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Geography of opportunity: a multilevel analysis of regional and school-level inequities in Somaliland's educational outcomes

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Persistent regional and school-level inequities continue to shape students' educational outcomes in Somaliland. Despite policy advances, empirical evidence quantifying how much variation in academic achievement is attributable to individual, school, and regional factors remains limited. This study applies the geography of opportunity framework to investigate how location and institutional context influence student performance across Somaliland's secondary schools. A cross-sectional multilevel analysis was conducted using a comprehensive administrative dataset from the Somaliland National Examination and Certification Board (SLNECB), comprising 505,398 subject-level grade records from 186 secondary schools (2020-2023). Using linear mixed-effects models estimated in R (lme4), students (Level 1) were nested within schools (Level 2). Three models were fitted: a null model, a random intercept model (including sex, subject, and year as fixed effects), and a random slope model allowing the effect of sex to vary by school. Model comparison was based on AIC, BIC, and marginal/conditional R^2 values. The Intraclass Correlation Coefficient (ICC = 0.234) indicated that 23.4% of total variance in student grade points stemmed from school-level factors, revealing a strong "school effect." The random slope model demonstrated the best fit (AIC = 1,587,694.8; BIC = 1,587,895.2; R^2_conditional = 0.348). Performance varied markedly across subjects: Mathematics ($d = -0.73$) and Chemistry ($d = -0.66$) showed the largest deficits, while History ($d = +0.39$) performed highest. Although the overall sex difference was trivial ($d = 0.02$), the effect varied significantly between schools. A negative correlation ($r = -0.35$) between school intercepts and gender slopes indicated that higher-performing schools reduced or reversed gender gaps. Results reveal a deeply unequal educational landscape in Somaliland where student achievement is strongly conditioned by school context. The substantial between-school variance confirms that location and institutional quality, rather than individual characteristics, are primary drivers of inequality. Strengthening underperforming schools—especially in regions such as Sool, Togdheer, and Xaysimo—and investing in STEM teaching capacity are crucial for equity. The findings underscore the importance of geographically targeted policies and reinforce that enhancing school quality also promotes gender equity.

KEYWORDS

educational inequality, geography of opportunity, multilevel modeling, Somaliland, student achievement, school effectiveness, spatial disparities

Introduction

Educational equity is fundamental to global development, promoting social mobility and economic advancement (Jurado de los Santos et al., 2020). Education systems often mirror and worsen existing inequalities rather than leveling the playing field (Perry et al., 2021). Research shows these disparities form systematic "geographies of opportunity" where location shapes educational prospects (Hayvon, 2024). This inequality is particularly evident in developing and post-conflict countries, where limited resources create regional disparities (Molla, 2021). School location often determines academic success more than personal effort (Katz and Acquah, 2021). Studies in sub-Saharan Africa demonstrate location's influence on educational outcomes (Frola et al., 2024; Takyi et al., 2019). Understanding these geographic factors is crucial for effective policy (Cobb, 2020). Somaliland presents a relevant case study. Since 1991, it has rebuilt its education system, increasing primary and secondary education (Melesse and Obsiye, 2022). However, educational resources and achievement remain concentrated in urban areas like Hargeisa, creating an uneven landscape that limits youth potential (Diamond and Lewis, 2022). While regional disparities in Somaliland are recognized, empirical studies measuring these inequalities are scarce (Constancio, 2024). Previous research has been mainly qualitative or policy-focused, lacking statistical power to distinguish between student, school, and regional effects (Giacomazzi et al., 2022; Melesse and Obsiye, 2022). This has led to generic solutions that inadequately address location-based disadvantages (Cairney and Kippin, 2022).

A significant gap exists in understanding educational inequality in Somaliland, particularly how student performance is influenced by individual factors, schools, and administrative regions. Without this understanding, policymakers cannot determine whether to prioritize student support, school programs, or regional development (Binning and Browman, 2020). While geospatial and multilevel analyses have proven effective in revealing these influences elsewhere (Banerjee et al., 2022; Cobb, 2020), these methods remain unapplied in Somaliland. This research, one of the first comprehensive quantitative studies using national exam data, employs multilevel modeling to explain inequality's origins (Zapfe and Gross, 2021). The results will help the Somaliland Ministry of Education and partners inform resource distribution and policy development, contributing to a fairer education system.

In light of this, the primary objectives of this study are:

1. To empirically map the geographic and subject-level disparities in academic performance among secondary school students in Somaliland.
2. To quantify the proportion of variance in student achievement that is attributable to school-level factors versus individual-level factors.
3. To investigate the influence of student-level predictors (Sex, Subject, Year) and school-level context on academic performance using multilevel modeling.

Literature review

This review compiles academic research to examine educational disparities in Somaliland through the lenses of geography and multilevel frameworks. The "geography of opportunity" concept suggests that location is a fundamental determinant of life outcomes, while a multilevel approach helps unravel the layered influences on student performance. It surveys literature on the factors driving educational inequality and the analytical methods required to investigate them. The geography of opportunity framework asserts that social and economic opportunities are unevenly distributed across different areas (Hayvon, 2024). The location influences access to resources, networks, and institutions essential for upward mobility (Butler and Sinclair, 2020; Hayvon, 2024). This includes the interaction of social structures, institutional quality, and historical context that concentrates opportunities in specific regions (Liodaki et al., 2024). In education, high-quality schools and resources tend to cluster in certain areas, forming "islands of opportunity" amid broader disadvantage (Cobb, 2020; Otto et al., 2021). This spatial sorting continues through "opportunity hoarding," where privileged communities preserve their advantages by controlling access to key institutions (Diamond and Lewis, 2022; Naveed et al., 2023). This is achieved through segregation, selective school policies, and unequal distribution of resources (Jabbari et al., 2024; Yoon, 2019). Well-resourced schools attract advantaged students, while under-resourced schools inadequately serve vulnerable populations (Kraftl et al., 2021; Perry et al., 2021). The framework is particularly relevant in post-conflict settings like Somaliland, where limited state capacity means that the distribution of education is shaped by political, economic, and clan-based geographies (Melesse and Obsiye, 2022; Zapfe and Gross, 2021). The legacy of conflict creates regional disparities in stability, aid, and investment (Green et al., 2020; Vincent and Cundill, 2021). Consequently, the "school effect" has a more significant impact on academic outcomes than in well-resourced systems (Cairney and Kippin, 2022; Katz and Acquah, 2021).

This research employs a multilevel theoretical framework, acknowledging that educational results are influenced by factors at various levels: the student, classroom, school, and the wider community (Constancio, 2024; Green et al., 2020). The learning experiences of students are influenced by the institutional context of their school within its regional setting (Cruz and Firestone, 2023; Kraftl et al., 2021; Tanhan and Young, 2021). Overlooking this hierarchy can result in ecological fallacy or neglecting the contextual effects on learning (Hammad and Alazmi, 2020; Zapfe and Gross, 2021). Multilevel models empirically examine these assumptions by dividing outcome variance into different components (Booth et al., 2020; Cavallera et al., 2019), showing how much of the variation in student performance is attributable to individual factors versus school influences. The variance at the school level directly assesses the geography of opportunity, measuring the "school effect" (Banerjee et al., 2022; Miseliunaite et al., 2022). A high variance at the school level suggests an inequitable system (Hayvon, 2024). This framework explores cross-level interactions, where the impact of individual-level predictors may differ depending on the school context (Jindal-Snape et al., 2021). For instance, gender performance disparities can vary between schools, highlighting how institutional factors contribute to inequalities (Campbell and Neff, 2020; Cruz and Firestone, 2023). This structural approach focuses on identifying systems that perpetuate disadvantage rather than concentrating on individuals (Kolluri and Tichavakunda, 2022; Nilholm, 2020).

Empirical research has identified key drivers of educational inequality. Student-level factors like gender, socioeconomic status, and prior achievement influence performance (Ajayi, 2022). Gender gaps exist in specific subjects, with varying performance patterns between boys and girls, though these are context-dependent (Bellibaş and Gümüş, 2019; Perry et al., 2021). School-level factors include teacher quality, leadership, resources, and school culture (Bellibaş and Gümüş, 2019; Chen and Yang, 2024; Katz and Acquah, 2021). The study of these inequities has evolved methodologically. While early research used mean comparisons and OLS regression models (Cairney and Kippin, 2022; Welty Peachey et al., 2020; Zhou and Deng, 2022), these methods failed to account for nested educational data, leading to statistical errors (Armstrong et al., 2020; Hogg and Volman, 2020). GIS and spatial analysis have enabled mapping of disparities and their geographic correlations (Cobb, 2020; Jurado de los Santos et al., 2020; Sharma and Patil, 2022). Multilevel modeling represents a major advance by analyzing nested data structures (Cotache-Condor et al., 2021; Sharma, 2023; Zapfe and Gross, 2021), becoming the standard in educational effectiveness research (Armstrong et al., 2020; Binning and Browman, 2020). Studies using this approach show 15–30% of variance in student achievement occurs at school level, supporting the "school matters" thesis (Banerjee et al., 2022; Frola et al., 2024).

The existing literature provides a foundation for this research, highlighting geography of opportunity as a key framework and endorsing multilevel modeling as the analytical approach. However, there is a gap in using these methods in fragile settings like Somaliland (Constancio, 2024). While education system challenges have been documented (Melesse and Obsiye, 2022), no comprehensive quantitative evaluation has identified where and why disparities persist. This study addresses this gap through multilevel analysis of an extensive national dataset to chart Somaliland's geography of opportunity and its impact on youth education.

Methodology

This research utilizes a quantitative, cross-sectional approach with multilevel modeling to explore the geographic and demographic elements affecting student academic performance in Somaliland. The methodology is designed to systematically divide the variance in student achievement across individual, school, and regional levels, thus pinpointing major sources of educational inequality.

Data source and sample

The analysis is based on an anonymized administrative dataset supplied by the Somaliland National Examination and Certification Board (SLNECB). This dataset includes all individual grade records for students who took the national secondary school leaving exams from 2020 to 2023. Initially, the raw data comprised 505,399 subject-level entries. After excluding one entry with a missing grade point, the final dataset for analysis contained 505,398 entries from 186 different secondary schools spread across Somaliland's administrative regions. The data's hierarchical structure, with individual subject grades (Level 1) grouped within students, who are further grouped within schools (Level 2), makes it particularly suitable for multilevel analysis.

Variables

The variables outlined in Table 1 were selected to develop a comprehensive model of student achievement. Grade Point was analyzed as a continuous outcome, allowing for a detailed examination of performance through linear mixed-effects models. At the student level, we incorporated Sex, Subject, and Year as fixed effects to account for essential demographic, curricular, and temporal differences, ensuring that the estimated effects of schools are not skewed by these individual factors. At the school level, School ID was employed as a random effect to capture the overall variance linked to each school's unique context, which is central to our exploration of the "geography of opportunity." Although the Region variable was crucial for initially illustrating geographic disparities, it was excluded as a predictor in the final model, as its impact is already more precisely represented by the School ID random effect. This strategy prevents statistical redundancy

TABLE 1 Description of variables used in the multilevel analysis.

Variable	Level	Role in analysis	Description and coding
Outcome variable			
Grade point	Student (Level 1)	Outcome variable	Continuous measure of academic performance. Treated as continuous on a 5-point scale (1 = *Fail* to 5 = *Excellent*).
Predictor variables			
Sex	Student (Level 1)	Predictor (fixed effect)	Categorical variable indicating student's sex. Coded as 0 = Female (reference), 1 = Male.
Subject	Student (Level 1)	Predictor (fixed effect)	Categorical variable for the 10 core subjects. *Arabic* used as the reference category.
Year	Student (Level 1)	Predictor (fixed effect)	Categorical variable for the examination year. Coded with 2020 as the reference category.
School ID	School (Level 2)	Grouping variable (random effect)	Unique identifier for each of the 186 schools. Defines the Level 2 clusters for the random intercept and slope.
Region	School (Level 2)	Descriptive variable	Categorical variable for the administrative region of each school. Used for visualization of geographic disparities but not as a fixed effect in the final model.

This table outlines the operationalization of all variables included in the study. Level 1 variables represent individual student-subject records, while Level 2 variables represent the school context.

and concentrates the analysis on the specific institutional settings influencing student outcomes.

Analytical strategy

The analysis was carried out in three distinct phases, adhering to a systematic method for constructing and interpreting models. All analyses utilized R (Version 4.4.x) with the lme4 and performance packages. Initially, we performed a descriptive statistical analysis to outline the sample's features. This was succeeded by a visual examination of the data, where we created bar charts to depict the average Grade Point across various subjects, years, and importantly, administrative regions. This step aimed to empirically confirm the presence of geographic and subject-level differences, which are central to this study's focus. Considering the data's hierarchical structure, we specified a series of linear mixed-effects models to appropriately address the non-independence of observations within schools. This method allows for the separation of variance in Grade Point into components at the student level (within-school) and the school level (between-school). We employed Maximum Likelihood (ML) estimation for the models to facilitate valid comparisons using information criteria.

Three nested models were sequentially built and compared:

1. *Model 1 (Null Model)*: An unconditional, intercept-only model was specified to decompose the total variance in Grade Point into its within-school and between-school components. This model served as a baseline and was used to calculate the Intraclass Correlation Coefficient (ICC), which quantifies the proportion of variance attributable to school-level differences.

$$\mathrm{Grade\_Point\_}\{ij\} = \beta\_\{0\} + u\_\{0j\} + e\_\{ij\}$$

2. *Model 2 (Random Intercept Model)*: Student-level predictors (Sex, Year, Subject) were added as fixed effects. This model assumes that while the average school performance (the intercept) varies across schools, the effects of the predictors are constant for all schools.

$$\mathrm{Grade\_Point\_}\{ij\} = \beta\_\{0\} + \beta\_\{1\}\left(\mathrm{Sex\_}\{ij\}\right) + \ldots + u\_\{0j\} + e\_\{ij\}$$

3. *Model 3 (Random Slope Model)*: This model extended Model 2 by allowing the effect of Sex to vary randomly across schools. This was done to test the hypothesis that the relationship between student sex and academic performance is context-dependent and differs from one school to another.

$$\mathrm{Grade\_Point\_}\{ij\} = \beta\_\{0\} + \beta\_\{1\}\left(\mathrm{Sex\_}\{ij\}\right) + \ldots + u\_\{0j\} + u\_\{1j\}\left(\mathrm{Sex\_}\{ij\}\right) + e\_\{ij\}$$

Model selection was based on a combination of theoretical justification and statistical fit indices, including the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and marginal and conditional R-squared values. The model with the superior fit was chosen for final interpretation.

To ensure the validity of the final selected model, a comprehensive set of diagnostic checks was performed on its residuals. We assessed the assumptions of normality (via a Normal Q–Q plot and histogram of residuals) and homoscedasticity (by plotting residuals against fitted values). These checks confirmed the robustness of the model and the reliability of its estimates.

Results

This section presents the analysis of academic performance in Somaliland's national examinations. The analysis begins with descriptive statistics, followed by performance visualizations by subject, year, and region. The final part focuses on multilevel model comparisons and interpretation.

Descriptive statistics

The comprehensive analytical dataset comprised 505,398 student-subject entries from 186 secondary schools, encompassing national exams conducted from 2020 to 2023. A single entry lacking grade point information was omitted. The sample was composed of 57.5% male and 42.5% female students. The records were fairly evenly distributed among the 10 core subjects. The average grade point across all subjects and years was $M = 3.49$, SD = 1.30 on a 5-point scale, with a median of 4.00, suggesting a slight leftward skew in the grade distribution. Detailed descriptive statistics are provided in Table 2.

Performance trends by subject and year

Performance patterns differed among subjects and across years. As shown in Figure 1, subjects such as History consistently achieved higher average grades, whereas Mathematics and Chemistry recorded the lowest performance throughout the 4-year period. Across all subjects, performance fluctuated modestly from year to year, indicating that contextual or exam-specific factors may have influenced outcomes.

Regional performance disparities

To explore differences across regions, average grade points were categorized by region, subject, and year. Figure 2 illustrates notable variations in performance across Somaliland's regions. Regions such as Maroodijeeh and Sahil consistently achieved higher average grade points, whereas Sool, Togdheer, and Xaysimo recorded lower averages. The most significant regional disparities were observed in technical subjects like Mathematics and Chemistry, highlighting persistent geographic inequalities in educational outcomes. These visual patterns emphasize the importance of employing multilevel modeling to account for the influence of school and regional factors.

TABLE 2 Descriptive statistics of the analysis sample (N = 505,398).

Variable	Category	N	Percent
Sex	Female	214,941	42.5%
	Male	290,457	57.5%
Year	2020	105,367	20.8%
	2021	116,485	23.0%
	2022	143,202	28.3%
	2023	140,344	27.8%
Subject	Arabic	50,532	10.0%
	Biology	50,551	10.0%
	Chemistry	50,477	10.0%
	English	50,580	10.0%
	Geography	50,506	10.0%
	History	50,550	10.0%
	Islamic	50,557	10.0%
	Math	50,580	10.0%
	Physics	50,544	10.0%
	Somali	50,521	10.0%
Grade point			M = 3.49, SD = 1.30
			Median = 4.00
			Min = 1.00, Max = 5.00

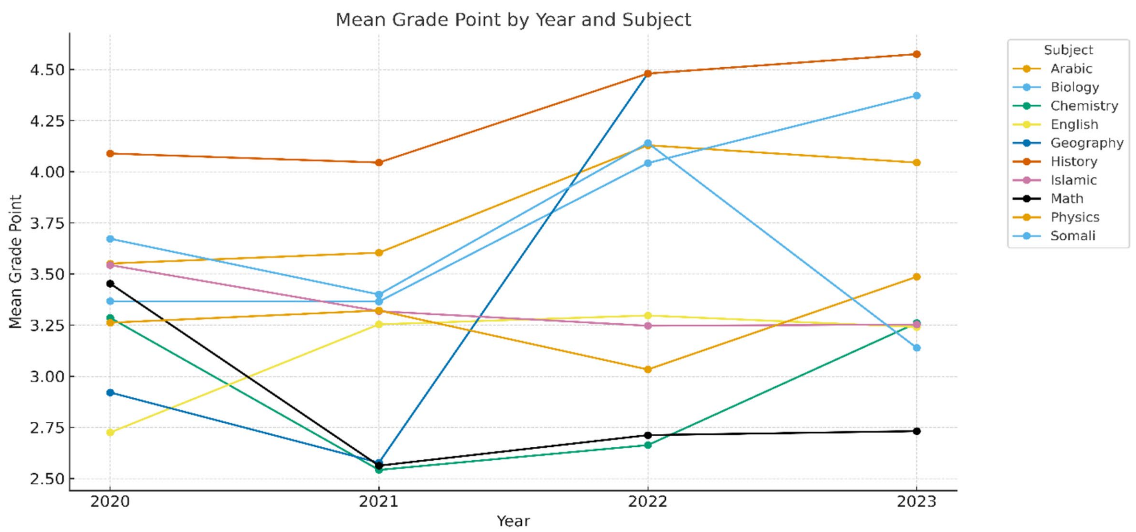

FIGURE 1
Mean grade point by year and subject.

Multilevel modeling of academic performance

To address the hierarchical nature of the data, a multilevel modeling strategy was employed. The initial null model, which included only an intercept, revealed that 23.4% of the variance in grade points could be attributed to school-level differences (Intraclass Correlation Coefficient [ICC] = 0.234). Following this, two further models were developed: the Random Intercept Model (RI), which incorporated fixed effects for Sex, Year, and Subject, and the Random Slope Model (RS), which allowed the influence of Sex to differ among schools. Model fit was evaluated using the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and both marginal and conditional R^2. As detailed in Table 3, the Random Slope Model demonstrated the best fit, evidenced by the lowest AIC and BIC values and the highest BIC weight.

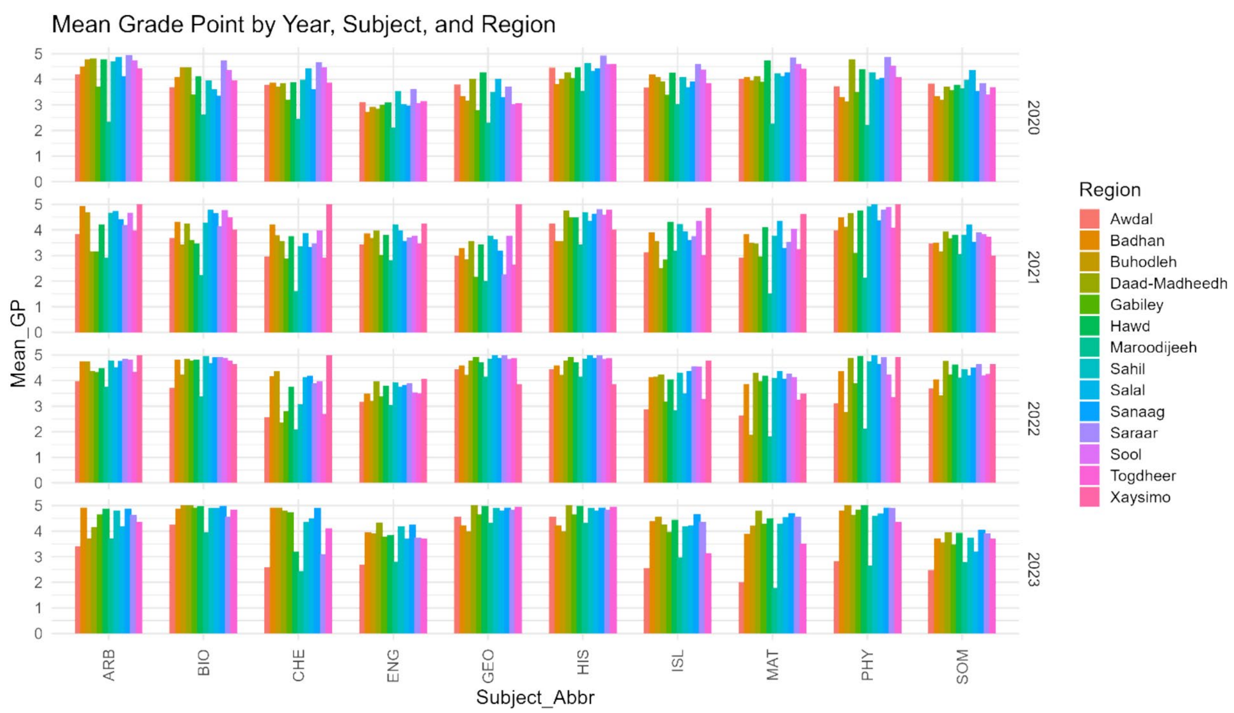

FIGURE 2
Mean grade point by year, subject, and region.

TABLE 3 Comparison of multilevel model fit indices.

Model	AIC	BIC	R^2 (Marginal)	R^2 (Conditional)	ICC	BIC weight
Null model	1,668,427.7	1,668,461.1	0.000	0.234	0.234	<0.001
Random intercept	1,588,423.4	1,588,601.5	0.113	0.346	0.263	<0.001
Random slope	1,587,694.8	1,587,895.2	0.113	0.348	0.265	>0.999

Model diagnostics

To verify the assumptions of the final Random Slope model, an extensive diagnostic analysis of the residuals was performed. The Normal Q–Q plot of the Pearson residuals showed that they were roughly normally distributed, with only slight deviations at the extreme ends, which is typical in large datasets. A histogram of the residuals also supported this near-normal distribution. To evaluate homoscedasticity, we plotted the Pearson residuals against the fitted values. This scatterplot displayed no noticeable pattern or funnel shape, indicating constant variance across the range of predicted values. Together, these diagnostic checks confirm that the final model is robust and its assumptions have been reasonably satisfied. For complete transparency, the diagnostic plots are presented in Figure 3.

Final model

Year-to-year performance differences were statistically significant but trivial to small in magnitude. The 2021 decline relative to 2020 ($d = -0.13$) was trivial, while the improvements in 2022 ($d = 0.17$) and 2023 ($d = 0.20$) were small. These results indicate that exam performance fluctuated modestly across years and should not be overstated.

By contrast, subject-level disparities were more substantial. Mathematics ($d = -0.73$) and Chemistry ($d = -0.66$) showed medium-to-large disadvantages relative to Arabic, highlighting systemic weaknesses in STEM education. English ($d = -0.60$) and Physics ($d = -0.41$) reflected medium disadvantages, while Islamic Studies ($d = -0.39$) and History ($d = +0.39$) indicated small-to-moderate differences. Somali ($d = -0.23$) showed a small disadvantage, whereas Biology ($d = -0.02$) and Geography ($d = -0.09$) revealed trivial effects.

Sex differences were negligible overall ($d = 0.02$, trivial), although the random slope variance confirmed that gender effects varied significantly across schools. The negative correlation ($r = -0.35$) between school intercepts and gender slopes suggests that higher-performing schools tended to minimize or reverse gender performance gaps (Table 4).

Discussion

This study set out to investigate the geography of educational opportunity in Somaliland by analyzing the nested factors that

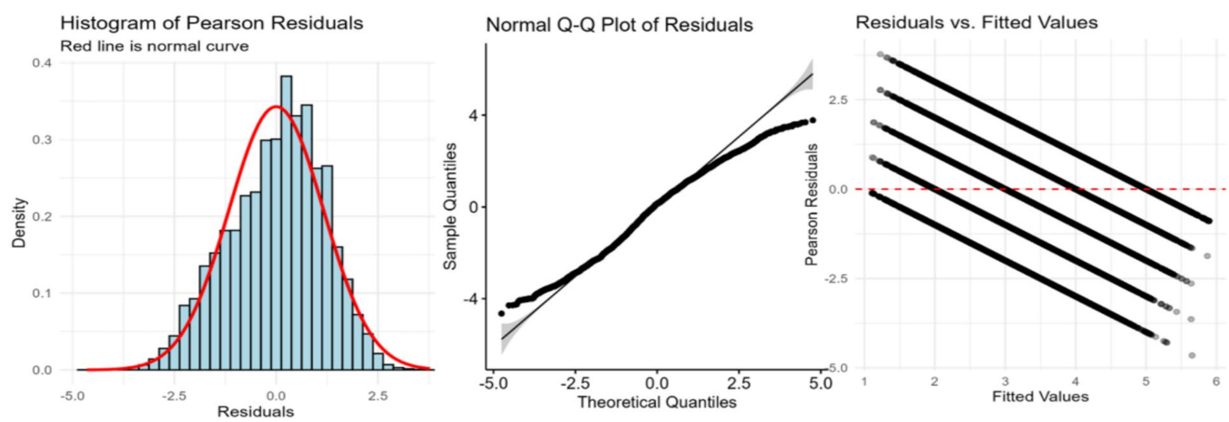

FIGURE 3
Model assumption test.

TABLE 4 Fixed and random effects of the final multilevel model predicting grade point.

Effect	Estimate (β)	Std. error	*t*-value	Cohen's *d*
Fixed effects				
Intercept	3.97	0.05	74.60***	
Sex (Male)	−0.003	0.01	−0.31	0.02 (Trivial)
Year (2021 vs. 2020)	−0.20	0.005	−39.82***	−0.13 (Trivial)
Year (2022 vs. 2020)	0.23	0.005	48.23***	0.17 (Small)
Year (2023 vs. 2020)	0.30	0.005	60.44***	0.20 (Small)
Biology	−0.03	0.007	−3.73***	−0.02 (Trivial)
Chemistry	−0.93	0.007	−127.57***	−0.66 (Medium)
English	−0.71	0.007	−97.39***	−0.60 (Medium)
Geography	−0.12	0.007	−16.51***	−0.09 (Trivial)
History	0.46	0.007	62.98***	0.39 (Small-Medium)
Islamic	−0.54	0.007	−73.48***	−0.39 (Small–Medium)
Math	−1.03	0.007	−140.45***	−0.73 (Medium–Large)
Physics	−0.59	0.007	−80.88***	−0.41 (Small–Medium)
Somali	−0.27	0.007	−36.93***	−0.23 (Small)
Random effects	Variance (σ^2)	Std. Dev. (σ)		
School intercept	0.513	0.716		
Sex (Male) slope	0.014	0.118		
Correlation (Intercept, Slope)			−0.35	−0.35
Residual	1.351	1.162		

In addition to statistical significance, effect sizes (Cohen's *d*) were calculated for all fixed-effect comparisons using the Campbell Collaboration calculator for unequal group sizes. Interpretation follows Cohen (1992) guidelines: trivial ($d < 0.20$), small ($d \approx 0.20$), medium ($d \approx 0.50$), and large ($d \geq 0.80$). ***$p < 0.001$.

influence student academic performance. The findings from the multilevel analysis provide a statistically robust and nuanced picture of a deeply inequitable educational landscape. This section interprets these findings, situates them within the broader scholarly literature, and discusses their implications for theory and our understanding of educational systems in post-conflict contexts.

The most striking finding is the magnitude of the "school effect." The null model revealed that 23.4% of total variation in student grade points is attributable to differences between schools. This substantial proportion confirms that the school a student attends in Somaliland strongly determines their academic success, independent of individual characteristics (Katz and Acquah, 2021). This finding validates the "geography of opportunity" framework, which posits that access to quality institutions is spatially determined (Hayvon, 2024). While the substantial ICC value quantifies the influence of schools, it's important to acknowledge that this 'school effect' might also be partially driven by unmeasured student-level socioeconomic factors or school-level resources, which were not available in this dataset. The significant ICC value moves this concept from theory to reality in the Somaliland context (Butler and Sinclair, 2020). While research consistently finds that schools account for significant performance variation (Zapfe and Gross, 2021), the 23.4% figure is notably high, suggesting a particularly stratified educational system (Perry et al., 2021). The large effect implies vast gaps between high- and low-performing schools, evidenced by regional disparities in grade points (Frola et al., 2024; Sharma and Patil, 2022). This finding challenges narratives that locate poor academic performance solely within students or families (Kolluri and Tichavakunda, 2022). Instead, it reveals a structural problem where the system perpetuates inequality (Cairney and Kippin, 2022). The school-level variance indicates that systemic reforms focused on equalizing school quality are essential, highlighting the need to shift from expanding access to ensuring all schools are effective learning environments (Molla, 2021).

The examination of fixed effects uncovered notable patterns of inequality. There are performance disparities among subjects, with Mathematics and Chemistry trailing behind History, highlighting systemic challenges in STEM education (Constancio, 2024). This may be due to a shortage of qualified science educators, insufficient resources, or ineffective teaching methods (Giacomazzi et al., 2022). Such disparities impede the development of human capital essential for national progress (Brekke, 2020). The fixed-effects model found no significant overall difference in performance between male and female students (Takyi et al., 2019). However, the random slope model indicated that the link between gender and academic performance varies by school. The significant variance in the gender slope ($\sigma^2 = 0.014$) suggests that gender performance gaps differ across schools (Hogg and Volman, 2020). This interaction between individual traits and school context illustrates how institutions impact societal inequalities (Jindal-Snape et al., 2021). While the multilevel model effectively quantifies the variability in gender performance across schools, it does not, however, elucidate the underlying reasons or specific practices within these schools that contribute to these differential outcomes. Understanding the 'how' and 'why' of these patterns would necessitate qualitative investigations. The negative correlation between school intercept and gender slope (−0.35) indicates that higher-performing schools foster more equitable environments, reducing male advantage. These schools might employ inclusive practices or offer better academic support (Nilholm, 2020). This implies that school improvement directly promotes gender equity.

The negative correlation ($r = -0.35$) between the school intercept (average school performance) and the gender slope is particularly significant. This indicates that schools that generally perform better tend to exhibit smaller or even reversed gender performance gaps. In essence, efforts to enhance overall school quality may inherently contribute to greater gender equity within the educational system. This suggests that strategies for school improvement can be a powerful lever for fostering more equitable outcomes for both male and female students, rather than solely relying on gender-specific interventions. It underscores that the context provided by a school is a crucial determinant in how gender impacts academic achievement.

This research makes a substantial contribution to the study of educational inequality in developing countries. It offers empirical support for using the geography of opportunity framework in post-conflict settings, highlighting spatial and institutional elements as key influences on educational outcomes (Liodaki et al., 2024). The study measures the impact of schools, illustrating that "place matters" (Butler and Sinclair, 2020) in assessing progress toward fair distribution of opportunities. Methodologically, it showcases the effectiveness of multilevel modeling for examining complex educational datasets in environments with limited data. By utilizing a large-scale administrative dataset, this research addresses the constraints of small-scale case studies (Banerjee et al., 2022; Cobb, 2020) and serves as a model for national examination bodies to perform policy-relevant research. The findings underscore the necessity of analytical methods that reflect the nested nature of educational systems, as simpler approaches would overlook the context-specific aspects of gender inequality (Green et al., 2020). The results indicate that educational opportunity in Somaliland is primarily geographic, with schools accounting for nearly a quarter of academic achievement and influencing social outcomes such as gender equity.

Policy implications

The findings of this study have direct implications for educational policymakers in Somaliland and international development partners. Evidence suggests shifting from universal interventions towards a geographically targeted, context-sensitive approach. The large between-school variance (23.4%) indicates policies must equalize resources across schools. The Ministry of Education should develop a school-level "equity index" to identify disadvantaged institutions. Resources should be channeled to low-performing schools, particularly in Sool, Togdheer, and Xaysimo regions. The underperformance in Mathematics and Chemistry indicates a crisis in STEM education, requiring a multi-pronged response. Policy should prioritize recruiting and training qualified STEM teachers, with incentives for serving in underserved regions. A curriculum review may be needed to ensure effective content and pedagogy. Investment in science laboratories is essential to close performance gaps. The finding that high-performing schools are more gender-equitable offers important lessons. School improvement and gender equity should be treated as interconnected goals. The Ministry should identify successful practices from these equitable schools and scale these across the system. The finding that high-performing schools are more gender-equitable offers important lessons. School improvement and gender equity should be treated as interconnected goals. The Ministry should identify successful practices from these equitable schools and scale these across the system, recognizing that enhanced school quality can be a pathway to greater gender parity.

Conclusion

This study examined the geography of educational opportunity in Somaliland. Using multilevel analysis of national examination data, the research shows the educational landscape is deeply unequal, with student achievement significantly tied to school attendance. The finding that nearly a quarter of achievement variance stems from school-level factors demonstrates the uneven distribution of educational quality. The analysis reveals that outcomes, including gender performance gaps, are shaped by school environments. The study provides data-driven evidence that moves policy debate from acknowledging disparities to understanding their structural roots. In a nation building toward prosperity, addressing these place-based inequities remains a national imperative.

Study limitations

While this study offers significant insights, it is important to acknowledge its limitations. First, the cross-sectional nature of the data precludes any definitive claims of causality. While we can associate school attendance with performance, we cannot prove that the school *caused* the outcome. Furthermore, the cross-sectional nature of the data prevents us from establishing definitive causal relationships and understanding the temporal evolution of these educational disparities. Second, the administrative dataset, while extensive, lacked crucial variables that could further explain the observed variance. The absence of student-level socioeconomic status (SES), parental education, and prior academic achievement means our individual-level model is underspecified. The identified 'school effect' might, in part, capture the influence of these unmeasured student background factors. Similarly, the lack of school-level data on teacher qualifications, school funding, or specific resources limits our ability to isolate the causal mechanisms driving differential school performance. Without these variables, we cannot fully disentangle the effects of school quality from student background and material resources. Similarly, the lack of school-level data on teacher qualifications, school funding, or specific resources limits our ability to explain *why* some schools perform better than others. Finally, the analysis is restricted to students who successfully reached the end of secondary school and sat for the national exam, meaning it does not capture the experiences of students who dropped out earlier, who may face even greater disadvantages.

Recommendations

Drawing from the study's results, the following suggestions are made for key stakeholders: For the Somaliland National Examination and Certification Board (SLNECB): It is highly advised that the SLNECB formalize the process of gathering school-level data in conjunction with examination records. This data should encompass essential metrics such as student-teacher ratios, teacher qualifications and experience, and spending per student. Connecting this information to student outcomes would allow for more insightful and explanatory analyses to inform policy decisions. For the Ministry of Education: A specialized research and policy unit should be created to consistently analyze national assessment data using advanced statistical methods. This unit should focus on pinpointing underperforming regions and schools and assessing the effects of targeted interventions over time. For Development Partners and NGOs: International aid and educational initiatives should be realigned to reflect the evidence of geographic disparities. This involves prioritizing collaborations with schools and communities in the most underserved areas and concentrating on capacity-building efforts that have been shown to improve school quality, such as professional development for teachers and leadership training.

Recommendation for future research

This research establishes a foundation for a comprehensive agenda of future studies. The following avenues are suggested: Clarifying the "School Effect": Future investigations should focus on dissecting the 23.4% of variance linked to schools. This involves gathering detailed data at the school level (such as funding, teacher experience, and leadership practices) and integrating it into multilevel models to pinpoint the specific, adaptable factors that characterize an effective school. Qualitative Exploration: Although this study found that some schools are more effective and equitable, it does not explain the reasons. Conducting qualitative case studies of high-performing schools in disadvantaged areas and low-performing schools in advantaged areas would offer valuable, context-rich insights into the specific processes, pedagogical approaches, leadership styles, and school cultures that drive these outcomes. This would provide the 'why' behind the quantitative findings and bridge the gap between observed patterns and actionable strategies.

Longitudinal Study: To gain a better understanding of student trajectories and the long-term effects of school quality, future research should track a cohort of students over time. A longitudinal approach would allow for controlling prior achievement and provide stronger evidence of the value added by different schools. Inclusion of Socioeconomic Data: Future data collection efforts should include measures of student socioeconomic status. Adding this variable to the models would enable a more accurate assessment of the school effect, independent of student background, and a deeper analysis of how school context interacts with social class to shape opportunity.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: the data used in this study, while not publicly available, will be obtained from the corresponding author upon reasonable request. Written informed consent was obtained from all participants prior to data collection. Requests to access these datasets should be directed to jibrilabdikadir@amoud.edu.so.

Author contributions

MC: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. MA: Methodology, Writing – original draft, Writing – review & editing, Investigation, Validation. TA:

Writing – review & editing, Conceptualization. AM: Investigation, Methodology, Software, Supervision, Validation, Writing – original draft, Writing – review & editing. BA: Writing – review & editing, Validation. JA: Writing – review & editing, Conceptualization, Data curation, Methodology, Writing – original draft.

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