Research Article

Child Health through the Lens of Big Data: A Machine Learning Study on Food Habits

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Abstract — Big data analytics is used to collect, to examine and to analyze the large quantity of data to take decisions. Big data analytics in healthcare examines the large quantity of data from thousands of children through classification process. Infants and young children requirelarge amount of foods to address the nutrient demands to grow physically and mentally. Dietary food habits are linked with child growth resulted in long-term health outcomes. The parents limit their children's food intake by choosing nutritious foods that are easy to chew and digest. Food consumption is appropriate and meets the nutrients kids need to meet the nutritional requirements that impact their growth and development.

Keywords — Big data analytics, healthcare, dietary food habits, classification, nutrients, carbohydrates

1. Introduction

Adolescence is a vulnerable stage of life marked by rapid development and increased dietary needs. With low intakes of fruits and vegetables, Indian teenagers' diets are regarded as unsatisfactory. The sedentary lifestyle was caused by the teenagers. According to the data, bad lifestyle choices cause teenage obesity and related health issues. Teenagers in India who engage in bad eating habits raise their risk of obesity and the related health issues. With parents influencing their children's eating and exercise habits, the home food environment is a crucial setting for fostering healthy lifestyle behaviors in adolescents. Mothers were the target of the parental influence. In underdeveloped nations such as India, there is a dearth of research on fathers' participation in physical exercise and a nutritious diet.

For children's health and wellbeing, proper diet is crucial. Healthy habits were formed and maintained into adulthood. Australian primary school-aged children are at risk for adverse health consequences, such as significant weight gain, poor mental health, and poor academic performance, due to inadequate dietary intake. Since the kids spend a large amount of time in school, it's the perfect place to encourage good health. By providing wholesome meals during school hours, school meal programs have the ability to advance equity and enhance the nutritional well-being of all students. The genetic tendency for child and health behavior is explained in Figure 1.

Energy and nutrients are obtained from food. The health of humans depends on nutrients. Foods are found to contain other substances, and their health benefits are known. For the prevention and development of chronic diseases such as diabetes, cancer, cardiovascular disease, and chronic respiratory conditions, the relationship between nutrients, foods, and dietary patterns is crucial. Food preferences fluctuate during the course of a person's life due to biological, social, and environmental influences. Food choices and diet quality are significantly influenced by personal preferences. Human behavior is influenced by a variety of environmental influences as well as individual traits including age, gender, and heredity.

The family and peers, who are impacted by the community, society, media, and food contributions, make up the child's ecological knowledge. Children are exposed to food settings, food experiences, and eating by their parents. Children imitate the eating habits, lifestyle, attitudes, and levels of pleasure or discontent of their employed parents. Dietary practices are established early in childhood and maintained throughout time through monitoring. Childhood eating habits persist, leading to consequences such as fussiness and a lack of diversity in one's diet, or heightened sensitivity to food cues and an increased risk of obesity. Parental feeding habits provide a strong target for interventions aimed at preventing children from developing unhealthy eating habits and gaining too much weight. The article's primary contribution is as follows:

The study's objective was to evaluate the eating habits of 100 children in good health, ages 6 to 12, and the impact these habits had on their dental risk profile.

• Seven-day food intake replication and a survey to identify underlying eating habits and preferences were used to evaluate their nutrition.
• The findings showed that the children's diet was out of balance and that they were consuming more simple sugar, which raises the risk of development.

This paper's contents are organized as follows: Section 1 included the topics' challenges and an overview of child health with regard to eating habits. The overview of different machine learning concepts for kid health about eating patterns is presented in Section 2. The dietary habit datasets utilized in this study are described in Section 3. The overview of several machine learning techniques for kid health about eating patterns is given in Section 4. The many performance indicators used to assess children's eating habits are explained in Section 5. Section 6 presents and discusses the findings from a variety of experiments. The work is concluded with future directions in Section 7.

2. Literature Survey

Dietary habits that impact family members' health, such as the nutritional status of children, were gathered from the home setting. In [1], 139 children were selected using non-probabilistic purposive sampling in a cross-sectional approach. Participants' socio demographic data was documented, and biochemical assays were used to calculate their nutritional status. However, cross-sectional design did not raise the level of accuracy.

Teenagers in India have shown that their eating habits raise their risk of obesity and have detrimental effects on their health. In India, there was a lack of research on fathers' participation in physical exercise and a nutritious diet. In order to understand Indian fathers' perspectives on children's healthy behaviors, a qualitative study was conducted in [2]. Teenagers from Kolkata city between the ages of 10 and 19 were recruited using convenience sampling combined with snowball sampling techniques. For effective data analysis, every interaction was conducted and translated into English. However, the qualitative study did not reduce the time complexity.

In [3], a semi-structured interview guide was used to facilitate productive conversations. NVivo's thematic content analysis was used to record the interviews. SES parents mentioned an online grocery store food buying platform as an intervention to help lower SES parents who are concerned about product pricing make sustainable and healthful food choices. However, because meal boxes were more expensive, SES parents did not try them.

Primary schools were shown to help youngsters improve their food skills and to increase their healthy eating habits. The qualitative study's strengths and drawbacks in relation to healthy eating were reviewed with Australian primary school parents and teachers in [4]. Nvivo was used to aid transcribe audio recordings. Children were encouraged to eat healthily by their parents and teachers. However, the planned investigation did not lower the mistake rate.

In order to increase attention span with nutrition education messaging, a gamification strategy was created in [5] using AdobeXD. All participants were given a questionnaire to complete in order to gather information about concepts in nutrition education. For the digital prototype evaluation based on the Technology Acceptance Model (TAM) framework, an extra questionnaire was assigned to the intervention group. However, the gamification technique did not raise the level of precision.

To ascertain the relationship between dietary awareness and overweight/obesity in children and adolescents, a cross-sectional study was carried out in [6]. A questionnaire in the input database was used to assess adolescents' food knowledge. The body mass index (BMI) was used to determine the condition of overweight and obesity. Cross-sectional research did not, however, lessen the computational complexity.

In [7], the relationship between children's health, healthcare use, and food security was evaluated using an adjusted logistic regression using parent-provided meals. Nevertheless, the updated logistic regression model did not reduce the processing cost. In [8], a qualitative in-person investigation was carried out with South Australian schoolchildren. Snowballing employed coded and audio-recorded sample participants. Participants' eating habits and dietary behaviors for sustaining food patterns and fluctuations in food patterns were explained by the general themes. However, qualitative in-person investigation did not lower the accuracy.

Preschoolers' short-term health outcomes were influenced by the preschool reform program in [9]. The change made it easier for them to offer full-day center-based education, together with on-campus health services and school meals. The difference-in-differences and triple-difference methodologies were used to discuss and execute the variations in established preschools across the provinces. However, the preschool reform model did not reduce the amount of complexity.

Continuous co-creation process was introduced in [10] with Thinking Methodology. The designed solution authorized children with families and educators for health control through collecting information from IoT devices. The designed process interconnected the healthcare professionals to support the healthy habits and prevention of obesity onset. However, the accuracy level was not increased by continuous co-creation process.

In order to examine the informational circumstances surrounding food choices in elementary schools, a food decision process was examined in [11]. By informing parents about their meal choices, the food products were rated according to their nutritional worth. Parental participation in the decision-making process has been found to increase the selection of nutritious foods that last for months. However, the food decision process did not reduce the computing time.

A study on the factors influencing children's feeding behavior was conducted in [12]. The domestic life of children in the

family system was crucial in shaping and encouraging behaviors that lasted throughout their lives. The number of cattle at the local level, along with microdata on eating patterns and food consumption costs, were the subjects of the new, manually gathered historical data in [13]. Children who experience meat scarcity wind up spending more money on food when they get older. In order to present food rejection studies in preschool-aged children in cognitive literature, a narrative review was conducted in [14]. Using decision-making techniques, the relationship between children's cognitive development and dietary knowledge was investigated. Pediatricians, pediatric surgeons, obstetricians, nurses, midwives, dieticians, and lactation consultants were among the experts, decision makers, and healthcare officers who participated in [15].

3. Dataset Explanation

Experimental evaluation of the existing methods is carried out using two datasets, namely diet-plan-recommendation dataset and Diets, Recipes and Their Nutrients. Firstly, Diet Plan Recommendation Dataset combines the two different data source files, namely food and their calories as well as diet plan recommendation. Diet plan recommendation dataset is used to predict the diet plan depending on calories to maintain their weight. The dataset comprised 11 features and 23998 instances.

Age, weight (kg), height (m), gender, activity level, BMI, BMR, calories to maintain weight, BMI tags, and label are among the properties. Food and their calories dataset comprised the food like soup, ice-cream, pizza, vegetables, fruits etc, the serving where the calories are calculated. Food and their calories dataset comprised three columns, namely Food, Serving and Calories.

Secondly, Diets, Recipes and Their Nutrients are used with recipes from different diets and cuisines. The designed dataset are aimed for providing healthy and nutritious meal options. The dataset comprised the information on macronutrients of every recipe with extraction day and time. The dataset make valuable resource for those interested in healthy diet for studying the relationship between diet and health. This dataset is used to find healthy and nutritious recipes from different diets and cuisines. To ensure that the recipes fit within a healthy eating plan, the macronutrient information is employed. The recipes extracted on a given day are identified by the extraction time and day. For those who are interested in eating a nutritious diet, the dataset generates a healthy meal plan.

4. Methodology

Food is essential for children's healthy growth and development. With its ability to increase resistance and promote ongoing substance renewal in children's cells and tissues, it promoted both oral and physical health. The World Health Organization states that food plays a crucial part in preventing oral health issues. Consuming too many low-molecular-carbohydrate foods is a major health issue that has

a negative effect on one's health. Children's eating habits have a significant impact on their physical, emotional, and psychological development, making them vital to their health and wellbeing. The prevalence of childhood obesity and other health problems around the world has made children's eating habits extremely important. Childhood poor eating patterns lay the stage for negative health outcomes, such as obesity, diabetes, and heart disease. Unhealthy eating patterns that include a high energy density and a poor consumption of fruits and vegetables are associated with childhood obesity. Unhealthy eating practices have effects on mental health, cognitive development, academic achievement, and emotional well-being in addition to physical health.

Eating a nutritious, well-balanced diet provides nutrition. The nourishment and energy were provided by food and drink. Making better eating choices is made easy by the nutrition. Based on physical characteristics like height or weight, each individual is unique. As a result, each person has unique nutritional demands. Every individual has a different dietary plan. The Indian cuisine dietary plan is created by the nutrition recommendation system, which takes into account a number of elements that influence an individual's nutritional requirements.

Food habits are predicted using machine learning approaches. K-Means clustering and input are used to group the meal by calories. A random forest classifier is used to categorize and forecast the food. The initial phase in the system's design is to divide food items into groups for breakfast, lunch, and dinner. Healthy weight loss, weight gain, and weight maintenance all depend on the nutrition. The foods appropriate for the recommended diet were predicted by the Random Forest classifier. The user interface requests information from the user, including body weight, gender, size, and diet reason. For effective clustering, the food products are categorized and suggested to the consumer.

4.1 Dietary Practices and Nutritional Status
Dietary habits that impacted family members' health based on the nutritional status of the children were gathered in a family setting. The study's objective was to calculate the correlation between the feeding habits and nutritional status of children from foster families in Cartagena's SOS Children Villages program. Children from the SOS Children Villages Cartagena program participated in the study using non-probabilistic purposive sampling. Anthropometric and biochemical measurements were used to assess the children's nutritional condition and document the participants' sociodemographic background. A standardized questionnaire was used to examine dietary behaviors. Poisson regression with robust variance was used for the analyses. The prevalence ratios (PR) with confidence intervals were displayed by the regression model. Families have meals together and watch TV while following dietary guidelines. Bananas, root vegetables, grains, fruits, and vegetables made up the majority of the diet.

4.2 Convenience Sampling
Adolescents in India were more likely to be obese and were linked to detrimental health outcomes. With parents

influencing their children's eating and exercise habits, the home food environment was identified as the critical environment for fostering healthy lifestyle behaviors in adolescents. In order to promote healthy eating and physical exercise habits for developing nations like India, the parents' actions affected the mother's and father's conduct. The purpose of the qualitative study was to identify Indian fathers' perspectives on teaching their kids healthful habits. The adolescents from Kolkata, India, who were between the ages of 10 and 19, were selected using the convenience sampling with snowball sampling technique.

A pre-checked and expanded interview guide was provided. Depending on participant preferences, interviews were conducted online in Bengali, Hindi, and English. For data analysis, every conversation was audio recorded, fully transcribed, and translated into English. NVivo software was used to examine the transcripts. Inductive and deductive methods were used to identify themes.

4.3 Healthy Eating Promotion

Primary schools are seen as appropriate venues for promoting children's healthy eating habits and fostering their culinary talents. The qualitative study found out what Australian primary school teachers and parents thought about the school's strengths and shortcomings in teaching kids food skills and encouraging healthy eating. Semi-structured interviews were conducted with Victoria's parents and instructors. Nvivo was used to transcribe the audio recordings and perform a theme analysis.

Many facilitators, according to the parents and teachers, encouraged kids to eat healthily through community-based schools, food and nutrition education (FNE) programs, and teacher role modeling. According to reports, the obstacles were a lack of funds, leadership, teacher skill, and time. Parents and teachers highlighted school food environments, such as canteens, lunch orders, fundraising activities, and school fairs, as both positives and disadvantages. Primary schools in Australia showed how effective it is to encourage children to eat healthily.

4.4 Gamification Approach

Using a digital application in AdobeXD, a gamification strategy was shown to lengthen the attention span for nutrition education messaging. 126 kids between the ages of 7 and 8 participated in the study, split into two groups: the control group and the intervention group. All participants were given a questionnaire to complete in order to gauge their understanding of nutrition education principles. The intervention group received an extra questionnaire for a digital prototype evaluation based on the Technology Acceptance Model (TAM) framework. The digital application has an efficient tool that can result in notable improvements in knowledge about nutrition. Intrinsic prototype features were used to get the higher content rating. The digital method is crucial for collecting nutrition education concepts.

4.5 Intervention Strategies

The prevention of obesity and chronic diseases, which are putting increasing strain on ecosystems, required a global shift toward sustainable and healthful diets. Parents had a crucial role in influencing children's eating habits and expanding intervention techniques to achieve beneficial behavioral variation in kids. Adapting interventions to the needs of parents from varying socioeconomic backgrounds (SES) was crucial. The study looked into how parents from better and lower socioeconomic backgrounds felt about the acceptability and applicability of various creative intervention techniques. Higher SES parents mentioned using online food buying platforms and grocery store nudging techniques as interventions to promote sustainable and healthful food choices. Due to their lower internet spending and product prices, parents from lower socioeconomic backgrounds were affected globally. Recipes that are sustainable and healthful can be inspired by mobile applications. Easy-to-access shopping lists with modest support from parents of both upper and lower socioeconomic status were the strategy's design.

4.6 Child Care Feeding Programs

The Child and Adult Care Food Program was a crucial national initiative that made it possible for child care facilities to serve nutritious meals to their patrons. Use of the Child and Adult Care Food Program in relation to child development and health was not well investigated. The relationship between children's health, development, use of healthcare, and food security through meal source was investigated. In order to participate in the Child and Adult Care Food Programs, the association was conducted among children from low-income families who received childcare subsidies to attend daycare centers.

Only children receiving daycare subsidies between the ages of 13 and 48 months were included in the sample. Every week, the planned programs went to the daycare facilities. Food security for households and children, child health, and growth and developmental risk were all included in the findings. The program's design made use of hospital admittance on the day of the ED visit. $\chi 2$ tests were used to analyze participant characteristics and meal source. Using modified logistic regression, the relationship between outcomes and parent-provided meals was investigated.

4.7 Food Behavior and Eating Habits

Chronic illnesses including diabetes, heart disease, and stroke, as well as being overweight or obese, indicate a serious public health burden. Food and a balanced diet reduced the risk factors. The study learned about the eating habits and food patterns of South Australian moms of children from Sub-Saharan Africa. Face-to-face interviews with South Australian schoolchildren were used in the qualitative investigation. Participants were sampled by snowballing, and the data were verbatim transcribed, categorized, and subjected to thematic analysis. Concerns about food settings in Australia, changes in eating habits and patterns, and participant food behaviors and habits for sustaining patterns were all covered by broad themes.

The issues of food access and availability in Australia were resolved. In order to preserve the customs, the mothers were determined to keep eating traditional cuisine. Participants

talked about difficulties when kids started eating more westernized cuisine. The parents felt powerless and gave in, pushing back against their children's requests. Participants' eating behaviors and habits were influenced by Australia's food settings, food system, access, and scarcity. Mothers and school-aged children are the target group of the customized healthy eating health promotion initiative.

5. Experimental Setup And Performance Metrics

The experimental analysis of existing methods is carried out using three different parameters, namely prediction time, prediction error, prediction accuracy.

The prediction time refers to the time consumed in predicting the child health based on food habits. Prediction time 'P_{time}' is measured by product of number ofchild food habit data 'FHD_i' and the actual time consumed in predicting the child health based on food habits '$Time(FHD)$'. It is computed in terms of milliseconds (ms). Prediction error is the second metric for accurate child health based on food habits. The prediction error 'P_{error}' is measured by ratio of the number of child food habit data that were not predicted accurately 'FHD_{NPA}' to the total number of child food habit data 'FHD_i'. It is measured in terms of percentage (%). The prediction accuracy is measured as the ratio of number of child food habit data that are accurately predicted 'FHD_{AP}' to the total number of child food habit data. It is measured in terms of percentage (%).The formulation of the performance parameters are listed in table 1.

The ratio of the number of child food habit data that are correctly predicted to be "〖FHD〗_AP" to the total number of child food habit data is used to calculate prediction accuracy. The percentage (%) is used to measure it. Table 1 lists the performance parameters that were developed.

6. Result and Discussion

The result is based on accurate child health prediction model based on their food habits. The performance measurement is based on the technical indicators for child health prediction depending on their food habits. Performance evaluation metrics are employed to determine the efficiency and performance of child health prediction based on food habits. The performance of existing methods is discussed with table and graphs

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Table 1 Performance Metrics

P_{time}	$\sum_{i=1}^{m} FHD_i * Time(CH)$
P_{error}	$\sum_{i=1}^{m} \dfrac{FHD_{NPA}}{FHD_i}$
P_{acc}	$\sum_{i=1}^{m} \dfrac{FHD_{AP}}{FHD_i}$

Table 2 Tabulation for Experimental Results of Diet Plan Recommendation Dataset

Techniques/ Parameters	Prediction Accuracy (%)	Prediction Time ms)	Prediction Error (%)
SOS Children Villages program	85.58	28	14.42
Convenience sampling with snowball sampling technique	87.15	22	12.85
Food And Nutrition Education (FNE) programs	82.85	25	17.15
Gamification Approach	94.95	15	5.05
Intervention Strategies	96.11	12	3.89
Child and Adult Care Food Program	80.11	19	19.89
Qualitative Inquiry	86.87	24	13.13

Table 3 Tabulation for Experimental Results of Diets, Recipes and Their Nutrients Dataset

Techniques/ Parameters	Prediction Accuracy (%)	Prediction Timems)	Prediction Error (%)
SOS Children Villages program	82.14	23	17.86
Convenience sampling with snowball sampling technique	86.77	21	13.23
Food And Nutrition Education (FNE) programs	83.13	23	16.87
Gamification Approach	93.67	15	6.33
Intervention Strategies	95.24	10	4.76
Child and Adult Care Food Program	86.38	19	13.62
Qualitative Inquiry	87.19	24	12.81

Table 2 and Table 3 describe the performance results for seven different techniques with three performance metrics and three datasets correspondingly. From the table, it is clear that Intervention Strategies attained better results than any other existing methods for two datasets. For Stock Market Dataset, Intervention Strategies attained 95.24% prediction accuracy, 10ms prediction time and 4.76% prediction error rate. For Diets, Recipes and Their Nutrients Dataset, Intervention Strategies attained 96.11% prediction accuracy, 12ms prediction time and 3.89% prediction error rate.
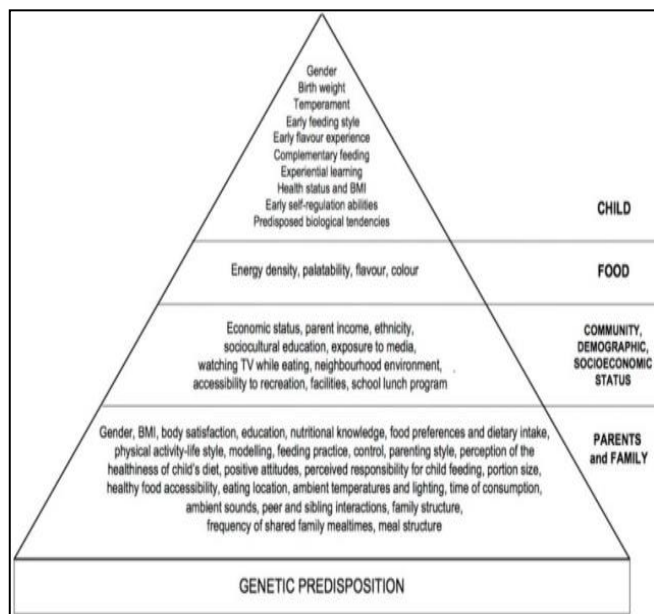
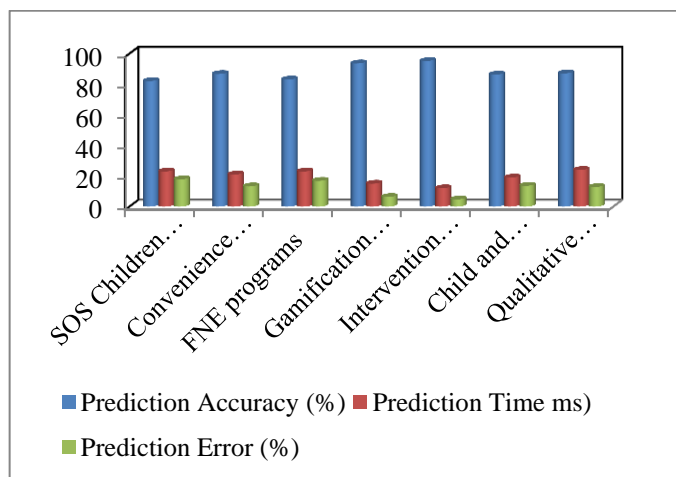**Figure 1 Genetic Predisposition of Child and Health**

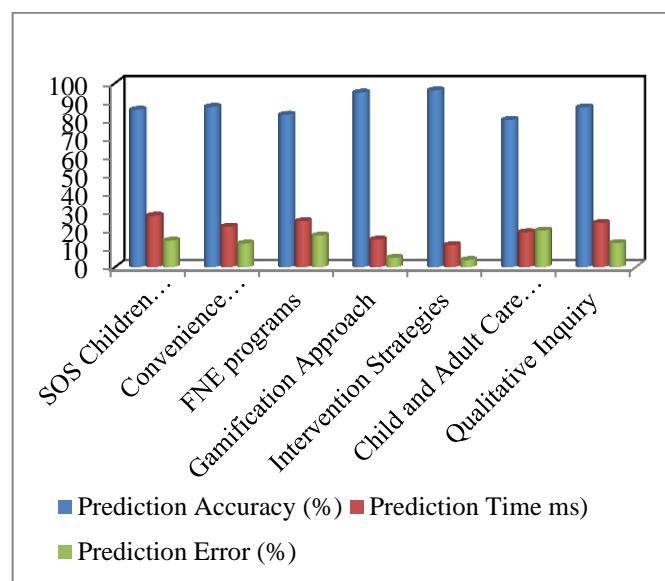**Figure 2 Measurement Analysis of Performance Metrics for Diet Plan**

Figure 3 Measurement Analysis of Performance Metrics for Diets, Recipes and Their Nutrients Dataset

Figure 3 and figure 4 illustrates the performance metric comparison of seven different existing methods for two different datasets correspondingly. From the graphical analysis, it clear that performance of Intervention Strategy is higher than any other techniques for two datasets. This is because grocery stores are using nudging tactics and online food buying platforms to implement interventions that promote sustainable and healthful food choices. Parents from lower socioeconomic backgrounds are shifting globally as they purchase products online and pay more for them. Recipes that are sustainable and healthful can be inspired by mobile applications. When compared to other methods currently in use, the Intervention Strategy improved accuracy by 10%, decreased time by 41%, and decreased error by 60% for the Diet Plan Recommendation Dataset. When compared to other methods currently in use, the Intervention Strategy improved accuracy by 12%, decreased time by 44%, and decreased error by 66% for the Diets, Recipes, and Their Nutrients Dataset.

7. Conclusion and Future Work

The survey uses several Machine learning (ML) and deep learning (DL) approaches to assess children's health based on their eating habits. Different performance metrics are employed to analyze the child health based on food habits results. When the result is compared with another study, machine learning and deep learning method has attained improved results. In this work, Intervention Strategy attained higher and approximately same accuracy for two different datasets. Transfer learning and deep learning is able to achieve highest accuracy result than all the other existing techniques. These results strongly suggest that ML and DL can be implemented in future for efficient child health based on food habits instead of the other conventional machine learning classifier discussed in existing studies.

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