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Original Article

Design of a Mobile Application to Predict Anemia

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Abstract *- The problem of anemia is perceived by different countries of the world; those who present it the most are children, adolescents, and pregnant women; in this investigation, an application for the prevention of anemia was designed. The report provided by the application is based on the intake of food consumed daily at breakfast, lunch and/or dinner. It is presented in a personalized way by mail or WhatsApp web; the evaluation is carried out according to the nutritional properties of the food according to the registered database. The algorithm was developed in C++ software and designed using the Scrum reference framework. This methodology was chosen because you have set tasks and deadlines, plus you can work with a small team. This design was validated by expert judgment, which yielded a 19.6 in the dimension of efficiency, and the validation of the survey was carried out with Comgrach's alpha, the result of which was an evaluation range of 0.898, whose rating was Good.*

Keywords *- Anemia, Iron deficiency, Iron, System of equations.*

1. Introduction

Anemia is a disease that affects a large part of the world's population. The WHO estimates that 42% of children under 5 years of age in the world have anemia; in the case of pregnant women, it occurs in up to 40% of the world population of pregnant women [1].

Despite the fact that in the world, there is the implementation of control programs that provide iron supplements, anemia continues to be a great global concern. The diet in the Middle East and North Africa are the most worrisome; countries such as Egypt, Lebanon, Sudan, Syria and Yemen have a low nutritional status due to food shortages, high prices to be able to obtain them, armed conflicts and humanitarian crises that exist above all in undeveloped countries.

The last event, the outbreak of the war in Ukraine, seriously worsened the children's health in those regions. In these countries, there were already problems that affected malnutrition, and due to the COVID-19 pandemic, active conflicts, political instability, and the war in Ukraine, those rates increased; the regions are witnessing and witnessing the rise in food prices along with their low purchasing power, says Adhele Khodr.

UNICEF points out that, in countries like Syria, Lebanon, Sudan and Yemen, more than 9.1 million children under 5 years of age need food aid; more than 86% of children in Yemen have anemia; in Sudan, the percentage of children with anemia is 50%, in Lebanon more than 40% of women and children under 5 years have anemia [2].

In Peru, the fight against anemia is currently a national priority and, together with the Ministry of Health, they are working to reinforce and improve actions for the prevention, detection, control, and treatment of this disease, mainly focused on pregnant women, also on children aged 3 years or younger, and in adolescent women [3].

In the world, many countries face the problem of malnutrition due to economic problems and war conflicts that leave sequelae or secondary effects of said war, hence the importance of having applications that provide us with information on the nutritional values of food—foods to avoid suffering from low iron intake.

In Peru, there are formal state agencies that provide statistical evidence of the problem of malnutrition; thus, the INEI (National Institute of Statistics and Informatics) indicates that the national percentage of children between 6 and 35 months with anemia decreased from 40% to 38.8% without However, there are still regions that exceed 50%, and none are below 20% (light category). Puno is the most worrying region because it reaches 70% of anemic children. There is Ucayali with 60%, and anemia has several factors that cause it, but something that these two regions have in common is that there is a lack of drinking water and poor

health sector management in their regions, point out J. Sotomayor and V. Rivera [4]. Today, anemia is considered worldwide as a serious health problem, which not only affects health but also has economic and social consequences [5].

In the world, Africa has the highest percentage of children and pregnant women with anemia. This is due to different reasons, the socioeconomic level and the individual. A study carried out in sub-Saharan Africa showed as a result that more than 60% of children in that place are anemic [6].

In Peru, anemia is a national priority since this disease occurs in more than 700,000 children under 3 years of age, where the most affected regions are in the mountains; Puno has almost 70% of its children under 3 years of age anemic, according to the INEI and the results of the Demographic and Family Health Survey (ENDES, 2019).

There are some applications, such as YICO, an application that has been designed and validated by nutritionists from the National Institute of Health (INS).

That provides important, complete, and easy-to-understand information for mothers on feeding and nutrition of children under 2 years of age with specific topics on breastfeeding, initiation of complementary feeding, nutritional composition of food, etc.

The difference in the application of this research is that it provides relevant information on the nutritional composition of different foods that can be consumed for any age; in this way, the low intake of nutritious foods low in iron can be prevented and replaced by those that add a significantly significant percentage of iron consumption and thus avoid a possible picture of anemia [7].

Peru makes multiple efforts to mitigate the increasing number of people with anemia. This effort is reflected in its great investment in prevention and reduction programs for this disease, such as Qali Warma, Cuna Más and Juntos, among the best known. But this implies a strong investment, according to the study called Economic Impact of Anemia in Peru; Anemia costs the state approximately 2,777 million soles, indicated Lorena Alcazar [8].

Like the INEI survey in 2019, students from Peru from the University of Sciences and Humanities, Faculty of Sciences and Engineering-Lima concluded that the region most affected by anemia is Puno, with its implementation of a web system to detect anemia in children in Peru and that in Lima, the most affected is Callao, they seek that in the future the development of this tool is useful for people who do not have an adequate diet or feel that they need an anemic diagnosis, in order to contribute to the health sector [9]. On the other hand, a study in Lima by the USMP, which focuses on the district of Carabayllo, was able to reduce the rates of anemia in children 8 and 9 years of age from the Santiago Apóstol de Punchauca school using the development of a system of recommendations in a mobile application that, through the information collected on frequently consumed foods, processes them to recommend nutrient-enriched foods that the body needs [10].

For this reason, in the following work, a program will design a mobile application to indicate iron deficiency anemia prevention.

2. Design

We present some important basic terms that are used in this research.

2.1. Basic Terms and/or Definitions

2.1.1. Anemia

Disease where the number of red blood cells is less than normal; it is not easy to know the optimal amount of hemoglobin that we need in our body for our physiological needs since these vary according to age, sex, smoking and pregnancy, indicated the WHO.

In the world, different types of anemia are related to various diseases and health problems; among them, we have: Pernicious, aplastic, hemolytic anemia and iron deficiency anemia, the latter being the most common, known as iron deficiency anemia [13].

2.1.2. Iron Deficiency Anemia

It is a common type of anemia that occurs due to the absence of iron in the body. If we do not have the necessary iron in our body, it will not be able to produce a sufficient amount of hemoglobin, a substance that is present in red blood cells and that allows them to transport oxygen. Some causes that originate it are blood loss, pregnancy, inability to absorb iron and a lack of iron in our diet [14].

2.1.3. Iron Absorption

The iron absorption process is found in the duodenum and proximal part of the jejunum. It all starts in the stomach, where hydrochloric acid favors the passage of ingested iron from the ferrous to the ferric form, and with it, there is greater absorption. To improve the absorption of iron in the body, it is suggested to drink citrus juice or eat other foods rich in vitamin C, such as oranges, tangerines, kiwi, and melons, among others [15].

2.1.4. Algorithm

An algorithm allows solving problems with a set of rules defined and ordered based on the data through systematic and finite operations, a definition given for the disciplines related to logic, mathematics, and computer science [16].

2.1.5. Database

Structure and relationship of a large amount of data stored in a program, which can be easily consulted according to the characteristics they want [17].

2.1.6. Coefficient

Relationship between two magnitudes [18].

2.1.7. Iron

Iron is a mineral that our body needs for the production of the hemoglobin and myoglobin proteins, but only the right amount of iron is needed because if it is less than the minimum range, iron deficiency anemia can develop; but ingesting them in an exaggerated way is already toxic to our system [19].

2.1.8. Hemoglobin

It is a hemoprotein of the blood, with a molecular mass of 64,000 g/mol, red in color as its main characteristic, carries out the transport of dioxygen O2, begins its journey from the respiratory organs and reaches the tissues, and carbon dioxide CO2, travels through the tissues to the lungs that eliminate it. It is also involved in regulating blood pH in vertebrates and invertebrates [20].

2.1.9. IMC

Body mass index, data calculated using the values of a person's weight and height. It is used to identify the weight categories of each person that can lead to health problems; it is a reliable indicator for most people [21].

2.1.10. System of Linear Equations

It is a collection or set of one or more linear equations, defined on a field, with known coefficients that are real or complex numbers. They have a large number of applications, such as structural analysis, estimation, prediction and, most importantly, linear programming [22].

2.1.11. Variable

It is a constituent symbol of a predicate, formula, algorithm, or proposition in mathematical or logical terms [23].

2.1.12. Milligrams (mg)

Unit of mass of the International System of Units. Being the third submultiple of the gram and the sixth of the kilogram [24].

2.1.13. Reference Nutritional Values (VNR)

It is a general term that includes a group of nutrient reference values and the average requirements (MLs), adequate intakes (AIs), and reference intake ranges for macronutrients (RIs). These numbers are useful for professionals since they would indicate and explain the necessary amount of a nutrient for each person or a group of people so that they continue to be healthy [25].

2.1.14. B12 Vitamin

Vitamin with water-soluble bacterial origin, essential for normal brain function, nervous system, and the formation of blood plus proteins [27].

2.2. Step 1: Design of the Algorithm Structure

For the design of the program structure, it was devised to process the amount of food consumed in grams by the user to estimate the total amount of iron ingested. For this, a database from the Peruvian table of nutritional values prepared by the National Institute of Health [11] was used, prioritizing the amount of iron present in meals.

These foods were arbitrarily selected and are made up of cereals, meats, tubers, and vegetables, which can be seen in the figures. (See figure 1).

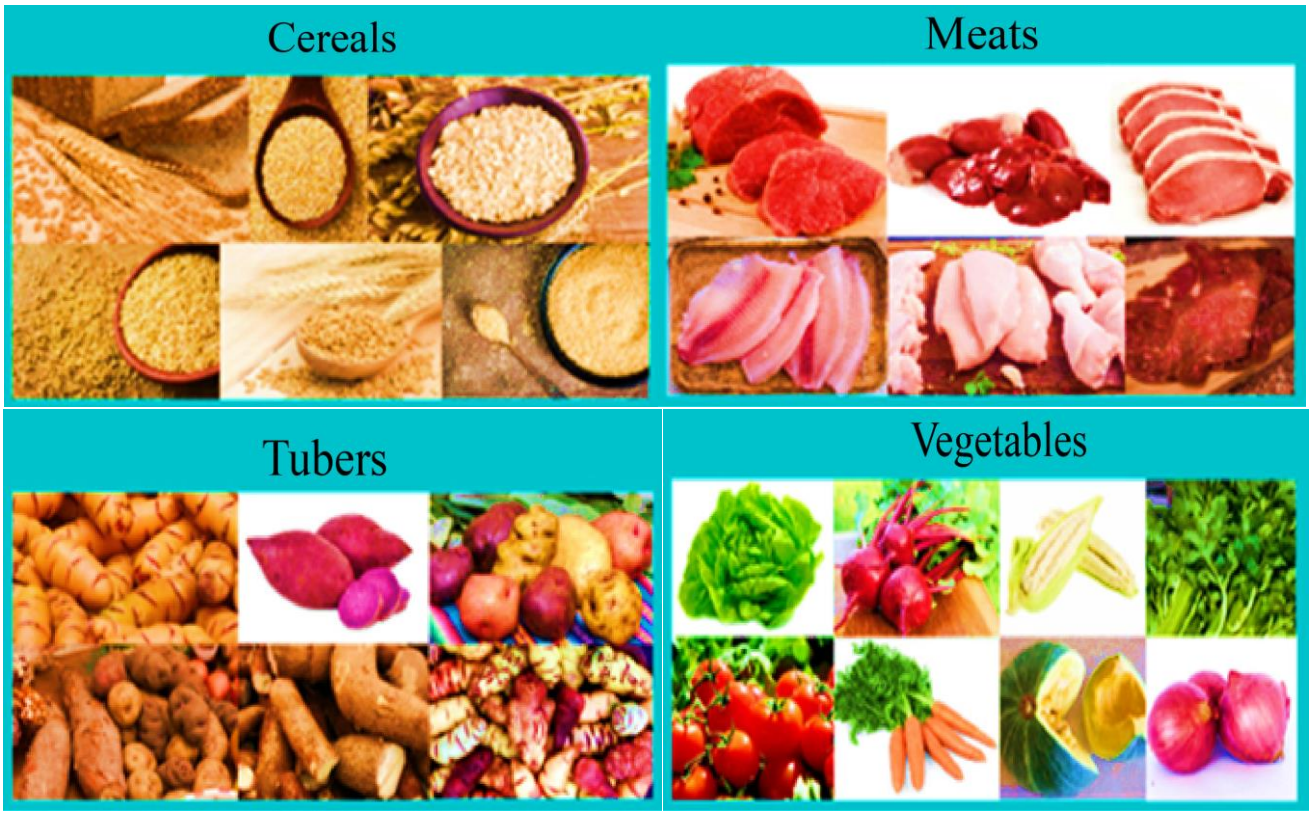

Fig. 1 Food varieties and types

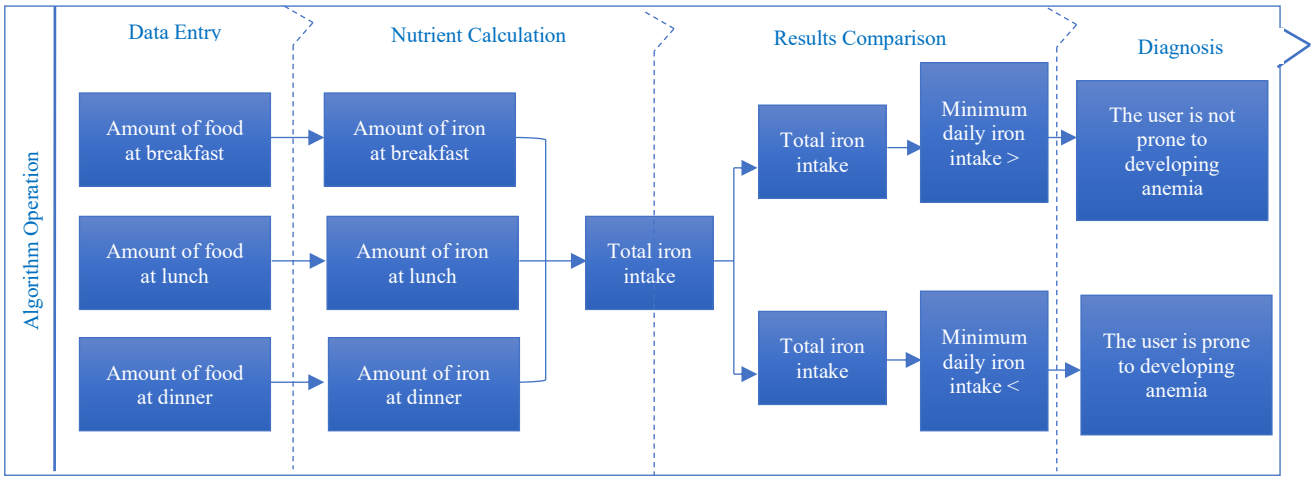

Fig. 2 Processing of the algorithm referring to obtaining iron

For the execution of the program, it was devised that the algorithm asks the user for data such as name, age, and sex. In order to establish a range of minimum iron intake necessary to avoid contracting iron deficiency anemia, according to the United States Department of Health and Human Services.

The algorithm requests the amount and type of food eaten at breakfast, lunch, and dinner, where the nutritional values of each food are found in the database using the switch command and later stored in a vector of the algorithm.

The for command is used to make the iterative addition of the amount of iron consumed in each food. Using the if/else conditionals, the program compares whether the total iron consumption values satisfy the minimum consumption range.

If this is not the case, it warns the user that he is incurring an inappropriate diet that can lead to the development of a picture of anemia due to a deficit in the amounts of these nutrients.

In the following image, we can see the procedure of the algorithm in the C++ program, referring to the total iron consumption in one day.

2.3. Step 2: Data Collection

Data from the Peruvian food composition table prepared by the National Institute of Health [11] was used to calculate the total iron in each meal, with iron as the main mineral consumed per 100g of food. In the following Figure 3, Figure 4, and Figure 5, we can see the prepared foods belonging to lunch that are made up of starters, seconds, and drinks, which are found in the algorithm's database.

2.3.1. Foods by Nutritional Amount

In the following Table 1, Table 2, Table 3, Table 4 and Table 5, we appreciate the lists of foods used for breakfast indicating their amount of iron per 100 grams.

Fig. 2 Inputs included in the algorithm

Fig. 3 Second included in the algorithm

Fig. 4 Drinks included in the algorithm

Table 1. Cereal type food list

Cereals	Iron (mg)
1. Oats, cooked flake	0.5
2. Oats, raw flake	4.1
3. Canihua gray	13
4. Soda cracker (salty)	1.5
5. Vanilla cookie (sweet)	0.6
6. Corn cornstarch	0
7. Barley bread (serrano)	6.5
8. Sliced bread	0.4
9. Iron Fortified French Bread	3.14
10. Cooked quinoa	1.6
11. Kiwicha precooked flake	7.21
12. Arabic bread	6.98
13. Ciabatta bread	5.59
14. Chapla bread	4.67
15. Egg Bread	5.79
16. Cornbread	3.49
17. Yolk bread	4.47
18. Lima Sweet Bread	3.3
19. Whole wheat bread	5.16

Table 2. Fruit type food list

Fruit	Iron (mg)
20. Prepared black olives	7.4
21. Aguaje	0.7
22. Peach- peach	0.59
23. Camu- camu	0.5
24. Plum	0.9
25. Cherimoya	0.29
26. Peach- peach	1.8
27. Coconut	1.5
28. Cocona	1.2
29. Grenadilla	1.28
30. Guava	0.3
31. Black fig	0.8
32. Lucuma	0.79
33. Tangerine	0.3
34. Handle	0.4
35. Orange	0.2
36. Avocado	0.6
37. Papaya	0.3
38. Water pear	0.1
39. Pineapple	0.4
40. Silk Banana	0.6
41. Island Banana	0.3
42. Watermelon	0.3
43. Black grape	2.2

Table 3. List of dairies - type foods

Dairy	Iron (mg)
44. Condensed milk	0.1
45. Skim milk powder	1.2
46. Skimmed evaporated milk	0
47. Whole evaporated milk	0
48. Fresh cow's milk	1.3
49. Breast milk	0
50. Fresh goat cheese	0.8
51. Fresh cow cheese	1.3
52. Buttery cheese	1.5
53. Fruity semi-skimmed milk yogurt	0.05
54. Fruity skim milk yogurt	0.07
55. Natural skimmed milk yogurt	0.09

Table 4. List of foods of the type eggs and derivatives

Eggs and derivatives	Iron (mg)
56. Whole chicken egg, boiled in water	3.04
57. Whole chicken egg, raw	2.6
58. Quail egg, whole boiled in water	0
59. Quail egg, whole raw	3.65

Table 5. List of foods of the type sugary products

Sugary products	Iron (mg)
60. Granulated or refined sugar	0.1
61. Brown sugar	1.7
62. Honeybee	0.4
63. Peach jam	1.4
64. Strawberry jam	1.2
65. Butter	0
66. Unroasted coffee beans	2.9
67. Cocoa	10.5

Table 6. Entree foods list

Starters	Iron (mg)
1. Chicken aguadito	0.7
2. Iamb broth	0.4
3. Hen soup	0.67
4. Caldo de mote	1.52
5. Fish soup	0.47
6. Beef broth	0.79
7. Chicken soup	1.12
8. Corn with cheese	1.22
9. Shrimp suck	0.82
10. Pumpkin cream	0.28
11. Salad	0.54
12. Menestron with chicken	3.29
13. Menestron with beef	0.87
14. Huancaina's style potato	0.64
15. Potato with egg	1.01
16. Chicken parboiled	0.52
17. Beef parboiled	0.4
18. Solterito	1.04
19. Minuta soup	0.87
20. Home soup	0.68
21. Choro soup	0.84
22. Offal soup	
23. Bell pepper soup with chicken	1.62
24. Bell pepper soup with beef	1.05
25. Semolina Soup	
26. Wheat soup with chicken	0.69
27. Wheat soup with beef	0.48
28. Wantan soup	1.88
29. Chicken tamale	1.24
30. Tequeños	0.75
31. Fried wantan	0.71
32. Stuffed cassava	0.87

Table 7. Seconds list

Main Dish	Iron (mg)
33. Chicken in a spicy sauce and rice	1.28
34. Alita broaster with french fries and rice	0.74
35. Anticuchos with potatoes and rice	1.95
36. Jardinera rice with chicken	1.09
37. Arabic rice with chicken	1.28
38. Chicken chaufa rice	0.73
39. Rice with beans and dried beef	2
40. Rice with beans and dried chicken	1.38
41. Rice with seafood	0.81
42. Chicken rice	0.97
43. Covered rice	1.28
44. Steak with fries and rice	0.59
45. Cabrito a la norteña con arroz	0.84
46. Carapulcra and rice	1.51
47. Cau cau with rice	0.61
48. Fish ceviche	1.53
49. Chicken ceviche with rice	0.75
50. Chanfainita con arroz	0.96
51. Russian salad with baked chicken	0.87
52. Fish marinade with rice	0.71
53. Marinated chicken with rice	1.19
54. Chicken stew with rice	0.74
55. Chickpea with fish and rice	1.6
56. Jalea mixed	1.17
57. Lentil with stew and rice	1.09
58. Lentil with milanesa and rice	1.81
59. Salted loin with rice	1.21
60. Macarroni with chicken	2.53
61. Pallares with fish and rice	1.57
62. Paw with peanuts and rice	0.79
63. Rice with fish	0.94
64. Grilled chicken with fries	0.95
65. Fried chicken with salad and rice	0.89
66. Puree with roast and rice	1.13
67. Stuffed hot pepper with rice	1
68. Chicken stir fry with rice	0.71
69. Seco a la norteña with rice	1.38
70. Seco with duch and rice	1.53
71. Tacacho with jerky	0.52
72. Tacu tacu with steak	1.74
73. Red spaghetti with chicken	2.24
74. Stir fried noodles with chicken	2.71
75. Green noodles with chicken	3.86
76. Wheat with chicken and rice	0.73

Table 8. Drinks list

Drinks	Iron (mg)
77. Beer	0.1
78. Chicha de aguaje	0.4
79. Chicha de jora	1.8
80. Chicha de maíz morado with sugar	1.3
81. Coke	0
82. Inca Kola	0
83.Tea without sugar	0.2
84. Coffee without sugar	0.2

In the Table 6, Table 7, and Table 8, we can see the list of meals prepared for lunch used in the algorithm, with the amount of iron each one has per 100g of food. The database established the amount of iron at the beginning of the algorithm, where we indicate how much iron each food has.

2.4. Formulating Linear Equations

The Peruvian food composition table prepared by the National Institute of Health [11] was used to obtain the amount of iron present in the selected foods. The amount of iron present in each food is measured in milligrams (mg) and is present per 100 grams of food.

To calculate daily iron intake, the following system of equations was used:

2.4.1. Calculation of iron Consumed at Breakfast

$$\sum_{i=1}^{n} \frac{a_i x_i}{100} = e$$

Where

a_i = nutritional value of iron the i-th food.
x_i = amount of food i- th consumed.
E = amount of iron consumed at breakfast.

2.4.2. Calculation of Iron Consumed at Lunch

$$\sum_{i=1}^{n} \frac{b_i y_i}{100} = d$$

Where:

b_i = nutritional value of iron in the i-th food.
y_i = amount of food i-th consumed.
D = amount of iron consumed at lunch.

2.4.3. Calculation of Iron Consumed at Dinner

$$\sum_{i=1}^{n} \frac{c_i z_i}{100} = f$$

Where:

c_i = nutritional value of iron in the i-th food.
z_I = amount of food i-th consumed.
F = amount of iron consumed at dinner.

Calculation of iron consumed in the day.

$$Iron_{total} = \sum e + d + f$$

2.5. Algorithm Application

The algorithm requests a name, which will be given as "USER1". The user's age and sex are also required to establish the range of minimum iron intake; an 18-year-old male will be assumed.

The algorithm considers 3 fundamental meals: first meal or breakfast, second meal or lunch and third meal or dinner. The program displays a list of foods, and the user, based on the food consumed, must enter the type of food that has been ingested and the amount in grams. As proof of the program, the consumption and quantity of 4 foods will

be assumed: 20 grams of oats, 70 grams of sliced bread, 10 grams of sugar and 10 grams of butter.

Based on the Peruvian food composition table, the program displays a list of prepared foods for the second meal or lunch. The consumption of 3 foods will be selected: 80 grams of mote broth, 150 grams of Broaster with fries and 50 grams of Inka Kola.

Finally, the algorithm will request food intake at the third lunch or dinner. In this, 3 types of food will be selected: 25 grams of barley, 15 grams of sugar and 60 grams of mold bread.

After collecting the amounts of each of the types of food and their amounts, the algorithm stores each data on the weight of iron consumed, corresponding to breakfast, lunch, and dinner, respectively.

After storing the amounts of iron consumed, these are added iteratively using the "for" command to be compared with the minimum iron intake values to avoid iron deficiency anemia, according to the United States Department of Health and Human Services [30]. See Table 1.

With the values provided, the program indicates the amounts of iron consumed in each main meal and diagnoses a deficit in iron consumption.

The following graph displays the recommended amount of iron according to the age or stage of life of a certain person.

Table 9. Amount of iron according to age

Stage of Life	Recommended Amount of Iron
Babies up to 6 months of age	0. 27 mg
Babies 7 to 12 months old	11 mg
Children from 1 to 3 years of age	7 mg
Children from 4 to 8 years of age	10 mg
Children from 9 to 13 years of age	8 mg
Adolescent boys between the ages of 14 and 18	11 mg
Adolescent women from 14 to 18 years of age	15 mg
Pregnant teens	27 mg
Adolescents who are breastfeeding	10 mg
Adult men 19 to 50 years of age	8 mg
Adult women 19 to 50 years of age	18 mg
Adults 51 years of age or older	8 mg
Pregnant	27 mg
Women who are breastfeeding	9 mg

3. Methodology

For the development of the application, the Scrum framework was used. Some important works developed with this methodology realize that Scrum is more practical to use than other methodologies, and it is highlighted that Scrum manages short cycles iteratively, called Sprints.

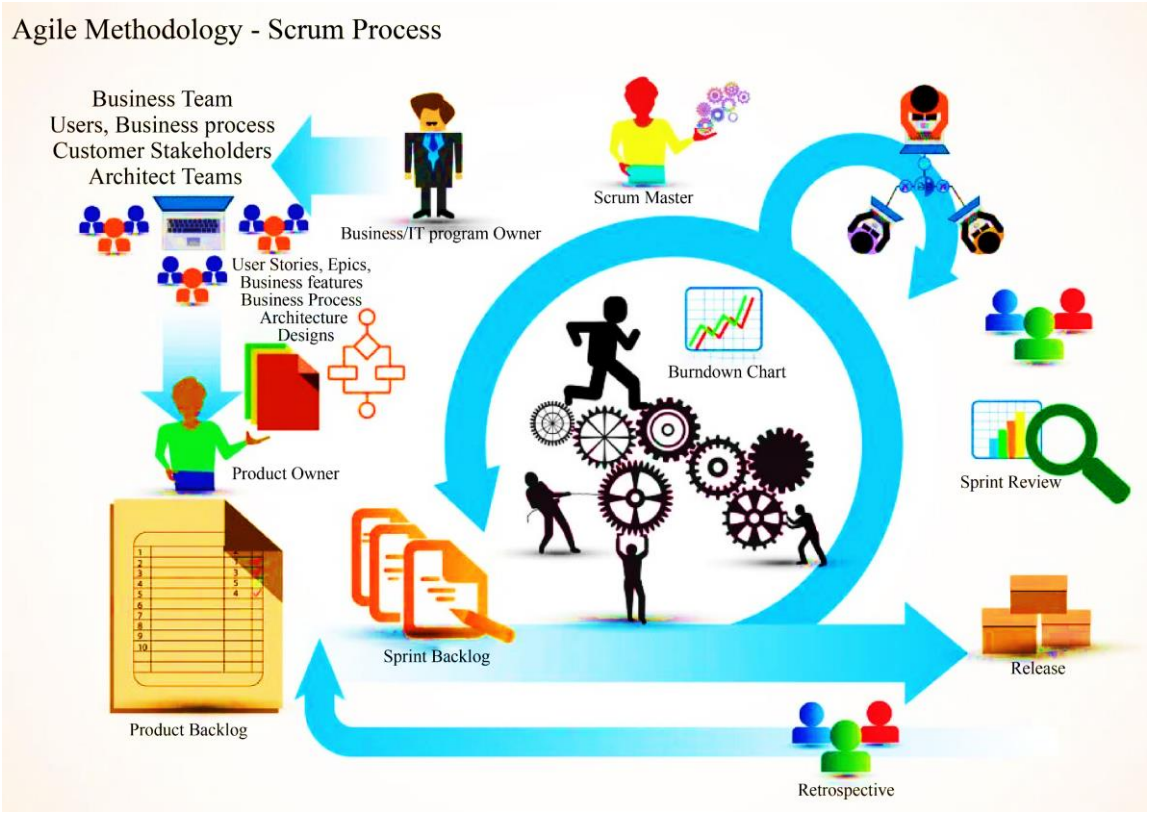

Fig. 5 Scrum life cycle

As the authors indicate, it is decided to use the Scrum methodology to carry out the development of the project where the Initiation, Planning and estimation [28], Implementation, Review, and retrospective and Launch phases are applied. The scrum methodology is used; it has important results related to managing the basic family basket, post-COVID-19 monitoring, and exponential sales, among others, which can be seen in [29].

3.1. Development of the Methodology

3.1.1. Start

Roles

The members of the team of the present investigation are designated to fulfill the roles according to their abilities and capacities; likewise, the authors take into account teamwork as one of the advantages that Scrum presents, where the commitment of each member to help each other is considered. to solve problems that may arise in the development of their activities.

Table 10. People and project roles

Persona	Rol
Miguel Cano	Scrum Master
Hugo Villaverde	Product Owner
Melva Bustamante	Team Scrum (Developer)
Fredy Rosas	Team Scrum (Developer)
Yostin Martinez	Team Scrum (Developer)
Alejandra Yarasca	Team Scrum (Developer)

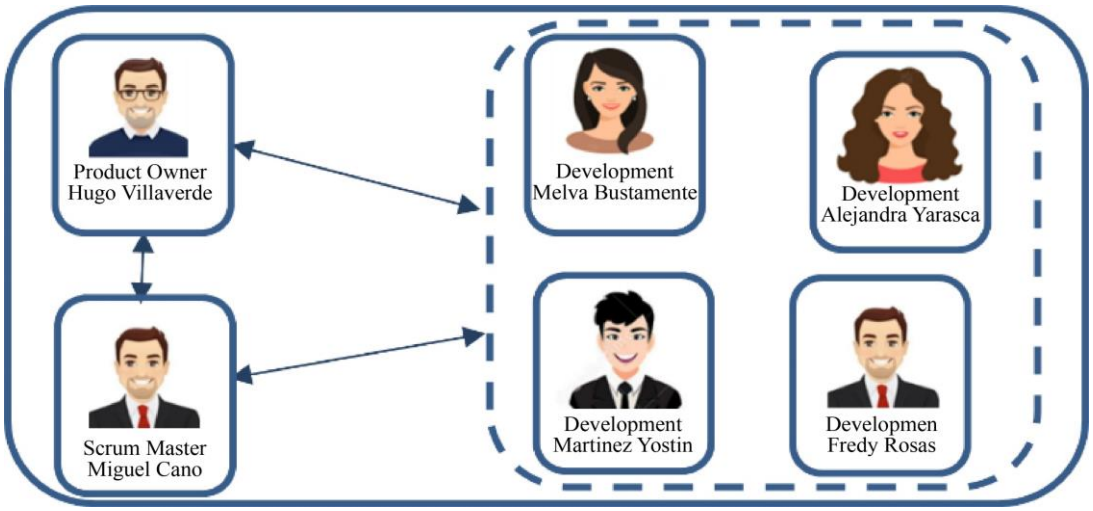

Fig. 6 Scrum team diagram

3.1.2. Planning and Estimation

User stories: The requirements obtained from the system are considered, and each user story has a brief description.

Table 11. User history taken from system requirements

HU	User Stories Description
HU01	As a User, I want to log in to the application with a username and password to be able to use the module that measures the amount of iron consumed in my food.
HU02	As a User, I want to have the option to reset my password in case I forget it to access the module measuring the amount of iron consumed.
HU03	As a user, I want my password to contain at least one uppercase, lowercase, symbol, and number character to provide security to the application.
HU04	As a User, I want to enter, modify, or delete foods containing iron to use the iron consumption control module later.
HU05	As a User, I want the foods to be ordered by the amount of iron from highest to lowest or vice versa, in alphabetical order.
HU06	As a User, I want you to see a detailed description of its properties when you click on a food to know it is not harmful.
HU07	As a User, I want to view a module where I can enter the food consumed and calculate the amount of iron consumed to manage my diet.
HU08	As a User, I want to see a food report and the amount of iron consumed to manage iron consumption.
HU09	As a user, I want the application to allow me to share the report via WhatsApp or email to be informed about the amount of iron consumed.

Next, we show the corresponding user stories in the following tables.

Table 12. User story 1 named login to the application

USER STORY		PRIORITY	T. ESTIMATED
Number: 1	**User:** User	1	1 Day
Story name: Application Login			
Programmer: Melva Bustamante, Alejandra Yarasca			
Description	The system must have a module to log into the application.		
Restriction	The user must be registered and active at the time of being able to change the password. The password could not be the same at the time of changing the password.		

Table 13. User story 2 named reset password

USER STORY		PRIORITY	T. ESTIMATED
Number: 2	**User:** User	1	1 Day
Story Name: Reset Password			
Programmer: Melva Bustamante, Alejandra Yarasca			
Description	The system must allow resetting the password in case of forgetfulness or other reasons.		
Restriction	The user must be active and remember their last password. You will receive an email to confirm that you are the user who changed the password.		

Table 14. User story 3 named password security

USER STORY		PRIORITY	T. ESTIMATED
Number: 3	**User:** User	1	1 Day
Story Name: Password Security			
Programmer: Melva Bustamante, Alejandra Yarasca			
Description	The system must accept an 8-character password that contains uppercase letters, lowercase letters, symbols, and numbers.		
Restriction	The system must accept an 8-character password that contains uppercase letters, lowercase letters, symbols, and numbers.		

Table 15. User Story 4 called food maintenance (CRUD)

USER STORY		PRIORITY	T. ESTIMATED
Number: 4	**User:** User	1	1 Day
Story Name: Food Maintenance			
Programmer: Fredy Rosas			
Description	The system must have a module to insert, update and eliminate foods that contain iron.		
Restriction	The user must be previously validated and registered to access this application module.		

Table 16. User story 5 called ordering food

USER STORY		PRIORITY	T. ESTIMATED
Number: 5	**User:** User	1	1 Day
Story Name: Sorting food			
Programmer: Fredy Rosas			
Description	The system must allow ordering foods by the amount of iron in ascending and descending order, as well as sorting alphabetically.		
Restriction	- The user must be previously validated and registered		

Table 17. User story 6 named food description

USER STORY		PRIORITY	T. ESTIMATED
Number: 6	**User:** User	1	1 Day
Story Name: Food Description			
Programmer: Fredy Rosas			
Description	The system must allow that, when clicking on a food, a detailed description of its properties can be seen.		
Restriction	- The user must be previously validated and registered		

Table 18. User story 7 named consult iron consumption in food

USER STORY		PRIORITY	T. ESTIMATED
Number: 7	**User:** User	1	1 Day
Story Name: Check iron intake			
Programmer: Yostin Martinez			
Description	The system must allow entering the food consumed during the day, these are at breakfast, lunch, and dinner, to later calculate the amount of iron consumed during the day.		
Restriction	The user must be registered and active at the time of being able to make the query.		

Table 19. User story 8 named report for iron consumption in food

USER STORY		PRIORITY	T. ESTIMATED
Number: 8	**User:** User	1	1 Day
Story Name: Report iron intake			
Programmer: Yostin Martinez			
Description	The system must allow for generating a detailed and summarized report for periods, days, weeks, and months of the amount of iron consumed.		
Restriction	The user must be registered and active at the time of being able to make the query.		

Table 20. User story 9 called sharing iron consumption report by WhatsApp

USER STORY		PRIORITY	T. ESTIMATED
Number: 9	**User:** User	1	1 Day
Story Name: Share report			
Programmer: Yostin Martinez			
Description	The system must allow the sharing of the report by WhatsApp or email to be informed about the amount of iron consumed after the control is carried out with the HU7.		
Restriction	The user must be registered and active at the time of being able to make the query.		

Table 21. Product backlog

PB_ID	DESCRIPTION
PB01	Login
PB02	Reset password
PB03	Password security
PB04	Food Maintenance (CRUD)
PB05	Ordering foods with iron
PB06	Description of foods with iron
PB07	Check consumption of foods with iron.
PB08	Report of consumption of foods with iron
PB09	Share report of consumption of foods with iron

3.1.3. Implementation

Figure 8 shows us the system architecture model developed by the controller view model because, according to the work structure, it is aligned with our work.

Table 22. Sprint 1 of the Project includes user stories from 1 to 3, plus the modeling of the database.

Sprint	Requirements	Estimate
Sprint 1	HU1, HU2, HU3, data modeling.	4 Day

Table 23. Sprint 2 of the Project includes the user stories from 4 to 6, plus the prototypes of the application

Sprint	Requirements	Estimate
Sprint 2	HU4, HU5, HU6, application prototypes.	4 Day

Table 24. Sprint 3 of the Project includes the user stories from 7 to 9, plus the report prototype

Sprint	Requirements	Estimate
Sprint 3	HU7, HU8, and HU9, report prototypes.	4 Day

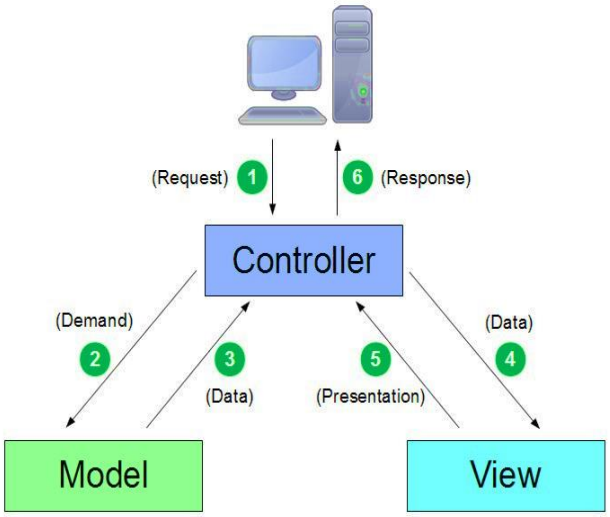

Fig. 7 System architecture

The following Figure 9, we can observe the database of the program.

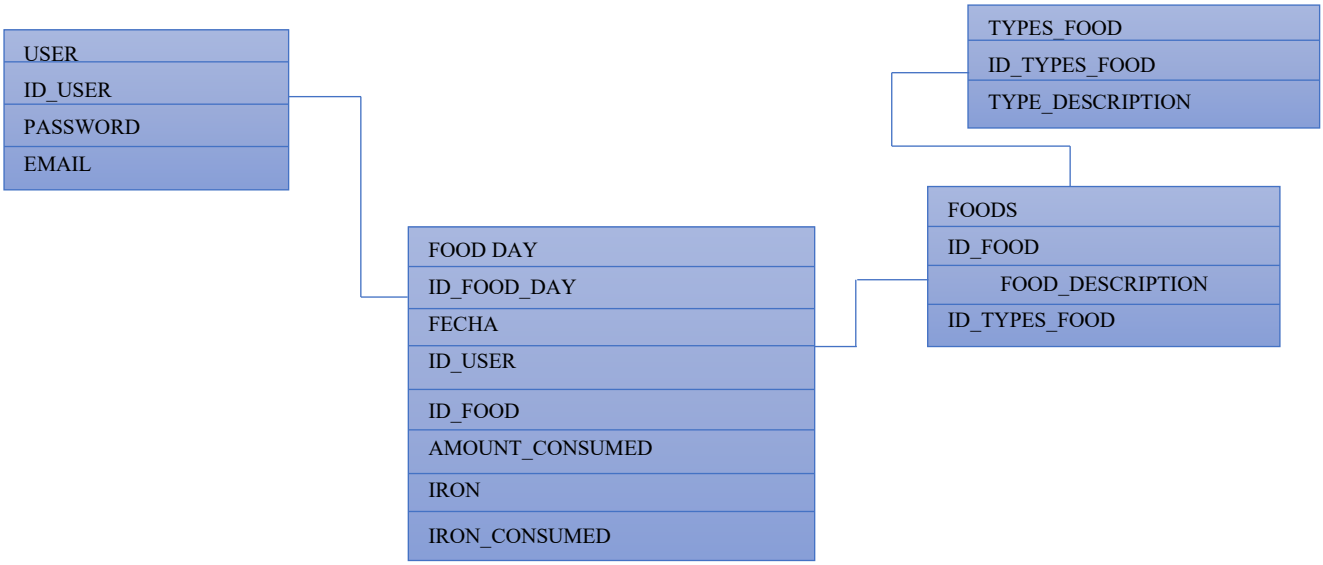

Fig. 8 Database diagram

4. Results and Discussion

4.1. Result by Sprint

We present the design of the prototypes according to each developed sprint.

4.1.1. One Sprint

Figures 10, Figure 11, and Figure 12 show the start of the application, followed by registration and verification; it will also be attached to your email for user verification.

Figure 12 shows verification, and Figure 13 shows the income of the day's first meal with their respective options.

4.1.2. Second Sprint

Figures 13, Figure14 and Figure 15 show the options of dishes to ingest, with their respective nutritional contribution according to the user's choice.

Fig. 9 Prototype cover

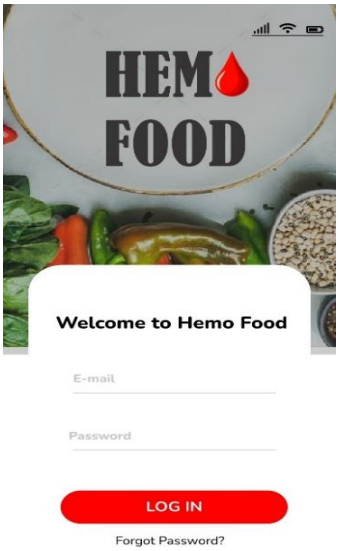

Fig. 10 Log in

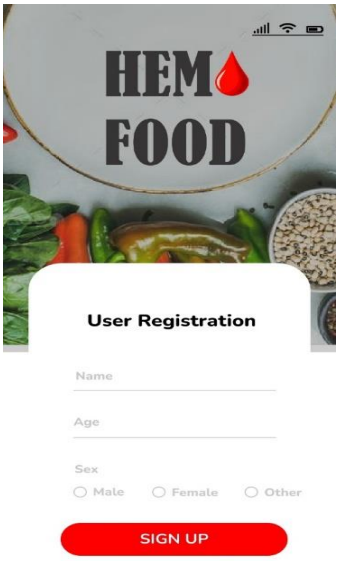

Fig. 11 User registration

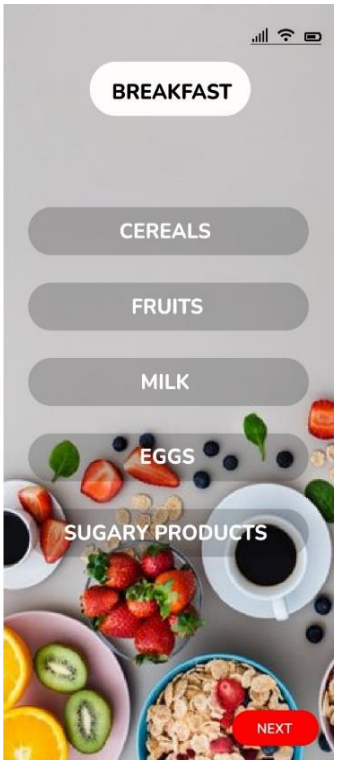

Fig. 12 Breakfast

Figure 14 shows us the nutritional iron component of some breakfast foods with their respective consumption amounts, which can be determined by pressing the tabs up and down.

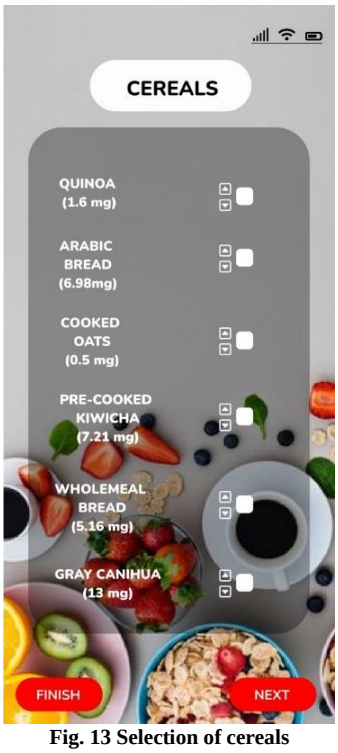

Fig. 13 Selection of cereals

Figure 15 shows us the existing variant for lunch, starting with the main dish and its respective drink as an entrance; Figure 16 shows us the nutritional contribution of the main dish.

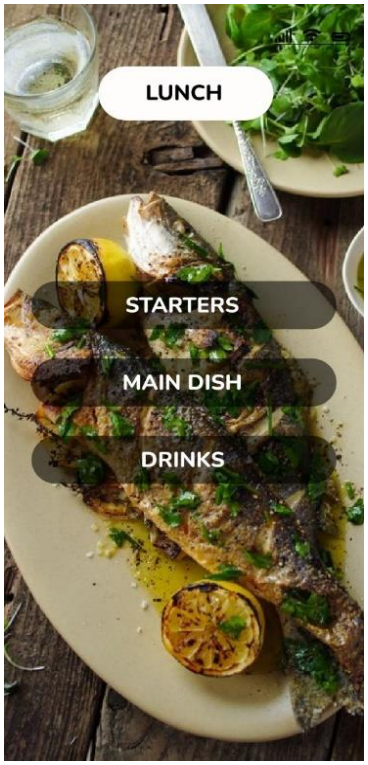

Fig. 14 Lunch

4.1.3. Third Sprint

Figures 16 and Figure17 present the nutritional report, which will be sent to WhatsApp or registered email.

Fig. 15 Selection of the main dish

Finally, Figure 17 shows the result of iron according to the food consumed.

Fig. 16 Calculation of iron consumed

4.2. Expert Judgment

Figure 18 shows the measurement results carried out by the judges, the same ones developed in accordance with the demanding criteria considered by those responsible.

In this figure, it can be seen that the efficiency criterion is the one with the highest score, followed by the innovation of use, security, and usability, respectively.

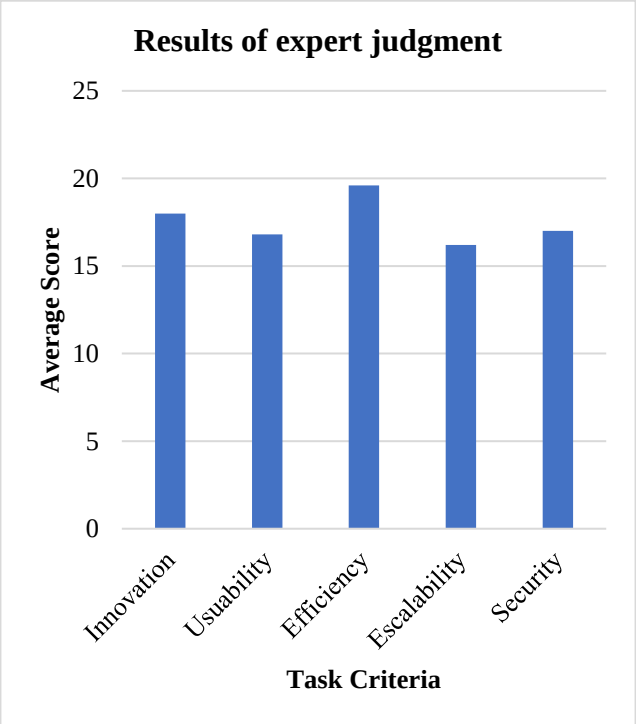

Fig. 17 Evaluation results of the expert jury

Table 25 shows us the result obtained by expert judgment.

We will also mention that Cronbach's Alpha was used as an evaluation instrument, whose result is 0.898, which is within the evaluation range that has this reliability coefficient whose criterion for this range is given by: "Good". This validation confirms that the instrument created, developed, and validated is correct.

Table 25. Results of the evaluation of expert judgment

Criteria	Jurors				
	1	2	3	4	5
Innovation	18	19	17	16	20
Usability	15	16	19	16	18
Efficiency	20	19	19	20	20
Scalability	15	18	16	17	15
Security	16	19	18	15	17

Table 26 shows us the weighted results of the expert judgment; it can be seen that the efficiency has an average of 19.6 of a vigesimal evaluation.

Table 26. Weighted results

Task	Average	Compliance
Innovation	18	High
Usability	16.8	High
Efficiency	19.6	High
Scalability	16.2	High
Security	17	High
Average	17.52	High

4.3. Discussion

The problem of anemia is relevant throughout the world; with respect to [2], the percentage obtained varies over time, so in countries such as Syria, Lebanon, Sudan, and Yemen, the projections vary. In relation to [3], children under 3 years of age are suffering from anemia due to poor nutrition of pregnant mothers; the same occurs with adolescents; due to this, prevention campaigns are managed through the Ministry of Health. According to [4], the lack of water is a problem that increases the health problem of anemia. This problem is not only related to management, but it is also related to food; according to information from formal institutions such as the INEI, this problem also occurs in the regions.

For the YICO application created by the National Institute of Health [7], this application is used for children under 2 years of age, unlike the application that can be used for any age; in addition, the evaluation of food is for breakfast, lunch and dinner, thus showing a variety of products to consume with their nutritional percentages for users of any age. Hence, the importance of the mobile application.

5. Conclusion

People are often unaware of the nutritional quality of the food they consume daily, and this has a negative impact on their health. The program, as an indicator of the prevention of iron deficiency anemia, is a tool that contributes to the fight against iron deficiency anemia, which unfortunately affects countless lives in the world. The algorithm achieves the purpose of warning the user about low iron intake in malnourished people, making use of mathematical tools such as the system of linear equations, which in the algorithm is applied to model the total consumption of iron consumed in a typical day.

With the algorithm provided is intended to provide information on how a basic scheme for the use of the switch, for and if/else commands in C++ language can be replicated in a more popular medium to increase the dissemination of this code to help many people and that it is easily accessible.

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