frontiers | Frontiers in Education

TYPE Original Research
PUBLISHED 10 September 2025
DOI 10.3389/feduc.2025.1651335

OPEN ACCESS

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RECEIVED 21 June 2025
ACCEPTED 18 August 2025
PUBLISHED 10 September 2025

CITATION
Assogba OKE, Madodé YE, Francisco AME, Kossou J, Lokonon J, Luginaah I and Amoussa Hounkpatin W (2025) Factors associated with academic underachievement: a cross-sectional study in Atacora Northern Benin republic.
Front. Educ. 10:1651335.
doi: 10.3389/feduc.2025.1651335

Factors associated with academic underachievement: a cross-sectional study in Atacora Northern Benin republic

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Aim: This study aimed to identify factors associated with low academic performance among public primary pupils in Atacora Department, Benin Republic.

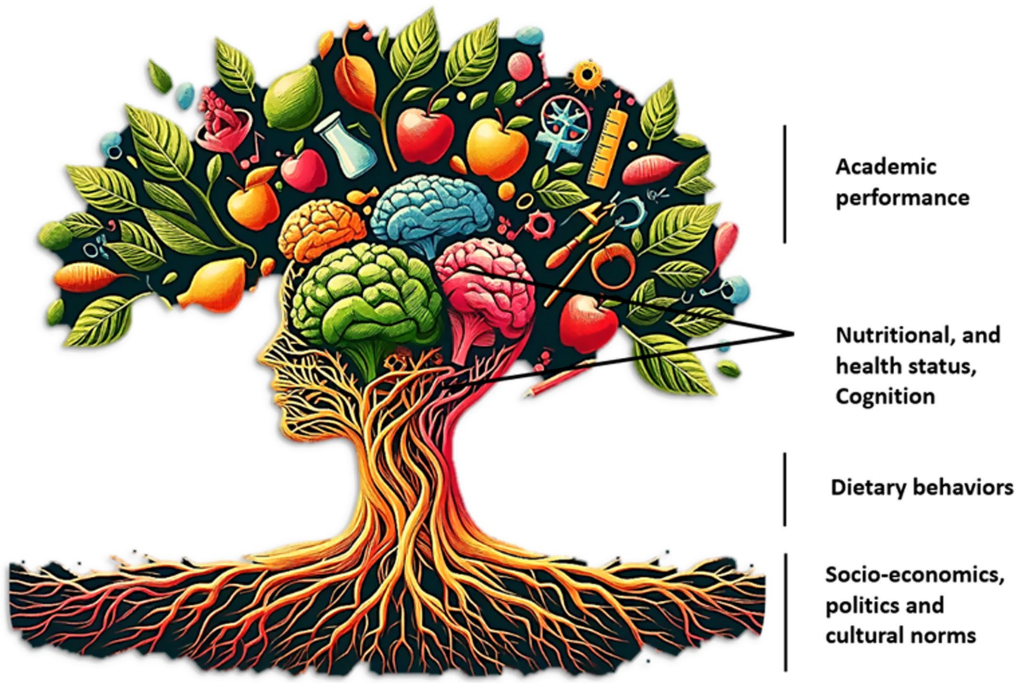
Methods: This cross-sectional study is conducted among pupils aged 8–14 years from public primary schools. Data on dietary diversity were collected using a 24-h dietary recall tool adapted from the FAO guidelines. Nutritional status was assessed through anthropometric measures and hemoglobin level, while cognitive abilities were assessed using Digit Span and Verbal fluency tests. The socio-economic, demographic and health characteristics were collected through digitalized questionnaires administered to pupils. Physical activity levels were measured using the Physical Activity Questionnaire for children (PAQ-C) Form. Academic performance was measured using end-of-month examination results provided by school boards.

Results: findings revealed that almost half (46.34%) of the pupils scored less than 10 out of 20 and were in fail category. Among pupils with normal growth according to WHO standards, cognitive factors as low Verbal fluency (OR = 3.119, $p < 0.05$); low Digit span (OR = 2.623, $p < 0.05$); nutritional factors as low dietary diversity (OR = 2.283, $p < 0.05$); socioeconomic conditions including paternal illiteracy (OR = 1.422, $p < 0.05$), and lack of household electricity (OR = 2.009, $p < 0.05$), and school related factors as long distance to school (OR = 3.187, $p < 0.05$), high level of absenteeism (OR = 1.052, $p < 0.05$), are predictors of academic underachievement.

Conclusion: Overall, Cognition, dietary diversity, access to electricity, pupils' gender, distance to school, father's literacy, are predictors of school performance in the study area. Integrated, context-sensitive policy interventions—spanning early childhood education, rural electrification, gender equity, parental engagement, school attendance, teacher training, nutritional support, and improved food accessibility—are crucial for enhancing academic performance in food-insecure regions of Northern Benin.

KEYWORDS

academic performance, dietary diversity, cognition, nutritional status, parent literacy, physical activity



GRAPHICAL ABSTRACT
Factors influencing academic performance in the department of Atacora in Benin Republic.

1 Introduction

Educational performance is a cornerstone of personal development and a driver of economic progress, influencing individual opportunities and national growth trajectories. Countries with high-performing education systems often experience accelerated economic development due to the cultivation of a skilled and innovative workforce (OECD, 2025). On the other hand, children in low- and middle-income countries (LMICs) face persistent barriers to academic achievement, including systemic inequalities, resource constraints, and socio-economic challenges. Sub-Saharan Africa, including Benin, exemplifies these disparities, where limited access to educational resources and persistent food insecurity significantly impact learning outcomes (WorldBank, 2025). For instance, studies have shown that food insecurity and malnutrition negatively impact cognitive function, reducing students' ability to concentrate and retain information in class (Black et al., 2017). Despite global efforts to improve education, regional inequalities persist, with rural areas often lagging far behind urban centers (UNICEF for every child, 2025). These disparities underline the importance of understanding the unique challenges of food-insecure and underserved rural communities as Northern Benin to design effective interventions.

In food-insecure regions, the intersection of poverty, malnutrition, and inadequate educational infrastructure poses severe challenges to school performance. Poverty affects over 35% of households in Atacora region, reducing access to adequate nutrition and essential educational resources (FAO, 2022). Nutritional deprivation, particularly deficiencies in micronutrients such as iron, zinc, and iodine, has been shown to impair cognitive development and learning capacity (Prado and Dewey, 2014). In addition, families living in poverty often struggle to afford learning materials, school fees, and transportation, further compounding educational disadvantages (UNICEF for every child, 2025). Poor school infrastructure and high student-to-teacher ratios exacerbate these issues, creating unconducive learning environments for academic success. For example, many schools in Northern Benin lack adequate classroom space, functional sanitation, and qualified teachers, all of which contribute to low academic performance (WorldBank, 2025). These interrelated factors highlight the need for a multi-dimensional approach to tackling educational disparities in such settings.

Beyond nutrition and poverty, a range of cognitive, household, and school-related factors influence academic achievement. Cognitive functioning is a critical predictor, with strong evidence linking working memory, attention, and language skills to school performance (Glewwe and Muralidharan, 2016; Alloway and Alloway, 2010). For instance, children with lower verbal fluency and digit span scores often struggle more in classroom settings. Yet, cognitive assessments in LMICs may underestimate children's capabilities if conducted in a language they do not fully master, particularly when local dialects differ from the language of instruction, as is the case in Benin (Piper et al., 2016; Baloubi, 2024).

Household characteristics, such as parental education and household size, also shape academic trajectories. Children of literate parents are more likely to benefit from academic support at home, while those in large families often experience resource dilution, with less time and fewer materials allocated to each child (Black et al., 2017; Filmer and Pritchett, 1999). Other household-level determinants include access to electricity, which affects study time, and parental involvement in school monitoring. These social factors interact with

children's motivation, attendance, and ultimately their academic success.

School-related factors such as absenteeism, long distances to school, and lack of school meals also play a significant role. Long commutes have been linked to fatigue and lateness, reducing classroom engagement, particularly in rural areas where infrastructure is poor (UNESCO, 2023). High absenteeism, whether due to illness, household responsibilities, or lack of interest, directly affects the continuity of learning and performance. Moreover, overburdened classrooms and low teacher-to-student ratios reduce the quality of instruction and individualized support (WorldBank, 2025). Schools that lack essential infrastructure or learning support services often report lower achievement rates and higher dropout rates.

School feeding programs have emerged as a promising intervention to address food insecurity and improve educational outcomes. By providing regular meals to students, these programs aim to alleviate short-term hunger, enhance nutritional status, and improve cognitive function (Kristjansson et al., 2007). In Northern Benin, where food insecurity is pervasive, such programs are particularly relevant and have shown positive effects on attendance, concentration, and enrollment rates (FAO, 2022). However, their direct impact on academic performance remains underexplored in this context. The effectiveness of school feeding programs depends on several factors, including the quality and nutritional value of meals, the frequency of distribution, and the socio-economic conditions of beneficiaries (Black et al., 2017). For instance, schools that consistently provide balanced meals report higher attendance and engagement levels than those with irregular or low-quality meals distributions (Albright and Bundy, 2018). Despite these potential benefits, gaps in implementation and limited evaluations hinder the scalability and optimization of these programs. Understanding their specific impact and factors that are associated to academic performance in Northern Benin could provide valuable insights for improving program effectiveness.

While existing research has examined the role of individual factors such as nutrition (Zaini et al., 2005; Abebe et al., 2017; Akubuilo et al., 2020; Hafte Teklay and Verstegen, 2023) and socio-economic status (Tomul et al., 2021) in academic performance, there remains a gap in understanding their combined effects in food-insecure rural contexts. Most studies tend to focus on urban settings or generalized populations, often overlooking the unique challenges of rural, food-insecure, and underserved communities like Toukountouna and Boukoumbé (UNICEF for every child, 2025). Furthermore, the interaction between nutritional status, feeding practices, and school-specific characteristics, such as distance to school, home tutoring, remain poorly understood. Addressing these gaps is crucial for developing targeted interventions that address the root causes of low academic performance in such contexts. This study aims to identify the factors associated with low school performance in Northern Benin and hypothesizes that child cognition, parental education and distance to school are associated with school performance. This study contributes to the broader discourse on achieving Sustainable Development Goal 4 (SDG 4), which seeks to ensure inclusive and equitable quality education for all by 2030 (United Nations Development Programme, 2024).

2 Theoretical framework

This study applies Bronfenbrenner's Ecological Systems Theory (EST) (Bronfenbrenner, 2013) and Becker's Human Capital Model (HCM) (Lindahl et al., 2014) to analyze factors influencing academic performance in Atacora North, Benin. EST highlights that child development results from interactions between biological traits and environmental contexts. HCM emphasizes investments in health and education as drivers of cognitive capacity and economic productivity (Bailey et al., 2016). Combining these frameworks enables a comprehensive understanding of how nutrition, health, socioeconomic status, and educational inputs jointly affect academic outcomes.

At the microsystem level, biological factors such as anemia and dietary quality have demonstrated strong links to cognitive function and learning. Studies in Sub-Saharan Africa revealed that anemia and micronutrient deficiencies adversely impact attention, memory, and school performance (Appiah et al., 2023; Boivin and Giordani, 1993). In rural settings in Sub-Saharan Africa, poor dietary diversity correlates with undernutrition and impaired child growth, which can negatively influence cognitive development (Hadidjaja et al., 1998; La Rue et al., 1997; Mantzorou et al., 2020). Parental involvement and early education programs further support cognitive and academic development by providing stimulating environments (Chang et al., 2009; Ma et al., 2016).

At the exosystem and macrosystem levels, household poverty and food insecurity limit access to adequate nutrition and schooling. Food insecurity is associated with increased school absenteeism and poorer academic outcomes across Africa, (Buthelezi et al., 2025; Jyoti et al., 2005; Tamiru et al., 2017). From the HCM perspective, improvements in nutrition and education represent investments that generate long-term cognitive and economic returns. Nutritional interventions targeting anemia and dietary quality have been shown to improve cognitive function and school performance in children in SSA (Kedir et al., 2024; Kyere et al., 2020; Neumann et al., 2002). Likewise, quality early childhood education improves foundational skills, increasing future educational attainment and productivity (Heckman, 2012). Integrating these theories offers a multidimensional approach to understanding and identifying the factors associated with low school performance in Atacora North.

3 Methods

3.1 Study context

This study is a cross-sectional study that took place in public primary schools in Atacora Department in Benin republic a Sub-Saharan Africa country. The Republic of Benin is a West African country bordered by Togo to the west, Nigeria to the east, Burkina Faso and Niger to the north, and the Atlantic Ocean to the south. Benin spans 114,763 km^2 and has a population of 13,712,828 (Benin Demographics, 2023). Atacora is currently ranked among the lowest two departments in the country in terms of pupils' academic performance in their final primary school completion certificate examination (La Nouvelle Tribune, 2024). In addition, Atacora has been identified as having a high prevalence of food insecurity, especially in the municipalities of Boukoumbe and Toukountouna (INSAE_AGVSA, 2018). Toukountouna and Boukoumbe are two rural municipalities with limited infrastructure and poor access

to public services. Known for their cultural richness and traditions, the majority of their population are engaged in agricultural and cultural craft activities.

The Beninese National Integrated School Feeding Program (PNASI) significantly improves educational outcomes and alleviates food insecurity for public primary schoolchildren particularly in rural regions like Atacora, where food insecurity and poverty are rampant (INSAE_AGVSA, 2018). Launched in 2017, the program provides daily hot meals to public primary school students, benefiting over 1.1 million children by 2022 across all 77 communes. This initiative not only addresses malnutrition but also boosts enrollment and attendance, reducing absenteeism and dropouts by mitigating hunger among schoolchildren (Amoussa Hounkpatin et al., 2024). Further, research highlights that school canteens encourage parents to keep their children, especially girls, in school, thereby promoting gender equity in education (Djagba et al., 2023). In addition, local management committees and parental contributions strengthen the program, although challenges such as delayed food supply and overcrowded classrooms persist (Djagba et al., 2023). Overall, the PNASI exemplifies a holistic approach to addressing educational and nutritional challenges, offering immediate benefits to children while fostering community development.

3.2 Subjects

Sample size estimation was performed using Charan and Biswas's (2013) sample size formula for quantitative cross-sectional studies. We assumed 95% for confidence interval, considered food insecurity prevalence in Atacora department (INSAE_AGVSA, 2018) and 10% drop out rate (Charan and Biswas, 2013). As a result, a total of 304 pupils were recruited for the study. Participants were selected from four (4) schools in each municipality. Those four schools were randomly selected from the municipality school list. In each school and in each class, the number of participants recruited were proportional to number of students, and gender. Pupils were eligible if they: (1) provided written informed consent from a parent/guardian and gave their assent to participate, (2) were in good health with no contraindications regarding meals served in the school canteen, (3) had no physical limitations, and (4) were 8–14 years of age and in grade 4 or 5. Children were excluded if they: (1) were found sick the day of data collection, (2) were taking medications (3) did not provide signed informed consent from their legal guardians or did not give their assent to participate in the study. The schools administrations and teachers were informed of the study and its objectives.

The data collection was held in October 2024. On the day of data collection, 5 selected pupils were absent, and 7 were reported sick. A total 5 pupil's data was incomplete, they withdrew from the study because of time constraints. Overall, 287 pupils participated in the study.

3.3 Ethical clearance

The study protocol was approved by the institutional review board of Ethics Research Committee of Applied Biomedical Sciences (N° 260 du 26/07/2024. Date of approval July 26 2024) and was conducted in accordance with the Declaration of Helsinki. The study design and objectives were communicated to the school administration and teachers. Before the study began, students and their parents or legal guardians were informed about the study objectives and procedures. Participant gave their assent and their parents or legal guardians gave their written informed consent.

3.4 Data collection

3.4.1 Academic performance

The grade point average scores in all studied subjects in October month for the academic years 2024–2025 represent the academic performance of the participants. The grading categories included: High performance (pass), score ranged from 10 to 20 and Low performance (fail) category, score ranged from 0 to 9.99. The subjects studied at school expand in Mathematics, life sciences, social sciences, languages, physical education and creative activities (as drawing) domains. The average grade in all subjects studied was used for consistency with current assessment practices in the Beninese primary school system to generate final grades and determine whether a pupil succeeded and will advance to the next grade the following year or failed. Given that this study is cross-sectional, we only used the October 2024 exam results.

3.4.2 Cognition

Cognition was assessed across three cognitive domains: attention, short-term memory retention, and thinking. Two cognitive tests were used: the Verbal fluency test (Regard et al., 1982) and the Digit Span test (Jasinski et al., 2011; Wechsler, 2008). The Digit Span test assessed how many items a pupil could recall immediately, in the order showed in the test. The performance on this test provides valuable information about an individual's short-term memory span and their ability to process and temporarily store information (Jasinski et al., 2011). The Wechsler Intelligence Scale for Children Digit Span Revised tasks have been proven reliable and enable valid measures of short-term memory capacity in several studies (De Paula et al., 2016; Conway et al., 2005). The test was administered according to Wechsler guidelines. Based on the methodological review and user's guide for memory span tasks (Conway et al., 2005), and the mean of score in the current study (5.88 rounded to 6), we categorized the pupils' scores into two groups: "low scores" = 0 to 5 lines correct, and "high scores" = 6 to 16 lines correct.

Additionally, the Verbal fluency test assessed the speed and ease with which pupils can use words, and their ability to think and organize information in a limited timeframe. The Verbal fluency test was evaluated in French according to Regard et al. (1982). Participants were asked to generate as many words as possible that began with a specific letter. The detailed description of the test can be found in prior literature (Sauzéon et al., 2004; Regard et al., 1982; Zorza et al., 2016). Two categories were considered in this study: "low scores" = 0 to 2 words, and "high score" = 2 to 16 words.

3.4.3 Anthropometry and hemoglobin measures

Body mass index for age was used to assess the pupils' nutritional status according to the World Health Organization standard operating procedures (WHO, 2006) using pupils' height and weight measured according to the WHO's guidelines. The *z*-scores were calculated via WHO's Anthro Plus software, following standard operating procedures. In the same way, hemoglobin level was measured according to World Health Organization standard operating procedures (Weltgesundheitsorganisation, 2006). Portable

hemoglobinometer (HemoCue AB) was used to determine hemoglobin level from a capillary blood sample collected from the fingertip of each child aseptically, using sterile single-use disposable lancet. It was done by trained and experienced laboratory technicians. The necessary safety measures were taken during blood collection. A child was identified as anemic if the hemoglobin concentration was <11.5 g/dL for children (5–11 years) and < 12 g/dL for children older than 12 years of age. These indicators are globally accepted and used in several studies to assess children's nutritional status (Assefa et al., 2014; Correa-Burrows et al., 2016; Sun et al., 2024).

3.4.4 Physical activity questionnaire

Physical activity was measured using the Physical Activity Questionnaire for children (PAQ-C) appropriate for school-aged children (4–14 years old) (Kowalski et al., 2004). Each of the first 9 (PAQ-C) questions is scored between 1 (low) and 5 (high physical activity), and a mean score of all items constitutes the overall PAQ score. The reliability and validity of the PAQ-C have been reported in different study populations and countries (Benítez-Porres et al., 2016; Janz et al., 2008; Kowalski et al., 2004; Voss et al., 2017).

3.4.5 Dietary diversity

Dietary diversity was assessed using a 2 weekday 24-h dietary recall (24HDR). A detailed description of all the food and drink consumed by pupils was recorded. According to FAO guidelines (Kennedy et al., 2011), the number of different food groups consumed over 24-h was generated to reflect their dietary diversity. A pupil's dietary food diversity was constructed based on 10 food groups. A child was considered as having a good dietary diversity when he had eaten 5 or more food groups, and a child's dietary diversity was considered poor when he reported fewer than 5 food groups (Kennedy et al., 2011; Nago et al., 2009; Coates et al., 2007).

3.4.6 Distance to school

The information was gathered on the distance to school by asking participants to record the time spent walking from their house to school. The variable distance to school were categorized based on empirical evidences (d'Aiglepierre, 2012; Oneya and Onyango, 2021), into three groups: pupils close (less than 15 min to school), pupils living far (between 15 min and 29 min) and pupils living very far from school (30 min and above).

3.4.7 Socioeconomics and other educational characteristics

The socio-economic characteristics of the study participants were collected using a digitalized questionnaire. The data collected included pupils' family wealth assessed through household asset ownership, household ownership of a bike, cell phone, radio, TV, stove, access to electricity, and access to running water in the house. Principal Component Analysis (PCA) was used to reduce the socioeconomic variables into two categories. Pupils from "poor households" and pupils from "non-poor households." Based on the PCA, the poverty line separating the poor and non-poor groups was −0.00477. Using PCA is a more pragmatic alternative to categorize household wealth in contexts where both money flow and household membership are volatile, seasonally dependent, and difficult to track. Empirically, this approach was considered reliable for predicting household wealth (Armah and Luginaah, 2012). The socio-demographic data included pupils' gender, age, parent literacy, and household size. Health issue data were gathered by administering questions to pupils to determine whether during the term they experienced any illness including endemic diseases such as malaria and anemia. Pupils were asked to bring to school their medical records to verify. All diseases, infections, or pain were recorded through the digitalized questionnaire. Other educational characteristics of the participants were collected, including absenteeism, whether they had attended pre-school program, and had a home tutor.

3.5 Statistical analysis

All statistical analyses were performed using Stata version 18.0. The data analysis involved a three-stage approach (univariate, bivariate, and multivariate). The univariate approach examined the descriptive statistics to understand characteristics and distribution of each variable before conducting further analysis. It provided valuable insights into the individual variables, which helped identify outliers, understand the central tendency, and assess the overall shape of the data distribution. We used binary logistic regression model in the second and third stages since the dependent variable (pupil's school performance) is binary. This allowed us to investigate the association between school performance and independent variables (Hedeker et al., 2000). The second stage involved bivariate ordered logistic regression to understand the relationship between school performance and each independent variable. This helped assess each variable's impact on the likelihood of passing or failing at school. The final stage involved investigating the association of the combined independent variables and their impact on the dependent variable (Hedeker et al., 2000). We used a likelihood estimation method to calculate the odds ratios for pupils having low school performance (Murad et al., 2003). The odds ratios exceeding one (OR>1) indicate a higher likelihood of low school performance, while those below one (OR<1) demonstrate a lower likelihood. Statistical significance was set at $p < 0.05$. The reliability of the model was assessed using R-squared, the Akaike Information Criterion (AIC), and the Bayesian Information Criterion (BIC).

4 Results

4.1 Univariate results

The univariate analysis is presented in Table 1. The survey revealed that 46.34% scored low academic achievement and 53.66% scored high. Only 23.34% of the pupil's had attended a preschool program. Most pupils' (51.57%) were reported to have moderate physical activity. Only one fourth (26.13%) of the pupils' household were reported to have access to electricity.

The survey revealed that among the participants, the majority of pupils were aged 11–14 years (66.55%). Only 45.64% of pupils had never been absent in the considered term. Dietary diversity, was limited for most pupils, with 58.54% reporting inadequate dietary diversity. Physical activity levels varied, with most pupils reporting low (51.57%) or high (35.54%) activity; boys were more likely to

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TABLE 1 Descriptive analysis of the sample.

Variables categories	Variables	Percentage (%)	Frequency
Dependent variable	School performance	10.37 (mean), SD: 2.53	Min:0; Max:16.56
	Low (fail)	46.34	133
	High (succeed)	53.66	154
Cognition	Digit span	5.88 (mean), SD: 2.89	Min: 0; Max: 10
	Low	53.31	153
	High	46.69	134
	Verbal fluency	2.36 (mean), SD: 2.66	Min: 0; Max: 16
	Low	88.85	255
	High	11.15	32
Other school data	Absenteeism		
	Never been absent	45.64	133
	have been absent	54.36	154
	Class		
	Grade 4	46.04	64
	Grade 5	53.96	75
	Pupil's age	11.34 (mean), SD: 1.52	Min: 8; Max: 14
	8 to 10	33.45	96
	11 to 14	66.55	191
	Preschool		
	Yes	23.34	67
	No	76.66	220
	Having a tutor		
	Yes	34.15	98
	No	65.85	189
	Distance to school		
	Close (*less than 15 min of walk*)	29.27	84
	Far (*between 15-30 min of walk*)	54.70	157
	Very far (*more than 30 min by walk*)	16.03	46
	Teacher level of education		
	High school	50	8
	College	31.25	5
	University degree	18.75	3
Nutritional status	Hemoglobin level (dL)	11.49 (mean), SD: 1.24	Min: 6.4; Max: 14.5
	Anemic pupils	52.61	151
	Non anemic pupils	47.39	136
	BMI-age		
	Severe	0.7	2
	Moderate	6.62	19
	Mild	27.18	78
	Normal	62.72	180
	Over	2.79	8
	DDS		
	≥5	68.99	198
	<5	31.01	89

(Continued)

TABLE 1 (Continued)

Variables categories	Variables	Percentage (%)	Frequency
Physical activity	Pupil's physical activity		
	Very low	11.50	33
	Moderate	51.57	148
	High	35.54	102
	Very high	1.39	4
Socio-economic characteristics	Electricity		
	Yes	26.48	76
	No	73.52	211
	Household wealth		
	Poor	26.13	75
	Non poor	73.87	212
	Household size	7.06 (mean), SD: 2.53	Min: 3; Max: 15
	3–7	62.37	179
	8–15	37.63	108
	Father work status		
	Working father	90.59	260
	Jobless father	9.41	27
	Mother or caregivers working status		
	Working caregivers	85.71	246
	Jobless caregivers	14.29	41
	Father literacy		
	Literate	49.13	141
	Illiterate	50.87	146
	Caregivers literacy		
	Literate	28.92	83
	Illiterate	71.08	204

**p-value<0.05; ***p-value<0.001; ^p-value < 0.10; OR: odd ratio; SE: Standard Error; Cont.: continuous variable; ref: group reference; Low performance (fail): score range 0–9.99; High performance (succeed): score range 10–20); Low digit span score: score range 0–6 lines correct; High digit span score: score range 6–16 lines correct; Low verbal fluency score: score range 0–2 correct words uttered; high verbal fluency score: score range 0–16 correct words uttered.

report high activity (38.85%) than girls (32.43%), whereas very low activity was more frequent among girls (14.86%) compared to boys (7.91%). Access to electricity was low overall, with 73.52% of households lacking it and almost three fourth pupils' were from non-poor household (73.87%).

4.2 Bivariate results

Table 2 shows the results of the bivariate binary logistic regression analysis. The findings showed that verbal fluency (OR = 4.300, $p < 0.05$) and digit span (OR = 3.023, $p < 0.001$) impacted significantly school achievements, with pupils showing lower scores being at least three time more likely to score low school performance. In addition, an increase in age (OR = 0.831, $p < 0.05$) reduced the odds of having low academic performance. Female pupils were significantly more likely to perform lower than their male counterparts (OR = 1.802, $p < 0.05$). Lack of electricity were a negative factor for academic performance, as pupils from households without electricity were nearly two time more likely to perform lower in school (OR = 1.832, $p < 0.05$). Pupils' not having a minimum dietary diversity were two time likely to fail at school (OR = 2.042, $p < 0.05$). In the same line, having suffered from malaria in the considered term (OR = 1.895, $p < 0.05$), were positively associated with low performance. Lacking preschool program (OR = 1.895, $p < 0.05$) negatively impacted outcomes. The relationship between distance to school and performance was inconclusive, although pupils living very far (OR = 2.065, $p < 0.05$) from school approached significance for poorer performance.

4.3 Binary logistic regression to predict low academic performance

Table 3 presents binary logistic regression analysis exploring the associations between nutritional, cognitive, socio-economic, and educational factors and low school performance, for both the full sample and pupils with normal BMI-for-age. Cognitive factors as verbal fluency (OR = 3.401, $p < 0.05$) and digit span

TABLE 2 Bivariate binary logistic regression analysis predicting low school performance among pupils (n =287).

Bivariate binary logistic regression analysis			
Variables	OR	SE	*p*-value
Verbal fluency *(ref. low)*	4.300	2.020	0.002**
Digit span *(ref. low)*	3.023	0.748	0.000***
Pupil's Age *(cont.)*	0.831	0.066	0.02**
Pupil's Gender (*ref male*)	1.802	0.432	0.014**
Mothers or caregivers working status (*ref working*)	1.121	0.378	0.735
Fathers Working status (*ref working*)	0.777	0.319	0.541
Mothers or caregivers literacy (*ref. literate*)	1.359	0.358	0.245
Paternal literacy (*ref. literate*)	0.687	0.163	0.115
Household wealth (*ref. non-poor*)	1.176	0.316	0.546
Electricity (*ref. having electricity*)	1.832	0.506	0.028**
Household size (cont)	1.192	0.291	0.471
Anemic status (*ref. Normal hb stores*)	0.800	0.190	0.346
Dietary Diversity Score (*ref. DDS≥5*)	2.042	0.530	0.006**
Malaria (*ref. had not suffer of malaria*)	1.895	0.615	0.049**
BAZ (*ref. normal BMI-Age*)	0.953	0.136	0.739
Home tutor (*ref. had home tutor*)	0.8	0.200	0.371
Preschool (*ref. attended preschool*)	0.536	0.151	0.027**
Absence (*ref. had never been absent*)	1.026	0.018	0.144
Distance to school (*ref. close*)	1.321	0.239	0.124
Far	0.877	0.239	0.633
Very far	2.065	0.776	0.054*
PA (ref very low + low PA)	1.027	0.030	0.357
High (high + very high)	1.341	0.329	0.232
Teacher's level of education *(ref. secondary school diploma)*			
College	0.88	0.400	0.779
University degree	0.618	0.272	0.275

**p-value < 0.05; ***p-value < 0.001; *p-value < 0.10; OR: odd ratio; SE: Standard Error; Cont.: continuous variable; ref: group reference; low performance (fail): score range 0–9.99; High performance (succeed): score range 10–20; Low digit span score: score range 0–6 lines correct; High digit span score: score range 6–16 lines correct; Low verbal fluency score: score range 0–2 correct words uttered; high verbal fluency score: score range 0–16 correct words uttered; PA: Physical Activity.

(OR = 2.431, $p < 0.05$) were significantly associated with higher odds of low school performance, underscoring the importance of cognitive skills. Among nutritional factors, higher food diversity was inversely associated (OR = 2.015, $p < 0.05$) with the odds of having low school performance. In contrast, hemoglobin levels and malaria showed no significant associations. Gender (OR = 1.938, $p < 0.05$) also played a significant role, showing a marginal association with increased risks for girls. Father's literacy (OR = 1.533, $p < 0.05$) emerged as a protective factor, suggesting that paternal literacy could reduce the risk of low performance. Additionally, considerable long distance to school (OR = 2.813, $p < 0.05$) was found to increase the risk of academic underachievement.

Among pupils with normal BMI for their age, similar patterns were observed, though with some variations. Cognitive performance in verbal fluency (OR = 3.119, $p < 0.05$) and digit span (OR = 2.623, $p < 0.05$) continued to be significant predictors. Food diversity remained a significant protective factor for academic performance (OR = 2.283, $p < 0.05$), reinforcing the importance of dietary diversity in supporting cognitive and academic outcomes. Socio-economic and demographic variables such as access to electricity (OR = 2.009, $p < 0.05$) showed similar trends as in the full model, with electricity access being a significant factor. Gender exhibited no effect. Paternal literacy continued to be protective (OR = 1.422, $p < 0.05$), highlighting the role of parental education in shaping academic success. School-related factors such as school absence (OR = 1.052, $p < 0.05$) were significantly associated with low performance, revealing the importance of regular school attendance. Additionally, considerable long distance to school (OR = 3.187, $p < 0.05$) was found to increase the risk of academic underachievement.

These results emphasize the continued relevance of cognitive performance, food diversity, and socio-economic context, in influencing school performance, particularly in pupils with normal BMI-for-age.

5 Discussion

This study investigated the factors associated with school performance in a food-insecure context in Northern Benin, specifically in Toukountouna and Boukoumbé. The findings highlight the complex interplay of cognitive abilities, nutritional aspects, socio-economic factors, and school patterns in influencing school performance.

Consistent with our hypothesis, we found that cognitive abilities especially attention and working memory are essential for academic success. This aligns with evidences suggesting that attention, working memory and ability to organize information are core skill for school performance (Lemos et al., 2025; Demetriou et al., 2020; Peng and Kievit, 2020; Bettini and Giuliani, 2016). Peng and Kievit went further, and showed that working memory is longitudinally linked to school performance throughout childhood (Peng and Kievit, 2020). In other words, pupils with good executive functions will perform better at school than those with cognitive disorders. Other authors even claimed that cognitive abilities are the best predictor of school performance (Karbach et al., 2013). Cognitive development in early childhood and throughout childhood and early adolescence is crucial and closely tied to educational outcomes.

One crucial aspect of our study is that, low dietary diversity influenced negatively school performance. This means that pupils not meeting the minimum dietary diversity have higher chances of exhibiting low school performance. Indeed, pupils with inadequate dietary diversity may fail to provide their bodies essential macronutrients like protein, micronutrients like calcium magnesium that promote optimum growth and brain development resulting later in lower academic results (Lee, 2022; Neumann et al., 2007; Stephenson et al., 2023). This finding aligns with broader agreement that proper feeding practices including dietary diversity are crucial for adequate cognitive development and better academic performance in literature (Beckmann et al., 2021; Uzosike et al., 2020; Yeh et al., 2025). This evidence adds to those in Eastern Morocco (Bouchefra et al., 2023) and Port Hacourt in Nigeria (Uzosike et al., 2020) highlighted low dietary diversity as one of the main predictor of poor academic performance. In contrast, Beressa and collaborators revealed a mixed effect

TABLE 3 Binary logistic regression analysis predicting Low school performance among all the pupils and among pupils with normal Body mass index for age.

Variables group	Variables	Model 1: binary logistic regression (all)			Model 2: binary logistic regression (BMI-age normal pupils)		
		Mixed multiple model			Logistic regression model		
		OR	SE	*p*-value	OR	SE	*p*-value
Cognition	Verbal fluency *(ref. high)*	3.401	1.808	0.021**	3.119	1.689	0.036**
	Digit span *(ref. high)*	2.431	0.686	0.002**	2.623	0.791	0.001**
Nutritional status and health	Hemoglobin level *(cont)*	1.091	0.125	0.448	1.066	0.129	0.599
	Malaria *(ref. normal pupils)*	1.637	0.632	0.202	2.149	0.903	0.069
	Dietary diversity Score *(ref. DDS≥5)*	2.015	0.625	0.024**	2.283	0.757	0.013**
Socio-economic characteristics	Pupils' age *(cont)*	0.881	0.088	0.204	0.888	0.096	0.272
	Gender *(ref. boys)*	1.938	0.557	0.021**	1.749	0.542	0.071
	Electricity *(ref. having electricity)*	1.710	0.556	0.099	2.009	0.691	0.042**
	Household size *(Cont)*	1.245	0.356	0.442	1.523	0.471	0.174
	Household wealth *(ref. non poor)*	1.155	0.368	0.652	1.281	0.441	0.473
	Home tutor *(ref. having a home tutor)*	1.134	0.334	0.670	1.104	0.351	0.755
	Mothers or caregivers working status *(ref. working mother)*	1.076	0.428	0.853	1.381	0.590	0.450
	Mothers or caregivers literacy *(ref. literate mother)*	1.638	0.550	0.142	1.402	0.495	0.338
	Fathers working status *(ref. working mother)*	0.769	0.380	0.596	1.035	0.539	0.947
	Paternal literacy *(ref. literate mother)*	1.533	0.159	0.035**	1.422	0.134	0.006**
Other school patterns	Preschool *(ref. Yes)*	0.667	0.229	0.240	0.710	0.254	0.338
	Absenteeism *(cont)*	1.039	0.022	0.077	1.052	0.025	0.032**
	Distance to school *(ref. close)*						
	Far	0.952	0.308	0.881	1.066	0.369	0.853
	Very far	2.813	1.241	0.019**	3.187	1.540	0.016**
Physical activity	Physical activity *(ref low +moderate physical activity)*	1.345	0.393	0.311	1.273	0.400	0.442
	constant	0.025	0.054	0.080	0.014	0.031	0.056
		R^2= 0.178			R^2=0.207		
AIC		367.810			333.504		
BIC		444.659			408.757		

**p-value < 0.05; ***p-value < 0.001; *p-value < 0.10; OR: odd ratio; SE: Standard Error; Cont.: continuous variable; ref: reference group; R^2: Rsquare.

between dietary diversity and academic performance, even though they concluded that dietary diversity positively influences growth measured with height-for-age z-scores (HAZ) (Beressa et al., 2024). The differences in these findings may be due to bias related to participants' health status, or population specific characteristics and/or geographic location. In fact, in Beressa and collaborators' study, 91.6% of the participants had experienced an illness (such as fever, pneumonia), and the study was conducted in pastoral communities in Southeast Ethiopia, which may exhibit specific context dependent patterns. Higher dietary diversity, by providing various essential building blocks for optimal growth, gives greater opportunities for better brain maturation and development of executive functions – core skills for high cognition and better educational outcomes later in life.

We also found that regarding socio-demographic patterns, electricity in households was significantly associated with better school performance, likely reflecting that improved study environments positively affect educational outcomes. This finding is consistent with studies in other low-income settings that link access to electricity to higher educational attainment (Khandker et al., 2012). Having electricity in a household can be a main factor in a pupils' ability to study at home. Indeed, some pupils have to walk a long distance to reach school and then return home at nighttime or dawn. In addition, once at home, pupils – and mainly girls – are required to help with household chores, and only once these tasks are completed can they reach back to their books, By this time, darkness may already completely fallen because class ends around five (5) in the afternoon. As a result, without electricity at home, they will either not study or will tend to seek other sources outside their houses, sometimes at gas stations or under street lamps, in order to have enough light to complete their homework or assignments. By relying on these outside sources, their studying time cannot be extended. This situation can, in the long run, negatively impact school performance and leads to school dropouts (Lee and Guadagno, 2015).

Moreover, as expected, parental education levels play a significant role in their children's academic achievement. Our

findings indicate that fathers' illiteracy is positively associated with pupils' low performance. In contrast, mothers' literacy did not show a significant influence on school performance. This may be attributed to the fact that in this specific location, the number of literate female caregivers were very few. As a result, the literate group was not substantial enough to allow for meaningful comparisons with the larger group of illiterate mothers. Literate parents with higher educational attainment often provide enriched home environments, including access to educational resources, and structured routines, which are conducive to better cognitive development and better school performance (Davis-Kean, 2005). They also tend to engage more actively in their children's education, promoting behaviors that support academic success in contexts where parents' daily occupations do not prevent them from being involved in their children's lives. Consequently, interventions to promote female education should be emphasized in rural location in Sub-Saharan African region and specifically in northern Benin.

Another important finding of this study is the impact of distance to school on pupils' academic achievement. The distance between pupils' home and school, is prone to affect attendance, punctuality, and access to educational resources. Long commutes often result in fatigue, reduced study time, and lower engagement with school activities, which cumulatively hinder academic performance (Frempong et al., 2011). Additionally, children in rural or remote areas with extended travel distances to school frequently face infrastructure and transportation challenges, leading absenteeism increase and lower academic outcomes (Dubow et al., 2009).

Therefore, School attendance is a fundamental factor influencing normal (normal growth according to WHO) children's academic success, as consistent classroom engagement provides essential opportunities for learning and development. Gottfried confirms that regular attendance is strongly associated with better academic outcomes, as it ensures exposure to the curriculum and fosters social and cognitive growth. Chronic absenteeism has been shown to disrupt learning continuity (Gottfried, 2010). However, the strength of this relationship has been contested in some settings. For example, evidence from South Africa suggests that effective teaching quality (Wills and Hofmeyr, 2019), implementing school feeding programs (Abotsi, 2013; Amoussa Hounkpatin et al., 2024; Cohen et al., 2021) in disadvantaged areas can mitigate the negative impact of absenteeism. Several studies investigated the relationship between teacher demographic characteristics, teaching quality, and students' academic performance by shaping teaching approaches, classroom dynamics, and role modeling. Evidences showed that teachers with higher educational qualifications tend to adopt more effective instructional strategies, that impact positively academic achievements (Clotfelter et al., 2007). Additionally, teacher gender (Antecol et al., 2012), marital status (Harris, 2011), and level of education influence academic achievements but their effect are often mediated by broader contextual factors, such as school resources and teacher training quality, which must be considered in educational policy and practice.

6 Limitation

In the current study, while hemoglobin levels were assessed using a precise tool and cognition and school performance were measured with standardized methods, several variables were self-reported by the schoolchildren. This reliance on pupil's self-reported data may have introduced errors due to potential recall bias and / or socially desirable responses. In addition, this study only assessed cognitive abilities using Digit span and Verbal fluency in French language, which is the national language of Benin but not the traditional mother tongue of the pupils. This could potentially result in lower scores for pupils who have limited comprehension of French. To mitigate this limitation we selected pupils in grades 4 and 5, assuming a higher proficiency in French at this stage. Additionally, only two week-day 24-h qualitative food recalls were done in this study, which may have limited the assessment of the dietary diversity of the participants and estimating the quantity of nutrients consumed. All schools in the study area were enrolled in the school feeding programs, which would make a comparative study challenging; however, a longitudinal study would be useful in revealing the overall impact of the school feeding program on pupils' cognition. Future research in this area could focus on diverse possibilities to improve the school feeding programs through the formulations of more nutritious menus to raise dietary diversity based on local dishes and evaluating their effects on cognition and school performance. Future research should consider employing bioelectrical impedance analysis (BIA) to precisely assess pupils' nutritional status by distinguishing body fat from lean mass, as z-score measurements may not accurately capture associations with school performance (Wu and Billard, 2021). In addition, future research may explore other precise methods to measure pupil's physical activity as Accelerometers or pedometers (Trost et al., 2005).

7 Conclusion and policy implications

This study highlights the complex interplay of factors influencing school performance among pupils benefiting from the National School Feeding Program in Northern Atacora, Benin. Key determinants to academic underachievement are low cognitive abilities, lack of electricity in households, paternal illiteracy, school absenteeism, low dietary diversity, and long distance to school. These findings underscore the need for targeted, multi-sectoral interventions to enhance educational outcomes in this food-insecure region. Policy efforts should prioritize the promotion of early childhood education programs, particularly preschool programs, to support cognitive development from an early age. Expanding rural electrification is crucial to improve home study conditions and facilitate the use of modern teaching tools in schools. Gender equity should be addressed through scholarships for girls, gender-sensitive teacher training, and community advocacy to dismantle cultural barriers to education. Enhancing parental literacy and engagement in education programs can create supportive home environments that foster learning. To ensure consistent school attendance and better nutritional status, strengthening school feeding programs is imperative, throughout efforts to provide balanced diverse meals and promote home and/or school gardens. Building schools closer to communities and providing safe, reliable transportation options are essential to reducing travel

barriers and improving access to education. Finally, investing in teacher training programs will strengthen teaching quality and contribute to better academic outcomes. By implementing these integrated and context-sensitive measures, policymakers can create a sustainable framework for improving school performance and addressing systemic disparities in education.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethics Research Committee of Applied Biomedical Sciences of the Faculty of Health Science University of Abomey-Calavi. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

OA: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Software, Supervision, Visualization, Writing – original draft, Writing – review & editing. YM: Conceptualization, Methodology, Validation, Writing – original draft, Writing – review & editing. AF: Data curation, Methodology, Resources, Software, Supervision, Writing – original draft. JK: Conceptualization, Investigation, Methodology, Validation, Writing – review & editing. LJ: Conceptualization, Formal analysis, Investigation, Methodology, Writing – review & editing. IL: Conceptualization, Formal analysis, Validation, Writing – review & editing, Writing – original draft. WAH: Conceptualization, Methodology, Validation, Visualization, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research and/or publication of this article.

Acknowledgments

We sincerely thank the International Atomic Energy Agency (IAEA) for biomedical equipment supply. We also thank all involved pupils, educators, principals and administrators of the selected school and all the enumerators involved in this study fieldwork.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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