Food Consumption Patterns and Predictors of Dietary Diversity in Pastoral Communities of Ngorongoro District, Tanzania

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Abstract: The aim of this study was to assess the patterns of household food consumption and examine the factors influencing dietary diversity. Data were collected from 238 randomly selected households. Food consumption was assessed in terms of Dietary Diversity Score (DDS) with a range of 0-12. The minimum and maximum DDS were one and eight, respectively. Groups of food consumed were classified into four Quantiles (Q) and households were categorized based on quartile cut-points: Q1 (1-3 DDS), Q2 (4), Q3 (5-6) and Q4 (7-8). Chi square test was used to assess the association between the food groups and quartile level. Ordered probit regression was employed to examine determinants for household dietary diversity. Results show that more than four in ten households (43.3%) consumed less than the minimum recommended four groups of food. Proportions of households consistently decreased with increasing quartile level (43.3% in Q1 to 6.7% in Q4). Only 18% of the households were in the upper quartiles (Q3 and Q4). The DDS means by quartiles were 2.47 (Q1), 4.00 (Q2), 5.00 (Q3) and 5.89 (Q4) with the overall mean DDS of 3.52. While cereal (96.2% of the households) was the most consumed food group, there was limited consumption of vegetables (12.6%), fruits (4.2%) and fish (2.9%). Food accessibility and livelihood diversification were the major determinants of dietary diversity. Demographic and socio-economic factors mediated household’s dietary diversity at varying degree of influence.

Keywords: Dietary diversity, dietary quality, food security, Maasai, ordered probit, pastoralism

INTRODUCTION

Food insecurity and micronutrient malnutrition are widespread public health problems that can be alleviated in part through increasing dietary diversity (Harris-Fry et al., 2015; Mphwanthe et al., 2018; Larson et al., 2019). Dietary Diversity Score (DDS), a qualitative measure of food consumption, has become a widely used method of determining variety in the diet and by proxy, nutrient adequacy (Labadarios et al., 2011; Arsenault et al., 2013; Martin-Prével et al., 2015). It measures the consumption of different food groups by any member of a given household over a reference period and used as an indicator of food security (Galié et al., 2019).

Studies show that higher DDS is positively associated with an increased nutrient intake, better nutritional status, dietary quality, food security and the overall wellbeing (Vandevijvere et al., 2010; Nti, 2011; Lo et al., 2012; Hooshmand and Udiip, 2013; Ares et al., 2014; Mekuria et al., 2017). Conversely, an emerging body of literature shows that low diversity in diets is associated with increased risk of chronic undernutrition and micro-nutrient deficiencies with particular concerns in young children and elderly people (Rah et al., 2010). Negative health consequences of low dietary diversity include cognitive impairment (Lv et al., 2019), child stunting (Mahmudiono et al., 2017), cardiovascular risk (Farhangi and Jahangiry, 2018), dyslipidemia (Li et al., 2011), higher probability of metabolic syndrome (Gholizadeh et al., 2018) and higher risk of mortality (Lv et al., 2019; Gebremedhin et al., 2017).

Indeed, DDS has been identified as a key indicator for surveillance of actions that aim to tackle various nutrition-related problems and food insecurity (Workicho et al., 2016). It provides information on the contribution of different food groups to the diet which sheds light on its quality and nutrient adequacy in a population. DDS varies across population groups, cultures and socio-economic levels (Keding et al., 2012; Powell et al., 2015; Kasimba et al., 2018). Further, it has been documented that there can be positive, neutral or even negative associations between agricultural production and dietary diversity (Sibhatu et al., 2015; Ickowitz et al., 2019). The varying nature...
between the production system and diets, points to the need for contextualizing site-specific linkages between the mode of livelihood and dietary diversity (Ritzema et al., 2019).

Pastoralism, a focus of this study, is itself an agricultural production system characterized by mobility of animals, with more than 50% of household gross revenue from livestock or livestock related activities (FAO, 2001). While literature finds a generally more food secure situation in most parts of Tanzania, there are reports indicating high level of persistent food insecurity among pastoralists (Yanda and William, 2010; Kneppel et al., 2010; Coulibaly et al., 2015). There are also records that pastoral areas are more prone to malnutrition (Loos and Zeller, 2014; Galvin et al., 2015). Climate variability, cattle diseases and unpredictable markets have been reported as important causes of food insecurity in these communities (Misiak et al., 2018). It is further noted that poverty and malnutrition, stemming from historical determinants of land access and land tenure, are compounded by deterioration of pastures and other aspects of the biophysical environment associated with integration of pastoralists into the market economy (Oyie et al., 2009; Lynn, 2010; Rufino et al., 2013). At the face of the nutritional related challenges in pastoral areas, information on food consumption patterns and dietary diversity is rather limited. Evaluating food consumption patterns and associated factors will inform the various nutritional initiatives in the country. Thus, the aim of this study was to assess the patterns of household food consumption and examine the factors influencing dietary diversity in pastoral communities.

**METHODOLOGY**

**Study area:** The data presented in this study were derived from an empirical cross sectional study which was conducted in July, 2019 in pastoral communities of Ngorongoro District in Northern Tanzania. Data were collected from the inhabitants of Maasai villages (bomas) located around Nainokanoka Ward in the Ngorongoro Conservation Area (NCA). Specifically, the study was conducted in three purposively selected villages; Nainokanoka, Erkeepusi and Bulati. The Maasai people form the dominant tribe in these villages whose main livelihood activity is transhumance livestock keeping of cattle, goats and sheep. To preserve wildlife, the Maasai of Ngorongoro are prohibited to cultivate in the NCA. Traditionally, the Maasai are semi-nomadic pastoralists who migrate within semi-arid lowlands and more humid uplands to obtain water and pasture for their livestock. This semi-arid area experiences seasonal rainfall, with wet seasons falling between April and May and between November and December. The average annual rainfall ranges from 500 to 1700 mm. The area faces limited water supply with acute shortages for several months a year.

**Data collection:** Sample size estimation was performed using a formula \( z^2 = p (1 - p)/d^2 \) (Cochran, 1977); where; \( z^2 \) = critical value (1.96 for 95% confidence level); \( p \) = percentage of households consuming the minimum diverse diet (0.5 was used in order to maximize sample size); \( d \) = maximum error and a design effect of 2. A total of 194 households had to be included for a statistical representative sample. An additional 44 households were selected to provide for possible dropout or non-response incidences. Thus, the final sample consisted of 238 randomly selected households. Informed verbal consent was obtained from the study participants before proceeding with interviews. The study involved use of questionnaires which were initially prepared in English. However, interviews were conducted in native language Maa and later translated back to English. Household DDS was assessed as described in Kant et al. (1993) which involves asking respondents to recall all the dishes they had consumed the previous 24 h. DDS is a common indicator that counts the number of food groups consumed at least once in a period of 24 h (Steyn et al., 2014). Food items were classified into 12 different food groups as proposed by the Food and Agriculture Organization of the United Nations (FAO, 2011). These were cereals, tubers, legumes, meat, eggs, vegetables, fruits, oil, sweets, milk, fish and sugar or honey. Each food group counted toward the household score adding “1” if any family member consumed a food item from the group. Dietary diversity score was constructed by adding up the number of food groups represented in the diet of the previous 24 h. Possible minimum and maximum household dietary diversity scores were 0 and 12, respectively.

Potential factors influencing household dietary diversity were inquired. The factors included age of the household head, sex of the household head, education level of the household head, household size, age distribution of the household members, the household main economic activity, type and number of livestock and distance to the nearest road and to the market. Others were those related to food availability, food access and average number of meals per day in the previous 30 days. Food availability was measured in terms of Months of Adequate Food Provisioning (MAHFP) score with a range of 0-12. MAHFP is defined as the number of months per year that households report no food shortages (Bilinsky and Swindale, 2010). Presence or lack of food storage facility was used as a proxy indicator of food availability. Household Food Insecurity Access Scale (HFIAS) score with a range of 0-27 was measured based on the frequency of occurrence of food insecurity related conditions as described in food security
indicator guideline (Coates et al., 2007). Households were then categorized as food secure if HFIAS<17 or food insecure if HFIAS≥17 (FAO, 2008).

**Theoretical framework:** The fundamental objective of this study was to analyze food consumption and examine the predictors of dietary diversity. In this regard, food consumption was assumed to be an outcome of a given set of food attributes and individual preferences (Otieno and Nyikal, 2017). Thus, food consumption patterns can be modeled as a consumer utility problem which is hypothesized to be a function of various factors including socio-economic characteristics as well as nutritional attributes of food (Rimal et al., 2000; Pritchard et al., 2019; Muricho et al., 2019). Following the work of Lancaster (1966), the amount of the nutritional attribute an individual derives is the sum of each attribute of food group consumed by the household during a given reference period. This amount can be represented as 

\[ F_p = \sum_i \delta_{pi} X_i, \]

whereby \( F_p \) is the amount of \( p \)th nutritional attribute of \( F \), \( \delta_{pi} \) is the unit of \( F_p \) in food \( i \) and \( X_i \) is quantity of food \( i \) consumed. However, as highlighted earlier, the consumption of a particular food is also influenced by socio-economic characteristics. Thus, an individual’s consumption pattern is directly reflected in the maximized utility function denoted as:

\[ U_j^* = \beta' X_j + \mu_i \]  (1)

where,

- \( U_j^* \): The utility level attained by the \( j^{th} \) household
- \( X_j \): A vector of explanatory variables including household demographics, socio-economic characteristics and food related attributes
- \( \mu_i \): The independently, identically and normally distributed error term

From (1), the utility level attained by the \( j^{th} \) household \( (U_j^*) \) is not observed (latent variable). What is observed is the indicated dietary diversity score that reflects nutritional attributes attained by consuming specific food groups. Basically, choice models such as logit or probit are suitable for estimating the utility functions (Smale et al., 2015; Gomez et al., 2015; Hirvonen et al., 2017). Because the variable dietary diversity has a natural ordering, an ordered probit model was considered in estimating the utility function on the ground that this model would give better and unbiased results (Fetai et al., 2015; Ziegler, 2019; Muraoka et al., 2018; Muricho et al., 2019). An ordered probit is a generalization of the probit analysis of the case of more than two outcomes of an ordinal dependent variable. In the analysis, the dietary diversity scores were categorized in Quantiles \( (Q) \) such that: \( Q_1 = 1-3 \) food groups; \( Q_2 = 4 \); \( Q_3 = 5-6 \) and \( Q_4 =7-8 \) with \( \alpha_i \) threshold. These categories can be represented in Eq. (2)-(5) as follows:

\[ Q = 1, \ \text{if} \ U_j^* \leq \alpha_1 \]  (2)
\[ Q = 2, \ \text{if} \ \alpha_1 < U_j^* \leq \alpha_2 \]  (3)
\[ Q = 3, \ \text{if} \ \alpha_2 < U_j^* \leq \alpha_3 \]  (4)
\[ Q = 4, \ \text{if} \ \alpha_3 < U_j^* \]  (5)

**Data analysis:** Data were encoded and analysed using Stata statistical software (version 13). The respondents were categorized according to the cut-points of DDS in quartiles Q1, Q2, Q3 and Q4. Household distribution of consumption of food groups and DDS quartiles were analysed using Pearson’s Chi-square test. To test for collinearity between variables, data were subjected to analysis of Variance Inflation Factors (VIFs). The VIF indicates whether a predictor has a strong linear relationship with the other predictor(s). Analysis showed low values of VIFs ranging between 1.02 and 2.13. Variables were, therefore, statistically valid for inclusion in the model as they were all <10 (Myers, 1990; Field, 2013).

The dependent factors were ordinal variables ranked as Q1, Q2, Q3 and Q4. Independent variables included a set of categorical variables. A binary variable was denoted “1” if age of the household head is above 35, sex of the household head is male, household head attended school, household diversified livelihood activities (petty business and beekeeping), owned food storage facility, had membership to a saving group and was categorized as food insecure. Others were continuous variables which included household size, dependency ratio, Total Livestock Unit (TLU), MAHFP, distance to the nearest road and to the market. Dependency ratio was defined as the number of dependent elderly over 65 years of age relative to the number of working aged adults in the household (Coates et al., 2018). Variables that showed wide variation among households were log transformed. Marginal effects were calculated as a discrete change from 0-1 for dummy variables and at means for continuous variables.

**RESULTS**

**Characteristics of the study participants:** Results in Table 1 show that majority of respondents (61.3%) were above 35 years of age, male (82.3%) and had not attended formal education (61.7%). The average household size was 6.6. The main economic activities were pastoralism only (52.5% of the households),
### Table 1: Summary statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>N (%)</th>
<th>Mean DDS</th>
<th>S.E.</th>
<th>95% C.I</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Household demographics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤35</td>
<td>92</td>
<td>38.7</td>
<td>0.11</td>
<td>3.18 3.63</td>
</tr>
<tr>
<td>&gt;35</td>
<td>146</td>
<td>61.3</td>
<td>0.09</td>
<td>3.39 3.76</td>
</tr>
<tr>
<td><strong>Sex of household head</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>196</td>
<td>82.3</td>
<td>0.08</td>
<td>3.36 3.67</td>
</tr>
<tr>
<td>Female</td>
<td>42</td>
<td>17.7</td>
<td>0.17</td>
<td>3.15 3.87</td>
</tr>
<tr>
<td><strong>Attended school</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>91</td>
<td>38.3</td>
<td>0.11</td>
<td>3.52 3.97</td>
</tr>
<tr>
<td>No</td>
<td>147</td>
<td>61.7</td>
<td>0.09</td>
<td>3.19 3.55</td>
</tr>
<tr>
<td><strong>Household size, mean = 6.6</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>235</td>
<td>100</td>
<td>0.77</td>
<td>3.39 3.70</td>
</tr>
<tr>
<td><strong>Household dependency ratio, mean = 0.3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>236</td>
<td>100</td>
<td>0.07</td>
<td>3.39 3.66</td>
</tr>
<tr>
<td><strong>Household economic activities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pastoralism only</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pastoralism and petty business</td>
<td>80</td>
<td>33.6</td>
<td>0.12</td>
<td>3.53 4.02</td>
</tr>
<tr>
<td>Pastoralism and beekeeping</td>
<td>33</td>
<td>13.9</td>
<td>0.15</td>
<td>3.63 4.24</td>
</tr>
<tr>
<td><strong>Livestock holding, mean TLU = 44</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>238</td>
<td>100</td>
<td>0.07</td>
<td>3.37 3.66</td>
</tr>
<tr>
<td><strong>Household location</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance to road, mean = 11.4 km</td>
<td>238</td>
<td>100</td>
<td>0.07</td>
<td>3.37 3.66</td>
</tr>
<tr>
<td>Distance to market, mean = 12.5 km</td>
<td>234</td>
<td>100</td>
<td>0.07</td>
<td>3.35 3.64</td>
</tr>
<tr>
<td><strong>Household food related characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAHFP, mean = 6.8 months</td>
<td>238</td>
<td>100</td>
<td>0.07</td>
<td>3.37 3.66</td>
</tr>
<tr>
<td><strong>Food storage facility</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>155</td>
<td>65.1</td>
<td>0.08</td>
<td>3.60 3.93</td>
</tr>
<tr>
<td>Absent</td>
<td>83</td>
<td>34.9</td>
<td>0.12</td>
<td>2.81 3.26</td>
</tr>
<tr>
<td><strong>HFIAS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secure</td>
<td>105</td>
<td>44.2</td>
<td>0.10</td>
<td>3.77 4.18</td>
</tr>
<tr>
<td>Insecure</td>
<td>133</td>
<td>55.8</td>
<td>0.14</td>
<td>2.96 3.31</td>
</tr>
<tr>
<td><strong>Meals/day</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two times</td>
<td>113</td>
<td>48.3</td>
<td>0.09</td>
<td>3.08 3.47</td>
</tr>
<tr>
<td>Three times</td>
<td>121</td>
<td>51.7</td>
<td>0.09</td>
<td>3.57 3.94</td>
</tr>
<tr>
<td><strong>Quartile (Q) of DDS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1</td>
<td>103</td>
<td>43.3</td>
<td>0.06</td>
<td>2.33 2.60</td>
</tr>
<tr>
<td>Q2</td>
<td>92</td>
<td>38.7</td>
<td>0.05</td>
<td>3.89 4.10</td>
</tr>
<tr>
<td>Q3</td>
<td>27</td>
<td>11.3</td>
<td>0.09</td>
<td>4.79 5.20</td>
</tr>
<tr>
<td>Q4</td>
<td>16</td>
<td>6.7</td>
<td>0.15</td>
<td>5.57 6.20</td>
</tr>
<tr>
<td><strong>All</strong></td>
<td>238</td>
<td>100</td>
<td>0.07</td>
<td>3.37 3.66</td>
</tr>
</tbody>
</table>

DDS: Dietary diversity score; S.E.: Standard error; C.I.: Confidence interval; TLU: Tropical livestock unit computed on conversion factors of 0.7 and 0.1 for cattle and sheep/goat, respectively (FAO, 1979); HFIAS: Household food insecurity access scale; MAHFP: Months of adequate household food provisioning; Quantiles: 1, 2, 3, 4 represent dietary diversity scores 1-3, 4, 5-6 and 7-8, respectively

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**Fig. 1:** Distribution of dietary diversity scores by household main economic activities
pastoralism and petty business (33.6%) and pastoralism and beekeeping (13.9%). Households exclusively dependent on pastoralism had the least score of dietary diversity. Engaging in petty business or beekeeping resulted in increased mean dietary diversity as depicted in Fig. 1. Households in the study areas are sparsely located with the average of 11.4 and 12.5 km to the road and to the nearest market, respectively. The average Months of Adequate Food Provisioning was 6.8. The HFIAS results showed that over half of the households (55.8%) were food insecure with 48.3% having on average 2 meals/day. Greater proportion of households (43.3%) were in the first quartile of the DDS consuming ≤4 groups of food. The proportions of households consistently decreased from Q1 to Q4. Only 18% of the households were in the upper quartiles (Q3 and Q4). The minimum and maximum DDS were one and eight, respectively. The DDS means by quartiles were 2.47 (Q1), 4.00 (Q2), 5.00 (Q3) and 5.89 (Q4) with the overall mean DDS of 3.52.

Patterns of food consumption: Distributions of food group consumption across the quartile categories of dietary diversity are presented in Table 2. The results show notable variations in the consumption of the food groups across the quartile levels. The most frequently consumed food groups were cereals (96.2% of the households); coffee and tea (69.3%); oil, fat and butter (56.3%) and milk or milk products (50.4%). Milk was often consumed after providing additives or adjuncts (herbs) to give it a special aroma. The most common herbs (in Maa language) are Oloirien, Orkonyiel, Ormisisigiyey and Engaitarakway. The findings also showed low consumption rates of vegetables (12.6%), fruits (4.2%), fish (2.9%) and eggs (2.5%). Except for cereals and sugar and honey for which the consumption levels were similar across the quartile categories, the rest of the food groups varied significantly in consumption (p<0.05). In Q1, for example, some of the food groups were consumed in very small proportions (e.g., eggs, fish and vegetables, all <2% of households) or not consumed at all (fruits, 0%). Only cereals and milk and milk products were consumed in greater proportions in Q1. This could mean that households in Q1 mainly ate cereals as the main dish with milk and milk products as side dishes. Similarly, households in Q2 had low consumption levels of fruits (2%), eggs (2%) and fish (5%). A relative higher consumption of fruits was observed in Q3 (19.2%) and Q4 (33.3%). As well, increased vegetable consumption can be noted from Q2 through Q4. Food groups consumed in greater proportions (>50% of households) were cereals (Q1 to Q4), milk and milk products (Q1 to Q4), coffee and tea (Q2-Q4), oil, fat and butter (Q2-Q4) and meat (Q4 only). Overall, with the exception of milk and milk products, there was very minimal consumption of animal source foods.

Predictors of household dietary diversity scores: Predictors of household DDS (Q1-Q4) were identified using marginal effects of the ordered probit regression analysis and results are presented in Table 3. The results infer to change in probability in a given quartile if a test variable or a household switches its status from “0” to “1” for categorical data and at means for continuous variables. Note that for each variable, the sum of probabilities across the quartiles equals zero. The HFIAS had the most significant effect on DDS. A household categorized as food insecure based on HFIAS indicator has 30% probability of falling into Q1. Its probability of being in Q2, Q3 and Q4 falls by 18, 11 and 2%, respectively. The second most important factor influencing DDS was livelihood diversification. Households engaged in pastoralism and beekeeping or pastoralism and petty business reported more diverse diets compared with those involved in pastoralism only. Membership in saving group favoured higher dietary diversity. A household that belonged to a saving group had 14% lower probability of being in Q1 and only 1% in Q4. If a household changes from having few members (≤6) to larger size (>6), the predicted probability of a given household being in Q1 falls significantly by 6%. Its chances of being categorized into Q2, Q3 and Q4 increases by 4, 3 and 2%.

Table 2: Percent distribution of households in food consumption by household dietary diversity score

<table>
<thead>
<tr>
<th>Food group consumed</th>
<th>No</th>
<th>Yes</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roots and tubers</td>
<td>90.3</td>
<td>9.7</td>
<td>1.9</td>
<td>16.0</td>
<td>19.2</td>
<td>0.0</td>
<td>0.002</td>
</tr>
<tr>
<td>Fruits</td>
<td>95.8</td>
<td>4.2</td>
<td>0.0</td>
<td>2.0</td>
<td>19.2</td>
<td>33.3</td>
<td>0.000</td>
</tr>
<tr>
<td>Sugar and honey</td>
<td>92.4</td>
<td>7.6</td>
<td>5.8</td>
<td>6.0</td>
<td>15.4</td>
<td>22.2</td>
<td>0.120</td>
</tr>
<tr>
<td>Cereals</td>
<td>97.5</td>
<td>2.5</td>
<td>1.0</td>
<td>2.0</td>
<td>0.0</td>
<td>33.3</td>
<td>0.000</td>
</tr>
<tr>
<td>Eggs</td>
<td>97.1</td>
<td>2.9</td>
<td>1.0</td>
<td>5.0</td>
<td>3.8</td>
<td>0.0</td>
<td>0.000</td>
</tr>
<tr>
<td>Fresh or dried fish</td>
<td>97.1</td>
<td>2.9</td>
<td>1.0</td>
<td>5.0</td>
<td>3.8</td>
<td>0.0</td>
<td>0.000</td>
</tr>
<tr>
<td>Milk and milk products</td>
<td>94.6</td>
<td>50.0</td>
<td>93.7</td>
<td>50.0</td>
<td>73.1</td>
<td>66.7</td>
<td>0.043</td>
</tr>
<tr>
<td>Coffee or tea</td>
<td>30.7</td>
<td>69.3</td>
<td>49.5</td>
<td>82.0</td>
<td>88.5</td>
<td>100</td>
<td>0.000</td>
</tr>
<tr>
<td>Vegetables</td>
<td>87.4</td>
<td>12.6</td>
<td>1.9</td>
<td>20.0</td>
<td>23.1</td>
<td>22.2</td>
<td>0.000</td>
</tr>
<tr>
<td>Oil, fat and butter</td>
<td>43.7</td>
<td>56.3</td>
<td>24.3</td>
<td>76.0</td>
<td>92.3</td>
<td>100</td>
<td>0.000</td>
</tr>
<tr>
<td>Meat</td>
<td>80.7</td>
<td>19.3</td>
<td>10.7</td>
<td>24.0</td>
<td>23.1</td>
<td>55.6</td>
<td>0.003</td>
</tr>
<tr>
<td>Beans</td>
<td>79.8</td>
<td>20.2</td>
<td>7.8</td>
<td>24.0</td>
<td>46.2</td>
<td>44.4</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Quantiles 1, 2, 3, 4 represent dietary diversity scores 1-3, 4, 5-6 and 7-8, respectively; p-value is for Pearson’s chi-squared test; p<0.05 is statistically significant; Bold: Indicates food groups consumed in greater proportion (>50%)
respectively. For continuous variables, their effects on dietary diversity are interpreted in a similar way. Taking the variable “TLU”, for example, an increase of one TLU reduced the probability of a household being in Q1 category by 16% while its probability for Q2 and Q3 categories increases by 10 and 6%, respectively. Similarly, an increase in one km from a household to the main road meant that the household had a 1% greater probability of belonging to Q1 and less probability to Q2-Q4 by 1% for each quartile. Of the thirteen explanatory variables included in the model, nine had significant influence on the dietary diversity (Table 3). Overall, lower HFIAS score, livelihood diversification, presence of food storage facility and higher TLU favoured diverse diets in that order. Other favourable factors were membership in saving group, lower dependency ratio, large family size and short distance to the nearest road and to the market.

**DISCUSSION**

Results from the present study have demonstrated that most households consumed less diversified diets. As documented previously, the diets offered in food-scarce environments are known for being monotonous and bulky and this has been described as the hallmark of poverty and poor nutrition (Moramarco et al., 2017). The mean DDS observed in this study compares well with the findings of other studies. These include a DDS of 3.1 in Zambia (Rosenberg et al., 2018), 3.1 in Malawi (Kang et al., 2019), 3.4 in Ethiopia (Weldehaweria et al., 2016) and 3.9 in Kenya (Bostedt et al., 2016). Several studies have identified sensitivity of nutrient adequacy with 4 food groups (Steyn et al., 2014; Dangura and Gebremedhin, 2017; Perkins et al., 2018). Thus, consumption of food from <4 groups represents the consumption of less than the minimum diverse diet and suggests that households had sub-optimal levels of nutrient adequacy. Of note is that consumption of a diverse diet within and between food groups is considered as an indicator of healthy patterns (Tavakoli et al., 2016). A study conducted in Ethiopia, for example, found that children who take <4 food groups/day have higher probability of stunting than their counterparts (Demilew and Alem, 2019). In this perspective, it has been argued that the most sustainable way to address malnutrition is through promoting the consumption of a diet that is both high in quality and diverse (Rah et al., 2010). As noted in previous studies (Warren et al., 2015; Dafursa and Gebremedhin, 2019) and demonstrated in the current work, consumption levels of protein-rich foods is generally low which raises concerns for attaining desired health outcomes. The low consumption of protein-rich foods other than milk could possibly be due to several reasons. First, it could be due to limited supply of food varieties in the local market especially because of the perishable nature of some of these foods. Second, the low consumption of protein-rich foods could be associated with limited nutritional awareness and access due to economic constraints given that these foods are relatively more expensive. Third, the low consumption levels can be linked to food culture. Traditionally, the Maasai do not consider certain foods including fish and eggs as decent meals. Fish demand in the study area is very low and so could be due to limited supply of food varieties in the local market especially because of the perishable nature of some of these foods. Egg collected in households raising chicken are normally meant for sale rather than for own consumption.

Although milk was the most common source of animal protein, its availability is limited during the lean season (July-December) as large number of animals migrate to areas with green pastures. Thus, there is a direct and positive relationship between availability of feed resources and household food availability. Reduction in consumption of milk adversely affects nutrition and food security during this season (Fenton et al., 2012). Results showed high consumption of oil, fat and butter. This could mainly be linked to a culture of preserving clarified butter or ghee (Engornonashola) for use especially during the dry season (Olamey) when...
milk yield is low. At any one season, therefore, availability of oil, fat and butter is to a large extent guaranteed.

The findings have also showed that fruits and vegetables which are rich in micro-nutrients (WHO, 2002; Guenther et al., 2007), contributed to a significant share of under-consumed food groups. In a study that details Maasai food symbolism, it was described that the Maasai dietary ideal excludes and strongly devalues all plant food (Århem, 1989). However, fruits and vegetables are specific food groups with high dietary antioxidants and multiple anti-inflammatory components (Narmaki et al., 2015). They contain different types of vitamins, minerals, carotenoids, polyphenols and many other bioactive compounds (Brighenti et al., 2005). Thus, limited intake of these food groups results in negative health consequences. Misiak et al. (2018), for example, reported that Maasai children are frequently undernourished and reproductive-age women suffer from anemia because of the general scarcity of food and a lack of fruits and vegetables in their diets. Martin et al. (2014) reported that 29% of reproductive-age women of the NCA suffered from anemia. These observations suggest that a strong association exists between diets deficient in micronutrients and poor health status as reported elsewhere (Biesalski, 2013; Cano- Ibáñez et al., 2019). The observation on the predominance of cereal based diets is indeed consistent with other reports in the developing countries (Ekesa et al., 2011; Kiboi et al., 2017) and calls for nutrition interventions that aim to help communities improve their diets.

Results on the determinants of dietary diversity indicated that multiple factors mediate household dietary diversity. Comparing the relative magnitudes of the effects of the variables, food accessibility pathway appears to be the most important in addressing the challenges of low dietary diversity. These results accord broadly with the findings of Oldewage-Theron and Kruger (2011) who found that household food insecurity led to poor food variety, food group diversity scores and subsequently inadequate nutrients. The findings provide further evidence that food insecure households in low-income countries often have diets that are less diverse (Becquey et al., 2010; Hadley et al., 2011; Mailumo et al., 2016; Passarelli et al., 2018). The role of local markets on increasing household dietary diversity was evident in this study. Elsewhere, the impact of food accessibility on dietary quality has been shown to be much stronger for those not engaged in agriculture production (Huang and Tian, 2019; Pritchard et al., 2019). There is increasing evidence from various countries that a substantial share of the food consumed in rural households is purchased from markets (Barrett, 2008; Luckett et al., 2015; Hirvonen et al., 2016). While farm production diversity is positively associated with dietary diversity, market access has been shown to be a more important factor influencing dietary diversity in smallholder farm households (Jones et al., 2014; Koppmair et al., 2017). Market and infrastructural development particularly in villages such as those of the NCA, where no crop production takes places, is more critical if positive nutritional effects are to be realized.

Livelihood diversification which was the second most important factor influencing dietary diversity draws attention on the need for promoting a range of alternative income generating activities other than pastoralism. Beekeeping, in particular, is known for its role in augmenting household income (Kinati et al., 2012; Gebiso, 2015). The higher dietary diversity recorded among those engaged in beekeeping could be the result of improved household income from bee products which was then used to purchase food. Nonetheless, the full potential of the beekeeping sub-sector has not been realized given that beekeeping in the area predominantly employs traditional system characterized by lack of necessary accessories (e.g., extractors, wax stumpers and bee smokers) and low productivity. This situation underscores the need to increase awareness and leverage interventions on modern beekeeping technology. The present study has also uncovered important linkages between household characteristics and dietary diversity. First, presence of food storage facility in a household was clearly associated with increased chances of more diverse food. It seems, however, that the Maasai perhaps because of a background in transhumance pastoralism have not had a history of using any long-term food storage techniques. Encouraging a culture of storing food would partly address the challenges related to poor food consumption and food security.

Second, an increase in probabilities from Q2 to higher quartiles with livestock units suggests increased income from livestock sales which possibly enabled households to purchase more food varieties. In this regard, however, small stocks are known to be more convenient for sale or consumption at household level (Misiak et al., 2018). Although cattle are considered an index of social status, its meat is rarely eaten (Smith, 2016). Third, the favorable effects of household membership in saving group on dietary diversity could be associated with the positive effects of community banks on household income (Lwezaura and Ngaruko, 2013). Fourth, the observation that dietary diversity increased with household size could be a result of more individuals having different preferences for food types, leading to more diverse diets. Lastly, the negative marginal effects of distance to the nearest road and to the market recorded in Q2 through Q4 imply that longer walking time to these points is associated with reduced access to diverse food. Such households have had reduced chances of being in Q2 or higher quartiles. This
finding is plausible given the fact that with an exception of the livestock products, most of the other food groups are typically purchased from the market.

Several limitations need to be stated. First, data were collected in a single round. Thus, the cause effect relationship cannot be established. Second, such data have clear limitations as day-to-day variation in food consumption cannot be captured. While such variation is often relatively low in resource poor households, it cannot be neglected in nutritional assessments. Third, the single-round data do not reflect seasonal variations. There can be marked differences in food availability and food accessibility and, therefore, dietary diversity between the dry season and the wet season. Collecting food consumption data during the wet season would allow for a more complete insight into the Maasai diets. Nevertheless, the present study provides important information on the nutrition-related challenges specific to communities in which livestock are central to their economy, culture and identity.

CONCLUSION

The findings from this study have highlighted the pattern of consumption of various food groups in pastoral communities of the Ngorongoro Conservation Area. Substantial proportion of households consumed less than the minimum diverse food. Most of the reported diets lacked fruits and vegetables and were characterized with low levels of protein-rich foods. The findings also provide indications that household dietary diversity is dependent on accessibility of food in the local market, livelihood diversification and various demographic and socio-economic factors. Market and infrastructural development coupled with nutrition education would significantly contribute to improved diets and the overall community wellbeing. Promotion of improved nutrition should take into account the physical, demographic and socio-economic factors influencing food consumption and dietary diversity in the study population.

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