KOCHI UNIVERSITY OF TECHNOLOGY

Social Design Engineering Series SDES-2021-15

Intrahousehold food intake inequality by family roles and age groups

Khatun Mst Asma
School of Economics and Management, Kochi University of Technology

Koji Kotani
School of Economics and Management, Kochi University of Technology
Research Institute for Future Design, Kochi University of Technology

6th December, 2021

School of Economics and Management
Research Institute for Future Design
Kochi University of Technology

Intrahousehold food intake inequality by family roles and age groups

Khatun Mst Asma[*,†] Koji Kotani[*,‡,§,¶,‖]

December 6, 2021

Abstract

Food intake inequality at individual level is rarely analyzed in intrahousehold settings. We examine dietary diversity scores of household members with a focus on their family roles (fathers, mothers, sons, daughters and grandparents) and age groups (children, adults and elderly). Whereas theory suggests that members in a household should have equal dietary diversity by receiving a certain share of available foods, this research hypothesizes that they do not do so by their roles and/or age groups. We conduct questionnaire surveys, collecting sociodemographic information and dietary data using a 24-hour recall method of 3248 subjects in 811 households from one urban and two rural areas in Bangladesh. The statistical analysis demonstrates three findings. First, poor and rural people have lower dietary diversity than non-poor and urban people, respectively. Second, grandparents (children) have lower dietary diversity than do fathers (adults), confirming an existence of intrahousehold food intake inequality by the roles and/or age groups, irrespective of poverty level and areas of residence. Third, father and mother educations are crucial determinants to uniformly raise the standard of dietary diversity for their household, however, they do not resolve the inequality. Overall, it is suggested that awareness programs of dietary diversity shall be necessary with a target group of fathers and mothers for the betterment of intrahousehold inequality and health at household level, contributing to SDGs.

Key Words: Dietary diversity; Family role; Age; Intrahousehold inequality; Bangladesh

[*]School of Economics and Management, Kochi University of Technology
[†]Department of Agricultural and Applied Statistics, Bangladesh Agricultural University
[‡]Research Institute for Future Design, Kochi University of Technology
[§]Urban Institute, Kyusyu University
[¶]College of Business, Rikkyo University
[‖]Corresponding author, E-mail: kojikotani757@gmail.com

Contents

Nomenclature

BDT Taka, Bangladeshi currency

CBN Cost of basic need

DDS Dietary diversity score

FAO Food and agriculture organization

NGOs Non-governmental organizations

SDGs Sustainable development goals

1 Introduction

Nutritional deficiency is one of the severe problems around the globe, especially in developing countries. It is also reflected in the sustainable development goals (SDGs) that highlight the need for special attention to eradicate the malnutrition problem. Recently, intrahousehold food allocation is getting priority to researchers, policy planners and development practitioners because household food adequacy does not imply the nutritional adequacy of individuals (Akerele, 2011). Individual nutritional status largely depends on food allocation among household members (Akerele, 2011). Inequality in intrahousehold food intake is one of the major processes that exacerbate the nutritional deficiencies in certain subgroups of the population within households (Engle and Nieves, 1993, Hadley et al., 2008, Akerele, 2011). Therefore, it is important to understand the dimensions of food intake inequality among household members and to identify the vulnerable subgroups of population at intrahousehold level. Such an understanding will support designing appropriate policies and enhancing equitable food intake within households for improving the nutritional status as well as contributing to SDGs. The present study addresses intrahousehold food intake inequality by subgrouping household members according to their family roles and age groups.

Literature analyzes intrahousehold adequacy in food intake with respect to gender, focusing on specific-age groups (Carloni, 1981, Nelson, 1986, Chaudhury, 1988, Gittelsohn, 1991, Wheeler, 1991, Messer, 1997, Harris-Fry et al., 2018, Madjdian, 2018, Fadare et al., 2019, Sassi et al., 2019). Chen et al. (1981) and Pitt et al. (1990) establish sex and age biases of family food allocation in Bangladesh, showing that calorie consumption of males is higher than that of females in all ages. Luo et al. (2001) indicate that males have a higher share of nutrient intake than females, particularly for young adults in China. Similarly, Akerele (2011) presents that adult males consume more calories than others in Nigeria. Harris-Fry et al. (2018) find that male household heads have higher dietary adequacy and they consume higher animal-source foods than household women in Nepal. Singh (2019) assesses intrahousehold food discrimination in India, finding that gender has a significant effect on child nutrition. However, Finaret et al. (2018) examine dietary patterns of children within households in Nepal and demonstrate that there are not sex biases but age biases in intrahousehold food allocation. Overall, these studies establish gender discrimination in intrahousehold food intake by focusing on certain age groups.

Another group of research examines food intake patterns and dietary practices in relation to sociodemographic characteristics by questionnaire surveys at individual and/or household levels. Fernández-Alvira et al. (2013) assess the relationship between parental education and children food intake behaviors in European and show that parental education has an effect on healthy dietary practices. Rabbani (2014) compares dietary diversity of poor and non-poor households in

Bangladesh by using secondary data and concludes that dietary diversity in poor families is lower than that in non-poor families. Bose and Dey (2007) examine household dietary patterns in rural and urban areas of Bangladesh and find that households suffer from food poverty not by cereals but by pulses, livestock and horticulture commodities in both areas. Ponce et al. (2006) find that the urban poor have higher dietary diversity than the rural poor in Mexico. Jayawardena et al. (2013) and Keino et al. (2014) estimate individual dietary diversity and its relation with sociodemographic factors in Sri Lanka and Kenya, respectively, reporting that age, gender, area of residence, education and ethnicity are highly correlated with the diversity. Overall, these studies suggest that sociodemographic characteristics are important determinants for explaining food intake patterns and diversity practices, regardless of the countries.

Most of the prior studies have examined food intake practices and patterns based on gender and specific-age cohorts by selecting a subgroup of the population at household level. However, there are few researches to address food intake inequality at individual level in intrahousehold settings. Given the scarcity of literature, we analyze dietary diversity scores (DDSs) of all members per household along with sociodemographic factors in a single framework, hypothesizing that there exists an inequality of dietary diversity by their family roles (fathers, mothers, sons, daughters and grandparents) and age groups (children, adults and elderly). Specifically, we seek to answer the following open research questions: (i) How do household members have dietary diversity by their roles and/or age groups, depending on poverty level and areas of residence? (ii) Who are the vulnerable food intake subgroups within households? To this end, we conduct questionnaire surveys, collecting sociodemographic information and dietary data using a 24-hours recall method of 3248 subjects in 811 households from one urban and two rural areas in Bangladesh.

2 Methods

2.1 Survey areas, sample and sampling strategy

A cross sectional design was applied to collect data from multiple members of household with a pre-defined questionnaire in three districts: Dhaka, Jashore and Satkhira of Bangladesh during the period between February 2019 to June 2019 (see figure 1). Dhaka district is an urban and high densely populated area, while Jashore and Satkhira districts are rural and less densely populated areas in Bangladesh. The current study randomly identified 900 households, among them 300 from Dhaka, 300 from Jashore and 300 from Satkhira districts. However, 874 households provided all information contained in the questionnaire, while 26 households have missing observations in urban and rural areas. We excluded the households and the associated members with such missing observations for our analysis. In total 811 households, 219 from urban and 592 from rural areas were selected for the final analysis. Among the selected households, in total 3248 (94 %) subjects participated in the surveys. The number of subjects per household ranges from 2 to 9, with a median of 4. Data of children aged between 2 to 10 years were collected from their mothers.[1]

[Figure 1 about here.]

Data collection procedures follow a hierarchical nature where subjects are nested into households. In urban area, we applied an occupation based randomization technique for precisely representing the population. We are interested to include all social classes of people from low-income to high-income groups. The occupation-based randomization technique allows us to include all income categories of households even those who reside in slam areas (Shahrier et al., 2017, Asma et al., 2021). In this technique, first, we computed the proportion of each occupation on the basis of previous reports conducted by governmental authorities in Bangladesh (Bangladesh Bureau of Statistics, 2018). Second, we proportionally identified the required number of households from randomly selected organizations based on each occupation. In rural areas, the list of house-

[1]Pregnant women and children aged below 2 years are not considered subjects from the beginning of our surveys.

holds who reside in Jashore and Satkhira districts was collected in cooperation with local non-governmental organizations (NGOs). By using this list and random number generator, we selected the required number of households from each rural area. Trained research staff contacted the selected households and obtained sociodemographic & dietary intake information through conducting our survey questionnaires.[2] The participated household head (a husband or wife in a household) provided a written consent form at the beginning. The first author served as the chief administrator and monitored the surveys.

2.2 Key variables

Dietary diversity is concerned with the number of food groups consumed by a person in a given period of time (Ruel, 2003, Aurino, 2017). For measuring a dietary diversity score (DDS) per subject, data on food items are categorized into 9 food groups by following the food and agriculture organization (FAO) guidelines (Food and Agriculture Organization, 2011): (i) starchy staples, (ii) dark green leafy vegetables, (iii) other vitamin A rich fruits & vegetables, (iv) other fruits & vegetables, (v) organ meat, (vi) meat & fish, (vii) eggs, (viii) legumes, nuts & seed and (ix) milk & milk products. A dummy variable is created for each food group assigning the values of 0 and 1. If a subject consumes any item from a particular food group, then the subject is assigned a value of 1, otherwise 0. A set of 9 food groups is used to calculate DDS through adding the number of food groups consumed by each subject in a period of past 24 hours. The maximum value of DDS is 9 and the minimum value is 0. We follow a $15\,\mathrm{g}$ minimum quantity to any of the food group when calculating DDS (Arimond et al., 2010, Food and Agriculture Organization, 2011). The diversity calculation with the 9 food groups adopted by FAO is established to perform well in developing countries to reflect micronutrient adequacy at individual level (Leroy et al., 2015, Ali et al., 2019). Therefore, in this study, the DDS is used as a measurement of dietary diversity per subject.

Each household member's nuclear role within a household was asked for confirmation and the data were recorded. Chan and Sobal (2011) apply the same procedure to identify the role of

[2]Research staff was carefully trained about how to conduct the surveys.

each household member within a household. In the present study, five types of family roles such as fathers, mothers, sons, daughters and grandparents were identified based on each household member's self-reported specific role as well as another reconfirmation from other members in the household. A husband or a wife is a household head and their family roles are categorized as fathers or mothers, respectively. Young and adult children are usually the roles of sons and daughters within households. Household members who reported their family role as grandparents are basically grandfathers and grandmothers.

The present study estimates poverty in both urban and rural areas based on the cost of basic need (CBN) method (Household Income and Expenditure Survey, 2017). The CBN method represents the level of per capita expenditure of a household to meet the basic needs of its members including both food and non-food allowances.[3] Specifically, in this method, the poverty line indicates the minimum average level of per capita expenditure below which a household cannot meet their basic food and non-food needs. The CBN approach is known as an official methodology for estimating poverty in Bangladesh where a household under absolute poverty is the one whose per capita expenditure is below the upper poverty line. The estimated upper poverty lines are 2929 and 2019 BDT in the selected urban and rural areas, respectively (Household Income and Expenditure Survey, 2017). In this study, a household is defined to be poor if per capita monthly expenditure (food and non-food) is less than the national estimated upper poverty line, otherwise non-poor.

During the questionnaire surveys, information was collected on age, areas of residence, father education, mother education, total household earners, occupation of the household head, religion, family structure and household eating practice. Some literature finds that the relationship between age and DDS is not linear (Humphries et al., 2017, Finaret et al., 2018). Therefore, the age of the subjects is categorized into three groups: children (below 16 years old), adults (between 16 to 60 years old) and elderly (above 60 years old), and we create the separate dummy variables to accommodate the possible nonlinearity in the analysis, following past literature (Islam and Nath, 2012, Mohajan, 2014, Barikdar et al., 2016). Table 1 represents the descriptions of all variables

[3]Non-food allowance includes expenditures of fuel & lightning, transport & travel, clothing, health, housing, education, recreation and leisure (Household Income and Expenditure Survey, 2017).

used in this study.

[Table 1 about here.]

2.3 Statistical analysis

We compute and interpret the descriptive statistics, such as mean, median and standard deviation of the dependent and independent variables. We apply some statistical analyses, such as chi-squared and Mann-Whitney tests, to compare the differences of the key variables by urban and rural areas. A Wilcoxon matched-pairs singed-rank test is implemented to assess the paired differences of DDS between fathers and others household members (mothers, sons, daughters and grandparents). To quantitatively identify the inequality of DDS among household members based on their family roles and age groups, we employ a Poisson regression in our analysis due to the positive and count values of DDS (Cameron and Trivedi, 2013, Wooldridge, 2019). The ordinary Poisson regression can be specified as follows:

$$\ln(\mu_i) = \beta_0 + \boldsymbol{\alpha}\mathbf{F}_i + \boldsymbol{\beta}\mathbf{A}_i + \boldsymbol{\gamma}\mathbf{X}_i + \varepsilon_i \tag{1}$$

where μ_i is the expected value of DDS for ith subject, $\mathbf{F}_i$, $\mathbf{A}_i$ and $\mathbf{X}_i$ are the vectors of family role dummies, age group dummies and sociodemographic variables, respectively, and ε_i is an error term. The β_0 is the parameter associated with the intercept, while $\boldsymbol{\alpha} = (\alpha_1, \alpha_2, \ldots, \alpha_5)$, $\boldsymbol{\beta} = (\beta_1, \beta_2)$ and $\boldsymbol{\gamma} = (\gamma_1, \gamma_2, \ldots, \gamma_9)$ are the vectors of the parameters associated with $\mathbf{F}_i$, $\mathbf{A}_i$ and $\mathbf{X}_i$, respectively. In this research, we are interested to estimate the coefficients of $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ in equation (1). We can interpret the coefficients of explanatory variables in Poisson regression in the following way. Suppose, an estimated coefficient of each sociodemographic variable, $\hat{\gamma}_j, j = 1, 2, \ldots, 9$, is considered to represent the marginal effect of that variable on DDS after the effects of the other variables are netted out. The marginal effect of a continuous explanatory variable, such as father education, is derived from a formula $\hat{\gamma}_1 \times 100$ to be a percentage change in the expected value of DDS when one year increase in father education. If a dummy explanatory variable, such as household poverty (poor $= 1$ and non-poor $= 0$), is calculated by $[\exp(\hat{\gamma}_3 - 1)] \times 100$ being interpreted as a percentage change in the expected value of DDS when the household poverty increases from 0 to 1 (see, e.g., Wooldridge, 2019).

The subjects are nested (or clustered) in (by) households, and thus, the ordinary Poisson regression model is customized to consider the cluster-specific effect in the model. The simplest modification is called the two-level random intercept Poisson regression model in which the intercept captures the cluster-specific effect from the other covariates (Goldstein, 2011). The multilevel model provides efficient estimates and captures the unobserved variation in the model (Alom et al., 2012, Imam et al., 2018). Moreover, the multilevel modeling is employed to differentiate the individual and household levels characteristics for the relationship between independent and dependent variables (Chan and Sobal, 2011). The two-level random intercept Poisson regression model considering subjects at level 1 and households at level 2 can be written as follows:

$$\ln(\mu_{ik}) = \beta_0 + \boldsymbol{\alpha}\mathbf{F}_{ik} + \boldsymbol{\beta}\mathbf{A}_{ik} + \boldsymbol{\gamma}\mathbf{X}_{ik} + \varepsilon_{0k} + \varepsilon_{ik} \tag{2}$$

where μ_{ik} is the expected value of DDS for ith subject living in kth cluster (household). $\mathbf{F}_{ik}$, $\mathbf{A}_{ik}$ and $\mathbf{X}_{ik}$ are the vectors of family role dummies, age group dummies and sociodemographic variables, respectively for ith subject in kth cluster (household). The regression coefficient β_0 is the intercept, while the coefficients $\boldsymbol{\alpha} = (\alpha_1, \alpha_2, \ldots, \alpha_5)$, $\boldsymbol{\beta} = (\beta_1, \beta_2)$ and $\boldsymbol{\gamma} = (\gamma_1, \gamma_2, \ldots, \gamma_9)$ are the vectors of the parameters associated with $\mathbf{F}_{ik}$, $\mathbf{A}_{ik}$ and $\mathbf{X}_{ik}$, respectively. The ε_{0k} is a cluster-specific random component that assumes to be independently and normally distributed and ε_{ik} is an error term. The interpretation of the regression coefficients in a two-level random intercept Poisson regression remains the same as an ordinary Poisson regression model but the intercept interpretation is different (Rabe-Hesketh and Skrondal, 2008). The cluster-specific random component can capture the unobserved variation in the model that is not explained by the explanatory variables. If the cluster-specific effect is significant in the model, then we conclude that subjects from different households with the same set of values and levels of the independent variables will show different DDS.

3 Results

Table 2 summarizes the descriptive statistics, such as mean, median and standard deviation of dietary diversity score (DDS) and food group consumption by the family roles. The mean DDS for the overall sample is 4.88 (see the "overall" column in table 2). The mean DDS is consistent with some previous studies and they find that the DDS is relatively low at all ages of people in Bangladesh as compared to the world average, varying between 4.00 and 5.00 in average (median) values (Bose and Dey, 2007, Rabbani, 2014, Ali et al., 2019, Islam et al., 2020). However, it is identified that grandparents have a lower DDS than other household members (see table 2). Food groups, such as starchy staples, dark green leafy vegetables, other vitamin A rich fruits & vegetables and meat & fish are mostly consumed, while consumption of animal sources of foods, such as organ meat, eggs, milk & milk products, consumption of other fruits & vegetables and legumes, nuts & seeds are relatively low consumed by subjects, irrespective of the family roles. Overall, the DDS and food group consumption among household members vary by their family roles.

[Table 2 about here.]

Table 3 presents the summary statistics of the key dependent and independent variables for urban and rural areas. A major difference is observed in the mean DDS in urban and rural areas. Urban subjects (5.61) have significantly higher dietary diversity than rural subjects (4.63). Considering family role dummies, the differences exist in the percentages of grandparents between urban ($3\,\%$) and rural areas ($6\,\%$). Based on age groups, the percentages of children and elderly ($22\,\%$ and $5\,\%$) are higher in rural areas than urban area ($17\,\%$ and $3\,\%$). There are variations in father and mother educations between urban and rural areas. The median of father education (mother education) in urban area is 12 (11) years of schooling, while this median is 7 (7) years of schooling in rural areas. Regarding the household poverty, $17\,\%$ overall subjects are considered poor people and a largest variation is found in the percentages of poor people living in urban and rural areas. In urban area, $5\,\%$ subjects are living below the poverty line, while this percentage is $21\,\%$ in rural areas. According to the national estimation, the percentages of poor people in the selected urban and rural areas are $8.45\,\%$ and $22.75\,\%$, respectively (Household Income and Expenditure Survey, 2017).

[Table 3 about here.]

The number of total household earners is 1 as a median in both urban and rural areas in table 3. Regarding the occupation, all urban household heads are engaged with non-agricultural activities, while $41\,\%$ rural household heads are engaged in agricultural activities. Table 3 also shows that $90\,\%$ of urban subjects are Muslim, while $87\,\%$ of the subjects are Muslim in rural areas. The main family structure of the overall sample in both areas (urban and rural) is the nuclear family, however, the percentage of the extended family is relatively higher ($30\,\%$) in rural areas than urban area ($19\,\%$). In terms of household eating practices, $68\,\%$ ($85\,\%$) of urban subjects (rural subjects) have a practice to eat together with their family members. In summary, rural areas have lower dietary diversity but higher number of grandparents, children and elderly than urban area. Most of the sociodemographic variables, such as poverty, education, earners, occupation, religion, family structure and eating practices vary between urban and rural areas.

Figure 2 (a) shows the boxplots of dietary diversity scores (DDSs) of household members by their family roles and figure 2 (b) presents the boxplots of DDSs by their age groups. In figure 2 (a), the DDS distribution in grandparents is lower than those in fathers with respect to the medians. We apply a Wilcoxon matched-pairs singed-rank test to compare the distributional differences of fathers' DDS with other household members' DDS. A null hypothesis is that the distributions of DDS between fathers and mothers pairs are the same. The following pairs are tested: (i) fathers' DDS *vs* mothers' DDS (ii) fathers' DDS *vs* sons' DDS (iii) fathers' DDS *vs* daughters' DDS and (iv) fathers' DDS *vs* grandparents' DDS. We find that all cases (i) ($Z = 3.36, p = 0.01$), (ii) ($Z = 2.07, p < 0.04$), (iii) ($Z = 1.64, p < 0.10$) and (iv) ($Z = 4.96, p < 0.01$) reject the null hypotheses. In figure 2 (b), it can be seen that the DDS distributions in children and elderly are lower than those in adults with respect to the medians. We run a Mann-Whitney test with a null hypothesis that the DDS distributions between children and adults are the same. The following pairs are considered: (i) children' DDS vs adults' DDS (ii) elderly' DDS vs adults' DDS. We reject the case (i) ($Z = -4.61, p = 0.01$), implying that there is a distributional difference of DDS between children and adults. However, case (ii) ($Z = 1.59, p = 0.11$) does not reject.

[Figure 2 about here.]

The descriptive statistics, tests and diagrams suggest that the DDS varies among household members by their family roles and/or age groups. We run ordinary and two-level random intercept Poisson regressions to further characterize the relationships of DDS with the family role and age group dummies after controlling sociodemographic variables. Table 4 reports the estimated coefficients of the explanatory variables on DDS in the ordinary and two-level random intercept Poisson regressions with several model specifications, respectively. At first, we include the family role dummies with fathers as the base group in Model 1-1 (Model 2-1) in the ordinary Poisson regression (the two-level random intercept Poisson regression). Then, we exclude the family role dummies and include the age group dummies with adults as the base group in Model 1-2 (Model 2-2) in the ordinary Poisson regression (the two-level random intercept Poisson regression). Finally, we include all the independent variables, such as family role dummies, age group dummies and sociodemographic variables in Model 1-3 (Model 2-3) in the ordinary Poisson regression (the two-level random intercept Poisson regression), in addition to the base group specifications of Models 1-1 and 1-2 (Models 2-1 and 2-2) in table 4.

[Table 4 about here.]

Sociodemographic variables, such as father education, mother education, household poverty, area and total household earners, are identified to be statistically and economically significant in Model 1-3 (Model 2-3) in the ordinary Poisson regression (the two-level random intercept Poisson regression) (see table 4). The effects of father and mother educations are generally demonstrated to be positive on their household nutrition. In terms of the father education, the ordinary Poisson regression (the two-level random intercept Poisson regression) in Model 1-3 (Model 2-3) finds that the expected DDS increases by $0.7\,\%$ ($0.7\,\%$) per one-category increase in schooling. In case of the mother education, the expected DDS increases by $1\,\%$ ($1\,\%$) per one-category increase in schooling (see table 4). The results suggest that education is one of the important factors to improve dietary diversity at households, being consistent with Guldan et al. (1993), Borooah (2004), Huq and Tasnim (2008) and Fadare et al. (2019). Overall, we corroborate that there is a positive relationship between education and healthy food practices in intrahousehold settings.

The regression results of household poverty in Model 1-3 (Model 2-3) find that the expected DDS of poor is $15\,\%$ ($15\,\%$) lower than non-poor, holding other factors fixed. Household poverty is a dummy variable, therefore, we use the following formula to calculate the marginal effect of household poverty: $\exp(0.14) - 1 \approx 0.15 = 15\,\%$. The results indicate that poor people have lower dietary diversity than non-poor, being consistent with the past literature. Rabbani (2014) reports that poor families' foods are not diversified compared to non-poor families. Likewise, the results of area dummy in Model 1-3 (Model 2-3) can be interpreted. The expected DDS of rural subjects is calculated to be $12\,\%$ ($12\,\%$) lower than that of urban subjects (the marginal effect of the area dummy $= \exp(0.11) - 1 \approx 0.12 = 12\,\%$). The results demonstrate that dietary diversity of urban subjects is higher than that in rural subjects, being in line in literature. For instance, Bose and Dey (2007) show that consumption of non-cereal foods in urban areas is diversified as compared to rural areas. The number of total household earners has an effect on DDS, i.e., the ordinary Poisson regression (the two-level random intercept Poisson regression) in Model 1-3 (Model 2-3) estimates a $5\,\%$ ($5\,\%$) increase in the expected DDS per one-earner increase within the household. Bashir et al. (2010) also demonstrate the same result in a survey study, finding that the likelihood of being secured in food intake is likely to increase in a number of earners per household.

Models 1-3 and 2-3 examine the effects of family role and age group dummies on DDS in table 4, more precisely, controlling for other sociodemographic variables. The regression results of family role (age group) dummies in Model 1-3 (Model 2-3) do not differ from that of Model 1-1 (Model 2-1), confirming the consistency and robustness of our results. Family role and age group dummies are identified to be important determinants of DDS in both the ordinary and two-level random-intercept Poisson regressions, with $5\,\%$ statistical and economic significance. The ordinary Poisson regression (the two-level random intercept Poisson regression) estimation in Model 1-3 (Model 2-3) reveals that the expected DDS of grandfathers and grandmothers are $19\,\%$ and $14\,\%$ ($16\,\%$ and $13\,\%$) lower than those of fathers. The marginal effects of family role dummies are calculated by using the formula: $[\exp{(\hat{\alpha}_j - 1)}] \times 100$, $\hat{\alpha}_j$ is the estimated regression coefficient of the dummy variable. For example, $\exp(0.17) - 1 \approx 0.19 = 19\,\%$. Likewise, the results of age group dummies in Model 1-3 (Model 2-3) can be interpreted. The expected DDS of children is calculated to be $8\,\%$ ($6\,\%$) lower than those of adults. The marginal effects of the age group dummies are calculated by using the earlier mentioned formula (i.e., $\exp(0.08) - 1 \approx 0.08 = 8\,\%$). Consistent with the summary statistics, both regression estimations confirm that the inequality in food intake among household members and identify that grandparents and children are the vulnerable food intake subgroups within households.

In table 4, we notice that father and mother educations are important to uniformly raise the standard of dietary diversity for their household, however, they do not resolve the inequality. In addition, the cluster-specific effect is observed and significant in Models 2-1, 2-2 and 2-3 in the two-level random intercept Poisson regressions, meaning that subjects from different households with the same set of values and levels of the independent variables will show different DDS (see table 4). The magnitude of the cluster-specific effect is greater than the effects of some of the important explanatory variables in the models. For instance, the standard deviation of the random cluster-specific effect in Model 2-3 is 0.16, indicating one standard deviation change in the cluster-specific effect has a greater effect on DDS than household poverty ($\gamma_3 = -0.14$). In such a situation, the cluster-specific effect needs proper investigation for appropriate policy intervention. For example, household-specific characteristics, such as food practices, frequencies of the main meals, nutritionally balanced foods and father & mother nutritional awarenesses, could be given priority for the improvement of household dietary diversity practices.

Now, it is time to provide the answers to the following open research questions: (i) How do household members have different dietary diversity by their roles and/or age groups, depending on poverty level and areas of residence? The summary statistics, tests and diagram suggest that household members do not have equal dietary diversity by their family roles and/or age groups. The regression results further accomplish that household members have different DDSs after controlling for sociodemographic variables. Overall, it can be concluded that household members have different dietary diversity, confirming an existence of intrahousehold food intake inequality, irrespective of poverty level and areas of residence. Another research question is: (ii) Who are the vulnerable food intake subgroups within households? The regression results consistently show that grandparents (children) have lower dietary diversity than those of fathers (adults). This indicates that grandparents and children are the vulnerable subgroups in case of nutritional adequacy within households.

4 Discussion

Inequality in intrahousehold food intake is a major concern that promotes nutrient deficiencies and perpetuates the malnutrition problem (Rizvi, 1983, Engle and Nieves, 1993, Luo et al., 2001, Hadley et al., 2008, Akerele, 2011). Literature argues that family roles influence how people perceive and behave toward food and nutritional outcomes in a certain way (Boutelle et al., 2003, Therborn, 2004, Fulkerson et al., 2006, Chan and Sobal, 2011, Madjdian and Bras, 2016, Humphries et al., 2017). However, it is currently unknown about whether or not intrahousehold food intake inequality exists by the family roles and/or age groups. This research confirms intrahousehold food intake inequality and finds that grandparents and children are the vulnerable food intake subgroups within households. Now, it is time to answer "why do household members have significantly different food intakes?" We make the following two arguments to explain intrahousehold food intake inequality in Bangladesh. One is the "contribution rule" and another one is the "lack of mothers' nutritional knowledge."

Intrahousehold food intake inequality can be explained by using the "contribution rule." It describes a situation where household members who have contribution to the family are more likely to be favored for food and nutrition than others (Engle and Nieves, 1993, Luo et al., 2001). For example, an income earner receives a higher percentage of household food than do non-income earners (Pelto, 1983, Pitt et al., 1990). Another example is given by Bhalotra and Attfield (1998), describing that working males and boys are more advantaged in terms of intrahousehold food allocation than the dependent ones. According to the "contribution rule," it is considered that household heads and adults are favored in terms of food and nutrition, because they are the main sources of financial support and security to the household in the present and future time. On the other hand, grandparents and children are not favored, because they are considered to have no contribution to the household. We argue that the "contribution rule" implicitly remains as part of food cultures in Bangladesh, being applicable to explain an existence of intrahousehold food intake inequality. At the same time, we note that household members should have equal dietary diversity and receive a certain share of available foods in a well-balanced manner for the betterment of health in theory (Engle and Nieves, 1992, Dos-Santos, 2020).

A household woman, i.e, a mother, is the sole decision-maker of preparation, serving and allocation of food in Bangladesh. For allocating meals, mothers often underestimate calories and nutritional requirements of household members. In reality, it is very difficult to measure the relative size of dietary needs for every household member, especially for children and older people. Moreover, there are many misconceptions regarding nutritional knowledge. For example, one statement regarding nutrition is that children consume nearly one-fourth as much food as they require at adult life (Abdullah and Wheeler, 1985, Finaret et al., 2018). This type of perception may create difficulty to ensure equitable food intake within households. Appropriate allocation of food among household members is also related to mothers' attitudes, beliefs and perceptions (Engle and Nieves, 1992). Several studies document that mothers' nutritional knowledge is positively related to receive a good nutritious diet to the family members (Gibson et al., 1998, Block, 2004). If this is the case, we conjecture that lack of mothers' nutritional knowledge shall be responsible for intrahousehold food intake inequality. Therefore, it is recommended to specifically examine how mothers' nutritional awareness is related to intrahousehold food intake and take good nutritional care of household members.

The study has several implications in the field of research and policy formulation regardless of the developed and developing countries. Previous studies examine the levels and patterns of malnutrition. However, they often fail to take into account family roles and age effects on intra-household food intake. As a result, policymakers might have been misguided to take appropriate policies for eliminating the malnutrition problem. National health and nutrition policies always focus on the underprivileged population for improving nutritional status. Although females are reported to be disadvantaged in food allocation (Chen et al., 1981, Luo et al., 2001, Harris-Fry et al., 2018), this study does not find any gender difference in dietary diversity. The reason may be that the government of Bangladesh takes many actions regarding gender gap and inequality. We confirm that grandparents and children are the vulnerable groups in terms of food intake within households, therefore, it is necessary to focus on improving their dietary diversity. Father and mother educations have effects to uniformly raise dietary diversity for household members, but they do not resolve the intrahousehold inequality. Systematically organizing awareness programs of diversity practices at household level shall be necessary for the resolution of intrahousehold food intake inequality with a target of fathers and mothers for the betterment of nutritional and health status as well as contributing to SDGs.

5 Conclusion

We have examined dietary diversity scores (DDSs) of household members with a focus on their family roles (fathers, mothers, sons, daughters and grandparents) and age groups (children, adults and elderly). Whereas theory suggests that members in a household should have equal dietary diversity by receiving a certain share of available foods, this research hypothesizes that they do not to do so by their roles and/or age groups. We conduct questionnaire surveys, collecting sociodemographic information and dietary data using a 24-hour recall method of 3248 subjects in 811 households from one urban and two rural areas in Bangladesh. The study has three major findings: (i) Poor and rural people have lower dietary diversity than non-poor and urban people, respectively. (ii) Grandparents (children) have lower dietary diversity than do fathers (adults), confirming an existence of intrahousehold food intake inequality by the roles and/or age groups, irrespective of poverty level and areas of residence. (iii) Father and mother educations are crucial determinants to uniformly raise the standard of dietary diversity for their household, however, they do not resolve the inequality. Overall, we suggest that specific awareness and education programs of dietary diversity shall be necessary for resolving the inequality with a target group of fathers and mothers for the betterment of nutrition and health at household level, contributing to SDGs.

We list some limitations of our study and provide some guidelines for future research. First, we use a 24-hour recall method to calculate DDSs, while multiple dietary recalls including both weekdays and weekends may be considered an alternative way to have a good picture of the habitual food intake for household members. Second, applying a 24-hour recall method may suffer from reporting and recall biases. However, several studies mention that the DDS by using a 24-hour recall method is reliable enough to measure individual nutrient adequacy without being significantly biased (Food and Agriculture Organization, 2011, Headey and Ecker, 2013). Third, there may be additional determinants of DDSs, such as nutritional awareness, health and disease-related variables that are not included in this study. We could not collect the data due to several constraints we face with respect to time, subjects and budgets. More detailed data about multiple dietary recalls, nutrition, health and disease-related characteristics should be considered in the future studies, enabling us to have panel data to fully characterize intrahousehold food intake inequality. These caveats notwithstanding, it is our belief that the findings of our study are robust enough and become the first important step that quantitatively identifies intrahousehold food intake inequality including all household members by the family roles and/or age groups.

Acknowledgments

We would like to thank the anonymous referees, Makoto Kakinaka, Hiroaki Miyamoto, Kenta Tanaka, Yoshinori Nakagawa, Yuki Yanai, Raja Rajendra Timilsina, Mostafa Shahen and Pankaj Koirala for their helpful comments, advice and supports. The authors specially thank Moinul

Islam for his technical support on preparing the picture files for maps. We are also grateful to the financial support from the Japanese Society of the Promotion of the Science as the Grant-in-Aid for Scientific Research B (19H01485) and Kochi University of Technology.

References

Abdullah, M. and Wheeler, E. (1985). Seasonal variations, and the intra-household distribution of food in a Bangladeshi village. *American journal of clinical nutrition*, 41:1305–1313.

Akerele, D. (2011). Intra-household food distribution patterns and calorie inadequacy in south-western Nigeria. *International journal of consumer studies*, 35:545–551.

Ali, N., Tahsina, T., Hoque, D., Hasan, M., Iqbal, A., Huda, T., and Arifeen, S. (2019). Association of food security and other socio-economic factors with dietary diversity and nutritional statuses of children aged 6-59 months in rural Bangladesh. *PLoS ONE*, 14:e0221929.

Alom, J., Quddus, M., and Islam, M. (2012). Nutritional status of under-five children in Bangladesh: A multilevel analysis. *Journal of biosocial science*, 44:525–535.

Arimond, M., Wiesmann, D., Becquey, E., Carriquiry, A., Daniels, M., Deitchler, M., Fanou-Fogny, N., Joseph, M., Kennedy, G., Martin-Prevel, Y., and Torheim, L. (2010). Simple food group diversity indicators predict micronutrient adequacy of women's diets in 5 diverse, resource-poor settings. *Journal of nutrition*, 140:2059S–2069S.

Asma, K., Shahrier, S., and Kotani, K. (2021). Cooperation and cognition gaps for salinity: A field experiment of information provision in urban and rural areas of Bangladesh. *Journal of cleaner production*, 311:127562.

Aurino, E. (2017). Do boys eat better than girls in India? Longitudinal evidence on dietary diversity and food consumption disparities among children and adolescents. *Economics and human biology*, 25:99–111.

Bangladesh Bureau of Statistics (2018). District statistics. Technical report, Bangladesh Bureau of Statistics.

Barikdar, A., Ahmed, T., and Lasker, S. (2016). The situation of the elderly in Bangladesh. *Bangladesh journal of bioethics*, 7:27–36.

Bashir, M., Naeem, M., and Niazi, S. (2010). Rural and peri-urban food security: A case of district Faisalabad of Pakistan. *World applied sciences journal*, 9:403–411.

Bhalotra, S. and Attfield, C. (1998). Intrahousehold resource allocation in rural Pakistan: A semi-parametric analysis. *Journal of applied econometrics*, 13:463–480.

Block, S. (2004). Maternal nutrition knowledge and the demand for micronutrient-rich foods: Evidence from Indonesia. *Journal of development studies*, 40:82–105.

Borooah, V. (2004). Gender bias among children in India in their diet and immunisation against disease. *Social science and medicine*, 58:1719–1731.

Bose, M. and Dey, M. (2007). Food and nutritional security in Bangladesh: Going beyond carbohydrate counts. *Agricultural economics research review*, 20:203–225.

Boutelle, K., Birnbaum, A., Lytle, L., Murray, D., and Story, M. (2003). Associations between perceived family meal environment and parent intake of fruit, vegetables, and fat. *Journal of nutrition education and behavior*, 35:24–29.

Cameron, A. and Trivedi, P. (2013). *Regression analysis of count data*, volume 53. Cambridge university press.

Carloni, A. (1981). Sex disparities in the distribution of food within rural households. *Food and nutrition*, 7:3–12.

Chan, J. and Sobal, J. (2011). Family meals and body weight. Analysis of multiple family members in family units. *Appetite*, 57:517–524.

Chaudhury, R. (1988). Adequacy of child dietary intake relative to that of other family members. *Food and nutrition bulletin*, 10:26–34.

Chen, L., Huq, E., and D'Souza, S. (1981). Sex bias in the family allocation of food and health care in rural Bangladesh. *Population and development review*, 7:55–70.

Dos-Santos, L. (2020). Equitable food distribution and sustainable development. In Leal, F., Walter, A., Azul, A., Brandli, L., Özuyar, G., and Wall, T., editors, *Zero hunger. Encyclopedia of the UN sustainable development goals*, pages 1–9. Springer International Publishing.

Engle, P. and Nieves, I. (1992). Intra-household food distribution among Guatemalan families in a supplementary feeding programme: Mothers' perceptions. *Food and nutrition bulletin*, 14:1–11.

Engle, P. and Nieves, I. (1993). Intra-household food distribution among Guatemalan families in a supplementary feeding program: Behavior patterns. *Social science and medicine*, 36:1605–1612.

Fadare, O., Mavrotas, G., Akerele, D., and Oyeyemi, M. (2019). Micronutrient-rich food consumption, intra-household food allocation and child stunting in rural Nigeria. *Public health nutrition*, 22:444–454.

Fernández-Alvira, J., Mouratidou, T., Bammann, K., Hebestreit, A., Barba, G., Sieri, S., Reisch, L., Eiben, G., Hadjigeorgiou, C., Kovacs, E., Huybrechts, I., and Moreno, L. (2013). Parental education and frequency of food consumption in European children: The IDEFICS study. *Public health nutrition*, 16:487–498.

Finaret, A., Miller, L., Joshi, N., Mahato, S., Lohani, M., Drozdowsky, J., and Rogers, B. (2018). Longitudinal analysis of the intrahousehold distribution of foods in rural Nepal: Relative variability of child dietary quality across age and sex cohorts. *Food policy*, 79:101–110.

Food and Agriculture Organization (2011). Guidelines for measuring household and individual dietary diversity. Technical report, Food and Agriculture Organization.

Fulkerson, J., Neumark-Sztainer, D., and Story, M. (2006). Adolescent and parent views of family meals. *Journal of American dietetic association*, 106:526–532.

Gibson, L., Wardle, J., and Watts, C. (1998). Fruit and vegetable consumption, nutritional knowledge and beliefs in mothers and children. *Appetite*, 31:205–228.

Gittelsohn, J. (1991). Opening the box: Intrahousehold food allocation in rural Nepal. *Social science and medicine*, 33:1141–1154.

Goldstein, H. (2011). *Multilevel statistical models*. John Wiley and Sons.

Guldan, G., Zeitlin, M., Beiser, A., Super, C., Gershoff, S., and Datta, S. (1993). Maternal education and child feeding practices in rural Bangladesh. *Social science and medicine*, 36:925–935.

Hadley, C., Lindstrom, D., Tessema, F., and Belachew, T. (2008). Gender bias in the food insecurity experience of Ethiopian adolescents. *Social science and medicine*, 66:427–438.

Harris-Fry, H., Paudel, P., Shrestha, N., Harrisson, T., Beard, B., Jha, S., Shrestha, B., Manandhar, D., Costello, A., Cortina-Borja, M., and Saville, N. (2018). Status and determinants of intra-household food allocation in rural Nepal. *European journal of clinical nutrition*, 72:1524–1536.

Headey, D. and Ecker, O. (2013). Rethinking the measurement of food security: From first principles to best practice. *Food security*, 5:327–343.

Household Income and Expenditure Survey (2017). Description of the official methodology used for poverty estimation in Bangladesh for 2016/17. Technical report, The World Bank.

Humphries, D., Dearden, K., Crookston, B., Woldehanna, T., Penny, M., and Behrman, J. (2017). Household food group expenditure patterns are associated with child anthropometry at ages 5, 8 and 12 years in Ethiopia, India, Peru and Vietnam. *Economics and human biology*, 26:30–41.

Huq, M. and Tasnim, T. (2008). Maternal education and child healthcare in Bangladesh. *Maternal and child health journal*, 12:43–51.

Imam, M., Islam, M., and Hossain, M. (2018). Factors affecting poverty in rural Bangladesh: An analysis using multilevel modelling. *Journal of Bangladesh agricultural university*, 16:123–130.

Islam, M. and Nath, D. (2012). A future journey to the elderly support in Bangladesh. *Journal of anthropology*, 2012:6.

Islam, M., Rahman, S., Tarafder, C., Rahman, M., Rahman, A., and Ekström, E. (2020). Exploring rural adolescents' dietary diversity and its socioeconomic correlates: A cross-sectional study from Matlab, Bangladesh. *Nutrients*, 12:2212–2230.

Jayawardena, R., Byrne, N., Soares, M., Katulanda, P., Yadav, B., and Hills, A. (2013). High dietary diversity is associated with obesity in Sri Lankan adults: An evaluation of three dietary scores. *BMC public health*, 13:314.

Keino, S., Plasqui, G., and Borne, B. (2014). Household food insecurity access: A predictor of overweight and underweight among Kenyan women. *Agriculture and food security*, 3:2.

Leroy, J., Ruel, M., Frongillo, E., Harris, J., and Ballard, T. (2015). Measuring the food access dimension of food security: A critical review and mapping of indicators. *Food and nutrition bulletin*, 36:167–195.

Luo, W., Zhai, F., Jin, S., and Ge, K. (2001). Intrahousehold food distribution: A case study of eight provinces in China. *Asia Pacific journal of clinical nutrition*, 10:19–28.

Madjdian, D. (2018). Gender, intra-household food allocation and social change in two Himalayan communities in Nepal. In Niehof, A., Gartaula, H., and Quetulio-Navarra, M., editors, *Diversity and change in food wellbeing: Cases from southeast Asia and Nepal*, chapter 8, pages 153–175. Wageningen Academic Publishers.

Madjdian, D. and Bras, H. (2016). Family, gender, and women's nutritional status: A comparison between two Himalayan communities in Nepal. *Economic history of developing regions*, 31:198–223.

Messer, E. (1997). Intra-household allocation of food and health care: Current findings and understandings-introduction. *Social science and medicine*, 44:1675–1684.

Mohajan, H. (2014). Child rights in Bangladesh. *Journal of social welfare and human rights*, 2:207–238.

Nelson, M. (1986). The distribution of nutrient intake within families. *British journal of nutrition*, 55:267–277.

Pelto, G. (1983). Intrahousehold food distribution patterns. In *Malnutrition: Determinants and consequences*, volume 10, pages 285–293. Emerald Group Publishing Limited.

Pitt, M., Rosenzweig, M., and Hassan, M. (1990). Productivity, health, and inequality in the intrahousehold distribution of food in low-income countries. *American economic review*, 80:1139–1156.

Ponce, X., Ramirez, E., and Delisle, H. (2006). A more diversified diet among Mexican men may also be more atherogenic. *Journal of nutrition*, 136:2921–2927.

Rabbani, A. (2014). Household food security in Bangladesh: Going beyond poverty measures. *Bangladesh development studies*, 37:103–125.

Rabe-Hesketh, S. and Skrondal, A. (2008). *Multilevel and longitudinal modeling using Stata*. STATA Press.

Rizvi, N. (1983). Effects of food policy on intrahousehold food distribution in Bangladesh. *Food and nutrition bulletin*, 5:1–6.

Ruel, M. (2003). Operationalizing dietary diversity: A review of measurement issues and research priorities. *Journal of nutrition*, 133:3911S–3926S.

Sassi, S., Abassi, M., Traissac, P., Gharbia, H., Gartner, A., Delpeuch, F., and Ati, J. (2019). Intra-household double burden of malnutrition in a north African nutrition transition context: Magnitude and associated factors of child anaemia with mother excess adiposity. *Public health nutrition*, 22:44–54.

Shahrier, S., Kotani, K., and Saijo, T. (2017). Intergenerational sustainability dilemma and the degree of capitalism in societies: A field experiment. *Sustainability science*, 12:957–967.

Singh, N. (2019). Gender, intra-household discrimination and cash transfer schemes: The case of Indian Punjab. *Economies*, 7:75.

Therborn, G. (2004). *Between sex and power: Family in the world 1900-2000*. Routledge.

Wheeler, E. (1991). Intra-household food and nutrient allocation. *Nutrition research reviews*, 4:69–81.

Wooldridge, J. (2019). *Introductory econometrics*. South-Western College Publishing.

List of Figures

Figure 1: Location of study areas in Bangladesh

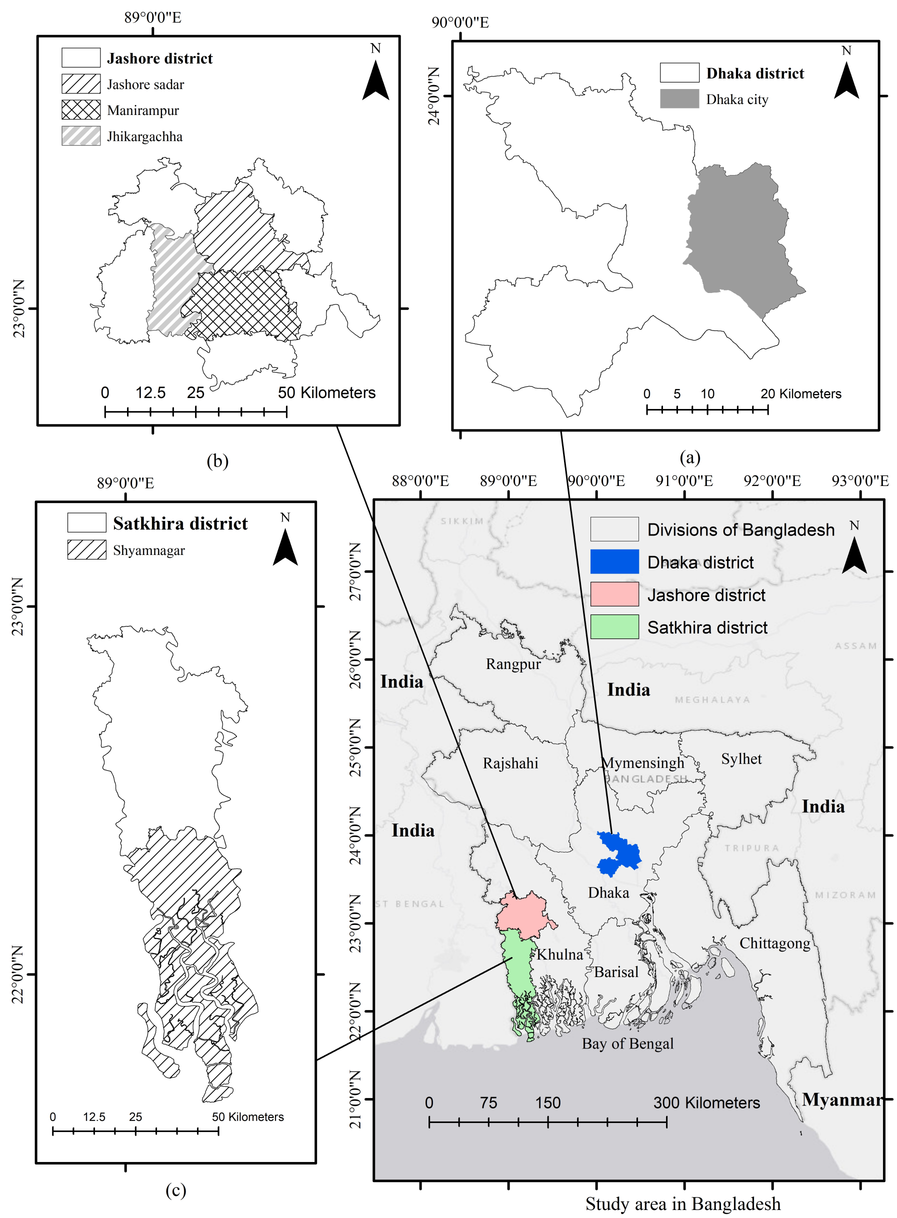
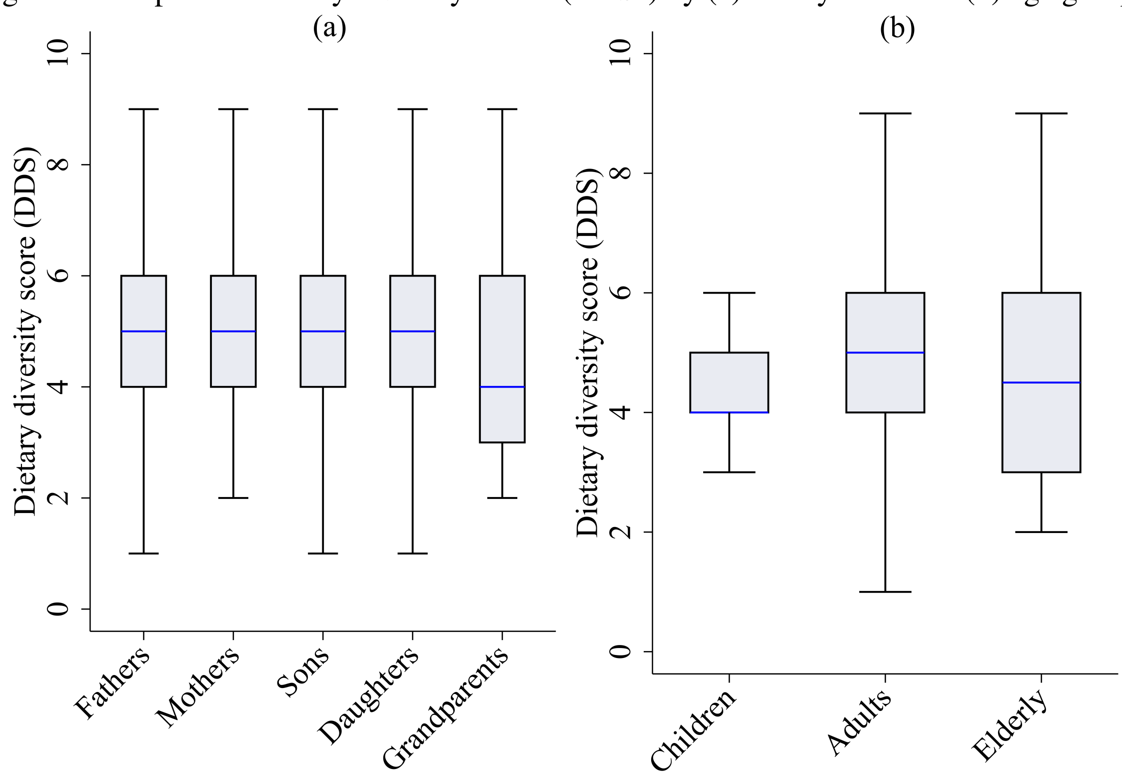


Figure 2: Boxplots of dietary diversity scores (DDSs) by (a) family roles and (b) age groups



List of Tables

Table 1: Definitions of variables

Variables	Description
Dependent variable	
Dietary diversity score (DDS)	Dietary diversity score is defined as a count variable that takes values from 0 to 9 based on the number of food groups consumed over a 24-hours period.
Independent variables	
Family role dummy variables (Base group = Fathers)	
Mothers	Fathers 0 and Mothers 1.
Sons	Fathers 0 and Sons 1.
Daughters	Fathers 0 and Daughters 1.
Grandparents	Fathers 0 and Grandparents 1.
Age group dummy variables (Base group = Adults)	
Children	Adults 0 and Children 1.
Elderly	Adults 0 and Elderly 1.
Sociodemographic variables	
Father education	Years of schooling 0 to 14 (0 = No schooling and refused group [1]; 1 = Class one, 2 = Class two, 3 = Class three, 4 = Class four, 5 = Class five, 6 = Class six, 7 = Class seven, 8 = Class eight, 9 = Class nine, 10 = SSC/equivalent, 11 = Eleven class/equivalent, 12 = HSC/equivalent, 13 = Graduate/equivalent, 14 = Post graduate/equivalent).
Mother education	Years of schooling 0 to 14 (0 = No schooling and refused group [1]; 1 = Class one, 2 = Class two, 3 = Class three, 4 = Class four, 5 = Class five, 6 = Class six, 7 = Class seven, 8 = Class eight, 9 = Class nine, 10 = SSC/equivalent, 11 = Eleven class/equivalent, 12 = HSC/equivalent, 13 = Graduate/equivalent, 14 = Post graduate/equivalent).
Household poverty	Non-poor 0 and Poor 1.
Area	Urban 0 and Rural 1.
Total household earners	Numbers.
Occupation of the household head	Non-agriculture 0 and Agriculture 1.
Religion	Non-Muslim 0 and Muslim 1.
Family structure	Nuclear family 0 and Extended family 1.
Household eating practices	Takes the value 1 when household members eat together, otherwise 0.

[1] The subjects who do not provide their educational qualification is refused group. We merge refused group with no schooling because most of the uneducated people refused to provide their educational level.

Table 2: Summary statistics of the dependent variable by family roles

	Family roles					Overall
	Fathers	Mothers	Sons	Daughters	Grandparents	
Dietary diversity score (DDS)						
Average (Median) [1]	5.00 (5.00)	4.92 (5.00)	4.93 (5.00)	4.74 (5.00)	4.44 (4.00)	4.88 (5.00)
SD [2]	1.62	1.60	1.54	1.50	1.48	1.57
Starchy staples						
Average (Median)	0.99 (1.00)	0.99 (1.00)	0.99 (1.00)	0.99 (1.00)	0.98 (1.00)	0.99 (1.00)
SD	0.06	0.04	0.04	0.07	0.11	0.06
Dark green leafy vegetables						
Average (Median)	0.72 (1.00)	0.71 (1.00)	0.69 (1.00)	0.65 (1.00)	0.68 (1.00)	0.69 (1.00)
SD	0.45	0.45	0.46	0.48	0.47	0.46
Other vitamin A rich fruits & vegetables						
Average (Median)	0.78 (1.00)	0.78 (1.00)	0.77 (1.00)	0.73 (1.00)	0.77 (1.00)	0.77 (1.00)
SD	0.42	0.41	0.42	0.44	0.42	0.42
Other fruits & vegetables						
Average (Median)	0.30 (0.00)	0.28 (0.00)	0.30 (0.00)	0.29 (0.00)	0.18 (0.00)	0.29 (0.00)
SD	0.46	0.45	0.46	0.45	0.38	0.45
Organ meat						
Average (Median)	0.35 (0.00)	0.35 (0.00)	0.34 (0.00)	0.31 (0.00)	0.30 (0.00)	0.34 (0.00)
SD	0.48	0.48	0.47	0.46	0.46	0.47
Meat & fish						
Average (Median)	0.71 (1.00)	0.70 (1.00)	0.71 (1.00)	0.65 (1.00)	0.71 (1.00)	0.69 (1.00)
SD	0.45	0.46	0.45	0.48	0.45	0.46
Eggs						
Average (Median)	0.39 (0.00)	0.37 (0.00)	0.36 (0.00)	0.41 (0.00)	0.29 (0.00)	0.38 (0.00)
SD	0.49	0.48	0.48	0.49	0.46	0.48
Legumes, nuts & seeds						
Average (Median)	0.52 (1.00)	0.51 (1.00)	0.52 (1.00)	0.47 (0.00)	0.42 (0.00)	0.50 (1.00)
SD	0.50	0.50	0.50	0.50	0.49	0.50
Milk & milk products						
Average (Median)	0.23 (0.00)	0.22 (0.00)	0.25 (0.00)	0.23 (0.00)	0.10 (0.00)	0.23 (0.00)
SD	0.42	0.41	0.43	0.42	0.31	0.42
Sample size	798	802	799	686	163	3248

[1] Median in parentheses.
[2] SD stands for standard deviation.

Table 3: Summary statistics of the dependent and independent variables by areas

	Area		Overall	p-value
	Urban	Rural		
Dietary diversity score				
Average (Median)[1]	5.61 (6.00)	4.63 (4.00)	4.88 (5.00)	
SD[2]	1.78	1.40	1.57	0.01[3]
Family role dummies (Base group = Fathers)				
Mothers				
Average (Median)	0.26 (0.00)	0.24 (0.00)	0.25 (0.00)	
SD	0.44	0.43	0.43	0.27[4]
Sons				
Average (Median)	0.26 (0.00)	0.24 (0.00)	0.25 (0.00)	
SD	0.44	0.43	0.43	0.48[4]
Daughters				
Average (Median)	0.19 (0.00)	0.22 (0.00)	0.21 (0.00)	
SD	0.40	0.41	0.41	0.18[4]
Grandparents				
Average (Median)	0.03 (0.00)	0.06 (0.00)	0.05 (0.00)	
SD	0.17	0.23	0.22	0.01[4]
Age group dummies (Base group = Adults)				
Children				
Average (Median)	0.17 (0.00)	0.22 (0.00)	0.21 (0.00)	
SD	0.38	0.41	0.41	0.01[4]
Elderly				
Average (Median)	0.03 (0.00)	0.05 (0.00)	0.04 (0.00)	
SD	0.16	0.21	0.20	0.02[4]
Father education				
Average (Median)	10.55 (12.00)	6.04 (7.00)	7.19 (8.00)	
SD	3.96	4.47	4.77	0.01[4]
Mother education				
Average (Median)	9.60 (11.00)	5.99 (7.00)	6.91 (8.00)	
SD	4.11	4.01	4.33	0.01[4]
Household poverty (Base group = Non-poor)				
Average (Median)	0.05 (0.00)	0.22 (0.00)	0.17 (0.00)	
SD	0.22	0.41	0.38	0.01[4]
Total household earners				
Average (Median)	1.51 (1.00)	1.40 (1.00)	1.42 (1.00)	
SD	0.66	0.63	0.64	0.01[3]
Occupation of the household head (Base group = Non-agriculture)				
Average (Median)	0.00 (0.00)	0.41 (0.00)	0.30 (0.00)	
SD	0.00	0.49	0.46	0.01[4]
Religion (Base group = Non-Muslim)				
Average (Median)	0.90 (1.00)	0.87 (1.00)	0.88 (1.00)	
SD	0.30	0.34	0.33	0.01[4]
Family structure (Base group = Nuclear family)				
Average (Median)	0.19 (0.00)	0.30 (0.00)	0.27 (0.00)	
SD	0.40	0.46	0.44	0.01[4]
Household eating practices (Base group = Others)				
Average (Median)	0.68 (1.00)	0.85 (1.00)	0.80 (1.00)	
SD	0.47	0.36	0.40	0.01[4]
Sample size	831	2417	3248	

[1] Median in parentheses.
[2] SD stands for standard deviation.
[3] Mann-Whitney test is applied to check a distributional difference of the variable between urban and rural areas.
[4] Chi-square test is applied to examine whether or not the frequencies of the variables are independent of urban and rural areas.

Table 4: Regression coefficients of the independent variables on DDS in the ordinary Poisson and two-level random intercept Poisson regressions

	Ordinary Poisson regression			Two-level random intercept Poisson regression		
	Model 1-1	Model 1-2	Model 1-3	Model 2-1	Model 2-2	Model 2-3
Family role dummies (Base group = Fathers)						
Mothers	−0.02		−0.01	−0.02		−0.01
Sons	−0.01		0.03	−0.02		0.01
Daughters	−0.05**		0.01	−0.04*		0.003
Grandfathers	−0.13**		−0.17**	−0.12*		−0.15**
Grandmothers	−0.11**		−0.13**	−0.10**		−0.12**
Age group dummies (Base group = Adults)						
Children		−0.07***	−0.08***		−0.05**	−0.06**
Elderly		−0.04	0.07		−0.04	0.05
Sociodemographic variables						
Father education			0.007***			0.007***
Mother education			0.01***			0.01***
Household poverty (Base group = Non-poor)			−0.14***			−0.14***
Area (Base group = Urban)			−0.11***			−0.11***
Total household earners			0.05***			0.05***
Occupation of the household head (Base group = Non-agriculture)			0.03			0.03
Religion (Base group = Non-Muslim)			−0.001			0.003
Family structure (Base group = Nuclear family)			0.01			0.01
Household eating practices (Base group = Others)			0.02			0.02
Observations	3248	3248	3248	3248	3248	3248
Groups: Household	-	-	-	811	811	811
Random effect (SD[1]) : Household	-	-	-	0.20***	0.20***	0.16***
Likelihood-Ratio/Wald χ^2	12.51**	14.04***	258.02***	7.98	6.58**	172.80***
AIC[2]	12686.37	12678.85	12464.45	12511.65	12507.10	12384.42

***significant at the 1 percent level, **at the 5 percent level and *at the 10 percent level.
[1] SD stands for standard deviation.
[2] AIC stands for Akaike information criterion.