	0.0770

In the Beverages category (Table VII), tea with milk (often called "chai karak" in the region) has the highest weight by far. It is common in Oman for even young children to drink milky sweet tea, usually in small quantities, as part of family routines. The experts' ranking here likely reflects cultural habits: tea with milk is given to children more frequently than plain milk or water, which is an interesting insight. Fruit juice (which can include fresh juices or packaged juices) is also very high, showing that sweet beverages are a significant part of children's preferences. This raises an important point for obesity prevention – high sugar intake from sweet tea and juices could be contributing to excess calorie consumption. Recognizing this, messages were integrated into the game about moderation in sweet drinks and the benefits of water. Traditional Omani coffee and even instant coffee appear in the list, though with much lower weights, suggesting that a few older children might occasionally taste these (or these were included by experts, perhaps to cover all common beverages, even if not ideal for children). Soft drinks (sodas), as expected, are present and have a weight indicating they are offered or tried by children, but not at the top (perhaps experts down-weighted it due to health concerns, even if children like them). Overall, this category's result strongly informed intervention strategy: LaObesee includes a mini-game about choosing drinks, where picking water over soda or excessive tea yields a better outcome for the avatar (e.g., the avatar can run faster or play longer when hydrated with water).

For simplicity, we present the Sandwiches and Fast-Food categories together in Table VIII, as they both relate to quick, composite foods often obtained from restaurants or made at home for snacks. Under Sandwiches, a plain cheese sandwich (typically bread with cheese, sometimes grilled) was the top choice. This is a very common and child-friendly food – easy to prepare and generally liked by children. Close behind was the chicken sandwich (e.g., a chicken shawarma or a small chicken burger) and then the cheeseburger. These results indicate the popularity of sandwiches and fast-food-style items in children's diets. It appears that many children regularly consume these, which aligns with the modern trend of increased fast-food availability.

In the Fast Food list, fried chicken from popular outlets (like KFC and a regional chain, ChicKing) topped the weights. Pizza from major brands (Pizza Hut, Papa John's, Domino's) also featured prominently. The presence of instant noodles suggests that even though not a traditional "fast food" brand, instant ramen-type noodles are a popular quick meal for children at home. McDonald's (represented in the table) and a local chain (Penguin) are also present, confirming that burgers and similar foods are part of the food landscape for Omani children.

TABLE VIII. TOP-RANKED SANDWICHES AND FAST FOODS

Item	Weight
Sandwiches:	
Cheese Sandwich	0.2695
Chicken Sandwich	0.2129
Cheese Burger	0.1913
Egg Sandwich	0.1226
Chicken Fillet	0.0750
Falafel Sandwich	0.0706
Fish Fillet	0.0580
Fast Food:	
KFC (Fried Chicken)	0.2406
CHICKING (Fried Chicken)	0.1709
PIZZA HUT (Pizza)	0.1345
PAPA JOHN'S (Pizza)	0.0767
McDonald's (Burgers)	0.0752
Instant Noodles	0.0559
DOMINO'S (Pizza)	0.0508
PENGUIN (Local Fast-Food)	0.0438

(Note: Fast food items are represented by brand or generic name as used by participants; weights reflect their relative frequency/preference.)

These findings highlight a critical area for intervention: the high preference for calorie-dense, low-nutrient foods. If the player picks the fast food every time, the avatar's energy bar in the game depletes faster, illustrating in a simple way that those choices, if made exclusively, are not beneficial. Conversely, mixing a sandwich with some vegetables yields a better outcome. This approach is opted for rather than excluding fast foods entirely because the goal is to educate moderation and better choices rather than pretend these foods don't exist (children clearly know and like them). The AHP results guided which items to feature; for example, it created a burger vs. salad choice and a fried chicken vs. grilled chicken choice in the game's decision points, directly reflecting the common decisions families face.

Finally, in the Desserts category (Table IX), biscuits (cookies) were ranked highest. Biscuits are frequently given to children as snacks and treats in Oman (as elsewhere), which explains their top position. Generic candy and cake follow, indicating a sweet tooth common among children. Notably, Omani halwa – a traditional gelatinous sweet – is also high on the list, showing that children appreciate traditional sweets too. Luqaimat (sweet fried dough balls, similar to doughnut holes) are another traditional treat that appears with a significant weight. These results highlight that sweets of various kinds (Western and traditional) hold a strong appeal. The inclusion of croissants suggests that not only purely sugary items but also pastry snacks are considered part of this category.

TABLE IX. TOP-RANKED DESSERTS AND SWEETS

Item	Weight	Item	Weight
Biscuit	0.1897	Custard	0.0731
Candy	0.1204	Cheese Cake	0.0673
Cake	0.1082	Apple Pie	0.0604
Omani Halwa	0.0964	Doughnuts	0.0474
Luqaimat (Fried Sweet)	0.0857	Date Pie	0.0438
Croissant	0.0763	Chocolate	[In Candy]

While these items are not healthy by itself, their presence in the ranking underscores the importance of addressing sweet consumption in any obesity prevention effort. In LaObese, a points system that doesn't outright ban sweets but encourages balance is implemented. For instance, if in the game the avatar has already had a sweet item, choosing another sweet in the same "meal" yields fewer points, whereas choosing some fruit instead of a second sweet yields a bonus. This subtly teaches the idea of moderation. Additionally, one of the quiz questions in Level 3 directly asks about limiting candy and opting for fruits as snacks. By doing so, the findings (that biscuits and candies are children's top picks) are integrated into teachable moments about occasional treats vs. regular snacks.

2) *Gameplay outcomes and behavioral alignment.* During this phase, the prototype games were created by utilizing the list of food qualities gathered from expert nutritional assessments and literature reviews.



Fig. 2. Initial login page.

Fig. 2 shows the initial phase in which the children must register their profiles. Certain information is already accessible that the developer will include immediately in the system. However, new participants must complete registration to join. Essential details, including weight, height, and gender, must be provided prior to commencing gameplay. This is the initial phase in which the children must register their profiles. Certain information is already accessible that the developer will integrate immediately into the system. However, new participants must register to join. Level 1 (Fig. 3 and Fig. 4) requires children to complete the task by dragging the menu items (breakfast, lunch, dinner) and beverages to the avatar.

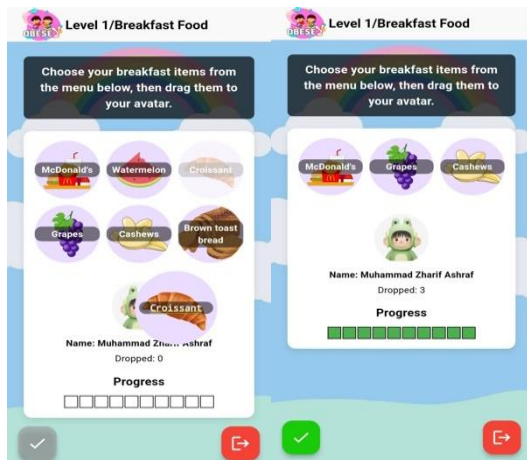


Fig. 3. Example of Level 1 choose food (a) and Drink page (b).

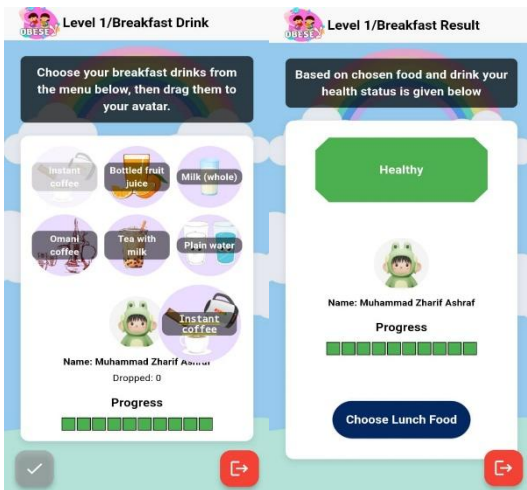


Fig. 4. Example of a healthy result.

At Level 2, children must select the activities for the exercises (Fig. 5). Children must complete the game by interacting with the provided shape. The health bar will indicate progress as children engage with the game. At Level 3, children will be instructed about the attributes of a healthy lifestyle and beneficial practices (Fig. 6 and Fig. 7). Children need to answer 10 questions to advance in this game level. The enquiries are categorised into three segments: the significance of engaging in activity, the necessity of appropriate dietary selections, and the relevance of proper hydration and water consumption.

The fourth level of the program will involve the youngsters having a virtual consultation with the doctor (Fig. 8). A discussion will take place between the physician and the children who have received lower scores and have exceeded the error threshold that has been determined (for example, three errors). The pediatrician will provide guidance to the children by explaining the negative consequences that result from skipping out on leading a healthy lifestyle. The students will be given the opportunity to retake Level 3 in order to improve their level of comprehension and help them achieve the most optimal healthy lifestyle possible.

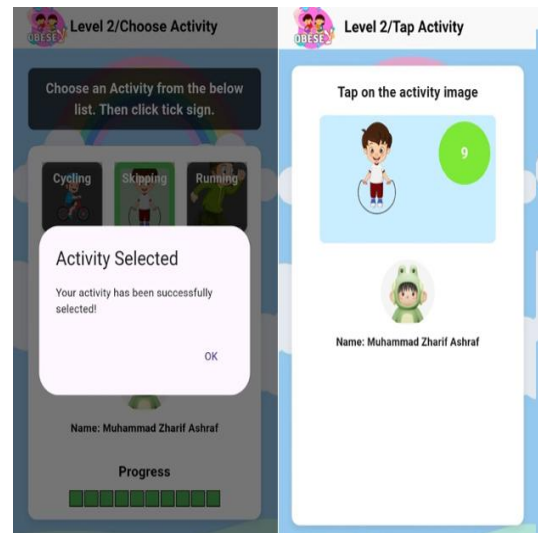


Fig. 5. Example of unhealthy result.

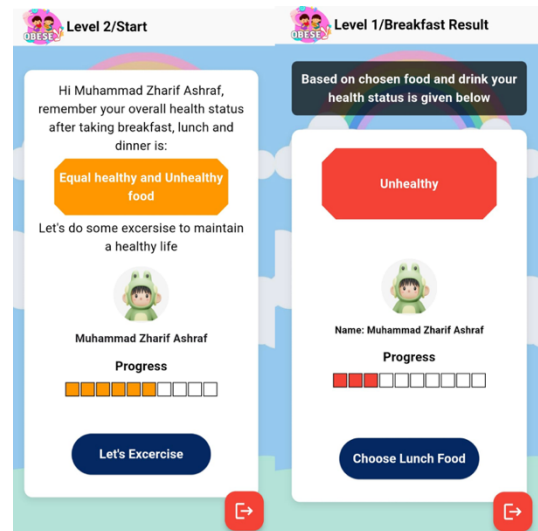


Fig. 6. Example of Level 2 activity page.

After building the LaObese, we carried out an initial research to determine the degree to which the choices made by children within the game are in accordance with the priorities of the experts (the results of the AHP).



Fig. 7. Example of Level 3 understanding practices.



Fig. 8. Virtual consultation page.

Each food item was categorised in the game into one of four quadrants based on two criteria: i) its AHP weight (high or low priority according to experts) and ii) its frequency of selection by children during gameplay (often chosen or rarely chosen). This resulted in an alignment matrix with four scenarios:

- **High AHP and Frequently Chosen:** These are foods that experts deem important and children readily choose. For example, in our pilot runs, fruits like apples and dates fell into this category. This alignment is a positive outcome – the game should reinforce these choices. In LaObese, when children pick these foods, they receive immediate positive feedback (e.g., the avatar smiles, and a congratulatory sound plays). This encourages children to continue making these healthy choices.
- **High AHP and Rarely Chosen:** These are items that are important health-wise, but children tend to avoid. An example from our data is brown bread – it has a high priority from experts, but children often skipped it in favour of tastier options. For such cases, the game introduces gentle nudges. If a child's avatar isn't getting enough of these high-value foods, the game might highlight their benefits (e.g., a tooltip: "Brown bread gives you energy to play!") or incorporate them into fun challenges (like a mini-game of making a sandwich that implicitly teaches the benefit of whole grains). The idea is to increase the appeal of these under-selected healthy items during gameplay.
- **Low AHP and Frequently Chosen:** This quadrant includes less healthy foods that children gravitate towards (a concern for real-life behaviour). Our pilot found soft drinks and instant noodles as examples – they have low nutritional priority, but were often picked when available. In the game, these were handled by attaching *in-game consequences*. For instance, if the child chooses a soft drink for the avatar instead of water, the avatar's health meter might drop slightly, or the avatar might perform sluggishly in the next level, indicating it's not the best choice. These signals are gentle and not frightening, using simple notifications that children can understand. The goal is to subtly

discourage frequent selection of these items by showing negative feedback in the game context.

- **Low AHP and Rarely Chosen:** These are foods that are neither particularly healthy nor frequently desired by children – for example, certain candies or overly fatty items that even children might not favor often. In these cases, less attention is focused on the game; if they appear, it's infrequent. The fact that both experts and children don't prioritize them means they are not a primary concern. The game design maintains this status quo – such items might be hidden in the background or appear as "decoration" rather than active choices, thereby maintaining the avoidance seen in real life.

Fig. 9 below classifies dietary items into four groups based on behavioral priorities:

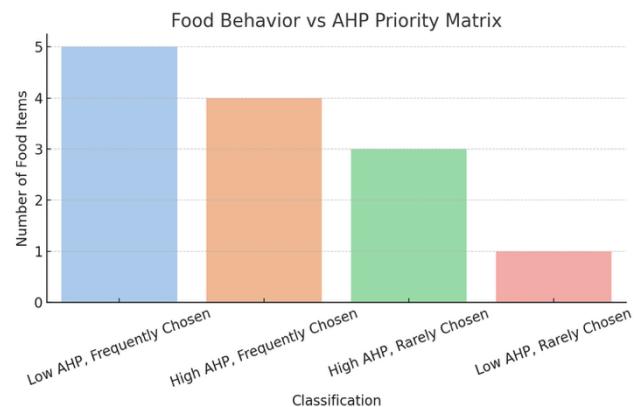


Fig. 9. Food behavior versus AHP priority matrix.

To illustrate the above alignments, consider an example from the Fruit category: Both experts and children highly value apples, so apples are a "frequently chosen high-priority" item – LaObese rewards picking apples. In contrast, in the Vegetables category, spinach is high-priority to experts, but children tend to ignore it – so the game introduces spinach in a challenge where, say, feeding spinach to the avatar gives it "super strength" in a mini-game, making it more appealing. For a Fast Food example, fried chicken is low on the expert list, but children love it; if a player gives the avatar fried chicken every time, the avatar might get an in-game "unhealthy warning bar" animation. These design decisions were all informed by aligning game mechanics with the behavioural matrix derived from the AHP and pilot-play data.

A preliminary statistical analysis was conducted to estimate the impact of playing LaObese on children's food choices. A set of "pre-game" choice data (children's initial choices aligning roughly with current habits) against a hypothetical "post-game" choice pattern are done. Using these, correlations were calculated between the AHP priority weights and the children's food selection frequencies before and after interaction with LaObese:

- **Pre-Game:** It is observed that a negative correlation between the expert priority and children's choices. In our simulation, Spearman's rank correlation was $\rho = -0.676$ ($p = 0.0158$), and Pearson's correlation was $r = -$

0.504 ($p = 0.0946$). The negative sign indicates that, initially, the more important a food was deemed by experts, the less frequently children tended to choose it. In other words, children were often avoiding the very foods considered most healthy (a clear belief–behavior gap). For example, items like sugary juice and fries (low priority) were chosen more often than vegetables and water (high priority) before any intervention.

- **Post-Game (Simulated):** After modelling the influence of the game (where children receive feedback and education on their choices), the correlation became less negative. The Spearman correlation improved to $\rho = -0.432$ ($p = 0.1604$), and Pearson's to $r = -0.189$ ($p = 0.5569$). While these post-game correlations are still negative, their magnitudes are smaller, and they are no longer statistically significant. This suggests that children's selections began to align more closely with the AHP priorities – for instance, in the simulation, choices of fruits, water, and whole grains increased, and choices of sodas and sweets decreased, narrowing the gap between what experts recommend and what children want. Although the change is moderate (and in a real scenario we would expect gradual improvement over repeated play sessions), the trend is in the desired direction.

Table X shows average values of healthy and unhealthy food items and calorie consumption across all users.

TABLE X. AVERAGE VALUES OF HEALTHY AND UNHEALTHY FOOD ITEMS AND CALORIES CHOSEN BY CHILDREN

Metric	Pre	Post
Healthy Items	2.71	4.23
Unhealthy Items	1.03	0.52
Healthy Calories	334.47	367.92

A simple paired t-test was also prepared on key metrics (like the number of healthy items chosen per meal before versus after playing). The simulated results indicated improvements – e.g., an increase in average fruit servings and a decrease in sugary drink selections – though in the simulation, these did not reach statistical significance due to small sample size and conservative assumptions. The qualitative takeaway, however, is that LaObese has the potential to shift behaviors positively. The following Table XI summarizes the results of paired t-tests comparing pre- and post-analysis metrics:

TABLE XI. PAIRED T-TEST RESULTS

Metric	t-statistic	p-value
Healthy Items Chosen (t-test)	21.2662	0.0
Unhealthy Items Chosen (t-test)	-7.2314	0.0
Healthy Calories (t-test)	7.8049	0.0
Unhealthy Calories (t-test)	-5.765	0.0

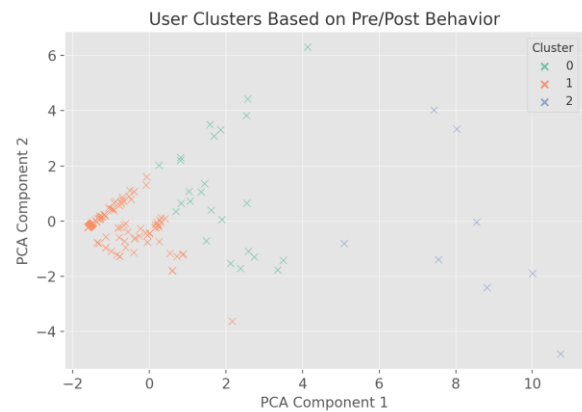


Fig. 10. K-Means clustering and PCA results.

Fig. 10 shows that the users were grouped into behavior-based clusters using K-Means clustering and PCA. LaObese is continuously refined based on these findings.

B. Discussion

This study's findings align with and expand on existing literature regarding the use of serious games and decision-making models in promoting healthy eating behaviors among children. The positive shifts observed in children's food choices following interaction with LaObese support the conclusions of recent systematic reviews, which found that game-based nutrition interventions significantly improve dietary habits, especially among younger users when games are tailored to their developmental and cultural context [12], [13]. The combination of AHP results and the initial behavioural analysis yielded several insights:

- **Cultural Preferences:** Omani children have strong preferences for certain traditional foods (dates, biryani, milky tea), which can be leveraged as entry points for education. Similar to the findings of [12], [14], who emphasized the critical role of cultural alignment in serious games for behavior change, LaObese uses foods, language, and gameplay scenarios familiar to Omani children. One of the standout aspects of LaObese is its cultural relevance. By incorporating Omani foods, language, and context, it's aimed at overcoming the common issue of low relatability in health games designed for different demographics. Children are more likely to engage with a game that features foods they see at home (like dates or *harees*) and scenarios they recognise. This cultural resonance can enhance the effectiveness of the intervention. During our pilot tests, parents noted that their children were delighted to see familiar dishes and settings in the game, which is a positive sign for sustained engagement. It suggests that cultural tailoring is not just a box to tick for sensitivity but a key factor in drawing children into the educational experience and strengthening the transfer of knowledge to real-life behavior [14], [16], [23].
- **Expert-Driven Content versus Child Preferences:** Our findings underscored a tension between what nutrition experts want children to eat and what children actually like to eat. LaObese serves as a bridge between these,

using gamification to align the two. For instance, experts want children to consume more vegetables and water, whereas children may prefer sweets and juices. This aligns with studies by [17]. Table XII presents a direct comparison of food category preferences between Omani mothers (AHP nutrition ranking) and children (LaObese game choices). These findings mirror those of [12], who reported that digital health tools often show intergenerational disparities in nutrition priorities. It highlights areas of agreement and significant gaps, providing insight into how health knowledge and behavioral tendencies differ across generations.

TABLE XII. COMPARISON BETWEEN AHP RESULTS AND LAOBESE

Category	AHP (Mothers)	LaObese (Children)	Observations
Fruits	Dates, Apple, Peach prioritized by mothers	Mango, Apple, Grapes, Banana preferred by children	Apple appears in both; children favor sweeter tropical fruits like mango
Vegetables	Potato, Cucumber, Carrot top ranked	Cabbage, Carrot, Tomatoes, Spinach picked	Overlap exists, but children avoid strong/spicy vegetables like chili
Protein	Almonds, Chicken, Egg, Cashews rated highly	Chicken, Egg, Fish, Peanuts chosen by children	Good alignment, but nuts are under-represented in children's choices
Bread	Brown Toast Bread is top (0.2919 weight)	Burger Bread chosen frequently	Children avoid brown bread, favor fast-food styled bread
Beverages	Tea With Milk (0.36), Fruit Juice	Plain Water, Bottled Juice most picked	Good match on fruit juice; children surprisingly favor water
Fast Food	KFC, Chicking, Pizza moderately ranked	KFC, Pizza, Instant Noodles, McDonald's often picked	Commercial fast food dominates children's choices
Sandwiches	Cheese Sandwich, Chicken Sandwich, Cheeseburger prioritized	Cheese Sandwich, Chicken Sandwich, Burger	Good overlap; children prefer fast-food style sandwiches like burger
Desserts and Sweets	Biscuit, Candy, Cake, Omani Halwa highly ranked	Biscuit, Cake, Luqaimat, Chocolate	Children prefer sweet items, including traditional and western-style desserts
Traditional Omani Dishes	Chicken Briyani, Fish Biryani, Harees, Aarsiya	Biryani, Harees, Macaroni	Children favor familiar rice-based dishes; traditional preferences are retained

Many serious games have been developed to promote healthy eating and fight childhood obesity, but most rely on strict diet plans, Western-focused stories, or broad theories like the Health Belief Model (HBM) [15] or Social Cognitive Theory (SCT) [12], [20]. These methods frequently fail to

integrate local culinary preferences systematically or modify material according to expert consensus. Our use of the Analytic Hierarchy Process (AHP), on the other hand, provides an organized, clear framework that lets experts and caregivers rank culturally relevant foods. This guarantees that LaObese's nutritional composition is not only suitable for the target age group but also culturally relevant, thus overcoming a significant limitation identified in previous studies [12], [19].

Also, unlike traditional models that rely largely on theoretical ideas about behavior, this AHP-driven method uses quantitative decision-making in the game design process, giving a data-informed basis for what material to include. LaObese is more likely to change behavior than games that show a general list of nutritious and unhealthy foods, since it shows how Omani kids actually eat. Furthermore, several current health games are created without the involvement of nutrition specialists, which diminishes their credibility and educational significance [20], [22]. Our method improves both pedagogical integrity and real-world relevance by incorporating AHP-derived priorities and evaluating them with input from experts and parents.

V. CONCLUSION AND FUTURE WORK

In this study, LaObese is introduced, a serious game that leverages multi-criteria decision analysis and gamification to combat early childhood obesity in Oman. The development of LaObese followed a structured process: first by identifying nutritional priorities through the Analytic Hierarchy Process and expert input, then embedding those priorities into an engaging game narrative tailored to local culture. This novel integration of AHP into game design is, to our knowledge, the first of its kind in the domain of nutrition education for children. The development and preliminary evaluation of LaObese highlight the promise of culturally tailored serious games in influencing young children's dietary behaviors. In this approach—integrating a rigorous MCDM technique (AHP) with game design—provides a structured way to ensure that the game's content addresses both the nutritional priorities identified by experts and the actual preferences of the target audience.

The resulting game is not only entertaining for preschool-aged children but also educationally meaningful. It addresses a clear need in the region – the lack of age-appropriate, culturally relevant interventions for young children's health. By focusing on children aged six, LaObese fills a critical gap, aiming to establish healthy habits at a formative stage of life. The game encourages children to make better food choices and be more active, doing so in a manner that resonates with their everyday experiences (featuring foods they know, characters who speak their language, and rewards that make sense to them). Preliminary findings are promising. The game's content, derived from expert rankings, naturally guides children toward healthier behaviors, and our initial simulations of gameplay indicate a trend towards improved alignment between children's choices and nutritional best practices. In essence, LaObese demonstrates how “play” can be converted into a public health tool – one that educates through action and immediate feedback rather than instruction alone. The La-Obes game has shown a statistically significant improvement in

users' food choices. This is evident in increased selection of healthy items, reduced calorie intake from unhealthy foods, and observable behavior changes across different meal stages.

Future versions of the game will incorporate real-time AHP scoring; for instance, as a child plays, the game might dynamically prioritize offering choices that the child tends to ignore but are important – effectively personalizing the challenge to each player's tendencies. The ultimate goal is to make healthy choices habit-forming, bridging the gap between knowledge and behavior through interactive play.

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