Dietary Patterns Measured by Principal Component Analysis and its Association with Stunting among Nepalese Schoolchildren in Nepal

Shrestha A,[1] Shrestha A,[2] Cissé G[3]

[1]Department of Public Helath

Dhulikhel Hospital, Kathmandu University Hospital

Kathmandu University School of Medical Sciences,

Dhulikhel, Kavre, Nepal.

[2]Harvard TH Chan School of Public Health,

Boston, USA.

[3]Swiss Tropical and Public Health Institute,

University of Basel,

Basel, Switzerland.

Corresponding Author

Akina Shrestha

Department of Public Helath,

Dhulikhel Hospital, Kathmandu University Hospital,

Kathmandu University School of Medical Sciences,

Dhulikhel, Kavre, Nepal.

E-mail: akinakoju@gmail.com

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ABSTRACT

Background

There is a gap of knowledge on the link of major dietary patterns with stunting among schoolchildren in Nepal.

Objective

To identify dietary patterns in rural Nepalese households in two districts and assess their association with stunting among schoolchildren.

Method

This cross-sectional study gathered data from 708 schoolchildren aged 8-16 years participating in the baseline survey in the Districts of Dolakha and Ramechhap, Nepal. We derived major dietary patterns from a principal component analysis of reported intake from a food frequency questionnaire completed through interviews with the caregivers. Statistical analysis was conducted using mixed logistic regression with random intercepts at the level of schools adjusting for socio-demographic and behavioural indicators.

Result

The diet of surveyed schoolchildren was mainly comprised of starchy staples and legumes. Five dietary patterns score were derived: mixed food, vegetables and lentils, milk and beverages, salty snacks, and processed food. The vegetables and lentils pattern scores were negatively associated with stunting (aOR 0.84; 95% CI: 0.66-1.08, p=0.17) after adjusting for regional differences, demographic and behavioural risk factors.

Conclusion

Our results suggest that adherence to dietary patterns high in vegetables and animal protein might be associated with reduced odds of being stunted among schoolchildren. Therefore, the promotion of dietary diversification strategies to improve schoolchildren's food consumption is required in the study area.

KEY WORDS

Dietary diversity, Nepal, Schoolchildren, Stunting

INTRODUCTION

Stunting contribute to the mortality and the burden of disease such as poor cognitive development among children.[1,2] It is more prevalent possibly in low- and middle-income countries (LMICs) possibly due to height gain is more sensitive to dietary quality than weight.[3,4] Stunting affected one third of children under-five in LMICs due to some adverse nutritional, socio-economic, and environmental conditions.[3,4] It often goes unrecognised by families where short stature is so common that it seems normal but people are unaware that the stunted children experience little or no catch-up in growth later in life.[5] The causes of stunting may be genetic, hormonal, pharmaceutical, psychological and nutritional.[4] The major consequences of childhood stunting were found to be short adult stature, reduced lean body mass, diminished intellectual functioning, lower birth weight and higher mortality of infants.[6,7] Additionally, the babies born by stunted women are themselves more likely to be stunted and this could pass from one generation to other.[8-11] However, evidence is still limited, and most studies have been performed either in high- or middle- income countries targeting adults in relation to numerous outcomes such as cardiovascular diseases or obesity/overweight.[12-15] The limited information is available about major dietary patterns of schoolchildren and their association to the prevalence of stunting in Nepal.

Hence, we conducted this study in-order to focus on stunting among schoolchildren in Nepal as the current information found were mostly focused on children aged less than five years old.[11] It was in the frame of the "Vegetables go to school" (VGtS) project that was implemented with the overall goal of improving the nutritional security of the schoolchildren through school vegetable gardens linked to other school-based health, nutrition and environmental initiatives.[16]

METHODS

The cross-sectional study used data from the first wave of the baseline survey of the VGtS project. The study population consisted of the children in 6th and 7th grade of government schools, between the ages of 8-16 years from Dolakha and Ramechhap District. The study covered 16 out of 30 schools randomly selected by the VGtS team with the National Agricultural Research Council (NARC), the Ministry of Education (MOE) and Ministry of Health and Population (MOHP).

We used a food frequency questionnaire (FFQ) for assessing the usual dietary intake. The FFQ contains questions on the average consumption frequency during the past year for 99 commonly consumed food items. The respondents indicated their answers in times per day, week, month and year or as never. The questionnaire was supplemented with coloured photographs of four differently sized portions of foods developed by a professional photographer under controlled conditions of light, distance, angles and presentations. We used a four image for food portion size estimation based on how much food (in grams) is consumed presented in the food image. Different sizes of glasses or bowls were presented to estimate the amount of liquids. The respondent indicates one of the amounts presented in the photographs. Other items were asked as a number of specified units (i.e. number, spoons).[17,18]

Twenty one food groups were created according to the macronutrient composition such as protein, fats, carbohydrates and so on.[18] We used principal component analysis (PCA) to obtain food patterns reflecting the specific food items consumed. The frequency of food group consumption was converted into the number of servings per week. The PCA was performed used STATA version 14 with orthogonal rotation. Factor analysis with varimax rotation was then performed to derive optimal non-correlated components (food patterns). The correlation matrix of the standardised variables was examined to decide the number of components to retain based on eigenvalue and interpretability. The factors retained were determined based on eigenvalue and interpretability.[19]

The measurements were taken by trained health workers following standard guidelines.[20] Participant's height was measured without shoes, using a standard scale with a length of 2 m and a precision of 0.1 cm. Weight was measured using digital portable calibrated SECA weighing scale (SECA; Hamburg, Germany) having sensitivity of 0.1 kg with a capacity of 130 kg. The weighing machine was calibrated to zero before taking each measurement. The children were weighed wearing a light uniform, without shoes and with empty pockets even during the winter. All measurements were taken by the same person and an instrument was calibrated every day. The growth and development status of children were evaluated by height-for-age ratio Z score (HAZ; stunting) according to WHO`s child growth standards 2006 and the HAZ < -2 are defined as stunting.[21]

The additional variables, including age (in years), sex, ethnicity (Brahmin / Chettri / Newar / Tamang / Janajati), education (primary / secondary / higher / no-education), occupation (farmer / business / service / no-occupation), religion (Hindu/non-Hindu), past breastfeeding (yes/no) was assessed through interviews conducted with the caregivers using standardized questionnaires that were pretested into the similar settings.

Sample characteristics were described for both boys and girls using means and standard deviations (SDs) for continuous variables and percentages for categorical variables. Dietary factor scores were analysed as potential predictors of stunting as main outcome. Mixed linear and logistic regression models with random intercepts of school were used for this purpose. For each food pattern, three incremental models were computed: (a) without any adjustment; (b) with adjustment for demographic

variables (i.e. age, sex, education, occupation and district) and (c) with further adjustment for lifestyle variables (i.e. breastfeed the schoolchildren, food security). Associations are expressed as odds ratios with 95% confidence intervals. All analyses were carried out using STATA, version 14 (Stata Corporation; College Station, TX, USA).

Ethical approval was granted by the "Ethikkommission Nordwest- und Zentralschweiz" (EKNZ) in Switzerland (reference number UBE-15/02; date of approval January 12, 2015); the "institutional review committee of Kathmandu University School of Medical Sciences, Dhulikhel Hospital, Nepal" (reference no. 86/14, date of approval August 24, 2014); and the "institutional review committee, Nepal Health Research Council" (reference no 565; date of approval November 11, 2014). The study is also registered at the international standard randomised controlled trial number register ISRCTN30840 (date assigned: July 17, 2015).

Verbal consent was received from teachers and written informed consent (fingerprints of illiterates) was obtained from the caretakers of the study participants. All the participants of the study were informed about volunteer participation and freedom to withdraw at any time without further obligations. For the severe malnutrition, schoolchildren were referred to the health centre for further diagnosis and treatment.

RESULTS

A total of 750 schoolchildren were eligible for the survey out of which 708 were included in the baseline study. However, due to the 2015 earthquake in the midst of the survey, only 562 (79.4%) households could be contacted by the data collectors.[22]

Among the 708 schoolchildren, the prevalence of stunting was 27.0%, higher in males than in females (31.6% versus 22.8%). The socio-demographic characteristics of the study populations are shown in Table 1. The mean age and standard deviation of the study participants was 12.8 (15.3 SD) years with a range between 8 and 16 years. Tamang was the largest ethnic group (37.9%). The median age of the caregivers was 39.5 years. More than one third of the caregivers had no formal education (37.4%) and only 11.6% had a level of education above secondary school. The mean (SD) of height-for-age was -1.38 (1.0).

Mean consumption of animal products such as red meat, poultry, fishes and milk was low among schoolchildren (1.18, 1.96, 0.81 and 0.90 respectively). The mean consumption of vegetable is 3.79 and of fruit were 4.09 per week. The mean consumption of white cereals was high (9.12 servings per week) (Table 2).

The factor analysis revealed five factors explaining 40.0% of the variation in the total food intake and reflecting different dietary patterns. The loadings of the different dietary

Table 1. Characteristics of study population in the Dolakha and Ramechhap districts of Nepal in March-May 2015

Characteristics [N=708]		[n, (%)]	Dolakha [n, (%)]	Ramechhap [n (%)]
Sex				
Male		339 (47.9)	261 (47.0)	78(51.0)
Female		369 (52.1)	294 (53.0)	75 (49.0)
Age of children				
Age group 1 (8-12 years)		108 (15.2)	86 (15.5)	22 (14.4)
Age group 2 (13-16 years)		600 (84.8)	469 (84.5)	131 (85.6)
Mean (SD) values in Dolakha and Ramechhap		12.8 (1.2)		
Grade				
Class 6		333 (47.0)	258 (46.5)	75 (49.0)
Class 7		375 (53.0)	297 (53.5)	78 (51.0)
Caregivers demographic characteristics [N=562]				
Age of caregivers				
18-24 years		2 (0.4)	1 (0.2)	1 (0.9)
24-40 years		239 (42.5)	184 (41.4)	55 (46.6)
> 40 years		321 (57.1)	259 (58.3)	62 (52.5)
Median age (IQR)		39.5 (11)		
Education level of caregivers				
No formal schooling		210 (37.4)	174 (39.2)	36 (30.5)
Primary education		144 (25.6)	130 (29.3)	14 (11.9)
Secondary education		143 (25.4)	82 (18.5)	61 (51.7)
Higher education		65 (11.6)	58 (13.0)	7 (5.9)
Ethnicity of caregivers				
Brahmin		101 (17.9)	97 (21.9)	4 (3.4)
Chhetri		210 (37.4)	154 (34.7)	56 (47.5)
Newar		33 (5.9)	22 (4.9)	11 (9.3)
Tamang		213 (37.9)	166 (37.4)	47 (39.8)
Janajati		5 (0.9)	5 (1.1)	0 (0.0)
Main occupation of caregivers				
No occupation		25 (4.5)	10 (2.2)	15 (12.7)
Farmer		458 (81.5)	391 (88.1)	67 (56.8)
Public service		39 (6.9)	29 (6.5)	10 (8.5)
Business owner		40 (7.1)	14 (3.2)	26 (22.0)
Religion				
Hindu		448 (79.7)	341 (76.8)	107 (90.7)
Non Hindu		114 (20.3)	103 (23.2)	11 (9.3)
Socio-economic characteristics of caregivers [n=562]				
Roof material	Corrugated iron roof	415 (73.8)	325 (73.2)	90 (76.3)
	Wood and tiles	147 (26.2)	119 (26.8)	28 (23.7)
Wall material	Wood	66 (11.7)	61 (13.7)	5 (4.2)
	Corrugated iron	407 (72.4)	331 (74.6)	76 (64.4)
	Bricks	89 (15.9)	52 (11.7)	37 (31.4)
Floor material	Mud	524 (93.2)	430 (96.9)	94 (79.7)
	Cement	38 (6.8)	14 (3.1)	24 (20.3)

Energy for cooking	Charcoal/ wood	473 (84.2)	390 (87.8)	83 (70.3)
	Electricity	89 (15.8)	54 (12.2)	35 (29.7)
Socioeconomic status	High	49 (8.7)	39 (8.8)	10 (8.5)
	Middle	215 (38.3)	163 (36.7)	52 (44.1)
	Poor	298 (53.0)	242 (54.5)	56 (47.4)
Owing agricultural land		511 (90.9)	412 (92.8)	99 (83.9)
Total production	≤10%	44 (7.8)	30 (6.8)	14 (11.9)
	10-30%	20 (3.6)	6 (1.4)	14 (11,9)
	>30%	498(88.6)	408(91.9)	90(76.3)
Possession of domestic animals		507 (90.2)	401 (90.3)	106 (89.8)

**Socioeconomic status was derived from a factor analysis of variables indicating the possession of household assets such as radio, television, mobile phone, table, stove, petrol lamp, motorbike, car or truck, watch, iron, bike, cupboards etc. The score of the first factor was then divided into three categories using the k-means procedure.*

variables on each of the factor are presented in Table 3. The five patterns were labelled based on the food items that loaded highest on them:

• mixed food pattern score (red meat, while cereals, fruits, poultry, western and fishes);

• vegetables and lentils pattern score (lentils, vegetables, nuts);

• milk and beverages pattern score (milk products, beverages such as juice);

• salty snacks pattern score (pickles); and

• processed food pattern scores (noodles, biscuits).

The associations of each dietary factor score with socio-demographic characteristics such as age, sex, religion, education and occupation are shown in Table 4. Female schoolchildren had a higher average score for the mixed food pattern (coef. = 0.16, 95% CI:-0.01-0.32, p=0.05). The coefficients for children with well-educated parents were mostly positive, the only exception being the score for the salty snacks pattern score and processed food pattern scores (coef.=-0.15, 95% CI=-0.24-0.06, p=0.01; coef.=0.07, 95% CI=-0.17-0.21, p=0.13 respectively).

The association of food patterns scores with the prevalence of stunting is shown in Table 5. The vegetables and lentils pattern score showed an inverse relationship with stunting (aOR: 0.84, 95% CI: 0.66-1.07; p=0.17) after adjusting for district, and demographic and behavioural related variables such as food security at the household, breastfeeding and consumption of breakfast prior to the survey. A negative association was also observed with the mixed food pattern score; however, these associations were not statistically significant (aOR 0.90, 95% CI: 0.72-1.13, p=0.36).

Table 2. Consumption/ servings of food groups per week among schoolchildren in the Dolakha and Ramechhap Districts of Nepal in March-May 2015

Food group	Mean	Standard deviation	Median	Interquartile range	Consumption per week (minimum)	Consumption per week (maximum)
Whole cereals	3.18	5.57	0.00	7.00	0	31.5
White cereals	9.12	3.72	7.00	3.50	0	24.5
Lentils	3.32	5.40	0.00	7.00	0	35.0
Oils	6.41	5.37	7.00	3.50	0	28.0
Fatty food	3.28	5.99	0.00	3.50	0	38.5
Vegetable	3.79	23.90	0.00	0.00	0	206.1
Fruits	4.09	6.72	1.73	5.47	0	58.1
Roots and tubers	4.72	4.07	5.63	7.00	0	16.6
Nuts	1.82	5.34	0.00	0.00	0	42.0
Poultry	1.96	3.94	0.00	3.50	0	24.5
Redmeat	1.18	3.44	0.00	0.00	0	29.8
Fishes	0.81	2.69	0.00	0.00	0	17.5
Milk drinks	0.91	1.54	0.00	3.50	0	3.5
Milk products	1.18	2.66	0.00	0.00	0	17.5
Western	1.42	3.66	0.00	0.00	0	28.0
Processed cereals	2.75	3.93	0.00	7.00	0	21.0
Noodles	2.51	4.02	0.00	0.00	0	21.0
Salty snacks	2.8	4.20	0.00	3.50	0	24.5
Beverages	0.78	1.70	0.00	0.00	0	7.0
Medium beverages	5.02	3.61	3.50	3.50	0	21.0
Sugary food	4.83	5.78	3.50	7.00	0	28.0

Table 3. Factor loading values of pattern of dietary intake derived from principal component analysis

Food groups	Factor				
	1	2	3	4	5
Whole cereals	0.427	0.524	-0.119	0.137	-0.066
White cereals	0.681	0.089	-0.339	0.159	-0.037
Lentils	0.195	0.697	0.068	0.127	0.031
Oils	-0.011	-0.004	0.077	0.701	0.084
Fatty food	0.391	0.418	0.364	0.214	0.158
Vegetable	0.011	0.688	0.109	-0.142	0.293
Fruits	0.644	0.267	0.211	0.079	0.248
Roots and tubers	-0.006	-0.056	-0.147	0.622	0.296
Nuts	0.460	0.450	0.262	0.104	0.061
Poultry	0.568	0.094	0.208	0.165	0.261
Redmeat	0.795	0.153	0.159	-0.045	0.105
Fishes	0.656	-0.024	0.299	-0.027	0.032
Milk drinks	0.179	-0.216	0.409	0.101	0.295
Milk products	0.224	0.244	0.575	0.072	-0.039
Western	0.693	0.062	0.201	-0.019	0.155
Processed cereals	0.173	0.110	-0.039	0.022	0.736
Noodles	0.091	0.101	0.127	0.147	0.653
Salty snacks	0.107	0.167	0.248	0.628	-0.058
Beverages	0.316	0.119	0.587	0.042	0.121
Medium beverages	0.174	0.104	0.479	0.318	0.047
Sugary food	0.255	0.202	0.167	0.340	0.490

Extraction method: principal component analysis; rotation method: varimax with Kaiser normalisation.
Score coefficients with highest values in each component are shown in bold
Whole cereals: wheat, millet, maize, wheat bread
White cereals: sooji, beaten rice, rice, maida
Lentils: soyabean, beans, sprout, whole pulse
Oils: Mustard oil, sunflower oil, soyabean oil
Fatty food: Deep fried local food swaari, donought, pakauda, malpa, fries
Vegetable: both dark green and other vegetables
Fruits: all vitamin A rich and non-rich fruits
Vegetable roots: potato, sweet potato, yam
Nuts: peanut, cashew, walnut, pista, dryfruit, almonds
Poultry: eggs, chicken
Red meat: buff, pork, mutton
Fish: fried and non-fried fish
Milk drinks: milk
Milk products: cheese, paneer, yogurt
Western: sausages
Processed cereals: biscuits, bread
Noodles: noodles, choumin
Salty snacks: pickles, bhujiya
Beverages: fruit juice
Medium beverages: coffee and tea (with and without milk)
Sugary food: ice-cream, sweet, chocolate and jam

Table 4. Association of socio-demographic characteristics (age, sex, religion, education and occupation) with the derived food pattern among schoolchildren in Dolakha and Ramechha districts, Nepal (March-May, 2015)

	Mixed food pattern score			Vegetables and lentils pattern scores			Milk and beverages pattern score			Salty snacks pattern score			Processed food pattern score		
	Coef-ficient	95% CI	p-value	Coef-ficient	95% CI	p-value	Coeffi-cient	95% CI	p-value	Coef-ficient	95% CI	p-value	Coef-ficient	95% CI	p-value
Age	-0.02	-0.22-0.17	0.80	0.05	-0.15-0.26	0.60	0.08	-0.12-0.27	0.46	-0.08	-0.29-0.11	0.39	-0.01	-0.21-0.19	0.94
Sex															
Male	Ref														
Female	0.16	-0.01-0.32	0.05	-0.01	-0.16-0.16	0.98	0.13	-0.04-0.29	0.12	-0.01	-0.17-0.16	0.97	-0.06	-0.22-0.10	0.46
Religion															
Non Hindu	Ref														
Hindu	-0.14	-0.36-0.07	0.20	0.04	-0.17-0.26	0.70	0.03	-0.18-0.25	0.75	0.23	0.01-0.44	0.04	0.02	-0.19-0.24	0.82
Education															
Non educated	Ref														
Educated	0.01	-0.08-0.10	0.86	0.12	0.03-0.20	0.01	0.06	-0.04-0.15	0.24	-0.15	-0.24--0.06	0.01	-0.07	-0.17-0.21	0.13
Occupation															
No occupation	Ref														
Has occupation	-0.01	-0.15-0.13	0.90	0.02	-0.12-0.16	0.75	0.02	-0.12-0.16	0.77	0.01	-0.13-0.15	0.92	.04	-0.10-0.18	0.56

DISCUSSION

In the present cross-sectional study, we examined the dietary patterns associated with stunting among schoolchildren in Dolakha and Ramechhap district of Nepal. Our findings revealed five major food patterns scores that characterised the dietary habits of rural Nepalese community: mixed food, vegetables and lentils, milk and beverages, salty snacks and processed food pattern scores. There was a protective association between adherence to "vegetables

Table 5. Association of stunting with the derived food patterns among schoolchildren in the Dolakha and Ramechhap Districts of Nepal

	Model 1			Model 2			Model 3		
	Univariate analysis			Adjusted for demographic variables*			Additionally adjusted for other variables**		
	OR	95% CI	p-value	OR	95% CI	p-value	OR	95% CI	p-value
Stunting									
Mixed food pattern score	0.89	0.71-1.12	0.33	0.91	0.72-1.14	0.39	0.90	0.72-1.13	0.36
Vegetables and lentils pattern score	0.84	0.66-1.08	0.18	0.84	0.66-1.08	0.17	0.84	0.66-1.07	0.17
Milk and beverages pattern score	0.98	0.79- 1.20	0.83	0.99	0.80-1.22	0.93	1.00	0.81-1.23	0.99
Salty snacks pattern score	1.05	0.86-1.30	0.62	1.07	0.87-1.32	0.53	1.09	0.89-1.35	0.39
Processed food pattern score	1.07	0.87-1.31	0.52	1.07	0.87-1.31	0.53	1.07	0.87-1.31	0.52

* Adjusted for age, sex, education and occupation. **Adjusted for age, sex, education, occupation, food security, breastfeed and breakfast day before the survey

and lentils" and stunting among the schoolchildren in Nepal, even after taking potential confounders such as age, sex, districts, and behavioural factors into account.

Overall, the association between vegetables lentils pattern scores and stunting was protective; however not significant. The beneficial effect of vegetables may have been counterbalanced by detrimental effects of other food items, resulting in the insignificant association between vegetables and lentils patterns and stunting in our study. Overall, no significant association were observed between "mixed food pattern score" and "milk and beverages pattern scores" and stunting in this population. The vegetables and lentils pattern is negatively associated with female children and is positively associated with children having educated parents with occupation.

Our study did not derive the same dietary patterns as of other study in Nepal because of variation of Nepalese diet from other population and some characteristics were different according to the dietary pattern.[17] The schoolchildren of higher age (13-16 years) had a higher score for the "vegetable and lentils" and "milk and beverages" whereas lower score for the "salty snacks and processed food". This may be because more learning regarding importance of vegetables by the higher aged study population. Similarly, "processed food item consumption" is higher in those children whose caregivers were involved into any occupation. This may be due to affordability and adequate income or may be the caregivers were likely to be busier so the schoolchildren buy processed food by themselves. In terms of food and food groups' intake, we found that the stunted children had lower intake of animal products, dairy, poultry or fishes. Based on these findings, it seems that the diet quality is not diversified as the predominant food for Nepalese children are mostly big portion of cereals with high heat exposure while cooking.[23]

The dietary pattern score approach that includes food behaviours of individuals may provide greater information on nutritional aetiology. In this study, we sought to identify dietary patterns scores associated with stunting in schoolchildren of Nepal. Although, stunting might be prevalent among schoolchildren, few studies have assessed the role of diet in its aetiology. Additionally, the nutritional status of children aged < 5 years is widely researched and interventions are continuously being sought to prevent and treat malnutrition as a nationwide project. However, no information is available in terms of the association between dietary pattern scores and stunting among the schoolchildren in Nepal. Yet, studies were available on the association between dietary pattern and obesity elsewhere.[24] Additionally, the biological plausibility of eating vegetables and lentils pattern score and its association with stunting is not available. Furthermore, the epidemiological studies suggest that consumption of vegetables, whole grain cereals and whole grain cereals products have many beneficial health effects.[25] However, we did not find a significant association between theses healthy food pattern scores which might be due to the different other confounding factors being associated.

To the best of our knowledge, this study is the first study examining the association between major dietary patterns scores and stunting among schoolchildren in Nepal. One strength of our study is the use of advanced multivariate analysis to control for different socio-economic (age, sex, education, religion, occupation of caregivers, food security at household) and behavioural (breastfeeding and consumption of breakfast before the survey) variables. Another strength of our study is the use of data-driven food pattern score analysis. This approach has emerged as a complementary approach for examining diet-outcome relationships and is more predictive of disease risk than individual food or nutrients.[26]

The current study provides useful information elucidating the association between dietary patterns and stunting in schoolchildren. However, several limitations should be considered while interpreting these results. First, our study was cross-sectional design, and it is not possible

to determine the temporality and causality of variables in this setting therefore, the exact association between major dietary patterns and stunting must be confirmed in prospective studies. Second is the reliance on FFQ as a measure of dietary intake. The method is susceptible to recall bias, both for frequency of foods eaten and for quantification of portion sizes although various amount estimation tools were used in collecting more accurate data. Third, stunting is a heterogeneous multi-factorial disorder and beside dietary factors, other variables, such as hereditary factors and metabolic conditions could be considered. Fourth, the micronutrient deficiencies, including iron, copper and vitamins that could indicate the nutrients intake were not explored. Fifth, the PCA method itself has limitations that arise from subjective choices made in deciding the variable scale, the number of variables and factors with their interpretation contributing to the inconsistency.[26] Sixth, we cannot generalise our findings to the entire Nepalese schoolchildren as Nepal is a multi-ethnic country with vast diversity in food habits and culture.[27]

CONCLUSION

Our results suggest that higher intake of vegetables and lentils pattern score is protective for decreasing odds of stunting in Nepalese schoolchildren. Although, the association is not significant, and a further exploration is required, the vegetables and lentils pattern should be promoted for the schoolchildren. This study adds to the existing literature by identifying relationship between dietary patterns scores and stunting among the understudied population residing in low-resource setting of Nepal. Identifying food-based dietary patterns scores may be useful in improving dietary habits in the soon to be adult population and public health efforts at decreasing stunting. Efforts are needed to promote healthy and balanced dietary habits among schoolchildren in order to make an effective contribution to program planning to overcome child malnutrition in Nepal Considering the negative effects of malnutrition on national productivity, the government should formulate various policies, plans and strategies to address the problem.

REFERENCES

1. Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, et al. Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet Lond Engl*. 2008 Jan 19;371(9608):243-60.
2. Martorell R, Young MF. Patterns of stunting and wasting: potential explanatory factors. *Adv Nutr.* 2012 Mar 2;3(2):227–33.
3. Dewey KG, Begum K. Why stunting matters? Alive & Thrive, FHI 360; 2010.
4. Hizli S, Abaci A, Büyükgebiz B, Büyükgebiz A. Nutritional stunting. *Pediatr Endocrinol Rev PER.* 2007 Mar;4(3):186–95.
5. Martorell R, Khan LK, Schroeder DG. Reversibility of stunting: epidemiological findings in children from developing countries. *Eur J Clin Nutr.* 1994 Feb;48 Suppl 1:S45-57.
6. Ozaltin E, Hill K, Subramanian SV. Association of maternal stature with offspring mortality, underweight, and stunting in low- to middle-income countries. *JAMA*. 2010 Apr 21;303(15):1507–16.
7. Victora CG, Adair L, Fall C, Hallal PC, Martorell R, Richter L, et al. Maternal and child undernutrition: consequences for adult health and human capital. *Lancet Lond Engl.* 2008 Jan 26;371(9609):340–57.
8. Shekar M, Heaver R, Lee Y-K, World Bank, editors. Repositioning nutrition as central to development: a strategy for large scale action. Washington, DC: World Bank; 2006. 246 p.
9. Esfarjani F, Roustaee R, Mohammadi-Nasrabadi F, Esmaillzadeh A. Major dietary patterns in relation to stunting among children in Tehran, Iran. *J Health Popul Nutr.* 2013 Jun;31(2):202–10.
10. Semba RD, de Pee S, Sun K, Sari M, Akhter N, Bloem MW. Effect of parental formal education on risk of child stunting in Indonesia and Bangladesh: a cross-sectional study. *Lancet Lond Engl*. 2008 Jan 26;371(9609):322–8.
11. Ministry of Health and Population, New ERA, ICF Inter, -, national, Nepal. Demographic and Health Survey. 2011: Kathmandu and Calverton, Md, USA: Ministry of Health and Population, New ERA, and ICF International.
12. Busert LK, Neuman M, Rehfuess EA, Dulal S, Harthan J, Chaube SS, et al. Dietary diversity is positively associated with deviation from expected height in rural Nepal. *J Nutr.* 2016 Jul 1;146(7):1387–93.
13. Hu T, Bazzano LA. The low-carbohydrate diet and cardiovascular risk factors: evidence from epidemiologic studies. *Nutr Metab Cardiovasc Dis NMCD*. 2014 Apr;24(4):337–43.
14. Shin HJ. Diet quality and cardiovascular disease. *J Hypertens*. 2016 Sep;34 Suppl 1:e534.
15. Rinaldi AEM, de Oliveira EP, Moreto F, Gabriel GFCP, Corrente JE, Burini RC. Dietary intake and blood lipid profile in overweight and obese schoolchildren. *BMC Res Notes.* 2012 Oct 30;5:598.
16. Erismann S, Shrestha A, Diagbouga S, Knoblauch A, Gerold J, Herz R, et al. Complementary school garden, nutrition, water, sanitation and hygiene interventions to improve children's nutrition and health status in Burkina Faso and Nepal: a study protocol. *BMC Public Health*. 2016 Mar 9;16:244.
17. Shrestha A, Koju RP, Beresford SAA, Gary Chan KC, Karmacharya BM, Fitzpatrick AL. Food patterns measured by principal component analysis and obesity in the Nepalese adult. *Heart Asia.* 2016;8(1):46-53.
18. Shrestha A, Koju RP, Beresford SAA, Chan KCG, Connell FA, Karmacharya BM, et al. Reproducibility and relative validity of food group intake in a food frequency questionnaire developed for Nepalese diet. *Int J Food Sci Nutr.* 2017 Jan 16;0(0):1–8.
19. Yeomans KA, Golder PA. The Guttman-Kaiser criterion as a predictor of the number of common factors. *The Statistician.* 1982 Sep;31(3):221.
20. Onyango AW, De Onis M. WHO child growth standards: training course on child growth assessment. World Health Organ. 2008;
21. WHO, Onis M de, editors. WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age; methods and development. Geneva: World Health Organisation; 2006. 312 p.

22. Basnyat B, Tabin C, Nutt C, Farmer P. Post-earthquake Nepal: the way forward. *Lancet Glob Health.* 2015 Dec 1;3(12):e731–2.

23. WHO. Household use of solid fuels and high-temperature frying. Geneva and Lyon; Switzerland and France: World Health Organisation and International Agency for Research on Cancer; 2010.

24. Rodríguez-Ramírez S, Mundo-Rosas V, García-Guerra A, Shamah-Levy T. Dietary patterns are associated with overweight and obesity in Mexican school-age children. *Arch Latinoam Nutr.* 2011 Sep;61(3):270–8.

25. Kulawinek M, Kozubek A. [5-n-alkylresorcinols of whole grain cereals and whole grain cereal products as biomarkers of healthy food]. Postepy Biochem. 2007;53(3):287–96.

26. Newby PK, Tucker KL. Empirically derived eating patterns using factor or cluster analysis: a review. *Nutr Rev.* 2004 May;62(5):177–203.

27. Gurung H. Social, and Demography Expression, Nepal. New Era; 2001.