Recommended System for Controlling Malnutrition in Iranian Children 6 to 12 Years Old using Machine Learning Algorithms

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Received: 2021/04/17 Revised: 2021/09/27 Accepted: 2021/10/08

***Abstract*— Iran is facing low levels of all three types of children's nutrition like nutrient and micronutrients deficiency and overeating. The most common nutritional problems and child deaths are vitamin deficiencies and food quality. The purpose of this research is to plan food recommended system to control malnutrition in children 6 to 12 years old using hybrid machine learning algorithms. The results of this research are applicable in terms of target research. In terms of the implementation method, it is a descriptive survey and the process of gathering information is quantitative data. The dataset used includes 1001 data points collected from the health centers of Mianeh city located in East Azerbaijan in Iran from the integrated apple web system. In this research, the Python programming language has been used to analyze the child nutrition dataset, and AdaBoost and Decision Tree hybrid algorithms have been utilized for the child nutrients recommender system. We concluded that the number of meal features using the Decision Tree algorithm with 98.5% accuracy was more important than other nutritional features of children in recognizing malnutrition in them. From a review of 1001 data into the child nutrition dataset, 807 children are underweight and malnourished, 170 children are normal weight, 20 children are obese and four children are overweight. Therefore, the high exactness of hybrid algorithms in these studies has been able to have a high alignment with the opinion of nutritionists from 2019 to 2020.**

Keywords*— *Malnutrition; Nutrition; Data Mining; Machine Learning; Recommender System.

1. INTRODUCTION

Malnutrition in children occurs when their bodies do not receive adequate amounts of calories, proteins, carbohydrates, fat, vitamins, minerals, and other micronutrients necessary for the health of their organs and their proper functioning [1]. Malnutrition consists of the interrelated measure of wasted, underweight, and stunted caused by deficiencies of essential vitamins and minerals [2]. Childhood malnutrition is a major public health issue which adversely affects short- and long-term health and economic well-being of children and can ultimately lead to inadequate adult productivity and national economic growth [3]. Malnutrition has long-term consequences on children's intellectual abilities, economic productivity, and vulnerability to heart and metabolic diseases. It directly or indirectly accounts for more than one-third of all deaths and 21% of disability-adjusted life years in children [2,4]. Despite classification of Iran as an upper-middle income country by the World Bank and an increase in the number of overweight and obese children, malnutrition is still a problem in this country. In the UNICEF global nutrition report in 2016, Iran has been ranked 14th and 53rd regarding stunting and wasting among nearly 130 countries, respectively [5]. Various medicinal devices have been created to evaluate the nutritional status of children. The main target of the diagnostic procedures is the correct prediction of the related disease. Machine learning, a scientific approach that intersects artificial intelligence and statistical learning research, is a way to investigate a lot of information to discover unknown relationships or patterns [6]. Currently, the assessment of the nutritional status is done vulnerably to human error and takes a long time. This problem can be overcome by creating a system that performs a classification of nutritional toddler status automatically [7].

The major contribution of this study is the incorporation of clinical symptoms with anthropometric parameters and the prediction of malnutrition. To date, no research has been published on the intelligent child nutrition recommendation system in Iran. Other studies [8, 10, 12, 13, 15, 17] employed public datasets, especially age, weight, and body mass index. Additionally, we used hybrid algorithms to increase the accuracy and quality of the model. The rest of this paper is organized as follows. The rest of this paper is organized as follows. Section 2, Related work in machine learning for child malnutrition. In Section 3, Materials and Methods for a system in a recommender system for malnutrition in children, and section 4, The steps and feature extraction, analysis is described, and our conclusion is drawn in the final section.

2. RELATED WORK

In this section, the performed researches about the recommended system for controlling malnutrition children using the machine learning approach are discussed. Although there is a very limited number of English language research in the recommended system for controlling malnutrition, recent and more reliable studies are mentioned here due to the importance of the results provided.

Table I represents the related works on recommendation nutrition and malnutrition children. The comparison is performed according to the following properties: and the learning method and the accurate model.

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In 2019, Mirza Shaheen Iqubal and Amit Kumar Das [8] Designed a nutrition recommender system to control malnutrition in children in Bangladesh based on a deep neural network. The nutritional level of these children was measured by the algorithm Base and the Decision Tree. The 6995 data were used to extract the features, of which 1742 were obtained. Of this dataset, 90% was for training information and 10% for data testing. Fig.1 shows the body's poor accuracy, low weight, and survival growth:

In 2020, Anand et al. [9], Designed a child malnutrition analysis system using evaluation and image processing of children's nails. In Fig.2, the system performed initial training data using machine learning algorithms such as CNN[1] . Then, they analyzed the initial data of children's nails with a set of experimental data to recognize children's malnutrition, diseases by changing the color of children's nails.

Ashis Talukder and Benojir [10], Analyzed a model for predicting child malnutrition using machine learning algorithms for Bangladeshi children in 2020. They surveyed 113 households and the features studied in Bangladesh Children's dataset include height, weight, and age of children. One of the main challenges of this article is the lack of nutritional features of children, such as the number of meals and consumption of the food pyramid. They used Five well-known ML algorithms such as linear discriminant analysis (LDA), K-Nearest Neighbors (k-NN), Support Vector Machines (SVM), Random Forest (RF), and Logistic Regression (LR) have been considered to accurately predict malnutrition status among children. Based on various performance parameters, the best results were accomplished with the RF algorithm, which demonstrated an accuracy of 68.51%, a sensitivity of 94.66%, and a specificity of 69.76%. Additionally, a most extreme discriminative ability appeared by RF classification (Cohen's k= 0.2434). Based on the findings, we can presume that the RF algorithm was moderately superior to any other ML algorithms used in this study to predict the malnutrition status among under-five children in Bangladesh. Finally, the present research recommends applying RF classification with RF feature selection when the prediction of malnutrition is the core interest.

In 2021, Rahman, S. J, et al. [11]. Studied and analyzed child malnutrition in Bangladesh using machine learning algorithms. They analyzed 7079 data, including the age, height, and weight of the child, the level of education and age of the parents, and the amount of water consumed using three machine learning classification algorithms. The average prevalence of stunted, wasted, and underweight was 35.4%, 15.4%, and 32.8%, respectively. It was noted that LR identified five risk factors stunting and underweight, as well as four factors for wasting. The results illustrated that RF can be accurately classified as stunted, wasted, and underweight children and obtained the highest accuracy of 88.3% for stunted, 87.7% for wasted, and 85.7% for underweight.

In [12], Anonnya et al. Suggested an approach to a nutrition proposal framework for children aged 8 to 13 years. This approach used the Naive Bayes algorithm and Logistic Regression to analyze and data mining children's features such as height, weight, body mass index, and meal. According to the obtained analysis, the body mass index feature was selected with 85% accuracy, using the Logistic Regression algorithm for the dietary recommendation.

The approach proposed by Ziaullah Momand et al. [13] Is to control malnutrition in children under five years of age using machine learning algorithms. In this approach, children's features such as height, weight, gender, and body mass index were analyzed using Random Forest, Naive Bayes, and

[1] Convolutional Neural Network

TABLE I. COMPARISON BETWEEN PREVIOUS RESEARCH

No.	*Reference*	*Learning Method*	*Accurate*
1	Shahriar, M. et al. [8]	Deep neutral network	89.97%
2	MANWANI, A. et al. [9]	Convolutional Neural Network	-
3	Talukder, A. et al. [10]	Random Forest	68.51%
4	Rahman, S et al. [11]	Random Forest	88.3%
5	Banerjee, A. et al. [12]	Logistic Regression	85%
6	Momand, Z. et al. [13]	Logistic Regression	97.20%
7	Nigar, N. et al. [14]	AdaBoost and Bagging	-
8	Putri, T. E. et al. [15]	Naïve Bayes	44.58%
9	Arathi, K. M. et al. [16]	K-Nearest Neighbors	-
10	Browne, C. et al. [17]	Random Forest	-

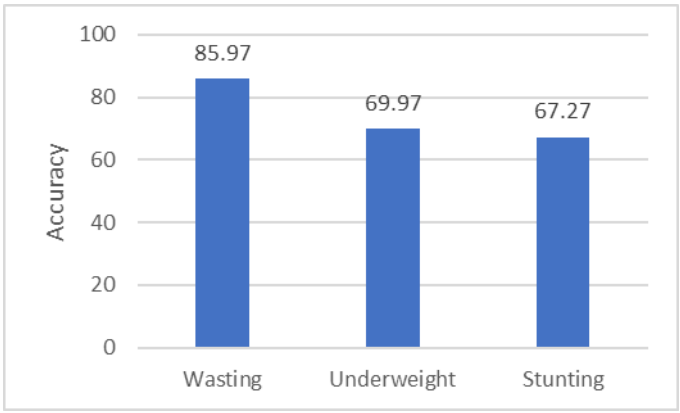

Fig. 1. Wasting of the body accuracy, Underweight and the growth of survival

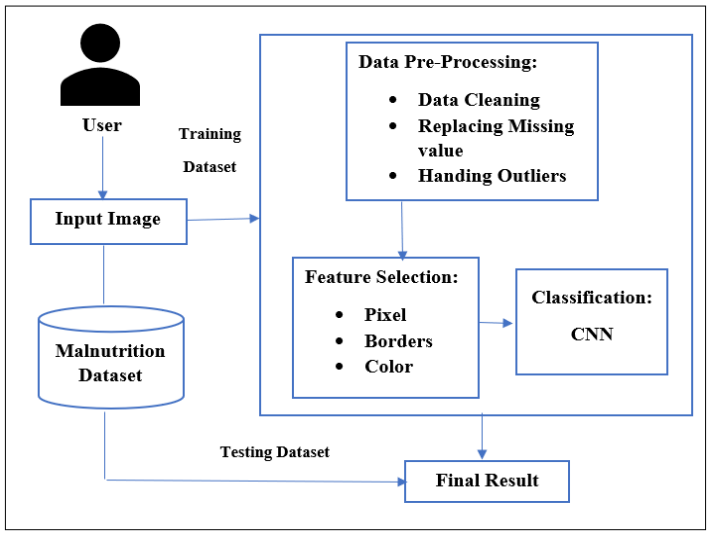

Fig. 2. System block diagram

Logistic Regression algorithms. In this analysis, using the Z-score technique to normalize the dataset. According to the obtained analysis, the accuracy of prediction in malnutrition of children using Logistic Regression algorithm is 97.20%.

Chowdhury et al. [14] Developed an intelligent healthcare system for children where different sorts of data are collected through separate modules or features. The data are then analyzed using Sqoop and reduced using MapReduce framework. After that, performance analysis was done using machine learning algorithms in order to detect current health status. This approach after recording the data from our child users, we compared our data with Bagging and AdaBoost algorithms.

In [15], Tiara Eka Putri et al. Developed an approach to a nutrition assessment system for toddlers. In this approach, they analyzed 225 children's data that included features such as age, height, and weight. To normalize the data, z-score, and index of Anthropometry techniques have been used. The result of this study was a system that could be used to perform the classification of nutritional status based on a combination of three anthropometric indices using the Naive Bayes Classifier. Naive Bayes Classifier performed classification, interpretation of nutritional toddler consisting of malnutrition, normal and over-nutrition. This study showed that the classification of nutritional status was on 175 data generating the highest percentage was malnutrition of 44.58%.

Vanika et al. [16] Proposed an approach to rapidly predict child malnutrition using data mining techniques. In this research approach, they used the K-Nearest Neighbors Algorithm to analyze child nutrition data. In this electronic system, the child receives information from the parents and detects that the child is malnourished. It also provides nutritional advice to the child's parents. If the child has acute malnutrition, he or she should contact the relevant doctor and give nutritional advice.

The approach proposed by Chris Brown et al. [17] Is to predict malnutrition using a Random Forest algorithm. In this approach, simultaneous predictions of malnutrition and poverty prevalence have been demonstrated using a set of features derived from open access data sources, along with Random Forest methods. They also analyzed 69 countries such as Ethiopia, Bangladesh, Kenya, Ghana, Nepal, Nigeria, etc. based on child nutrition conditions. The collected statistical data were normalized using the mean normalization technique. According to the analysis and accuracy, obtained, Bangladesh and Ethiopia had the highest prevalence of malnutrition in children.

3. MATERIALS AND METHODS

The results of this research are applicable in terms of the target. In terms of the implementation method, it is a descriptive survey and the gathering information method is quantitative data. This method of this study is presented as a pilot. The data include feeding and body-building habits of children aged 6 to 12-year-old 2019. We used to prevent possible decline information were collected 1001 data from health web centers of Iran in East Azerbaijan province located in Mianeh city. In this paper, in Fig 3, at first, we pre-processed data like normalizing, deleting unspecified information. To extract features and analyze data using machine learning algorithms such as Naïve Bayes and Decision Tree with the Python programming language which is performed initial analysis and data mining. Then, using integrated algorithms such as

Adaboost and Bagging in the Python programming language, we came up with a meta-heuristic model of a recommender system to control the nutrition of children aged 6 to 12-year-old.

3-1. Dataset

Dataset of food habits and anthropometry of children 6 to 12 years old has been collected from the health system web network, integrated apple system from Mianeh city located in East Azerbaijan province of Iran in 2019. The nutrition dataset for children 6 to 12 years old includes features such as age, height, gender, weight, body mass index, number of meals, vegetables, fruits, dairy, physical activity, and hours of electronic games.

3-2. Pre-processing

Data preparation and preprocessing include: cleaning data, discretizing data, and converting it to a format suitable for the algorithm used. There were no missing values in the data cleaning in the nutrition dataset of children 6 to 12 years old. In data discretization and conversion, data that is nominal and sequences can be converted to numerical and polynomial data. In the Children Nutrition dataset, we converted the children's body mass index feature to decimal numbers using the data reduction technique.

1) Normalization

One of the important techniques in the data conversion method is data normalization or standardization. One of the important challenges is converting the type of variables in the leading dataset into very different results, which can improve the accuracy and efficiency of algorithms in calculating metrics such as accuracy. In the children's nutrition dataset, we used the conversion of a nominal attribute to a binary attribute, in a gender feature. A binary attribute is a nominal attribute with only two categories or states: 0 or 1, where 0 typically means that the attribute is absent, and 1 means that it is present [18]. In this technique, we changed the gender of the girl to 1 and the gender of the boy to 0. In features such as the number of units consumed in the number of meals, vegetables, dairy, and fruit, the amount of physical activity of the child, and the amount of use of electronic devices that are nominal and sequential, we used the conceptual hierarchy technique based on the number of specific attribute values. Nominal attributes have a finite number of distinct values, with no ordering among the values. Examples include geographic location, job category, and item type. The concept hierarchies can be used to transform the data into multiple levels of granularity [18]. The method is that the values of these features are hierarchically assigned ascending or descending degrees. For example, in Table II, in the feature of daily consumption of child fruit, we changed the amount to less than 2 shares in 1 and the amount of 2 to 4 more shares to 2. In normalizing the feature of children's age, we stipulated that if the age of the child exceeds the first 6 months of the year, one year will be added to his age, otherwise his current age will be recorded. Out of 1005 data, 4 records became over the age of 12, which we had to delete. As a result, out of 1005 nutrition data for children aged 6 to 12, 1001 data were analyzed.

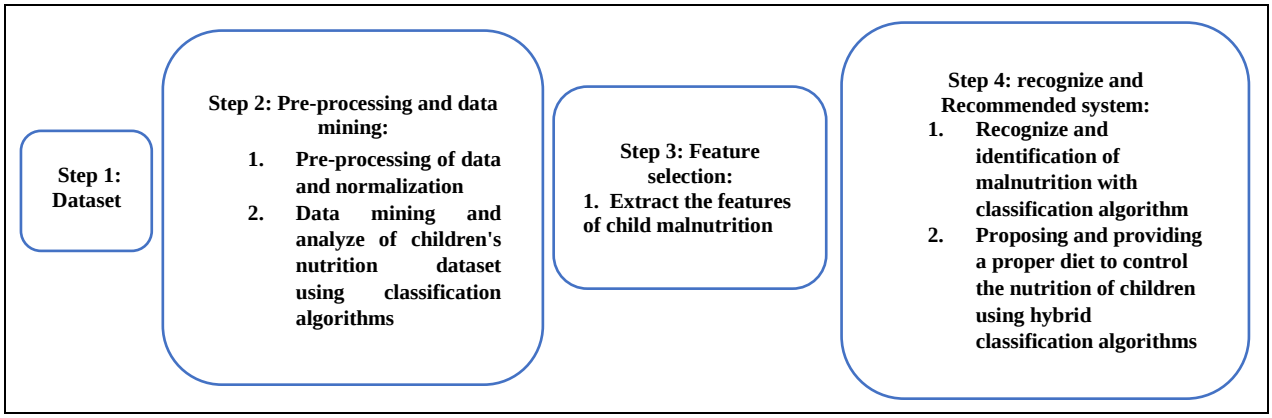

Fig. 3. Proposed Research Architecture

TABLE II. GRADING THE FEATURE OF THE DAILY CONSUMPTION OF CHILD FRUIT

Dataset		
No.	***feature of Daily Consumption of Child Fruit***	***Conceptual hierarchy Technique***
1	Less than 2 shares	1
2	2 to 4 more shares	2

4. FEATURE EXTRACTION

After pre-processing and normalizing the child nutrition dataset, we will extract the features in the child nutrition dataset. Feature extraction involves the following three steps:

4-1. Extraction of features in the children's nutritional dataset

Using the Python programming language and the revelatory search technique, we analyzed each of the features of the child nutrition dataset. In this technique, we place each feature as a label feature to calculate its accuracy. This classifier method is one of the methods used in the classification technique as well as the machine learning based on data training. Methods of naïve bayes classifier is good system in accuracy and efficiency to classify comparing with other classification methods, does not require a lot of training data to perform classification [19]. According to Fig 4, we have all the nutritional features such as age, height, gender, BMI[2] , consumption of vegetables, milk, and dairy products and fruits, number of meals, physical activity of the child, and the number of electronic games used individually as the top feature. We selected and checked the accuracy of all the features. We used the Naive Bayes algorithm using the wrapper technique to select the type of feature. We considered the number of training data to be 70% and the number of test data to be 30%.

According to Table III, the body mass index with 97% accuracy, the best feature was obtained from the analysis of a child nutrition dataset using the Naïve Bayes algorithm.

4-2. Analysis of BMI feature using the Decision Tree algorithm for recognize the malnutrition in children

To analyze child malnutrition, we divided the body mass index data into four parts using the discretization technique and the categorization and smoothing to reduce the data. So that we can convert and analyze data into packets of the same length.

According to a 2006 study by Johannsen, a classification for BMI was divided into four parts, defined in BMI from 2 to 20 years of age. This division includes [20]:

1) Less than 18.5, weight loss and refers to malnutrition.
2) Between 18.5 and 24.9, persons have normal weight.
3) Between 25 and 29.9, persons are overweight.
4) 30 and above, persons with obesity.

According to the mentioned classification, the feature of children's body mass index was divided into 4 classes, including normal weight, underweight, overweight, and obesity. To analyze children's malnutrition, according to Fig.5, we used the Decision Tree classification algorithm with a confidence rate of 25%, and by determining the Gain ratio index, selecting the underweight class as the top class of tree-link, we drew the children's nutrition dataset.

According to Fig.6, we analyzed the number of meals, eating fruit, and the child's physical activity features by using the Decision Tree algorithm and the Python programming language. We considered the number of training data to be 70% and the number of test data to be 30%. According to analysis in Table IV, the number of meals with 98.5% accuracy is the best feature in the child nutrition dataset.

4-3. Analyze AdaBoost and Bagging classification algorithm to dietary recommendations for controlling children's malnutrition

We used the Decision Tree and AdaBoost Algorithm hybrid model, as well as the Decision Tree and Bagging algorithms, to recommend a proper diet for the pediatric nutrition recommendation system. In Table V, we examined the accuracy of these two hybrid models by using the Python programming language, in which the two-hybrid algorithms, Decision Tree, and AdaBoost, in the 90% weight class were identified as the best algorithms for providing dietary recommendations.

4-4. Conceptual model of the module in the recommended system for controlling malnutrition in children using the Begging algorithm

[2] Body Mass Index

```
import pandas as pd
Data = pd.read_excel('Childrendataset.xlsx', sheet_name=0)
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test =train_test_split(Data.iloc[:,:5], Data['BMI'], test_size=0.3 )
print (X_train.shape, y_train.shape)
print (X_test.shape, y_test.shape)
from sklearn.naive_bayes import MultinomialNB
model = MultinomialNB()
model.fit(X_train, y_train)
predicted= model.predict(X_test)
print(model.score(X_test, y_test))
```

Fig. 4. Python Code for accuracy BMI

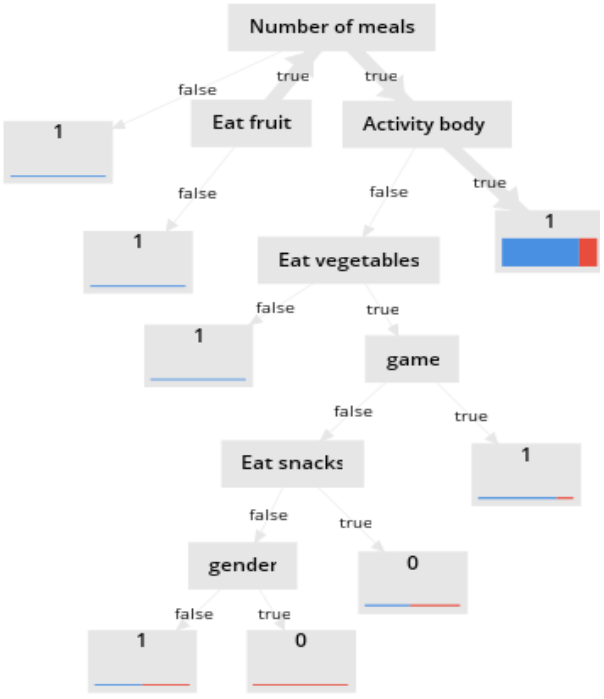

Fig. 5. Tree-link children's nutritional dataset by BMI

In Fig.6, each classifier has access to the dataset. In the Bagging algorithm method, a subset of the main data set is given to each of the classifiers. That is, each classifier views a portion of the data set and must select its model based on the portion of the data that is provided to it. For each classifier, a subset of the main data is selected. The selection of this subset will be by replacement. That is, a sample can be selected multiple times. For example, in category 1, the first model has examples of data sets that are also given in the other model. In this conceptual model, the work is done in the process that first recognizes normal weight, underweight and overweight are given, then using this conceptual model, the model is made and

TABLE III. ACCURACY OF BMI WITH NAÏVE BAYES ALGORITHM IN CHILDREN NOTRITIN DATASET

Dataset		
No.	***Classification Algorithm***	***Accuracy of BMI***
1	Naïve Bayes	97%

TABLE IV. ACCURACY OF THE NUMBER OF MEALS, ACTIVITY BODY AND EATING FRUIT BY DECISION TREE ALGORITHM

Dataset		
No.	***Features***	***Accuracy***
1	Number of meals	98.5%
2	Activity body	85.95%
3	Eat fruit	74.33%

TABLE V. ACCURACY OF THE HYBRID ALGORITHM OF THE MODELS IN DETECTING MALNUTRITION AND DIETARY RECOMMENDATION IN NUMBER OF MEALS FEATURE

Dataset		
No.	***Hybrid Models***	***Accuracy***
1	Decision Tree and AdaBoost	90.27%
2	Decision Tree and Bagging	90%

by using voting during recognizing, the recommending system is presented. Provides a suitable food offer for children.

5. CONCLUSION

Malnutrition in children gradually leads to joint diseases such as osteoporosis and braces of the child's legs, and eventually, the child lags behind in normal growth. The child reaches puberty late and suffers from acute and severe problems with short stature and unusual body compared to his age. In this paper, the main purpose of the study was carried out to examine the nutritional and malnutrition of children aged 6 to 12 years, in order to control the malnutrition of children in the recommended system. The nutrition dataset of children aged 6 to 12 years was collected from Iran Health and Medical Centers in Mianeh East Azerbaijan from the integrated apple web system. In this dataset, 1001 data were examined, of which 806 children were underweight and facing the possible malnutrition. In this research, 171 children had normal weight, and 20 children were obese, and 4 children were overweight. The results showed that the factor of body mass index in children was 97% with the Naïve Bayes algorithm and the number of meals is the best feature in children's nutrition dataset for malnutrition children with 98.5% accuracy with the Decision Tree algorithmIt was the most important feature in weight loss recognition and malnutrition. The hybrid model of the Decision Tree algorithm and the AdaBoost algorithm had better accuracy, sensitivity, and performance than other hybrid models. This hybrid model with 90.27% accuracy, the best model proposed in the paper was examined. Finally, based on the results obtained from the research, a diet recommendation system to control malnutrition in children can greatly help the child's health. Additionally, our discoveries would be valuable for identifying children who are at risk for malnutrition, later

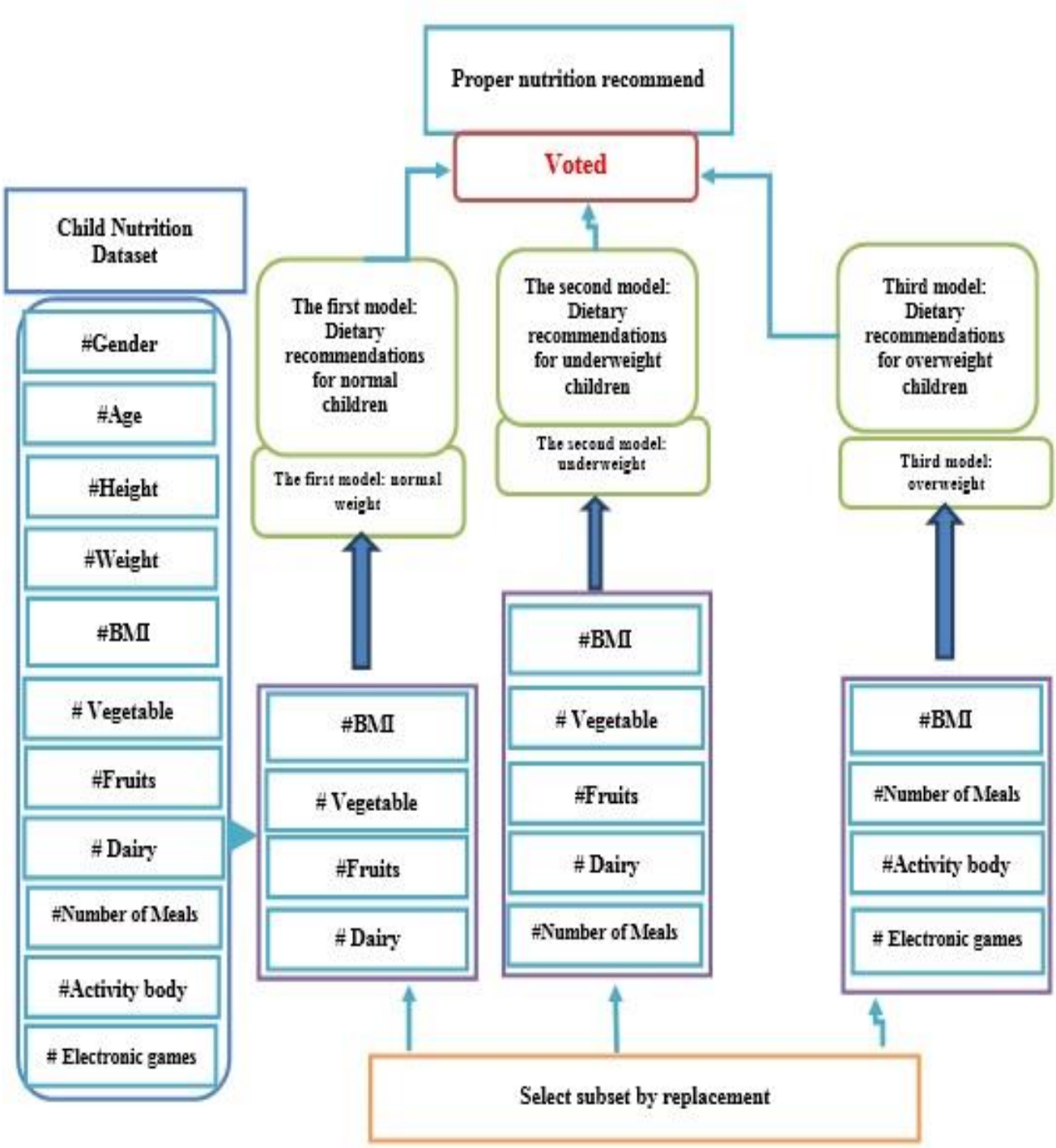

Fig. 6. `Conceptual model of Bagging algorithm in child nutrition dataset

on, thus providing policymakers and medicinal services, suppliers an instrument to execute important intercessions and improve care practices.

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