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RESEARCH

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Association between dietary diversity, nutritional status, and academic performance of school-age children in Southeast Ethiopia using structural equation modelling

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Abstract

Background Undernutrition, manifested as stunting and/or thinness, is a major public health concern in low-income countries, including Ethiopia. Factors such as sociodemographic, economic, and dietary status influence children's academic achievement. This study aimed to assess the association between dietary diversity, nutritional status, and academic performance of school-age children in pastoral communities in Southeast Ethiopia.

Methods A school-based cross-sectional study was conducted among 395 randomly selected school-age children. A multistage sampling followed by systematic random sampling was used to collect the data. Students' academic performance (AP) was evaluated by computing two-semester average grade scores of the 2016/17 academic year in all disciplines using the school record. A pre-tested, interviewer-administered, structured questionnaire was used to collect the data. To assess nutritional status, the z scores of height for age (HAZ) and BMI for age (BAZ) were employed according to WHO's new reference values. The WHO Anthroplus software was used to generate nutritional indices. A structural equation model (SEM) was used to examine the direct, indirect, and total effects of the dietary diversity score (DDS), HAZ score, and BAZ score on AP. The beta coefficient (β) along with the confidence interval (CI) were used to estimate the strength of the association.

Results The prevalence of stunting and thinness was 26.6% (95% CI: 21.8, 31.4%) and 28.9% (95% CI: 24.3, 33.2%), respectively. The proportion of dietary diversity (DD) among school-age children was 40% (95% CI: 35.7, 45.3%) low DD and 60% (95% CI: 54.7, 64.3%) adequate DD. The SEM revealed that a unit increment in the child's DDS (unstandardised $\beta = 0.130$, 95% CI: 0.049 to 0.211) did have direct and total effects on the HAZ score. However, HAZ score, BAZ score, and DDS did not have direct, indirect, or total effects on AP. Similarly, DDS did not have direct or total effects on the BAZ score.

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Conclusion The academic performance (AP) was low among these school-age children, and the prevalence of stunting and thinness was high. Thus, nutrition interventions on dietary diversity for school-age children would be crucial interventions for increasing academic achievement.

Keywords Academic performance, Dietary diversity, Ethiopia, Nutritional status, School-age children, Stunting, Thinness

Introduction

A well-balanced diet is essential for endurance, physical growth, cognitive development, and productivity [1]. Malnutrition is also seen as a serious issue that has an impact on children's abilities [2–4]. Undernutrition is a major public health issue with a negative impact on academic performance (AP) [5]. According to a study, health issues caused by poor nutrition in primary school-aged children are among the leading reasons for low enrolment, high absenteeism, early dropout, and poor classroom performance. Understanding children's nutritional state has far-reaching ramifications for future generations' growth in this area [6]. The relationship between nutritional status and scholastic attainment among school-age children in poor nations has not been well established [7].

Coexistence with malnutrition and education quality is a major concern in Ethiopia [8]. The Ethiopian Ministry of Education (FMoE) has documented the impact of poor health and nutrition on children's ability to learn, attend school, and concentrate [9]. A study conducted in Nekemte, Western Ethiopia, revealed that school-age children have low academic achievement [10]. According to another survey conducted in Jimma Town, Ethiopia the average school child score for both sexes was 71.13% [11]. Dietary diversity is a significant indicator of a high-quality diet, especially for school-aged children whose bodies have high nutritional requirements [12]. In school-aged children, poor dietary diversity raises the risk of undernutrition in linear growth but not in thinness [13]. The proportion of minimum dietary diversity among school-age children was 27.5% [14].

The prevalence of underweight, stunting, and thinness among school-age children was 21%, 22%, and 36% in the African region, respectively [15]. The magnitude of stunting ranges from 11 to 48.7% and underweight from 7.2 to 59.7% among school-age children [7]. The prevalence of stunting and thinness among school-age children was 29.4% and 11.2%, respectively, in Burkina Faso [16].

Primary investigations conducted in various settings of Ethiopia revealed that the prevalence of stunting was 8.5–57% [10, 17–28], thinness was 8–22.9% [18, 24, 27, 28], wasting was 6.3–14.3% [20–22, 26], and underweight was 11.4–45.9% [10, 17, 21, 22] among school-age children. The pooled prevalence of stunting, underweight, and wasting among school-age children in Ethiopia was 21.3 to 23.1%, 18.2%, and 17.7 to 22%, respectively [29, 30]. There was a significant association between stunting and academic performance in the Hawa Gelan district, notably in Ethiopia [26, 31–34]. Nevertheless, there was no significant relationship between wasting and AP among school-age children [22].

These study's findings would be an input to the government, policymakers, and different stakeholders to intervene in nutrition problems and improve academic achievement. Dietary diversity, nutritional status, and AP are all latent variables that are difficult to properly assess directly. The previous quantitative investigations in this domain undertook traditional statistical approaches to examine simple associations, such as logistic or linear regression analysis. Nevertheless, the relationship between all of these variables is likely to be more complicated. Thus, our study attempts to answer the research question: Was there an association between dietary diversity and the AP of school-age children via a mediator? Therefore, we aimed to assess the association between dietary diversity, nutritional status, and academic performance of school-age children in pastoral communities in Southeast Ethiopia using a structural equation modelling (SEM) approach.

Methods

Study design, setting, and participants

A school-based cross-sectional study design was used among grade 4 school-aged children in the Sewena and Dawe Katchen districts, Southeast Ethiopia from February to June 30, 2017. There were 15,949 (9,807 males and 6,142 females) and 7,829 (4,745 males and 3,084 females) school-age children in the Sewena and Dawe Katchen districts, respectively. In the Bale Zone, there were 9 pastoralist districts, with 45 schools in Sewena district, 4 schools (grades 1–4), 38 schools (grades 1–8), 2 schools (grades 9–10), and 1 preparatory school; 32 schools in Dawe Katchen district: 29 schools (grades 1–8), 2 schools (grades 9–10), and 1 preparatory school (Supplementary Fig. 1).

The authors generated the map of study settings using ARC GIS version 10.3.1 software.

All public school-aged children in Grade 4 in the pastoral community districts of Bale Zone, Southeast Ethiopia, were the source population. All school-aged children in Grade 4 in the selected pastoral community of the Sewena and Dawe Katchen districts, Bale zone, Southeast Ethiopia, were the study population. Primary school-aged children in Grade 4 who were residing in the study area for at least 10 months were included in the study. School-aged children and their parents who did not respond to the interview questions were excluded from the study.

Sample size determination

The sample size as the higher number calculated was determined for each objective of this study. Accordingly, the sample size for academic performance was calculated using G power software version 3.1 assuming an effect size of 0.2, 95% confidence interval (CI), precision at $\alpha=0.05$, and power $(1-\beta)=80$ [35]. The computed sample size was 191. After adding the design effect of 2 and considering the 5% nonresponse rate, the final sample size was 402. A maximum likelihood (ML) estimate of multivariate normal data based on Monte-Carlo investigations is recommended in SEM with a sample size of 200–400 [36].

Sampling techniques

Sewena and Dawe Katchen districts were selected by lottery among nine pastoralist districts. There were 71 primary schools in the pastoral communities of the two districts. Then, eight schools with sample sizes, namely, Micha ($n=165$), Arda Galma ($n=152$), Kalkalcha ($n=130$), Obere ($n=108$), Mi'oo ($n=187$), Sof Umer ($n=142$), Dipekilfa ($n=104$), and Kubi Walda ($n=121$) were selected randomly by the lottery method from the Sewena and Dawe Katchen districts. The number of school-aged children was obtained from the school roster. After a sampling frame was prepared from the students' roster in each school, the sample size was proportionally allocated to each school by sampling with probability proportional to the size of school-age children. School-age children were selected from each class using a systematic random sampling technique. If a student was absent from class during the interview, an eligible student in the next series was interviewed.

Data collection

Data collection tools were extracted from Ethiopian Demographic and Health Survey (EDHS) and existing literature [31, 37, 38]. A pretested, interviewer-administered, structured questionnaire was used to collect the data. The questionnaire was comprised of socio-demographic and economic factors (child age, sex, marital status of parents, religion, ethnic group, head of household, with whom the child lives, occupation of the parents, educational status of parents, wealth index, and family size); nutritional factors (weight, height, iodized salt, and being compelled to finish the food); health-related factors (illnesses: diarrhea, fever, and pneumonia); sources of drugs (health center, hospital, pharmacy, and traditional medicine); and school-related factors (attendance, time to reach school, and availability of books).

The child's weight and height were measured twice, and the average was taken. Bachelor of Science (BSc) health professionals collected the data. The age of the school-aged children was obtained from the school. The academic performance of school-age children was obtained from the school record. School-aged children and their parents were interviewed at school.

Android principal component analysis (PCA) was used to generate the wealth index. The 21 variables in the PCA comprised the availability of a water source, a latrine, a bank account, different types of living houses, livestock, agricultural ownership, and household asset items [37, 39]. The responses of all nondummy variables were categorized as "improved" (=1) and "unimproved" (=0) based on the WHO/UNICEF definition. Household income was classified into tertiles: "high," "medium," and "poor" [40]. Finally, the highest tertile was labelled having a high income, while the two lowest tertiles were labelled having a low income.

The following PCA assumptions were used: the correlation matrix for variables with two or more correlations>0.30; variables with measures of sampling adequacy should be greater than 0.50 (looking anti-image); overall measures of sampling adequacy, Kaiser−Meyer−Olkin (KMO)>0.5 [41], Bartlett test of sphericity (p value<0.05), communality>0.5, and not having a variable with a complex structure of correlation≥ 0.4. Components that collectively explain more than 60% of the variance in the set of variables and have eigenvalues ≥ 1 [42, 43] were used to identify variables to be included in further analyses. The interviewees' economic status was then classified into terciles: affluent, middle, and poor. Then, the top tertile was labelled as more wealthy, whereas the two lowest tertiles were coded as less wealthy.

Data quality control

The questionnaire was initially developed in English and translated into Afan Oromo, the local language, by a professional person. To ensure the quality of the data, three days of training were given to data collectors and supervisors on the objectives of the study, data collection instruments, and ethical issues. The questionnaire was pretested on 5% of the total sample size in a non-selected adjacent study setting. The researchers made close supervision of data collectors and supervisors.

Operational definitions

Academic performance/achievement was the outcome of interest, and the progress of students in the school was assessed by the results of examinations. The results of academic performance (AP) were extracted from primary school-aged children's rosters [44]. In this study, the semester of the 2016/17 academic year average exam results of all subjects that the students scored were taken from the records of each of their respective schools. High AP was considered if the result obtained was above the median of all subjects; low AP if the result obtained was below the median of all subjects.

Anthropometric measurements were converted to height to age and body mass index to age. Children below negative 2 standard deviations (−2 SD) according to the WHO median for height for age (HFA) and BMI for age (BAZ) were considered stunted or thin, respectively. Normal is a Z score greater than or equal to -2 SD [45, 46].

Dietary intake of school-age children was determined using the 24-hour recall technique, and a child diet variety was created using eight food categories. When a child ate four or more food groups, he or she was deemed to have good dietary diversity, but when a child ate three or fewer food categories, he or she was thought to have inadequate dietary diversity [47]. The dietary diversity score (DDS) was computed by summing the food categories eaten throughout the reference period. DDS was treated as a continuous variable in the SEM.

Primary school-age children Children aged 7–14 years who attend primary school according to the Education Sector Development Programme V (ESDP V) [48].

Data processing and analysis

Statistical analyses were performed using Stata 14 and SPSS version 20. Descriptive statistics such as frequencies, percentages, medians, and interquartile ranges (IQRs) were computed to describe the study subjects. The nutritional status of HFA and BAZ scores were generated using WHO Anthro Plus software version 1.0.4 [49]. The correlation matrix (R) among independent variables was 0.27. Multivariate normal distributions of the data were assessed using the skewness and kurtosis tests. A maximum likelihood (ML) along with non-parametric bootstrap replication (2000) estimations were used to correct the violation of multivariate normality of the data [50, 51]. Structural equation modeling (SEM) is a popular multivariate approach for studying the direct and indirect effects of correlations between observable and latent variables. A variable that has been directly measured and contributes to the composition of a latent variable is referred to as an observed variable in SEM. Latent variables, on the other hand, are unobserved factors that cannot be measured directly. A series of endogenous variables, as well as a series of exogenous factors, are connected in SEM. This approach offers three significant benefits over standard multivariate techniques: (1) explicit evaluation of measurement error; (2) estimate of latent (unobserved) variables via observed variables; and (3) model testing, in which a structure may be imposed and judged as a match to the data [52]. SEM theory simplifies complicated interactions between variables by employing a route model or analysis to elucidate the impacts of observable and latent factors [53, 54]. The approach clearly establishes the link between cause and effect factors. The SEM seeks to generalise a confirmatory factor analysis (CFA) model in order to analyse the link between latent variables and how they impact one another in a variety of ways. A linear structural connection is summarised by the SEM into a measurement model (CFA model) and a structural model [55].

We used path analysis to test the model once we had evaluated the tools in it. Path analysis is a causal modelling approach that may be used with either cross-sectional or longitudinal data. It is an extension of traditional regression that illustrates the direct and indirect effects, as well as the influence of each variable on the dependent variable (DV). A path model's variables can be classified as endogenous or exogenous. Endogenous variables are depicted in the model as being affected by other factors. The exogenous variables are those that are not influenced by anything. Although DVs are always endogenous, some independent (predictor or covariate) variables may be endogenous if they are affected by other independent variable (IDVs) in the model [52, 56]. Dietary diversity, HAZ score, BAZ score, and AP were modelled as continuous variables. The Stata commands 'linktest' and 'ovtest' were used to analyse model specification and omitted-variable bias, respectively. The cause-and-effect link between an IDV and a DV is referred to as a direct effect. An indirect effect is the causal influence of an IDV on a DV via a third variable, the mediator, which is an endogenous variable. The sum of all potential paths from an IDV to a DV, including both direct and indirect effects, is the total effect [57]. A mediator is a variable that exists between the exposure and the interest variable along the causal path [58]. Path coefficients can be represented as standardized or unstandardized. Unstandardized coefficients are more understandable because they indicate the change in the outcome variable per unit change in the causal variables; that is, both the outcome and the causal variables remain on the same scale as the original units of measurement [59]. The unstandardized beta coefficient (β), robust standard error (SE), and 95% CI were used to estimate the strength of associations between IDVs and academic performance. The level of statistical significance was declared at a p value of less than 0.05. Model fit indices were used to assess the model's overall fit to the obtained data, using recommended GoF indices and cut-offs [60]. Root mean square error approximation (RMSEA), comparative fit index (CFI), Tucker-lewis index (TLI), and goodness of fit index (GFI) were used to assess the measurement and structural model's performance [61].

Hypothesized path model

The hypothesized link between observable and latent factors and the relevant endpoint variable was constructed based on the outcomes of prior research, the theoretical correlation, and the authors' experiences. Then, credible links between dietary variety, undernutrition, and AP were built (Supplementary Fig. 2).

Ethical approval

The research protocol was ethically approved by the Ethical Review Committee of Madda Walabu University (Protocol Ref: RPD/0267). All methods were carried out in accordance with the relevant tenets of the Helsinki Declaration [62]. Informed written consent was obtained from the school-aged children's parents. Verbal assent was obtained from pupils. The privacy of the study subjects was maintained. Confidentiality of the data was maintained.

Results

Socio-economic and demographic characteristics

Out of 402 school-aged children sampled from the pastoral communities of Sewena and Dawe Katchan districts, Southeast Ethiopia, 395 respondents were included in the study, making a response rate of 98.25%. The median age of the school-age children was 12 with IQR of 11–13 ranging from 10 to 14 years. Slightly more than half (50.9%) of the school-aged children were males. The majority (93.2%) of school-aged children's parents were married. Almost (94.4%) of the school-aged children were Muslims. The majority of school-aged children (96.7%) were Oromo. 83% of the respondents' mothers were housewives. Most of school-aged children's mothers (28.4%) were literate. Three-forths (74.4%) of the families had low wealth terciles (Table 1).

Health-related factors of school-aged children

Most of (91.6%) school-aged children had an illness. Almost half (53.9%) of school-aged children encountered fever, whereas 1.5% of them developed pneumonia (Supplementary Fig. 3).

Dietary diversity and nutritional status-related factors of school-aged children

The median dietary diversity score (DDS) of school-age children was 4, with IQRs of 2 and 7. The proportion of dietary diversity (DD) among school-age children was 40% (95% CI: 35.7, 45.3%) low DD and 60% (95% CI: 54.7, 64.3) adequate DD. The prevalence of stunting and thinness of school-age children was 26.6% (95% CI: 21.8%, 31.4%) and 28.9% (95% CI: 24.3%, 33.2%), respectively, in Sewena and Dawe Katchen districts.

Academic performance of school-aged children

The median AP of school-age children was 70, with IQRs of 64.60 and 82.40. The proportion of high AP of school-age children was 49.9% (95% CI: 44.6, 55.0), whereas 50.10% (95% CI: 45.3%, 55.7%) scored low in the Sewena and Dawe Katchen districts.

Dietary diversity, nutritional status, and its relation to the academic performance of school-aged children in pastoral communities of Southeast Ethiopia via mediators

The final model contained the measurement of the relationship between latent variables and their indicators and structural model components (the relationship between latent variables) (Figs. 1 and 2).

The SEM revealed that a unit increment in the child's DDS (unstandardised $\beta=0.130$, 95% CI: 0.049, 0.211) did have direct and total effects on the HAZ score. However, HAZ score (β = -0.238, 95% CI: 0.766, 0.289), BAZ score ($\beta=0.136$, 95% CI: -0.499, 0.771), and DDS (β = -0.020, 95% CI: -0.433, 0.393) did not have direct, indirect, or total effects on AP. Similarly, DDS did not have direct or total effects on the BAZ score (β = -0.022, 95% CI: -0.087, 0.042) (Table 2).

Goodness-of-model fit

The GFI model test: X2, $p=0.089$; root mean squared error of approximations (RMSEA): 0.069 (90% CI: 0.001, 0.168); Pclose: 0.242; comparative fit index (CFI): 0.798; Tucker-Lewis index (TLI): -0.214; standardised root mean square residual (SRMR)=0.023; and coefficient of determination (CD)=0.028.

After controlling background characteristics, the SEM revealed that a unit increment in the child's DDS (unstandardised β = -0.302, 95% CI:-0.710, 0.104), HAZ score (β = -0.303, 95% CI: -0.806, 0.199), and BAZ score ($\beta=0.097$, 95% CI: -0.504, 0.699) did not have a direct effect on AP. However, a unit increment in DDS had a negative indirect effect on AP (β = -0.095, 95% CI: -0.068, -0.010). Being female (β = -3.018, 95% CI: -5.088, -0.947), having a literate mother (β = -2.754, 95% CI: -5.004, -0.504), and a unit increment in child age ($\beta=2.992$, 95% CI: 2.276, 3.708) had direct effects on AP. A unit increment in the DDS had a direct effect on the HAZ score ($\beta=0.128$, 95% CI: 0.036, 0.219). Having more wealth had a direct effect on the BAZ score ($\beta=0.438$, 95% CI: 0.051, 0.826). Having a literate mother ($\beta=1.163$, 95% CI: 0.639, 1.687), being increased in family size ($\beta=0.258$, 95% CI: 0.167, 0.347), and child age ($\beta=0.306$, 95% CI: 0.120, 0.492) had a direct effect on DDS.

Having a literate mother ($\beta=0.149$, 95% CI: 0.023, 0.274), having an increased family size ($\beta=0.033$, 95% CI:

Table 1 Sociodemographic and economic characteristics of school-aged children in pastoral communities of Southeast Ethiopia, 2017 ($n=395$)

Variables	Categories	Frequency (*n*)	Percent (%)
Age (years)	≤ 10	96	24.3
	> 10	299	75.7
Sex	Male	201	50.9
	Female	194	49.1
Marital status of parents	Married	368	93.2
	Widowed	10	2.5
	Divorced	2	0.5
	Separated	15	3.8
Religion	Orthodox	20	5.1
	Muslim	373	94.4
	Protestant	2	0.5
Ethnic group	Oromo	382	96.7
	Amhara	4	1.0
	Others (Sidama, Silte)	9	2.3
Maternal occupation	Housewife	328	83.0
	Government employee	4	1.0
	NGO employee	4	1.0
	Petty trade	15	3.8
	Student	44	11.1
Paternal occupation	Farmer	266	67.3
	Government employee	10	2.5
	NGO employee	9	2.3
	Petty trade	16	4.1
	Others	94	23.8
Maternal education	Illiterate	283	71.6
	literate	112	28.4
Paternal education	Illiterate	259	65.6
	Literate	136	34.4
Whom do you live with	Parents	367	92.9
	Mother	17	4.3
	Father	4	1.0
	Sibling	6	1.5
	Other	1	0.3
Family size	< 3	116	29.4
	4–5	25	6.3
	≥ 6	254	64.3
Wealth index	More wealthy	101	25.6
	Less wealthy	294	74.4

0.007, 0.059), and a unit increment in child age (β=0.039, 95% CI: 0.004, 0.074) had an indirect effect on HAZ score. Being female (β = -2.957, 95% CI: -5.023, -0.890), having a literate mother (β = -3.163, 95% CI: -5.321, -1.005), and a unit increment in child age (β=2.885, 95% CI: 2.153, 3.618) had total effects on AP.

Having a literate mother (β=1.163, 95% CI: 0.639, 1.687), having an increased family size (β=0.258, 95% CI: 0.167, 0.349), and a unit increment in child age (β=0.306, 95% CI: 0.120, 0.492) had total effects on DDS. A unit increment in DDS (β=0.128, 95% CI: 0.036, 0.219) and more wealth status (β=0.572, 95% CI: 0.133, 1.011) had total effects on HAZ score. Moreover, having more wealth had a total effect on the BAZ score (β=0.440, 95% CI: 0.053, 0.828) of school-aged children (Table 3).

Goodness-of-model fit

The goodness of fit (GFI) model test yielded the following results: X^2, p value=0.045; root mean squared error of approximations (RMSEA): 0.087 (90% CI: 0.011, 0.184); Pclose: 0.157; comparative fit index (CFI): 0.980; Tucker-Lewis index (TLI): 0.481; standardized root mean square residual (SRMR)=0.013, and coefficient of determination (CD)=0.334.

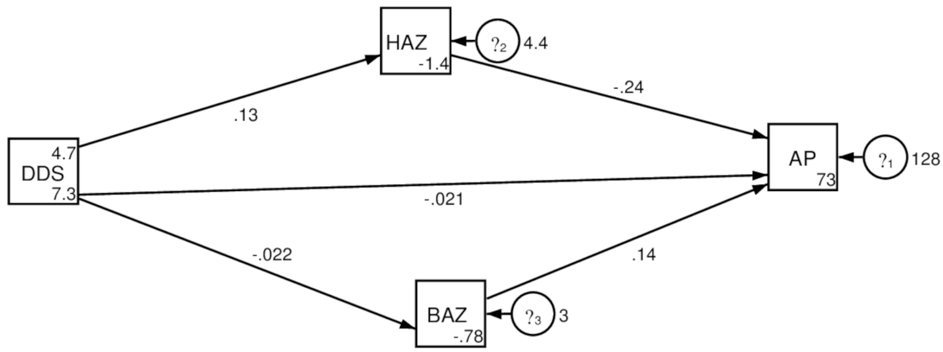

Fig. 1 Association between dietary diversity, nutritional status, and academic performance of school-age children in Southeast Ethiopia
AP: academic performance; HAZ score: height for age Z score; BAZ score: BMI for age Z score; BMI: body mass index; DDS: dietary diversity score

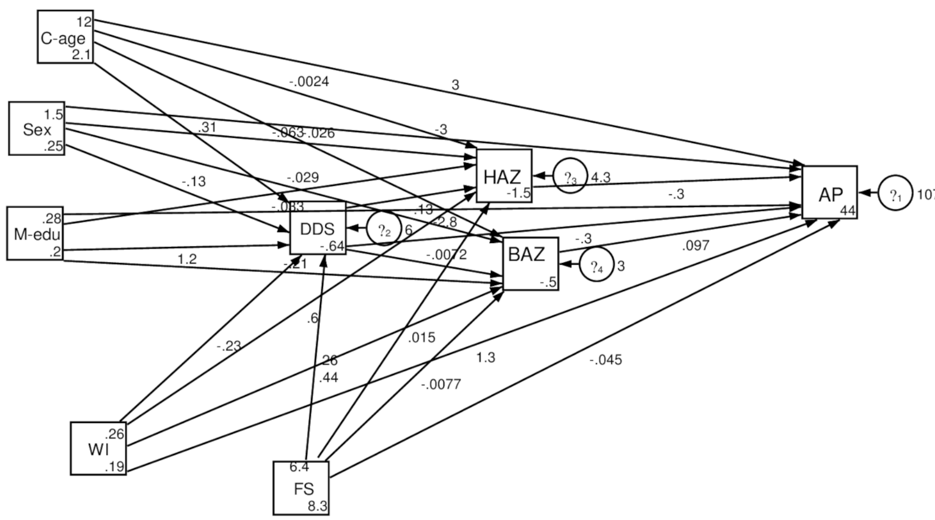

Fig. 2 Association between dietary diversity, nutritional status, and academic performance of school-age children in Southeast Ethiopia
AP: academic performance; HAZ score: hieght for age Z score; BAZ score: BMI for age Z score; DDS: dietary divesity score; C-age: child age; M-edu: maternal education; WI: wealth index; FS: family size

Table 2 Structural equation modelling to predict the direct, indirect, and total effects of child dietary diversity score on academic performance of school-aged children in pastoral communities of Southeast Ethiopia via mediators, 2017 ($n = 395$)

Academic performance (AP)	**Direct effect (unstandardized factor loading)**		**Indirect effect (unstandardized factor loading)**		**Total effect (unstandardized factor loading)**	
Variables	β (SE)	**95% CI**	β (SE)	**95% CI**	β (SE)	**95% CI**
DDS → AP	-0.020 (0.210)	-0.433, 0.393	-0.034 (0.037)	-0.107, 0.039	-0.055 (0.210)	-0.468, 0.359)
HAZ score→ AP	-0.238 (0.27)	-0.776, 0.288	0 (no path)		-0.239 (0.269)	-0.766, 0.289
BAZ score → AP	0.136 (0.324)	-0.499, 0.771	0 (no path)		0.136 (0.324)	-0.499, 0.771
DDS → HAZ score	0.130 (0.041)	**0.049**, **0.211***	0 (no path)		0.130 (0.041)	**0.049**, **0.211***
DDS→ BAZ score	-0.022 (0.033)	-0.086, 0.042	0 (no path)		-0.022 (0.033)	-0.087, 0.042

* Statistically significant; reference category: HAZ score (cont.); BAZ score (cont.); dietary diversity score (DDS) (cont.); AP: academic parformance; β: beta coefficient; SE: standard error; CI: confidence interval

Discussion

The objective of this study was to assess the association between dietary diversity, nutritional status, and academic performance of primary-school-age children in hard-to-reach pastoral communities in Southeast Ethiopia. Accordingly, the high performance of school-age children was 49.9% in Sewena and Dawe Katchen Districts. This study's finding was higher than that of a study

Table 3 Structural equation modelling to predict the direct, indirect, and total effects of child dietary diversity score on academic performance of school-aged children in pastoral communities of Southeast Ethiopia via mediators, 2017 (n=395)

Academic performance (AP)	Direct effect (unstandardized factor loading)		Indirect effect (unstandardized factor loading)		Total effect (unstandardized factor loading)	
Variables	β (SE)	**95% CI**	β (SE)	**95% CI**	β (SE)	**95% CI**
DDS → AP	-0.303 (0.208)	-0.710, 0.104	-0.039 (0.014)	**-0.068**, **-0.010***	-0.343 (0.211)	-0.755, 0.070
HAZ score→ AP	-0.303 (0.256)	-0.806, 0.199	0 (no path)		-0.303 (0.256)	-0.806, 0.199
BAZ score → AP	0.097 (0.307)	-0.504, 0.699	0 (no path)		0.097 (0.307)	-0.504, 0.699
Child sex	-3.018 (1.056)	**-5.088**, **-0.947***	0.060 (0.116)	-0.168, 0.289	-2.966 (1.055)	**-5.023**, **-0.890***
Maternal literacy	-2.754 (1.147)	**-5.003**, **-0.504***	-0.409 (0.275)	-0.949, 0.130	-3.163 (1.100)	**-5.321**, **-1.005***
Wealth index	1.340 (1.208)	-1.026, 3.708	0.059 (0.263)	-0.575, 0.456	1.281 (1.161)	-0.995, 3.558
Family size	-0.045 (0.180)	-0.399, 0.308	-0.093 (0.054)	-0.199, 0.012	-0.139 (0.177)	-0.485, 0.207
Child age	2.992 (0.365)	**2.276**, **3.708***	-0.107 (0.070)	-0.244, 0.031	2.885 (0.373)	**2.153**, **3.618***
DDS → HAZ score	0.128 (0.041)	**0.047**, **0.209***	0 (no path)		0.128 (0.046)	**0.036**, **0.219***
Child sex	-0.063 (0.224)	-0.501, 0.375	-0.016 (0.032)	-0.080, 0.047	-0.079 (0.224)	-0.519, 0.359
Maternal literacy	-0.033 (0.230)	-0.484, 0.418	0.149 (0.063)	**0.023**, **0.274***	0.116 (0.226)	0.0329, 0.260
Wealth index	0.602 (0.218)	0.176, 1.028	-0.030 (0.041)	-0.110, 0.050	0.572 (0.223)	**0.133**, **1.011***
Family size	0.014 (0.042)	-0.066, 0.096	0.033 (0.013)	**0.007**, **0.059***	0.048 (0.038)	-028, 0.124
Child age	-0.002 (0.075)	-0.149, 045	0.039 (0.018)	**0.004**, **0.074***	0.036 (0.076)	-0.112, 0.186
DDS→ BAZ score	-0.007 (0.037)	-0.081, 0.067	0 (no path)		-0.007 (0.037)	-0.081, 0.067
Child sex	-0.029 (0.186)	-0.394, 0.336	0.001 (0.005)	-0.009, 0.011	-0.028 (0.186)	-0.393, 0.336
Maternal literacy	-0.210 (0.206)	-0.614, 0.193	-0.008 (0.044)	-0.094, 0.077	-0.219 (0.199)	-0.609, 0.172
Wealth index	0.438 (0.197)	**0.051**, **0.826***	0.001 (0.009)	-0.016, 0.020	0.440 (0.197)	**0.053**, **0.828***
Family size	-0.007 (0.034)	-0.076, 0.061	-0.001 (0.009)	-0.020, 0.017	-0.009 (0.032)	-0.072, 0.053
Child age	-0.026 (0.068)	-0.016, 0.108	-0.002 (0.012)	-0.024, 0.020	-0.028 (0.069)	-0.162, 0.106
Maternal literacy → DDS	1.163 (0.267)	**0.639**, **1.687***	0 (no path)	0 (no path)	1.163 (0.267)	**0.639**, **1.687***
Child sex	-0.130 (0.253)	-0.627, 0.366	0 (no path)	0 (no path)	-0.130 (0.253)	-0.627, 0.366
Wealth index	-0.235 (0.298)	-0.821, 0.351	0 (no path)	0 (no path)	-0.235 (0.298)	-0.821, 0.351
Family size	0.258 (0.046)	**0.167**, **0.349**	0 (no path)	0 (no path)	0.258 (0.046)	**0.167**, **0.349***
Child age	0.306 (0.095)	**0.120**, **0.492***	0 (no path)	0 (no path)	0.306 (0.095)	**0.120**, **0.492***

* Statistically significant; reference category: HAZ score (cont.); BAZ score (cont.); dietary diversity score (DDS) (cont.); child age (cont.); male; illiterate; less wealthy; family size (cont.); AP: academic performance; β: beta coefficient; SE: standard error; CI: confidence interval

carried out in Nekemte, Western Ethiopia [10]. However, the result was lower than that of a study conducted in the Dawro zone, Southwest Ethiopia, in which approximately 65.8% of school-age children achieved below the mean grade score [63]. The possible explanation could be because of the difference in nutrient intake, tutorials, availability of learning resources, and accessibility.

The prevalence of stunting of school-age children was 26.6% in Sewena and Dawe Katchen Districts, Ethiopia. The finding agreed with a study conducted in Ethiopia [22]. Nevertheless, this study was lower than studies carried out in Ethiopia [10, 18, 20, 23, 24], Burkina Faso [16], Nuwara Eliya, Sri Linka [7], Southeast Asia [15], and Malaysia [64]. On the other hand, this study was higher than many reports, for example, Ethiopia [17, 19, 21, 25, 26, 30, 65, 66], Nigeria [67], and Africa Region [15]. The possible explanation might be because of the difference in the economic status of the family and the study period.

The magnitude of thinness was 28.9%. This study's finding was higher than studies carried out in Ethiopia [18, 24, 30], Nigeria [67], and Burkina Faso [16]. Nevertheless, it was lower than studies carried out in the African Region [15], Nuwara Eliya, Sri Linka [7], and Southeast Asia [15]. This could be because of the variation in obtaining a balanced diet, sociocultural beliefs, frequency of meals, and health conditions of school-aged children.

With a unit increment in DDS, the HAZ score of school-age children increased by 0.130 through the direct pathway. The finding agreed with studies conducted in Ethiopia [18], Nigeria [68], and a meta-analysis [13]. After controlling background characteristics, a unit increment in the age of school-age children by one year, their AP increased by 2.992 through the direct pathway. This finding agreed with the studies conducted in Goba town, Ethiopia [31, 69]. The possible explanation could be that younger school-age children give less attention to the lesson as compared to their counterparts. Being female decreased AP by 3.01. This study disagreed with studies conducted in South Gondar, Ethiopia [70] and Morocco [71]. The possible explanation is that females were too preoccupied with family duties and responsibilities to achieve higher academic achievement. Nevertheless, this study disagreed with studies carried out in Ethiopia [26], Malaysia [64, 72], and Nuwara Eliya, Sri Linka [7]. This might be because of the variation in the study setting and period.

School-aged children who had literate mothers were negatively associated with the AP of school-aged children who did not have literate mothers. The study results agreed with a study conducted in Hawassa Town [73]. However, this finding disagreed with studies carried out in Ethiopia [26, 74, 75], Kelantan, Malaysia [76], and Sri Lanka [77]. The possible justification could be the difference in the socioeconomic status of the school-aged children's parents and less attention to lessons.

As the age of school-age children increased by one year, their DDS increased by 0.306 through the direct pathway. This finding agreed with a study conducted in Ethiopia [78]. Perhaps this is due to the fact that older school-age children understand the benefits of DD for health and nutritional status. Having a higher wealth status increases the HAZ score of school-age children by 0.602. This result is in agreement with studies carried out in Ethiopia [24, 27] and Pakistan [79]. Having more wealth increases the BAZ score of school-age children by 0.438. This finding agreed with studies conducted in Ethiopia [27, 30, 80] and Pakistan [79]. This might be due to the fact that having more wealth improves purchasing power, which in turn enhances the nutritional status of school-age children. Dietary diversity was negatively associated with the AP of school-age children via an indirect pathway. This finding disagreed with studies conducted in Nigeria [81–83] and Morocco [84].

Policy implications

The findings of this study have important implications for food and nutrition policy. Despite the advantages of dietary diversity, low intake suggests a policy gap in Ethiopian child nutritional status. The findings have implications for improving food and nutrition policy , national nutrition strategy , and national nutrition programme to increase mothers' educational level and economic empowerment to promote dietary diversity intake, which in turn improves academic achievement in school-age children.

Strengths and limitations of the study

This study employed the SEM for the first time to assess the relationship between DD and academic achievement via nutritional status. It used valid and reliable instruments to assess the outcome of the interest and exposure variables. Nevertheless, the following limitations have to be acknowledged: the current study used only anthropometric measurements; biochemical parameters of school-age children were not assessed. In addition, physical performance and motor skills of school-age children were not assessed.

Families in pastoral regions frequently suffer financial hardships, which can limit access to a variety of dietary alternatives. Low socioeconomic position is associated with limited DD and undernutrition, which can distort the association between diet and AP [68]. Parents' educational backgrounds have a substantial impact on their children's food choices and nutritional health. Parents with lower education levels may lack information about nutrition, influencing their children's nutritional diversity and, hence, their academic achievements [85, 86]. Cultural norms and traditional dietary habits in pastoral communities may favour some food categories over others, resulting in a lack of variety in children's diets. This cultural component may hinder the effectiveness of programs to improve dietary variety [68].

The availability of different food sources is frequently limited in pastoral regions due to cattle dependency and limited farming methods. This can lead to monotonous diets lacking crucial nutrients required for cognitive growth and academic performance [68, 81]. Variability in the methodologies used to construct DDS may influence the veracity of the findings regarding their impact on academic achievement [85, 86]. The techniques used to assess academic success (e.g., standardised exams vs. teacher assessments) might differ significantly, thereby altering the apparent association with DD . Different disciplines may exhibit differing degrees of association with diet [68, 85].

Dietary assessment might be subjected to recall bias and social desirability bias. A 24-hour food consumption may have no influence on children's health or other markers. The dataset used for this study is relatively longer, and this can be another limitation of this study. Moreover, misclassification of the mediator is a significant potential source of error that might have an influence on exposure-endpoint variable relationships [87]. The study was carried out in the two pastoral districts of Sewena and Dawe Katchen in the Bale Zone, Southeast Ethiopia. Hence, these findings might not be generalizable to the larger population of the country. Since the current study used a cross-sectional study, it has limitations in identifying cause and effect relationships between DD , undenutrition, and academic achievements, as other confounding factors may affect outcome over time [85].

Conclusion

The overall academic performance (AP) of children attending primary schools was low in the Sewena and Dawe Katchen districts. The prevalence of stunting and thinness among school-aged children was high in the study sites. The structural equation modelling (SEM) revealed that a unit increment in the child's dietary diversity score (DDS) did have direct and total effects on the height for age (HAZ) score. However, HAZ score, BMI for age (BAZ) score, and DDS did not have direct, indirect, or total effects on AP. Similarly, DDS did not have direct or total effects on the BAZ score. Thus, nutrition interventions on dietary diversity for school-age children would be crucial for increasing academic achievement. Moreover, further study should be conducted in these pastoral communities to bottleneck undernutrition, which in turn improves AP of school-age children.

Abbreviations

AOR	Adjusted odds ratio
BAZ	Body mass index for age
BMI	Body mass index
FMOH	Federal ministry of health
HAZ	Height for age Z score
SPSS	Statistical package for social science
SD	Standard deviation

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

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Author contributions

GB participated in the conceptualization, formal analysis, investigation, methodology, software, supervision, validation, writing of the original draft, writing a review, and substantial editing. AB, BL, BS, DZ, DB, YT, and KB participated in the investigation, methodology, supervision, validation, and writing review and editing. All authors read and approved the manuscript.

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Data availability

All information used is available upon reasonable request from the corresponding author.

Declarations

Competing interests

The authors declare no competing interests.

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