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Abbreviation	Elaboration
HDD	Household dietary diversity
DDS	Dietary diversity score
SPSS	Statistical package for the Social Sciences
FAO	Food and Agricultural Organization of the United Nations
BMI	Body Mass Index
SD/ std Dev	Standard deviation
CI	Confidence Interval
%	Percentage
n	Number

Abstract

Background: Household dietary diversity has been closely connected to nutrient adequacy and thus managed to receive significant attention among the population. As no single food can satisfy a person's nutritional requirements, a diverse diet has been always considered to represent nutrient sufficiency. **Aim:** The goal of this study was to determine the prevalence and factors of dietary diversity in Bangladeshi rural households. **Methods:** A community based cross-sectional survey was conducted in Boalkhali, Chakaria and Raipura upazilla of Bangladesh. A total of 307 households were recruited and interviewed through a questionnaire. The Household Dietary Diversity (HDD)score were used to assess HDD. The HDD score were derived from a 24-h recall of food intake from 12 groups. The non parametic tests and multivariate logistic regression model were applied to find out the association between HDD and other covariates. **Results:** The mean household dietary diversity (HDD) score was 7.20 (SD 1.20). The prevalence of low, medium, and HDD score was 8 (2.6%), 100 (32.6%), and 199 (64.8%) respectively. Education and profession of father, family income, knowledge about nutrition, BMI of mother, livestock rearing were significantly associated with HDDS. People with lower income (OR: 0.24; CI: 0.141, 0.412) and less nutrition awareness (OR: 0.08; CI: 0.016, 0.343) had lower HDD scores. The HDD score was lower (OR: 0.54; CI: 0.193, 0.504) and higher (OR: 3.81; CI: 1.370, 10.576)in underweight and obese people compared to normal-weight people, respectively.**Conclusion:**The findings clearly demonstrated the importance of parental education, occupation, family income, and livestock rearing in rural households in achieving the necessary dietary diversity and enhanced the nutrient intake.

Keywords: Household dietary diversity, socio-demographic, livestock, rural, Bangladesh

Chapter 1:Introduction

Dietary diversity is defined as the consumption of a diverse range of foods or food groups during a given period. It is categorized as a reasonable calculation of food groups eaten up by a household or as an individual, normally 24 hours. HDDs (Household Dietary Diversity Score) Mbwana *et al*. 2016 is defined as qualitative food intake indicator that reflects access to a diversity of foods in any specific regions population or household. Appropriate nutrient consumption is required for healthy nourishment. Proper health has been linked to dietary diversity and the diet quality of individuals. Unfortunately, research suggests that micronutrient deficiency is still a serious public health concern in underdeveloped nations, owing to the consumption of ordinary, primarily starchy-based diets with little variety.

The dietary diversity of a certain population in a region is determined by numerous aspects, comprising the community's previous consumption behaviour, formal manners, and the extent of technology associated with food production, processing, preparation, and storage (Keding *et al*., 2013), the season (Kinabo *et al*., 2003), agricultural biodiversity in the region and diversity of its farming systems (Herforth, 2010), and the population's economic status (Taruvin, 2010).Dietary diversity can be assessed on an individual or household basis. It is commonly considered as an estimate of food access at the family level, that is, a household's proficiency to collect a sufficient amount of quality and quantity food to fulfil all family members' nutritional prerequisites for efficient lives, where it is measured by estimating the number of food groups consumed rather than individual food items eaten. It can be used to assess food access at the household level (for example capacity of households to receive luxurious food groups). Furthermore, it symbolizes dietary quality at the individual level, particularly the diet's micronutrient sufficiency. Dietary diversity reference periods may fluctuate, but the most common is a 24-hour recall time.

The eating patterns of households in various communities have a substantial impact on the members' quality of life. Dietary practice reflects the types, variety, and quality of food consumed and is highly dependent on the socio-demographic characteristics of the population. Increased dietary diversity has been associated with socioeconomic status and household food security in studies. Individual food products consumed by a household, as well as their frequency of consumption and nutrient content, can be used to establish broad assessments of that household's dietary practices. Suboptimal dietary habits were found in low-income countries due to either a lack of availability to food or a lack of understanding of the need of eating a healthy diet. Malnutrition is the most common nutritional problem in

impoverished countries, and it continues to be one of the leading causes of disease and mortality in both children and mothers. They require micronutrients and energy for physical and mental development, which can be obtained from a balanced diet that is limited among impoverished populations in developing countries. In rural Bangladesh, per capita consumption of vegetables, fish, and tubers is still below the government's advised minimum for a healthy life, while consumption of pulses, fruits, oils, and livestock products is still even lower. As a result, consuming a well-balanced diet rich in vital nutrients is crucial to solving these youths' nutritional fragility and combating various forms of malnutrition.

Accessibility, availability, usage, and stability in the interaction between people and food are all crucial features of food security since they ensure an important role in human health. Dietary diversity has been linked to these four pillars of food security favourably (Hillbruner & Egan, 2008; Steyn *et al*., 2006). Almost all dietary recommendations recommend eating a wide variety of meals from different food groups. (Fogli-cawley *et al*. 2006). This is because it is associated with higher energy and nutritional intake, resulting in a variety of enhanced health outcomes, such as nutrient adequacy and anthropometric indices (Bukania *et al*., 2014).Because no single meal can provide all nutrients, (Labadarios *et al*., 2011) demonstrated that the more food groups included in a daily diet, the more likely it is to meet nutrient needs. With this background, (Kennedy *et al*., 2009) claimed that a nutrient-diverse diet may indicate nutrient sufficiency. Until now, dietary diversity has been used as a benchmark for food security (Hoddinott, 2002). As a result, gathering data on household dietary diversity in populations can be a simple yet valuable indication for evaluating domestic food security (Vakili*et et al*.2013b). In recent years, both the nutrition and food security in communities have paid closer attention to dietary diversity indicators, which are obtained from recalling the number of items or food types ingested over a certain time period. Nutritional variety indicators are significant in part because the information is simple to gather and is linked to dietary quality, energy intake, and food security. Dietary variety indicators have the potential to be a significant tool for assessing and targeting needs, as well as monitoring and evaluating programs.

1.1. Objectives of the study:

The goal of this study was

- 1.To find out the prevalence of HDD score and
- 2. To assess the factors associated with HDD score

Chapter 2: Materials and Methods

2.1 Study setting and population

A community based cross-sectional study was conducted in Boalkhali, Chakaria and Raipura Upazila from Chattogram, Coxbazar and Narsingdi district of Bangladesh. Narshngdi district is located east side of capital which is 52.3 km away. On the other hand Chattogram and Coxbazar districts were situated at the south-east side of Dhaka with a distance of 248, km and 398 km respectively from the capital. The study population were the list of all households from the selected upazila.

2.2 Sample size and sampling procedure

The required sample size was determined by using single proportion formula based on the minimum dietary diversity 27% (Sheikh *et al*., 2020).Taking 5% level of significance, Z value = 1.96, a power of 80%, and the margin of error 5%, a single population proportion test was calculated and the estimated sample size was 302.We have worked with taking our whole sample size and it was 307. Stratified random sampling was used to select the sample from the lists of all households.

2.3 Study variables

The dependent variable of the study was the HDD score and the independent variables were socio-demographic factors (mothers' age, height, weight, parents education and occupation, mothers' body mass index), household factors (family size and type, capable family person for income, family income, rearing of livestock, expenditure and income from livestock and related products, microcredit loan and grants, basic knowledge related to different livestock products).

2.4 Data collection procedure

Dietary diversity score is the number of food groups consumed by the households out of the twelve food groups, these food groups include:

- Bread, rice noodles, biscuits, or any other foods made from millet, sorghum, Maize, rice, wheat (Cereals)
- Any potatoes, yams, manioc, cassava or any other foods made from roots or tubers? (Tubers and roots)
- Any vegetables? (Vegetables)

- Any fruits? (Fruits)
- Any beef, lamb, goat, rabbit wild game, chicken, duck, or other birds, liver, Kidney, heart, or other organ meats? (Meat, poultry, organ etc.)
- Any eggs? (eggs)
- Any fresh or dried fish or shellfish? (Fish and others sea food)
- Any foods made from beans, peas, lentils, or nuts? (Pulses, legumes and nuts)
- Any cheese, yoghurt, milk or other milk products? (Milk and other dairy products)
- Any foods made with oil, fat, or butter? (Oils and fats and butter)
- Any sugar or honey? (sugar and honey)
- Any other foods, such as condiments, coffee, tea? (Miscellaneous foods: condiments and processed foods like snacks, and beverages)

Dietary diversity of the respondents was assessed by 24 h recall: a single tick was given in the chart of 'YES' if the food from that food group was consumed over the reference period and also in the same manner tick was given "NO" box if the food from that group was not consumed over the reference period. The data was collected from 20th February 2021 to 20th June 2021. Then the total of all points was calculated. The HDD score ranged between 0 to 12. The HDD score was categorized in 3 ways, low dietary diversity (LDD <3), medium dietary diversity (MDD = 4 to 6), and high dietary diversity (HDD≥7) (Ahmed *et al*., 2019; Kundu *et al*., 2021). The score of the HDD showed right internal consistency in the present study with a Cronbach's alpha of 0.82.

2.5 Statistical analysis

Descriptive statistics of frequency, percentage, mean and standard deviation were done. We examined the prevalence of dietary diversity among household. The proportion of consuming foods from different food groups and the distribution and variations in mean HDD score across different socio-economic were explored. Since the HDD score was not normally distributed and we have applied non-parametric test of Kruskal-Wallis test and Mann-Whitney test. The nonparametric tests was performed to test the association between HDD score with categorical explanatory variables: mother's age, father's and mother's education, father's and mother's occupation, family income monthly, family types, family member, domestic animal rearing, microcredit loan taking, knowledge about giving energy by eating egg & drinking milk, knowledge about eating egg by adult people, mother's BMI. Binary logistic regression model was applied to find out the effect of different factors on HDD score. The final model selection was computed using Hosmer and Lemeshow

goodness-of-fit test and the significance of variables was assessed using the likelihood ratio test (LRT).We used the variance inflation factor (VIF) to assess multi-collinearity. Association of the explanatory variables with HDD score were reported using odd ratios and confidence interval. All statistical analysis was done using IBM SPSS 23.0 version and P-values <0.05 demonstrated statistically significant association.

2.6 Ethical considerations

This study was conducted in accordance with the ethical principle of the Helsinki declaration of 1964. Written consent was obtained from each respondent after explaining the purpose of the study.

Chapter 3: Results

3.1 Socio-demographic and other characteristics

Table 1 presents the frequency and percentages of socio-demographic and other characteristics in rural areas of Bangladesh. It was observed that, 59.6% mothers were aged above thirty and rest of them were below thirty. Our result indicate that the average age of mother was 35.64 years (Sd 11.39 years).The type of occupation one acquires is mostly determined by one's educational background, which in turn is likely to influence one's income. Near to half of the total fathers (48%) had secondary education whereas, most of the women (59.9%) reported secondary education as their highest level of education. Assessment of the respondent's occupation distribution indicates that majority of mothers were housewives (92.2%),whereas one third (32.9%) of the fathers worked as day laborers followed by job holder (27.3%), businessmen (24.2%), foreigners (15.6%). In respect to family income the study shows that most of the households had a monthly income in between 150001-30000 taka (46%). The average family income was 27398 (SD17192 taka). If we observe the family type, the majority of the families (82.1%) were nuclear whereas 55% of the families consist of more than four members. 61.2% of households rear livestock, 73.2% doesn't possess any microcredit loan and the majority of the population (89.9%) have knowledge about energy gain by egg and milk. Most of the mothers (64.6%) BMI was in normal range. The average BMI was 23.18 (SD 4.17).

Table 1: Frequency and percentages of socio-demographic characteristics in rural areas of Bangladesh

Determinants	**n**	**%**
Age of mother		
≤ 30	124	40.4
>30	183	59.6
Education of father		
No formal education	4	1.4
Primary	54	18.2
Secondary	142	48.0
Higher secondary and above	96	32.4
Education of mother		
No formal education	4	1.3
Primary	52	16.9

Secondary	184	59.9
Higher secondary and above	67	21.8
Profession of father		
Job	79	27.3
Business	70	24.2
Foreigner	45	15.6
Day labor	95	32.9
Profession of mother		
Homemaker	283	92.2
Job	24	7.8
Family income		
≤15000	95	30.9
15001-30000	141	46.0
>30000	71	23.1
Family member		
≤ 4	138	45
> 4	169	55
Type of family		
Nuclear	252	82.1
Joint	55	17.9
Domestic animal rearing		
Yes	188	61.2
No	119	38.8
Microcredit loan taking		
Yes	51	26.8
No	139	73.2
Knowledge about energy by eating egg & drinking milk		
Yes	276	89.9
No	31	10.1
Knowledge about eating egg by adult people		
Yes	160	52.1
No	147	47.9
BMI of mother		
Underweight	22	7.2
Normal	197	64.6
Overweight	64	21
Obese	22	7.2

3.2 Different food consumption by household

Table 2 represents the consumption of each food group in the households. There were 12 food groups (FG) that were set as a criteria in the questionnaire. More than 83.4 % of households consumed cereals-based grains 24 hours before the survey started. About 83.1 % of households consumed tubers and roots; 85% of households consumed vegetables and 37.1% consumed fruits. In addition to, 49.8% of households consumed different types of meat, poultry. In comparison, 58.6 % of households consumed eggs, 70.4% of households consumed fish and other fish products, 48.9% of households consumed pulses, legumes and nuts; 35.8% of households consumed milk and other dairy products, 46.3% of households consumed food made with oil, fat or butter whereas 49.8% of households consumed sugar and honey and 72.6% of households consumed miscellaneous food products. A graphical presentation was provided in figure 1.

Table: 2 Food groups consumption by households

Food groups	Consumed		Not consumed	
	n	%	n	%
Cereals (FG1)	256	83.4	51	16.6
Tubers and roots (FG2)	255	83.1	52	16.9
Vegetables (FG3)	261	85.0	46	15.0
Fruits (FG4)	114	37.1	193	62.9
Meat, poultry organ (FG5)	153	49.8	153	49.8
Eggs (FG6)	180	58.6	126	41
Fish and other sea food (FG7)	216	70.4	90	29.3
Pulses, legumes and nuts (FG8)	150	48.9	157	51.1
Milk and other dairy products (FG9)	110	35.8	197	64.2
Oils, fat and butter (FG10)	142	46.3	165	53.7
Sugar and Honey (FG11)	153	49.8	154	50.2
Miscellaneous (FG12)	223	72.6	84	27.4

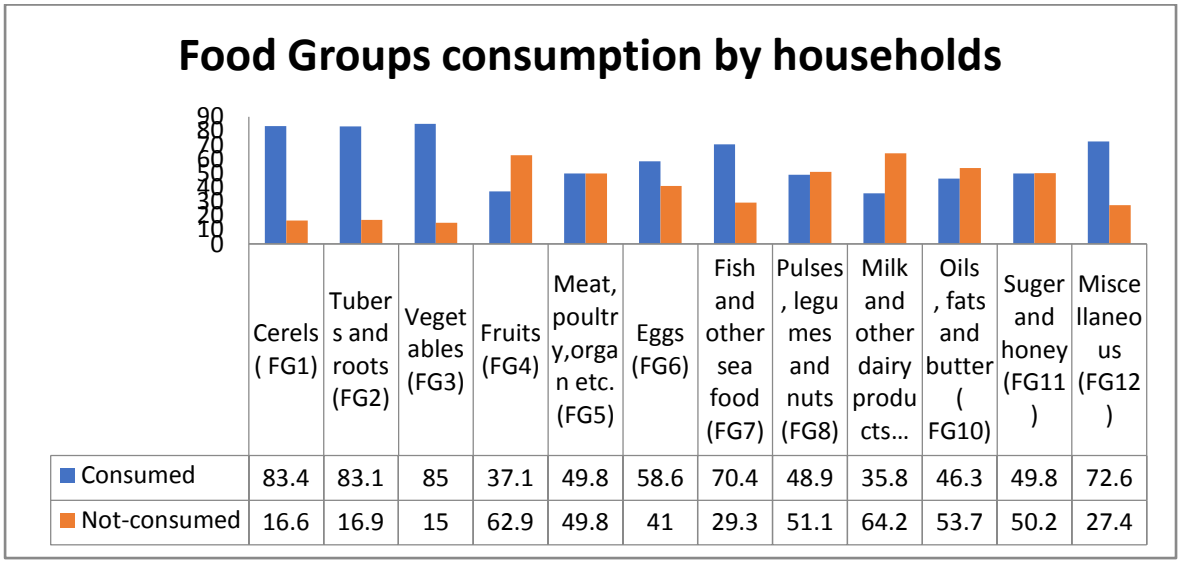

Fig 1: Food groups consumption by households

3.3 Prevalence of HDD score

The mean HDD score was 7.20 (SD 1.20). It was observed that the prevalence of low, medium, and high dietary diversity (DD) score was 8 (2.6%), 100 (32.6%), and 199 (64.8%) respectively. Since the low DD score frequency was very low, so we have created HDD score in two categories based on the mean (≤7.20=inadequate DDS and >7.20 adequate DDS) (FAO, 2013)

3.4 HDD score across socio-demographic and other characteristics

From table 3 it was observed that HDD score was significantly different from father's education, father's occupation, family income, family types, domestic animal rearing, knowledge about giving energy by eating egg and milk, knowledge about eating egg by adult people. On the other hand, age, education and profession of mother, family member, microcredit loan taking and BMI were not significantly associated with HDD score.

Table 3: Mean HDD scores across different socioeconomic and other characteristics in rural areas of Bangladesh

Determinants	n	Mean DDS (SD)	P values from (Kruskal-Wallis tests)	P values from (Mann-Whitney test)
Age of mother				
≤ 30	124	7.10 (1.93)		0.491
>30	183	7.26 (2.04)		
Education of father				
No formal education	4	4.75 (2.22)	0.000**	
Primary	54	6.88 (2.49)		
Secondary	142	7.26 (1.89)		
Higher secondary and above	96	7.40 (1.74)		
Education of mother				
No formal education	4	5.50 (3.0)	0.068	
Primary	52	5.72 (1.74)		
Secondary	184	7.70 (1.90)		
Higher secondary and above	67	7.35 (1.78)		
Profession of father				
Job	79	7.38 (1.99)	0.000**	
Business	70	7.36 (1.72)		
Foreigner	45	8.27 (1.75)		
Day labor	95	6.59 (2.0)		
Profession of mother				
Homemaker	283	7.18 (1.99)		0.521
Job	24	7.38 (2.08)		
Family income				
≤15000	95	6.22 (1.97)	0.000**	
15001-30000	141	7.13 (1.61)		
>30000	71			
Family member				
≤ 4	138	7.44 (2.05)		0.087
> 4	169	6.99 (1.93)		
Type of family				

Nuclear	252	7.10 (2.02)		0.024*****
Joint	55	7.65 (1.82)		
Domestic animal rearing				
Yes	188	7.54 (2.05)		0.000**
No	119	6.65 (1.79)		
Microcredit loan taking				
Yes	51	7.94 (2.05)		0.168
No	139	7.40 (2.02)		
Knowledge about energy by eating egg & drinking milk				
Yes	276	7.45 (1.89)		0.000******
No	31	4.97 (1.52)		
Knowledge about eating egg by adult people				
Yes	160	7.61 (1.71)		0.000******
No	147	6.73 (2.17)		
BMI of mother				
Underweight	22	7.82 (2.28)		0.329
Normal	197	7.11 (1.95)		
Overweight	64	7.19 (2.09)		
Obese	22	7.68 (1.59)		

SD standard deviation, * Significant at p <0.05; **Significant at p<0.001

3.5 Effect of socio-demographic and other characteristics on HDD score

Table 4 presents the adjusted odds ratio and p values of DDS from a multivariable logistic regression analysis which used socioeconomic predictors and knowledge of nutrition. DD score was 0.24 times lower for the household income less than or equal to 20000 takas relative to income greater than 20000 taka. The probability of DDS was 0.08 times lower without knowledge of nutrition by eating egg and milk compared to having knowledge about nutrition. The DDS was 0.54 times lower for underweight people relative to normal-

weight people. On the other hand, the DDS was 3.81 times higher for obese people compared to normal weight people.

Table 4: Association of socio-demographic and other characteristics with HDD score in rural areas of Bangladesh

Parameter	Estimate	Standard Error	Odds ratio (OR)	CI	P value
Intercept	-1.2223	0.4124	-	-	0.0030
Family income ($\leq$ 20000 vs $>$ 20000)	-0.7104	0.1364	0.24	0.141-0.412	< 0.0001**
Knowledge about nutrition (no vs yes)	-1.2942	0.3873	0.08	0.016-0.343	0.0008**
BMI (overweight vs normal)	0.2664	0.2864	1.81	0.930-3.529	0.3523
BMI (underweight vs normal)	-0.9473	0.4057	0.54	0.193-0.504	0.0196*
BMI (obese vs normal)	1.0088	0.4035	3.81	1.370-10.576	0.0124*

*** Significant at p < 0.05; **Significant at p < 0.001**

Chapter 4:Discussion

Our study aimed to focus on HDD score with the assumed goal of understanding rural households' food groups, investigating variations in food patterns, food quality, and a range of socio-demographic and economic potential factors that may influence rural HDD.

In our study, it was observed that prevalence of low, medium, and high dietary diversity score was (DDS) 2.6%,32.6% and 64.8% respectively and the mean HDD score was 7.2 which is much higher than the other similar study performed by (Hadijah *et al*.2016); Drammeh *et al*., 2020) and near to the study conducted by Kundu *et al*. (2020)and Achem*etal*. (2012). According to the findings, a simple household dietary diversity score made up of twelve's groups is fairly well correlated with commonly used indicators of food security and socioeconomic status in rural Bangladesh, such as total food spending, total household expenditures, parental education, house knowledge on nutrition etc. In our study it was observed that most of households ate cereals, roots and tubers and vegetables on a regular basis. Many studies in developing nations have found that the diet in these countries is primarily based on cereals (Kennedy *et al*.2004, 2007; Ekesa *et al*., 2011) The findings of this study add to this argument because practically most of the individuals in our study agreed. This study's findings support this notion because nearly most of the participants (83.4,83.1, and 85%) said they had eaten food made cereals, roots and tubers and vegetables respectively. On the other hand, families were less diversified in fruits, eggs, milk and milk products, meat or poultry compared to cereals and vegetables. Similar findings found the authors of Bangladesh, Vietnam, Ethiopia, and Tanzania (Nguyen *et al*., 2013; Knueppel *et al*., 2010). Consuming cereals may induce micronutrient deficiencies if households rely heavily on that without other dietary groups such as animal source foods, fruits and vegetables.

In terms of socioeconomic status, this study found strong evidence that dietary diversity is linked to a typical household or individual's socioeconomic position. A relation between food diversity and educational outcome was found. Father with more education had a better chance of meeting the minimal dietary diversity requirements. This could be because father with higher education are more likely to have learned essential information about proper feeding procedures and knowledge of nutrition. A study conducted in South Africa byTaruvinga *etal*.(2013)produced similar conclusions on the impacts of education on dietary diversity. Similarly, individuals who reported having a job or being employed were more concerned with achieving a minimal level of dietary diversity than those who did not.

This can be explained by the fact that individuals who are employed (salaried) have a consistent source of income, which increases their prospects of being able to afford to eat.

Family income and family types were associated with dietary diversity in our result. The income level of the household was found to be substantially associated with the dietary diversity. Families with a higher income had a better chance of consuming a diverse diet. The explanation for this could be that more income is associated with increased purchasing power, which can assist in the encouragement of dietary diversity. In terms of family types, there were favourable correlations between family types. A similar outcome was observed in the case of other authors (Kundu *etal.*,2020). The findings of this study are aligned with those of several other studies that have found a link between dietary diversity and socioeconomic level (Torheim *et al*.2004; Knueppel *et al.*2010 ; Karimbeiki *et al 2018*). Vakili *et al*. (2013) found a strong association between the dietary diversity score and the economic position of the respondents in Ahvaz, Iran. Another important observation in our study is those who rear domestic animal having a higher DD mean compare to those who don't rear. Similarly, another study conducted in Bangladesh (Harris-Fry *et al*., 2015) found considerable association between livestock ownership with household dietary diversity. Further, our study shows that the odds ratio in the case of underweight people is 0.54 times lower and 3.81 times higher in obese for DD than normal weight people which is also similar with our result found by Karimbeiki *et al*.(2018).

This study is not free from limitations. This study conducted in the community based; therefore, the generalize ability of the results is limited. No information was gathered on the sizes or quantities of food consumed by households from each food group. While a basic dietary diversity score may be a relatively precise predictor of nutritional sufficiency, recent research reveals that a score based on minimal portion size requirements increases the associations between the score and nutrient sufficiency. Similarly, giving the seven-day recall to families multiple times could reduce potential misclassifications associated with one-time events; such as marriages or funerals that might have been recorded in a single recall. Given the lack of variety in the rural Bangladeshi diet, the inclusion of fewer items may have nonetheless enabled us to capture much of the variability found in the diet when compared to situations where variation may be higher.

5. Conclusion

The results of the study indicate that dietary diversity is associated to rural households' socioeconomic condition. The findings clearly demonstrated the importance of parental education, occupation, monthly family income, livestock ownership and rearing in rural households in achieving the necessary dietary diversity and, as a result, enhanced nutrient intake. In light of this conclusion, new policies focused at these variables, which could particularly among the poor and vulnerable populations, are needed to support the existing structure. As a result, the emphasis should be on developing feasible interventions and programs to support these characteristics.

Recommendations

Despite the shortcomings, these findings suggest that the current dietary diversity score could be a useful tool for assessing food security in rural Bangladesh, particularly in situations where rapid assessments are required in the aftermath of disasters or where lengthy questionnaires are impossible to administer. Future research should look into the relationship between the dietary diversity score and nutritional status indicators. Regarding the seasonal nature of food availability in Bangladesh and articles focus on the impact of season on dietary diversification, the score should be examined for uniformity of usefulness across seasons.

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Bangladesh is a developing country in South Asia where livestock plays a very important role in our economy as well as the food chain. I expect to be a future researcher of life science to address the present challenges we have in this field.