Norwegian University of Life Sciences (NMBU)

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Centre for Land Tenure Studies

Centre for Land Tenure Studies Working Paper 02/24

ISBN: 978-82-7490-324-1

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Abstract

This study investigates the impact of sibling effects on children's educational outcomes in Ghana and Niger, with a focus on disability and gender disparities. Surveys conducted in both countries utilize the Washington Group Child Functional Module (WG-CFM) to identify children's disability status. The analysis reveals a performance gap for children with disabilities (CWD), highlighting the challenges they face compared to their peers without disabilities (CWOD). Gender disparities in school performance vary between countries, with girls outperforming boys in Niger but showing no significant differences in Ghana. While the study did not discover any significant sibling effects in impoverished Niger, these effects are significant for children with disabilities in Ghana. In Ghana, older sisters positively and significantly influence the performance of CWD, while younger siblings only negatively impact CWD girls. Overall, this study underscores the importance of addressing the gender bias that disfavours girls, especially among disadvantaged children such as CWD.

Keywords

Educational outcomes; children with disabilities, sibling effects, gender, school performance, Niger, Ghana

JEL codes

I24: Education and Inequality

1. Introduction

The sibling relationship is often regarded as one of the most enduring and pervasive relationships throughout one's life (Sanders, 2017). Particularly during childhood's developmental stages, siblings who share the same parents, resources, and life experiences and spend substantial time together at home can exert considerable influence on each other. While the peer effect on learning outcomes has been extensively studied in the school environment (Epple & Romano, 2011; Sacerdote, 2011), there is considerably less but growing attention among researchers towards exploring the role of sibling relationships in child and adolescent development (McHale et al., 2012). This is also a crucial avenue for understanding the impact of various family characteristics on children's development and education. The sibling relationship holds essential meaning not only for children's social behaviour (Chi et al., 2024) and mental health (Widmer & Weiss, 2000) but also for their educational outcomes in school (Nicoletti & Rabe, 2019; Joensen & Nielsen, 2018; Karbownik & Özek, 2023).

This paper examines the impact of siblings on children's educational outcomes in school. The sibling spillover effect operates through two main mechanisms influencing children's educational outcomes (Brody, 2004; Karbownik & Özek, 2023; Zang et al., 2023). The first mechanism is the direct sibling spillover effect, which occurs through direct sibling interactions (Nicoletti & Rabe, 2019). The older child may act as a provider, assisting with homework or accompanying their younger siblings to school, and serve as a role model for them (Joensen & Nielsen, 2018).

The second mechanism is the indirect sibling spillover effect, known as within-family spillovers or parental differential treatment (Feinberg & Hetherington, 2001). Siblings can indirectly influence each other through their parent's decisions regarding the allocation of family

resources among them. Parents may redistribute resources among children of different ages (Karbownik & Özek, 2023) and gender (Lindskog, 2013; Collins, 2022), between children with or without special challenges (Yi et al. 2015; Parman 2015), and among those perceived to have greater potential for future success and those who do not (Grätz & Torche, 2016). Furthermore, parents' earlier experiences with older children will influence their expectations and treatment of younger children (Brody, 2004).

Existing literature on the sibling effect, particularly in the United States, suggests that the direct sibling spillover effect is notably more pronounced among children from disadvantaged backgrounds. Compared to families with advantages, parents in disadvantaged households tend to participate less frequently in their children's activities but often adopt a hands-off approach, allowing children to engage in independent play (Lareau, 2018). Several American studies have highlighted that impoverished Black families often encourage sibling support, viewing their children as vulnerable (Anderson, 2015). This results in a more substantial direct sibling spillover effect, with older siblings exerting significant influence on their younger counterparts in studies of African American families (McHale et al., 2007; Loury, 2004).

At the same time, parents from disadvantaged backgrounds may allocate household resources unevenly based on their children's characteristics (Conley & Lareau, 2008; Breinholt & Conley, 2023). More specifically, parents tend to invest less in the education of children with health challenges than their siblings without health issues (Yi et al., 2015; Parman, 2015).

This paper addresses the following research questions: 1) Do children with disabilities (CWD) significantly underperform compared to children without disabilities (CWOD) in educational outcomes? 2) Is there a significant sibling spillover effect on children's educational

outcomes? 3) Are there gender differences in these spillover effects? 4) Do these spillover effects differ for CWD vs. CWOD?

This paper focuses on the educational outcomes of primary school children in 27 schools in the Ashanti region of Ghana and 18 schools in Niamey, Niger. our analysis is framed as a natural experiment (Card, 1999; Angrist & Imbens, 1995), where the presence or absence of disabilities or siblings is considered as random treatments. In the analysis, data is first normalized for each school subject at the class level, enabling us to compare children's relative school performance within each class. Subsequently, the four school subject records registered for each child are pooled as panel data. Finally, the random effects model is conducted with cluster-corrected standard errors to account for the clustering of children at the class level.

There is a dearth of empirical evidence and literature on sibling spillover effects on the educational outcomes of children in the impoverished African context. The few African studies predominantly concentrate on readily available educational outcomes, such as school attendance and the transition to secondary school (Lindskog, 2013; Kravdal et al., 2013). Furthermore, research on the sibling spillover effect concerning school performance and children with disabilities (CWD) has predominantly focused on how siblings of CWD might experience negative repercussions, leading to reduced educational outcomes due to the presence of a CWD (Breining, 2014; Black et al., 2021; Fletcher et al., 2012). However, to our knowledge, there is no evidence regarding the potential sibling spillover effect from siblings without disabilities (CWOD) to CWD.

This study is, to our knowledge, the first attempt to evaluate the sibling effect on children's school performance within the African context, with a particular focus on gender and disabilities. The study identifies unique challenges faced by children with disabilities. While the study did not discover any significant sibling effects in impoverished Niger, these effects are significant for

CWD in Ghana. In Ghana, older sisters positively and significantly influence the performance of CWD, while younger siblings negatively impact CWD girls. Overall, this study underscores the importance of addressing the gender bias that disfavours girls, especially among disadvantaged children such as CWD.

The paper is structured as follows: Section 2 outlines the conceptual framework and research hypotheses. Section 3 provides detailed descriptions of the data and elaborates on the empirical strategy, encompassing both non-parametric and parametric analyses. Section 4 presents the results, including tests for the natural experiment assumption and the outcomes of the non-parametric and parametric analyses. The findings are discussed in Section 5, and the paper concludes with Section 6.

2. Conceptual framework

There has been a growing interest among recent studies in investigating the impact of sibling relationships on children's educational outcomes (Black et al., 2021; Ferreira, 2023; Karbownik & Özek, 2023; Xiong et al., 2020; Zang et al., 2023). Besides school peers, siblings are the primary companions with whom children spend a large proportion of their daily lives, potentially exerting considerable influence on various aspects of their development. Recent literature has focused on two primary mechanisms regarding how children's educational outcomes are influenced by sibling relationships: direct and indirect sibling spillover effects (Brody, 2004; Karbownik & Özek, 2023; Zang et al., 2023).

2.1 Direct sibling spillover effect

The confluence theory (Zajonc & Markus, 1975) laid the groundwork for understanding the direct sibling spillover effect, proposing that an older sibling's academic success enhances the family's intellectual environment, thereby motivating younger siblings to strive for academic excellence. Zajonc (1976) further observed that older siblings with strong academic performance may voluntarily offer tutoring or be encouraged by parents, facilitating the transfer of knowledge and learning habits. Another perspective on sibling interactions, which helps elucidate the direct sibling spillover effects, is discussed in the role-modelling theory (Bank, 1975; Brim, 1958; Whiteman et al., 2011). Older siblings who achieve academic success often serve as prominent role models among siblings of similar ages, inspiring their younger siblings' positive attitudes, expectations and aspirations. Furthermore, educational decisions such as course selections or school choices often have a spillover effect on siblings (Joensen & Nielsen, 2018; Dustan, 2018).

Drawing on administrative school records from various regions including England (Nicoletti & Rabe, 2019), North Carolina (Qureshi, 2018a), and the United States (Oettinger, 2000), numerous empirical studies indicate a statistically significant positive spillover effect of school achievement from older siblings to younger ones. On the other hand, younger sibling's performance is often reported as having no significant influence on older siblings (Oettinger, 2000). However, by utilising school entry policies as a quasi-experimental shock in Florida, United States, Karbownik and Özek (2023) reported positive sibling spillover effects from older siblings to younger ones in economically disadvantaged families and adverse spillover effects from younger siblings to older ones in more affluent families.

Most empirical evidence concerning direct sibling spillover effects is based on developed country contexts, with a few exceptions. For instance, Qureshi (2018b) estimated the sibling effect

on schooling performance using data from schools in Pakistan and discovered that the schooling of the oldest sister has a significant and positive impact on the literacy, numeracy and overall schooling of younger brothers, advocating the multiple benefits of initiatives promoting girls' education. Moreover, both theory and empirical evidence suggest that children from disadvantaged backgrounds are more engaged in activities among siblings. At the same time, parents tend to participate and exert less influence on their children (Lareau, 2018). This indicates a stronger direct sibling effect in disadvantaged families, as reported in American studies (Zang et al., 2023; Karbownik & Özek, 2023; Loury, 2004). On the other hand, the positive direct sibling effects can also potentially be lower or negative for children from disadvantaged families if the older sibling from disadvantaged backgrounds tends to perform worse.

2.2 Indirect sibling spillover effect

The second mechanism of the sibling spillover effect on children is the indirect sibling spillover effect, primarily associated with parental differential treatment (Feinberg & Hetherington, 2001). Also referred to as differential parenting, this concept has been an important research area concerning the nonshared environmental influences within families on children's development and behaviour (Brody et al., 1992; 2017). The resource-dilution theory (Parish & Willis, 1993) suggests that children's educational attainment is often negatively influenced by the presence of other school-age siblings due to limited available resources. Parents may unevenly distribute educational resources among their children, a strategy that can reinforce or compensate for initial differences in ability.

Berry et al. (2020) conducted a lab-in-the-field experiment in rural southern Malawi to elicit parental preferences for children's education investment. Their findings reveal that parents

have a strong preference for equalising input and maximizing total household earnings but do not prioritize equalizing educational outcomes among their children.

Conley & Lareau (2008) highlighted that parents from low-income families, facing limited resources, tend to distribute resources and invest in their children unequally. They may divert the limited resources to the child perceived to have greater potential for upward mobility, expecting future contributions from this child to compensate for other siblings and minimize sibling inequality over the course of life. This suggests a stronger indirect negative sibling effect for disadvantaged children in low-income families (Yi et al., 2015; Parman, 2015). A study in the UK suggests that parents from disadvantaged backgrounds have a higher tendency to allocate parental investment to children unevenly based on their birth weight, cognitive ability, and school outcomes (Breinholt & Conley, 2023).

However, an alternative perspective suggests that indirect sibling effects may be lower for children from disadvantaged families, as these parents often lack the resources or capability to influence children's educational outcomes. For example, Grätz and Torche (2016) reported in their study based on childhood studies in the United States that disadvantaged parents do not adjust their responses to children's ability differences in cognitive stimulations. In contrast, advantaged parents provide reinforced responses to higher-ability children.

Several studies indicate that parents adjust their allocations or shift their educational investments for their children in response to positive or negative shocks. For example, Landersø et al. (2020) utilized Danish school entry policies as a quasi-experimental shock to study sibling spillover effects on siblings' school performance. They found that delaying the school start of a younger sibling (born right after the school entry date) allowed parents to redirect resources to the

older siblings, resulting in substantially better performance in school subjects based on memorization, such as basic arithmetic and grammar.

Parman (2015) analyzed census data on American childhood household data during the 1918 influenza pandemic and discovered that families with a child in utero reallocated household resources toward older siblings. This reallocation led to notably higher educational attainments for these older siblings, reinforcing rather than mitigating the educational disparities resulting from adverse childhood health shocks during the pandemic. Similarly, Yi et al. (2015) examined census data from Kunming, China, revealing that twin siblings who experienced adverse health shocks received increased investments in health but fewer educational resources compared to their healthy twin counterparts.

2.3 Sibling spillover effect in the African context and gender aspect of sibling effect

Limited evidence exists in the African context regarding the direct and indirect effects of sibling relationships on children's educational outcomes. Studies conducted in African countries reporting sibling spillover effects primarily focus on school enrolment. For instance, Lindskog (2013) reported negative sibling effects of younger siblings' school enrolment on girls' school entry in the Ethiopian highlands. Similarly, Kravdal et al. (2013) reported similar effects across 26 sub-Saharan African countries, based on Demographic and Health Survey data. The only study that used exam or test scores is the study by Ferreira (2023) in Tanzania. However, the paper solely focused on the sibling effect on young siblings' school transition to secondary education or passing the national exam and did not find a significant effect.

Our survey was conducted in two distinct regions: the Ashanti region of Ghana and urban Niamey, the capital city of Niger. Niger, ranked third to last in the UN Development Program's

Human Development Index in 2022 (UNDP, 2022), stands among the poorest nations globally. Accompanied by a poor economy, Niger has one of the world's highest fertility rates. Despite slight decreases, Niger's total fertility rate has remained high, declining from 7.5 in the 1960s to 6.8 in 2021. In contrast, Ghana has witnessed substantial economic growth over the past decades, leading it to be an upper-middle-income country among African nations. Following this socioeconomic development, Ghana has experienced a rapid reduction in its fertility rate, dropping from a comparable level to Niger, around 7 in the 1960s, to 3.6 in 2021 (World Bank, 2024).

Several studies suggest that a higher number of siblings is often associated with reduced investment in education and a skewed allocation of educational resources towards boys or more abled children (Lee, 2008). For instance, Ayalew (2005) reported in a survey conducted in rural Ethiopia that parents tend to invest more in the education of children deemed more capable, especially under economic constraints. Previous research in African countries indicates a preference for investing more in boys' education than girls (Glick & Sahn, 2000; Hedges et al., 2016). Gender-biased investment is overwhelmingly observed among economically constrained parents but less in wealthier households (Rose & Al-Samarrai, 2001).

The theoretical model developed by Hazan and Zoabi (2015) explores the interplay among development, gender disparity, and education. The model indicates a trend of growing and narrowing gender gaps in educational returns alongside economic progress. This trend is accompanied by declining fertility rates, heightened educational attainment and educational returns for girls, reduced bias towards sons and diminishing gender disparities in education as prominent features of development. Recent research by Asravor (2021) supports this trend, showing higher returns to education for females over males in Ghana. Pasqua (2005) proposes another theoretical model emphasizing the importance of parents' preferences and decision-

making powers in shaping educational investments. The study suggests that traditional gender roles and parental preferences for sons persist in the African context, contributing to the gender gap in parental education investment, even when educational returns are equal for both genders.

Culturally, Niger predominantly adheres to patrilineal inheritance traditions influenced by Islamic cultural influence. In contrast, the Ashanti, a major ethnic group of the Akans in Ghana, represents the largest tribe in the country and one of the few societies in West Africa with a matrilineal inheritance system. However, there is no consensus regarding parental preferences in educational investments for sons and daughters across various kinship structures and inheritance traditions. Kaul (2018) conducted a study in Meghalaya, India, where matrilineal norms prevail, finding that educational investment favoured girls. Lowes (2022), analysing Demographic and Health Surveys (DHS) data from 14 sub-Saharan African countries, found that educational investment typically favours male children but tends to be more equalized in matrilineal systems. However, Collins (2022) examined 27 Sub-Saharan African countries using DHS data and found that having a brother negatively affects girls' educational outcomes in both patrilineal and matrilineal inheritance systems.

In the Ashanti region of Ghana, a study suggested that parents in the matrilineal Akan ethnic group invest more in boys' education to compensate for their loss in inheritance (La Ferrara & Milazzo, 2017). Conversely, following land reform that increased boys' chances of inheriting land from their fathers, there was a decline in boys' educational attainment. Mattison et al. (2023) observed similar patterns in ethnic Chinese Mosuo villages, indicating a gender disparity in educational attainment favouring men across matrilineal and patrilineal villages, with a broader gap in matrilineal contexts. Similarly, Quisumbing and Otsuka (2001) investigated Sumatra's matrilineal societies and highlighted significant disadvantages in women's schooling despite a

traditional preference for women in land inheritance. Nevertheless, the gender gap in education narrows among the younger generation.

The survey data from Niger and Ghana allows us to examine several factors associated with sibling effects on children's school performance related to gender and disabilities within the African context. The following hypotheses are formulated to be tested across both countries.

RQ1: Do children with disabilities (CWD) significantly underperform compared to children without disabilities (CWOD) in educational outcomes?

Hypothesis H1: *Negative disability effect: Children with disabilities (CWD) demonstrate lower educational outcomes than their peers without (CWOD).*

RQ2: Is there a significant sibling spillover effect on children's educational outcomes?

Hypothesis H2 (Among CWOD): *Positive net sibling effect: Children with siblings (CWS) demonstrate higher educational outcomes than their peers without siblings (CWOS).*

This hypothesis assumes that children can gain positive educational benefits from siblings, which outweigh the potential negative sibling effects when parents reallocate resources to support other siblings for children without disabilities in the poor African context. Therefore, the net sibling effect is positive.

RQ3: Are boys performing better than girls?

Hypothesis H3 (Among CWOD): *Gender effect: Boys have better school performance than girls.*

This hypothesis is based on the assumption that boys are given more priority by their parents in the African context.

RQ4: Are there gender differences in the sibling spillover effects?

Hypotheses H4a-H4e (Among CWOD):

H4a: The net effect of having older brothers on school performance is negative.

H4b: The net effect of having older sisters on school performance is positive.

H4c: The net effect of having younger siblings on school performance is negative.

H4d: The net effect related to gender (H3a and H3b) is larger in Niger than that in Ghana.

H4e: The net sibling effects for girls are lower than for boys.

The hypotheses are based on the assumption that girls are typically assigned caregiving roles for younger siblings, whereas boys and younger siblings are afforded more freedom and are competitively oriented (H4a, H4b, H4c). Additionally, we expect stronger gender bias favouring boys in patrilineal societies in Niger than the matrilineal societies as those in our study areas in Ghana (H4d). Education may be more important for boys in the matrilineal system as they cannot depend on inheriting the land from their parents.

RQ5: Do these sibling spillover effects differ for CWD vs. CWOD?

Hypotheses H5a-H5e (CWD):

H5a: The negative net effect of having older brothers is stronger for CWD.

H5b: The positive net effect of having older sisters is stronger for CWD.

H5c. The negative net effect of having younger siblings is stronger for CWD.

H5d: The net effect related to gender (H4a and H4b) is larger in Niger than that in Ghana.

H5e: The net sibling effects for girls are more negative and less positive compared to boys.

These hypotheses are based on the assumption that parents allocate more educational resources to CWODs, who demonstrate greater potential for success. This allocation pattern may exacerbate the negative indirect sibling effect, leading to a stronger negative net effect or weaker positive net effect for CWD (H5a, H5c). H5b assumes that CWD may benefit more from the care of older sisters, leading to a stronger positive net effect. Finally, stronger gender bias is expected in Niger (H5d) and the sibling effect on the school performance of girls are expected to be negative due to parents' preferences towards boys and gain lower positive sibling effect from having an older sister (H5e).

3. Data and empirical strategy

3.1 Data

The paper is based on surveys conducted in Ghana and Niger, utilizing the Washington Group Child Functional Module (WG-CFM) for children aged 5–17 to identify disability status. In December 2021, a total of 27 schools in the Ashanti region of Ghana and 18 schools in Niamey,

Niger[1], were selected from a comprehensive list of inclusive schools with registered CWD. Classes in grades 1, 3, and 5 in these schools were visited, and teachers completed the WG-CFM for all children. Children who reported severe functional challenges were selected for the survey, and another child in the same class who reported no functional challenge was randomly selected for comparison[2].

A follow-up survey was conducted one year later in the classes with selected children, during which school performance data of four main school subjects were collected for all children in the visited classes in both Ghana and Niger. School record data were gathered for 3,311 children in 98 classes in Ghana and 6,261 children in 110 classes in Niger. Altogether, 387 pupils in primary school in Ghana and 573 pupils in primary school in Niger were interviewed. Table 1 shows the sample size of various groups of children in Ghana and Niger.[3].

Table 1. Sample size in Ghana and Niger

		CWOD	CWD	CC
Ghana	CWOS	111	70	
	CWS	124	82	
	Total	235	152	2924
Niger	CWOS	124	77	
	CWS	222	150	
	Total	346	227	5688

CC: Counterfactual Classmates; CWOD: Children without disabilities; CWD: Children with disabilities
CWOS: Children without siblings; CWS: Children with siblings

School record data were collected in math, natural science, English, and the local language in Ghana, and for math, natural science, French reading, and French writing in Niger. The data collected includes the final 2022 school records in Ghana and the average school records for the first two or three terms in the 2022-2023 school year in Niger[4].

[1] In Ghana, five of the selected schools are private, while eight are located in rural areas. In Niger, all selected schools are public and in urban areas of Niamey.
[2]. CWOD's larger sample size is due to the readjustment of disability status after three rounds of evaluations by parents and teachers during the surveys.
[3] The sample size in Ghana is lower, partly because there is a smaller number of CWD resulting from screening children in the selected schools compared to Niger. Additionally, the response rate is lower in Ghana due to a higher rate of refusal among parents. In Ghana, the response rates were 75% and 90% in the two surveys, while they were 99% and 96% in Niger.
[4] Due to COVID-19, the school year was restructured in Ghana. During the year of the survey, the complete school year started from the beginning of each calendar year. Therefore, during the survey in early 2023, 2022 final school record data was collected in Ghana. However, in Niger, they still follow the previous school year arrangement, so the school year started from October 2022.

3.2 Empirical strategy

3.2.1 Variable construction

The outcome variables of school records are normalized using Z-score techniques with the "norm" command in STATA. Z-scores are calculated at class level separately for each school subject in Ghana and Niger as follows:

$$N_{cis} = (R_{cis} - \overline{R}_{cs})/\sigma_{cs} \quad (1)$$

Here, subscript c represents classes, s represents one of the four subjects, and i represents each child in the class. R_{cis} represents the original scores of the school subject s for child i in class c, while N_{cis} represents the normalized Z-scores of school records at the class level. $\overline{R}_{cs}$ is the mean school records of subject s in class c, and σ_{cs} is the standard deviation of the school subject s in class c. Children's school records collected in the survey are not based on a national standard test and may vary across classes and schools. To address this variation, Z-score normalization at the class level for each school subject is implemented. This means that only relative within-class performance differences are analysed. This within-class normalization allows us to compare the relative school performance of CWD and CWOD and how it is affected by different "sibling treatments" by gender across the schools included in the two countries of study.

3.2.2 Assessment of the natural experiment assumption for each of the treatment variables

Building upon the human capital models proposed by David Card (1994) and James Heckman (1997), as well as insights from Guido, Imbens and Angrist (1994), this study is framed as a natural experiment. Within this framework, the presence of disability and the presence of siblings are considered as random treatments, which may be considered to exert an impact on groups that are

For most schools, school records in the first two semesters were collected, and for some schools, school records for the first three semesters were collected. In Niger, the average of all the collected school records for each child is used in the analysis.

otherwise similar. The underlying assumption is that whether a child has functional challenges or has a sibling are exogenous variables. If this assumption holds, it may permit an identification of a causal effect of the random treatments on children's educational outcomes. However, it is essential to test this assumption regarding its correlations with relevant control variables.

To validate the natural experiment assumption, potential spurious correlations between the treatment variables (disability and sibling status) and various potential confounding factors, including school characteristics (urban/rural, public/private), household attributes (parents' education, family wealth), and child demographics (gender, age), are examined. If no significant correlations are detected, disability and sibling status can be treated as causal factors affecting differences in school performance. Moreover, gender and birth order are treated as random variables in this African context since they are not commonly manipulated. The gender of the sibling and whether they are older or younger than the CWD or CWOD subjects should not be correlated with children's disability status.

3.2.3 Non-parametric tests of treatment effects

To evaluate the difference between treatment and control groups, Cohen's *d*s are estimated, which represent the effect sizes in standard deviation units. First, Cohen's *ds* are estimated between CC and CWD to determine the presence of a disability effect related to Hypothesis H1. Next, Cohen's *ds* are estimated between the selected children without disabilities (CWOD) and other counterfactual classmates (CC) not selected for the survey in these classes. Since we only have sibling information of CWOD, we need to test the representativeness of CWOD for the class so that it could be used to replace CC in estimating the sibling effects. If CWOD is randomly selected, insignificant differences from their class means are expected. Thereafter, the sibling effects related

to Hypothesis H2 are estimated in Table 4, where Cohen's *ds* between children with and without siblings (CWS and CWOS) are estimated respectively in the subsample of CWD or CWOD. Finally, Cohen's *ds* are estimated to evaluate the presence of sibling effects related to gender, corresponding to Hypotheses H4 and H5, in Table 5. The Cohens *ds* estimations across each of the four school subjects as well as the pooled school subjects in Ghana and Niger are presented.

While Z-scores normalize variables at the class level, deviation from normality may still affect significance test reliability. As an additional robustness check, Kolmogorov-Smirnov (KS) non-parametric tests, which assess the equality of probability distributions for the normalized Z-scores of school records at the country level across sub-samples categorized by the natural experiment treatments. Additionally, cumulative distribution functions are presented to visually inspect the differences and assess stochastic dominance.

3.2.4 Parametric analyses

Utilizing the panel data structure in the cross-section data, linear panel data models are estimated. Due to the small sample sizes for many treatment categories, the parametric models are run on the pooled (within-class normalized) Z-score data of the four main school subject scores collected for each child in Ghana and Niger. Since these school subject scores are obtained from the same children, they are not independent. Therefore, the data are treated as panel data with cluster-corrected standard errors to account for the clustering of children at the class level.

The first set of regressions tests hypothesis H1, which states that CWD demonstrates lower educational outcomes than CC. A random effects model with a parsimonious specification is employed, initially including only a dummy variable for disability (D_{ci}), with CC as the reference category. As we only collected school records for CC, while CWD and CWOD participated in the

survey, control variables and sibling information are only available for the CWD and CWOD samples. Consequently, except the first parsimonious model for testing the disability effect, the CWOD sample serves as the counterfactual sample in all the expanded models and analysis of sibling effects. At the same time, we run an additional model with CWOD as the reference to assess whether this sample is representative of the CC (full class sample) in terms of school performance. Subsequently, the models are expanded by incorporating a set of school subject invariant control variables X_{ci}, encompassing children's age and gender, the highest educational attainment of both parents and the household asset index. Additionally, in the Ghana sample, two additional variables are incorporated: location (urban or rural) and school type (public or private). It is worth noting that the schools sampled in Niger are all public schools in urban Niamey.

The random effect model is specified as follows:

$$N_{cis} = \gamma_0 + Z_{ci}\gamma_{1ci} + D_{ci}\gamma_2 + X_{ci}\gamma_3 + \omega_{cis} \quad (2)$$

Here, *c* represents class, *s* represents school subject, and *i* represents child. *i*= 1, …. *M* with child *i* consisting of 4 observations of school subjects. Z_{ci} is the 4**M* design matrix for the random effects γ_{1ci} for child i in class *c*; D_{ci} refers to disability status and X_{ci} is a vector of child-level control variables. γ_0 is the intercept term, while γ_2 is of primary interest, representing the estimated disability effect on school performance. Analyses of the samples from Ghana and Niger are conducted, respectively (country ids are suppressed to keep the notation simple).

Following this, the regressions outlined below examine hypotheses H2 and H3 regarding the effects of siblings and gender on school performance among CWOD.

$$N_{cis} = \alpha_0 + Z_{ci}\alpha_{1ci} + B_{ci}\alpha_2 + X_{ci}\alpha_3 + u_{cis} \quad (3)$$

$$N_{cis} = \pi_0 + Z_{ci}\pi_{1ci} + G_{ci}\pi_2 + X_{ci}\pi_3 + \varepsilon_{cis} \quad (4)$$

Here, α_2 and π_2 represent the estimated sibling and gender effect on school performance. Random effect models are run initially with a parsimonious specification by including only a dummy variable for sibling status (B_{ci}) or gender (G_{ci}), using CWOS or boy as the reference category. Subsequently, the models are expanded by including a vector of child-level control variables (X_{ci}).

To examine hypothesis H4, which assesses the sibling effect among children with different types of siblings compared to children without siblings, the third set of regressions also focuses on CWOD.

$$N_{ciS} = \beta_0 + Z_{ci}\beta_{1ci} + OB_{ci}\beta_2 + OS_{ci}\beta_3 + YS_{ci}\beta_4 + X_{ci}\beta_5 + \epsilon_{cis} \quad (5)$$

Here, OB_{ci}, Os_{ci}, and YS_{ci} are dummy variables indicating whether each child in the sample has an older brother (*OB*), older sister (*OS*), and younger sibling (*YS*), respectively. The base category is a child without a sibling. The coefficients β_{1ci}, β_{1ci}, and β_{1ci} represent the effect of having older brothers, older sisters, and younger siblings, respectively, on school performance. A random effect model with a parsimonious specification includes only the dummy disability variables (OB_{ci}, OS_{ci}, and YS_{ci}). Subsequently, additional models are run, first incorporating only the interaction terms between disability status and gender and then adding a vector of control variables (X_{ci}).

Finally, hypothesis H5 is examined by conducting the same regressions as outlined in equation (5) on CWD and estimating the effects of different sibling types on their school performance.

4. Results

4.1 Natural experiment assumption tests

The natural experiment assumption is examined for each treatment variable by regressing disability and sibling status on school, family and children's characteristics in Ghana and Niger, respectively. The results are presented in Table 2. The coefficients reflect the expected change in the probability of a child being disabled or having a sibling for every 1-unit change in the explanatory variable, holding other variables constant. In Ghana, older children, those living in urban areas, attending public schools, or from affluent families show a positive correlation with disabilities. These correlations are not statistically significant in Niger. Given our sample of schoolchildren, this indicates that CWD in urban areas and from wealthier families are more likely to attend school and have better access to public schools than rural CWD. However, in Niger, gender is negatively correlated with disabilities, implying that boys with disabilities have a higher chance of school enrollment. Regarding sibling status, the mother's education emerges as a crucial confounding factor in both countries. The potential effect of these correlated variables is tested by running models without and with them and inspecting how their inclusion affects our main variables of interest and the robustness of our findings/conclusions.

Table 2. Natural experiment assumption tests on disability and sibling status in Ghana and Niger

Natural experiment test	Ghana		Niger	
	Disability	Sibling	Disability	Sibling
Gender (F vs. M)	-0.015	-0.051	-0.086**	-0.026
	(0.051)	(0.052)	(0.041)	(0.039)
Age (base category:6)	0.029**	0.012	0.012	0.002
	(0.012)	(0.013)	(0.010)	(0.010)
Rural vs. Urban	-0.121*	-0.031		
	(0.064)	(0.065)		
Public vs. Private	0.237**	0.095		
	(0.093)	(0.095)		
Fathers' highest education (base category: Primary or less)				
Primary	-0.04	0.108	0.085	-0.078
	(0.130)	(0.133)	(0.063)	(0.060)
Junior Secondary	-0.008	-0.008	0.084	-0.092
	(0.095)	(0.097)	(0.060)	(0.058)
Senior Secondary	-0.079	0.015	0.005	-0.074
	(0.103)	(0.105)	(0.077)	(0.073)
Died/ not in the household	-0.095	-0.096	0.081	-0.252***
	(0.102)	(0.104)	(0.074)	(0.070)

Mothers' highest education (base category: Primary or less)				
Primary	-0.045	0.032	-0.063	0.089
	(0.103)	(0.106)	(0.060)	(0.058)
Junior Secondary	-0.068	0.250***	-0.058	0.188***
	(0.072)	(0.073)	(0.070)	(0.066)
Senior Secondary	0.078	0.246***	-0.101	0.097
	(0.088)	(0.090)	(0.088)	(0.084)
Died/ not in the household	-0.184*	0.075	-0.059	-0.180**
	(0.109)	(0.112)	(0.090)	(0.086)
Wealth index	0.090***	0.061**	-0.02	-0.016
	(0.030)	(0.031)	(0.024)	(0.023)
Constant	0.071	0.253	0.394***	0.699***
	(0.208)	(0.212)	(0.127)	(0.121)
Sample size	387	387	573	573
R^2	0.059	0.058	0.02	0.061

Dependent variable: disability status (child with or without disability); sibling status (child with or without sibling)
Significance levels: * p<0.10; ** p<0.05; *** p<0.01.

4.2 Non-parametric analyses

Table 3 presents descriptive information on normalized within-class relative school performance for counterfactual classmates (CC), children without disabilities (CWOD) and children with disabilities (CWD), along with their effect sizes estimated in the form of Cohen's *ds*. These effect sizes are reported for each school subject individually and for pooled school subjects. The effect sizes between CWOD and CC are all below 0.2, suggesting that CWOD is a good representation of the children within the class.

Table 3. Descriptive statistics and non-parametric tests of within-class relative school performance by children's disability status and sample type in Ghana and Niger

		Ghana				Niger			
		Mean	Sample size	Cohen's *d* (95% CI)	KS test (P-value)	Mean	Sample size	Cohen's *d* (95% CI)	KS test (P-value)
Math	CWOD	0.15	230			0.00	346		
	CC	0.00	2,846	0.15**		0.02	5,687	-0.02	
	(CWOD vs. CC)			(0.02,0.28)	0.032			(-0.13,0.09)	0.605
	CWD	-0.16	145	0.16**		-0.46	227	0.49**	
	(CC vs. CWD)			(0.01,0.32)	0.046			(0.35,0.62)	0.000
Natural Science	CWOD	0.17	230			0.08	221		
	CC	0.00	2,803	0.18**		0.01	3,139	0.08	
	(CWOD vs. CC)			(0.04,0.31)	0.014			(-0.06,0.21)	0.419
	CWD	-0.21	144	0.21**		-0.26	137	0.27**	
	(CC vs. CWD)			(0.04,0.38)	0.079			(0.10,0.44)	0.009
English (French reading[1])	CWOD	0.15	230			0.13	346		
	CC	0.00	2,844	0.15**		0.01	5,688	0.12	
	(CWOD vs. CC)			(0.02,0.28)	0.017			(0.02,0.23)	0.034
	CWD	-0.21	143	0.21**		-0.32	227	0.33**	
	(CC vs. CWD)			(0.38,0.42)	0.012			(0.20,0.46)	0.000
Local Language (French writing[1])	CWOD	0.12	229			0.18	342		
	CC	0.00	2,920	0.12		0.00	5,317	0.18	
	(CWOD vs. CC)			(-0.01,0.25)	0.045			(0.07,0.29)	0.008
	CWD	-0.15	145	0.15		-0.26	218	0.26**	
	(CC vs. CWD)			(-0.15,0.32)	0.114			(0.13,0.40)	0.000
	CWOD	0.15	919			0.10	1,255		

Pooled school subjects	CC (CWOD vs. CC)	0.00	11,413	0.15 (0.08,0.22)	0.000	0.01	19,831	0.09 (0.03,0.15)	0.035
	CWD (CC vs. CWD)	-0.18	577	0.18** (0.10,0.27)	0.000	-0.33	809	0.34** (0.27,0.42)	0.000

CC: Counterfactual Classmates; CWOD: Children without disabilities; CWD: Children with disabilities
[1] School subjects in parentheses are those reported in Niger

Hypothesis H1 suggests a negative disability effect. The estimated differences between CWOD and CWD range from 0.29 to 0.44 standard deviation across different school subjects in Ghana and Niger, indicating a medium-level negative disability effect, which supports H1. Additionally, the Kolmogorov-Smirnov (KS) test is included as an additional robustness check for within-class relative differences in school performance between treatments and controls. Finally, cumulative distribution functions are presented in Appendix I.

Both the KS test and cumulative distribution suggest that CWD performs worse than CWOD across all school subjects in both countries, which supports H1. Furthermore, CWOD demonstrates a slight advantage over CC in school performance. This marginal benefit may stem from the fact that CWOD is selected from children reported by teachers to have no functional challenges. Conversely, children with moderate functional challenges are not included in either the CWD or CWOD groups but are part of the CC group.

Next, the estimated Cohen's *d*s effect sizes of normalized within-class relative school performance by children's sibling status (within a subsample of CWOD or CWD) are presented in Table 4. These effect sizes by children's sibling status are reported for each school subject individually and for pooled school subjects. Hypothesis H2 suggests a positive disability effect. All the Cohen's *d*s effect sizes are relatively small (<0.3 sd), indicating that sibling effects are relatively small, which does not support H2. The only significant (at the 5% level) but small effect (=0.18 sd) is found in Ghana's pooled school subjects between CWOS and CWS in the subsample of CWD, indicating that CWD without siblings performs overall better than CWD with siblings in Ghana.

Table 4. Descriptive statistics and non-parametric tests of within-class relative school performance by sibling status among children with and without disabilities (CWD and CWOD) in Ghana and Niger

			Ghana				Niger			
			Mean	Sample size	Cohen's *d* (95% CI)	KS test (P-value)	Mean	Sample size	Cohen's *d* (95% CI)	KS test (P-value)
Math	CWOD	CWOS	0.12	108			0.04	124		
		CWS	0.17	122	-0.06	0.777	-0.03	222	0.07	0.365
		(CWOS vs. CWS)			(-0.32,0.20)				(-0.15,0.29)	
	CWD	CWOS	-0.13	67			-0.45	77		
		CWS	-0.19	78	0.07	0.358	-0.47	150	0.01	0.726
		(CWOS vs. CWS)			(-0.26,0.40)				(-0.26,0.29)	
Natural Science	CWOD	CWOS	0.10	108			0.13	80		
		CWS	0.24	122	-0.15	0.586	0.05	141	0.07	0.96
		(CWOS vs. CWS)			(-0.41,0.11)				(-0.20,0.29)	
	CWD	CWOS	-0.07	67			-0.24	39		
		CWS	-0.34	77	0.26	0.026	-0.26	98	0.02	0.884
		(CWOS vs. CWS)			(-0.07,0.59)				(-0.35,0.29)	
English (French Reading[1])	CWOD	CWOS	0.10	108			0.24	124		
		CWS	0.18	122	-0.08	0.229	0.06	222	0.17	0.17
		(CWOS vs. CWS)			(-0.34,0.18)				(-0.05,0.29)	
	CWD	CWOS	-0.11	66			-0.37	77		
		CWS	-0.29	77	0.18	0.354	-0.29	150	-0.07	0.816
		(CWOS vs. CWS)			(-0.15,0.51)				(-0.35,0.29)	
Local language (French Writing[1])	CWOD	CWOS	0.09	107			0.20	123		
		CWS	0.15	122	-0.06	0.616	0.17	219	0.03	0.209
		(CWOS vs. CWS)			(-0.32,0.20)				(-0.19,0.29)	
	CWD	CWOS	-0.05	67			-0.24	73		
		CWS	-0.24	78	0.22	0.336	-0.27	145	0.03	0.908
		(CWOS vs. CWS)			(-0.11,0.55)				(-0.25,0.29)	
Pooled school subject	CWOD	CWOS	0.10	431			0.15	451		
		CWS	0.18	488	-0.09	0.148	0.06	804	0.09	0.131
		(CWOS vs. CWS)			(-0.22,0.04)				(-0.03,0.29)	
	CWD	CWOS	-0.09	267			-0.34	266		
		CWS	-0.27	310	0.18	0.003	-0.33	543	-0.01	0.958
		(CWOS vs. CWS)			(0.02,0.35)				(-0.16,0.29)	

CWOD: Children without disabilities; CWD: Children with disabilities
CWOS: Children without siblings; CWS: Children with siblings
[1] School subjects in parentheses are those reported in Niger

Furthermore, the results of the Kolmogorov-Smirnov test are presented in Table 4, and cumulative distributions of normalized school records by children's sibling status are depicted in Appendix II. These tests for each individual school subject are conducted in the subsamples of CWD and CWOD, respectively. These results also do not support H2 and indicate that the distributions of any school subject's records are not significantly different across CWS and CWOS, holding true for both CWD and CWOD.

Finally, Table 5 presents the effect size of normalized Z-scores of relative within-class school performance estimated from Cohen's *d*s between children with and without certain types of siblings across CWD and CWOD subsamples, stratified by gender. Only the results from the

pooled school subjects are reported in each country to get large enough samples to have more statistical power in these tests.

Table 5. Cohen's *d* effect size of school performance between children with and without various types of siblings across CWD and CWOD subsamples, by gender in Ghana and Niger (Pooled school subjects)

			Boy			Girl		
			Cohen's *d*	[95% Conf. Interval]		Cohen's *d*	[95% Conf. Interval]	
Ghana	CWOD	Older brother	-0.11	-0.37	0.15	0.11	-0.17	0.39
		Older sister	-0.07	-0.28	0.14	-0.30**	-0.55	-0.06
		Younger sibling	0.00	-0.19	0.20	0.01	-0.20	0.21
		Sample size		503			416	
	CWD	Older brother	-0.06	-0.30	0.19	0.35**	0.00	0.71
		Older sister	-0.38**	-0.66	-0.09	-0.29	-0.67	0.09
		Younger sibling	0.04	-0.21	0.29	0.69**	0.42	0.96
		Sample size		332			245	
Niger	CWOD	Older brother	0.02	-0.16	0.19	0.01	-0.18	0.20
		Older sister	0.08	-0.10	0.26	-0.08	-0.25	0.10
		Younger sibling	0.03	-0.13	0.20	0.02	-0.14	0.18
		Sample size		600			655	
	CWD	Older brother	0.08	-0.12	0.29	0.13	-0.12	0.39
		Older sister	0.04	-0.19	0.27	-0.11	-0.35	0.13
		Younger sibling	0.02	-0.17	0.21	0.04	-0.17	0.25
		Sample size		450			359	

CWOD: Children without disabilities in survey; CWD: Children with disabilities in survey

Hypothesis H4 suggests significant net sibling effects for various sibling types among CWOD. However, the only significant Cohen's *d* effect size (at the 5% level) is reported for CWOD girls (= - 0.30 sd) with an older sister, indicating a positive sibling effect of having an older sister among CWOD girls in Ghana. Other than that, no sibling effect is found for other types of siblings in Ghana and no sibling effect at all among CWOD in Niger.

Hypothesis H5 suggests significant and stronger net sibling effects for various sibling types among CWD, compared to CWOD. Cohen's *d*s are significant for CWD boys with an older sister (= -0.38 sd), CWD girls with an older brother (=0.35 sd) or younger sibling (=0.69 sd), indicating a positive sibling effect of having an older sister on CWD boys, and negative sibling effect of having an older brother or younger sibling on CWD girls in Ghana. However, all the Cohen's *d*s in Niger are small (<0.2 sd), indicating relatively small sibling effects related to gender in Niger.

Section 4.3-4.7 continues to test Hypotheses H1-H5 with parametric analysis. All the parametric analyses are conducted on the sample of pooled school subjects in Ghana and Niger to

have satisfactory statistical power. The data are treated as panel data with cluster-corrected standard errors to account for the clustering of children at the class level.

4.3 Disability effect on school performance

To test Hypothesis H1 regarding the impact of disability on children's school performance, the first set of random effects models on the pooled school subjects in Ghana and Niger is conducted. The results are presented in Table 6. In Ghana, children with disabilities (CWD) perform 0.18 standard deviations worse than their counterfactual classmates (CC) and approximately 0.3-0.33 standard deviations worse than children without disabilities (CWOD) in terms of pooled school performance. In Niger, this discrepancy is more pronounced, ranging from 0.36 to 0.45 standard deviations. Therefore, Hypothesis H1 is supported.

Table 6. Random effect model on disability effect in Ghana and Niger (Pooled school subjects)

	Ghana			Niger		
Disability status (base category: CC[1])	-0.184**			-0.357***		
	(0.077)[3]			(0.079)		
Disability status (base category: CWOD)		-0.332***	-0.301***		-0.446***	-0.424***
		(0.114)	(0.115)		(0.087)	(0.089)
Control[2]	No	No	Yes	No	No	Yes
Constant	-0.003	0.144**	0.068	-0.001	0.087**	-0.332
	(0.006)	(0.064)	(0.414)	(0.006)	(0.043)	(0.270)
Sample size	11990	1496	1496	16273	2064	2064
R^2 overall	0.002	0.027	0.055	0.006	0.037	0.059

Dep variable: normalized Z-scores of within-class relative school performance based on the pooled school subjects (four observations per child)
1. CC: Counterfactual Classmates; CWOD: Children without disabilities; CWD: Children with disabilities
2. Control variables include gender, age, location (urban/rural), public/private, father's highest education, mother's highest education, wealth index in Ghana; gender, age, father's highest education, mother's highest education, wealth index in Niger
3.Significance levels: * p<0.10; ** p<0.05; *** p<0.01. Cluster-corrected standard errors are reported in parentheses.

4.4 Sibling effect on school performance among CWOD

The second set of regressions tests Hypothesis H2, focusing on the net effect of overall sibling impact among CWOD (Table 7). However, no significant effect of net sibling impact is found on the pooled school subject data for both Ghana and Niger. Consequently, Hypothesis H2 is rejected.

Table 7. Random effect model on sibling effect among CWOD (Pooled school subjects)

	Ghana		Niger	
Sibling status (base category: CWOS[1])	0.086	0.078	-0.092	-0.106
	(0.124)[3]	(0.119)	(0.083)	(0.082)
Control[2]	No	Yes	No	Yes
Constant	0.099	0.652	0.147**	-0.126
	(0.110)	(0.540)	(0.064)	(0.293)
Sample size	919	919	1255	1255
R^2 overall	0.002	0.052	0.002	0.028

Dep variable: normalized Z-scores of within-class relative school performance based on the pooled school subjects (four observations per child)
1. CWOS: Children without siblings; CWS: Children with siblings
2. Control variables include gender, age, location (urban/rural), public/private, father's highest education, mother's highest education, wealth index in Ghana; gender, age, father's highest education, mother's highest education, wealth index in Niger
3.Significance levels: * p<0.10; ** p<0.05; *** p<0.01. Cluster-corrected standard errors are reported in parentheses.

4.5 Gender effect on school performance among CWOD (Pooled school subjects)

The third set of regressions tests Hypothesis H3, focusing on whether boys have better performance than girls among CWOD (Table 8). In Ghana, no significant gender difference is found in the pooled school subject data. However, in Niger, girls outperform boys by 0.21-0.22 standard deviations. Therefore, Hypothesis H3 is not supported.

Table 8. Random effect model on gender effect among CWOD (Pooled school subjects)

	Ghana		Niger	
Gender (base category: boy)	0.091	0.14	0.219***	0.208***
	(0.106)[2]	(0.095)	(0.081)	(0.080)
Control[1]	No	Yes	No	Yes
Constant	0.013	0.668	-0.245**	-0.227
	(0.161)	(0.532)	(0.121)	(0.295)
Sample size	919	919	1255	1255
R^2 overall	0.002	0.05	0.011	0.027

Dependent variable: normalized Z-scores of within-class relative school performance based on the four pooled school subjects
1. Control variables include gender, age, location (urban/rural), public/private, father's highest education, mother's highest education, wealth index in Ghana; gender, age, father's highest education, mother's highest education, wealth index in Niger
2.Significance levels: * p<0.10; ** p<0.05; *** p<0.01. Cluster-corrected standard errors are reported in parentheses.

4.6 Sibling effect related to gender on school performance among CWOD

Sibling effects related to gender and sibling types among CWOD are examined in Hypothesis H4. The results of the third set of regressions are presented in Table 9. No significant net sibling effect for any sibling type is found for either girls or boys in both Ghana and Niger. Consequently, Hypothesis H4 is not supported.

Table 9. Random effect model on sibling effect related to gender among CWOD (Pooled school subjects)

	Ghana			Niger		
Has sibling						
Older brother	0.019	0.115	0.083	-0.055	-0.012	0.017
	(0.119)[2]	(0.135)	(0.111)	(0.098)	(0.116)	(0.117)
Older sister	0.154	0.077	0.005	0.004	-0.063	-0.08
	(0.124)	(0.204)	(0.198)	(0.087)	(0.121)	(0.127)
Younger sibling	0.003	0.008	0.114	-0.03	-0.041	-0.071
	(0.108)	(0.155)	(0.162)	(0.094)	(0.137)	(0.139)
Sibling type##Gender						
Older brother##Girl		-0.223	-0.141		-0.047	-0.149
		(0.261)	(0.245)		(0.187)	(0.194)
Older sister##Girl		0.203	0.183		0.143	0.148
		(0.244)	(0.237)		(0.188)	(0.190)
Younger sibling##Girl		-0.019	-0.124		0.018	0.04
		(0.193)	(0.192)		(0.183)	(0.173)
Gender (base category: boy)		0.09	0.157		0.183	0.188
		(0.124)	(0.114)		(0.127)	(0.125)
Control[1]	No	No	Yes	No	No	Yes
Constant	0.108	0.068	0.769	0.113**	0.011	0.039
	(0.101)	(0.115)	(0.502)	(0.056)	(0.086)	(0.303)
Sample size	919	919	919	1255	1255	1255
R^2 overall	0.004	0.01	0.055	0.001	0.012	0.029

Dependent variable: normalized Z-scores of within-class relative school performance based on the four pooled school subjects
1. Control variables include age, location (urban/rural), public/private, father's highest education, mother's highest education, wealth index in Ghana; age, father's highest education, mother's highest education, wealth index in Niger
2.Significance levels: * p<0.10; ** p<0.05; *** p<0.01. Cluster-corrected standard errors are reported in parentheses.

4.7 Sibling effect related to gender on school performance among CWD

Finally, Hypothesis H5 examines the sibling effects related to gender and sibling types among CWD. The results are presented in Table 10. No significant net sibling effect for any sibling type is found for either girls or boys in Niger, thus not supporting H5d, which posits that the net effect related to gender is larger in Niger.

Table 10. Random effect model on sibling effect related to gender among CWD (Pooled school subjects)

	Ghana			Niger		
Has sibling						
Older brother	-0.108	0.087	0.189	-0.117	-0.088	-0.119
	(0.173)[2]	(0.198)	(0.191)	(0.115)	(0.149)	(0.149)
Older sister	0.22	0.359**	0.373**	0.053	-0.024	-0.077
	(0.191)	(0.150)	(0.155)	(0.126)	(0.191)	(0.202)
Younger sibling	-0.306*	0.007	-0.043	-0.02	-0.02	0.049
	(0.166)	(0.191)	(0.181)	(0.152)	(0.195)	(0.193)
Sibling type##Gender						
Older brother##Girl		-0.353	-0.282		-0.034	-0.003
		(0.439)	(0.404)		(0.268)	(0.278)
Older sister##Girl		-0.235	-0.108		0.157	0.142
		(0.485)	(0.487)		(0.292)	(0.298)
Younger sibling##Girl		-0.673**	-0.759**		-0.046	-0.129
		(0.296)	(0.299)		(0.267)	(0.258)

Gender (base category: boy)		0.518**	0.481**		0.162	0.201
		(0.215)	(0.217)		(0.219)	(0.197)
Control[1]	No	No	Yes	No	No	Yes
Constant	-0.11	-0.352**	-1.176*	-0.336***	-0.401**	-0.663
	(0.115)	(0.140)	(0.668)	(0.106)	(0.175)	(0.419)
Sample size	577	577	577	809	809	809
R^2 overall	0.032	0.071	0.162	0.003	0.008	0.056

Dependent variable: normalized Z-scores of within-class relative school performance based on the four pooled school subjects
1. Control variables include age, location (urban/rural), public/private, father's highest education, mother's highest education, wealth index in Ghana; age, father's highest education, mother's highest education, wealth index in Niger
2.Significance levels: * p<0.10; ** p<0.05; *** p<0.01. Cluster-corrected standard errors are reported in parentheses.

In Ghana, Table 10 suggests no net effect of having older brothers for CWD, which does not support Hypothesis H5a. For Hypothesis H5b, the model finds a significantly positive net effect of having older sisters (0.36 to 0.37 standard deviations), with no significant difference in this positive net effect between CWD boys and girls. On the other hand, the parsimonious model suggests a significantly negative net effect of having younger siblings for CWD (-0.3 standard deviations). However, when the model includes gender as an interaction term, the effect of having younger siblings is significantly negative for CWD girls (-0.67 to -0.76 standard deviations), while it is not significant for CWD boys. These findings support H5b (suggesting a positive net effect of having older sisters for both CWD boys and girls), H5c (implying a negative net effect of having younger siblings for CWD girls), and H5e (indicating a more negative net sibling effect for CWD girls) are supported in Ghana.

5. Discussions

Our study represents a pioneering effort in the African context, examining the sibling effect on children's school learning and performance, with particular emphasis on gender and disabilities. Based on surveys conducted in two African countries with distinct socio-economic and cultural landscapes -- Ghana and Niger -- our research builds upon theories established in developed contexts regarding potential direct and indirect sibling effects. Given the empirical challenge of

disentangling these effects, our analysis assesses the net sibling effect, which may encompass a combination of these influences.

The first hypothesis addresses the impact of disability on children's school performance. Analysis of the pooled data for four main school subjects reveals that children with disabilities (CWD) typically demonstrate a performance gap of approximately 0.3-0.33 standard deviations in Ghana and 0.42-0.45 standard deviations in Niger, compared to their peers without disabilities (CWOD).

The second hypothesis examines the net sibling effect on children's school performance. No significant overall net sibling effect was found for CWOD in either Ghana or Niger. This finding contrasts with extensive evidence from developed contexts, where sibling effects as part of family characteristics are crucial in shaping children's development and educational outcomes. The expectation that sibling effects may be stronger in disadvantaged backgrounds, where sibling support is more pronounced and encouraged by parents, as observed in American contexts (Conley, 2008; Yi et al., 2015; Parman, 2015), does not seem to apply in Ghana and Niger. Conversely, sibling effects may be weaker if all siblings perform poorly.

The third hypothesis suggests a gender bias favoring boys over girls in their school learning performance. However, no gender differences in school performance among CWOD are reported in Ghana; while in Niger, girls outperform boys with a performance gap of approximately 0.21-0.22 standard deviations.

No significant net sibling effect for any sibling type is detected among either girls or boys in both Ghana and Niger among CWOD, as proposed by hypotheses H4a-H4e. This absence of sibling effect appears to support the argument that parents from disadvantaged backgrounds may not react or adjust their responses to differences among their children, thereby exerting minimal

influence on their overall education (Grätz and Torche, 2016). However, this conclusion is based on an overall net effect estimation and warrants further exploration to fully understand parents' role in redistributing education investment concerning other aspects of children's differences, such as their ability.

Finally, among children with disabilities (CWD) in Ghana, the study reveals a positive net effect of having older sisters (0.36-0.37 standard deviation units). This finding confirms earlier studies suggesting that older sisters often demonstrate caregiving tendencies, positively influencing the school performance of their younger siblings with disabilities (Qureshi, 2018b).

Conversely, this study identifies a significant negative net effect of having younger siblings (0.67-0.76 standard deviations) on the school performance of CWD girls but no effect on CWD boys in Ghana. This supports arguments from some earlier studies. Even within the matrilineal system of the Ashanti region of Ghana, there exists a tendency to prioritize investment in boys' education (Collins, 2022; La Ferrara & Milazzo, 2017; Mattison et al., 2023). This prioritization may be due to boys in a matrilineal society needing to find livelihood options outside their parent's land or property, as they will not inherit property from their parents.

Initially, a more pronounced gender bias was anticipated in Niger due to its high household income constraints, high fertility rates, and patrilinear inheritance tradition. However, no sibling effect is detected among CWD in Niger. On the contrary, a positive net sibling effect of having older sisters for both CWD boys and girls, and a negative net sibling effect of having younger siblings for CWD girls, are found in Ghana. This suggests an intriguing link between gender bias and the socioeconomic development of a country concerning disadvantaged children. The findings indicate that within the context of extreme poverty and high fertility rates, parents and siblings may have limited influence on children's learning performance. However, as the economy and

educational opportunities develop and become more valued by households, as seen in Ghana, the gender bias becomes more pronounced, particularly for children with disabilities. Furthermore, these findings align with research indicating that parents have a strong incentive to redistribute educational investment in response to children with health challenges (Yi et al., 2015; Parman, 2015).

There are several limitations to this paper. Firstly, only cross-sectional data of school records from each of the two countries are available, necessitating reliance on the "natural experiment assumption" to tease out the effects of disability and siblings. The natural experiment assumption tests revealed weak but significant correlations between children's disability and several control variables in Ghana, as well as between mothers' education and sibling status in both countries. This indicates a potential risk that children's disability and sibling status are not random treatments, as assumed by natural experiments.

Therefore, as robustness checks, this study first conducts a non-parametric analysis using Cohen's *d*s and Kolmogorov-Smirnov (KS) tests to estimate the within-class relative school performance differences across different treatment groups, including disability effects, gender, sibling effects among CWOD, and gender-related sibling effects in both CWOD and CWD subsamples. Considering that several control variables are correlated with treatment variables, the parametric models assess these effects by carefully including and excluding these key variables. Finally, the non-parametric analysis has yielded similar results to both parametric analyses with and without key control variables.

Secondly, the school records collected are not based on standardized tests; thus, only children's relative performance within classes are reported. Consequently, the school performance

measures in this study do not provide insights into the absolute reading skill differences across classes or countries.

Thirdly, comprehensive and comparable data on the siblings' school performance are not available in this study. As a result, the estimated sibling effect represents an overall estimation, potentially overlooking positive sibling effects among those with high-performing siblings and negative effects among those with underperforming siblings.

Another crucial limitation is the exclusive reliance on data from children currently enrolled in school. The estimated sibling effect pertains to children's learning performance once enrolled, potentially underestimating the influence of siblings on children's access to education, particularly if not all children have equal opportunities to attend school. This scenario is less likely in Ghana, where the overall school enrollment rate is relatively high[5].

Finally, the surveys targeted CWD, resulting in a small sample size due to the rarity of disability among school children. Screening out children with disabilities from inclusive schools in Ghana and Niger is costly and challenging, leading to limited statistical power for assessing gender, disability-type and sibling-type differences. With small effect sizes, many of these were insignificant, given the relatively small sample sizes.

[5] In Ghana, primary school gross enrolment was 98% in 2021 and primary school completion rate was 88% in 2018; while in Niger, primary school gross enrolment was 65% in 2021 and primary school completion rate was 58% in 2021.

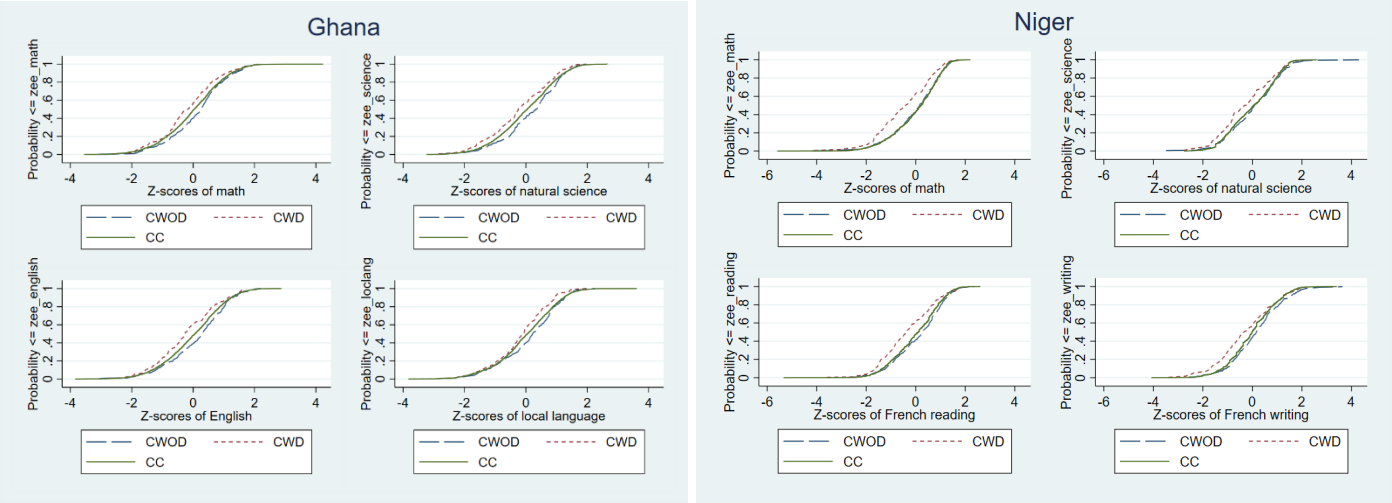
6. Conclusions

This study underscores the role of the disability and sibling effect in shaping children's development and educational outcomes within the African context, specifically focusing on Ghana and Niger. It identifies the unique challenges faced by children with disabilities in these countries. By comparing two African countries with distinct backgrounds, this research is the first to explore the gender-related sibling effect within the context of socioeconomic development and cultural influences.

While evidence from developed contexts suggests that sibling status influences children's development and education, this study finds that the overall sibling effects are relatively small in impoverished African settings. However, as socioeconomic conditions improve and educational opportunities become more valued by the parents, the sibling effect begins to align with findings from developed contexts. Notably, sibling effects are reported for children with disabilities, particularly girls, in environments where economic development and education are prioritized.

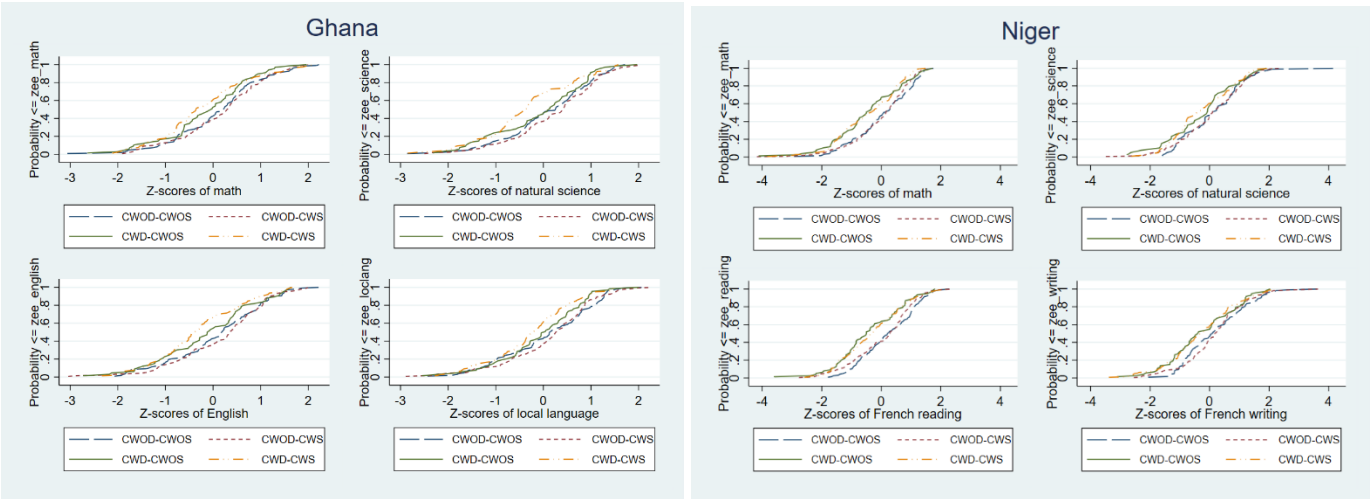
The study sheds light on the developmental risks faced by vulnerable groups from a gender perspective. It calls for further targeted research to explore the interconnections between socioeconomic development, gender and cultural norms. Additionally, it emphasizes the need to collect standardized data on learning performance among children and their siblings to better understand these dynamics.

7. Appendices



Appendix I. Cumulative distribution functions for normalized Z-scores of relative within-class school performance by disability status and sample type in Ghana and Niger

CC: Counterfactual Classmates; CWOD: Children without disabilities; CWD: Children with disabilities



Appendix II. Cumulative distribution functions for normalized Z-scores of relative within-class school performance by disability and sibling status in Ghana and Niger

CWOD: Children without disabilities; CWD: Children with disabilities

CWOS: Children without siblings; CWS: Children with siblings

Acknowledgements

This paper is a result of the research project titled "Education Outcome Variability in Children with Disabilities: Structure, Institution, or Agency?" funded by the Research Council of Norway (Project Number 300635). We extend our sincere appreciation to the project coordinator, Anne Hatløy, for her invaluable comments and guidance throughout this research.

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