Norwegian University of Life Sciences
School of Economics and Business

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Educational outcomes for primary school children in Africa: With a focus on children with disabilities

Utdanningsresultater for elever i barneskolen i Afrika: Med fokus på barn med nedsatt funksjonsevne

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Abbreviations and definitions

CC	--	Counterfactual Classmates
CRPD	--	Convention on the Rights of Persons with Disabilities
CWD	--	Children with Disabilities
CWOD	--	Children without Disabilities
DPIA	--	Data Protection Impact Assessment
DSQ	--	Disability Screening Questions
EFA	--	Education for All
GBD	--	Global Burden of Disease
HDI	--	Human Development Index (HDI)
ICF	--	International Classification of Functioning, Disability and Health
IPW	--	Inverse Probability Weighting
IV	--	Instrumental Variable
MDGs	--	Millennium Development Goals
MDS	--	Model Disability Survey
MICS	--	Multiple Indicator Cluster Surveys
NSD	--	Norsk Senter for Forskningsdata
SDGs	--	Sustainable Development Goals
SSA	--	Sub-Saharan Africa
TQ	--	Ten Question
UBE	--	Universal Basic Education
UNDP	--	United Nations Development Programme
UNESCO	--	United Nations Educational, Scientific and Cultural Organization
UNICEF	--	United Nations Children's Fund
UPE	--	Universal Primary Education
WG	--	Washington Group on Disability Statistics
WG-CFM	--	Washington Group Child Functioning Module
WG-ES	--	Washington Group Extended Set on Functioning
WG-SS	--	Washington Group Short Set on Functioning
WG-SSE	--	Washington Group Short Set Enhanced
WHO	--	World Health Organization

List of papers

Paper 1: Disability Types and Children's Schooling in Africa
Huafeng Zhang and Stein T. Holden (2024)
International Journal of Disability, Development and Education, 1-21.
https://doi.org/10.1080/1034912X.2024.2355621

Paper 2: Numeracy skills learning of children in Africa: - Are disabled children lagging behind?
Huafeng Zhang and Stein T. Holden (2023)
PLOS ONE 18(4), e0284821. https://doi.org/10.1371/journal.pone.0284821

Paper 3: Disparity in School Children's Reading Skills in 11 African Countries
Huafeng Zhang and Stein T. Holden
PLOS ONE (Submitted: Oct 2024; revision resubmitted: Jan 2025)

Paper 4: Disability, Gender, and Sibling Impacts on Learning Outcomes in Ghana and Niger
Huafeng Zhang and Stein T. Holden
Child Development (Submitted: Jan 2025)

Abstract

This doctoral thesis delves into the school enrolment and learning outcomes for children with disabilities (CWD) in selected African countries, compared with those for children without disabilities (CWOD). Based on data from the Multiple Indicator Cluster Surveys (MICS) conducted across 12 African countries and a project survey among school children in Ghana and Niger, this research investigates the disparities in school access and skills learning. It further investigates the influence of contextual factors, including gender, sibling roles, family socioeconomic status, and a country's macro-level educational development.

Paper 1 examines disparities in school enrolment between CWD and CWOD across eight African nations. The study reveals substantial gaps in enrolment rates, shedding light on the diverse barriers faced by CWD in accessing education. By categorising disabilities into functional domains—vision, hearing, physical, intellectual, and multiple—it highlights the heterogeneous challenges associated with different types of disabilities in primary school enrolment. The findings indicate that young children with physical disabilities encounter significant difficulties in enrolling during early childhood; however, their enrolment rates improve as they grow older. In contrast, children with intellectual disabilities face persistent challenges in school enrolment, both at early stages and later, and are at a heightened risk of dropping out. Furthermore, children with multiple disabilities experience the most significant barriers to educational participation, underscoring the compounded impact of multiple impairments.

Paper 2 investigates numeracy skills acquisition among school children aged 7-14 in eight African countries. Overall numeracy skills among children are notably low, with considerable variations across countries. The findings reveal systematic variations in numeracy skills across different types of disabilities. While children with vision and hearing disabilities demonstrate numeracy performance comparable to their peers without disabilities, those with physical, intellectual, or multiple disabilities significantly lag behind. These results illuminate the unique challenges associated with different forms of functional difficulties. Using Instrumental Variable (IV) methods, the study identifies two distinct effects of disability on numeracy skills. The first effect is attributed to differences in total

completed years of schooling, while the second pertains to variations in numeracy skills acquisition per completed school year. For children with physical and intellectual disabilities, lower numeracy outcomes are primarily driven by fewer completed school years. Conversely, children with multiple disabilities face dual disadvantages: reduced school attendance and lower numeracy skills acquisition per completed school year. Furthermore, the study underscores the crucial role of national-level improvements in shaping numeracy outcomes. It suggests that the variations in average numeracy skills across countries exceed the disparities observed within countries between CWD and CWOD.

Paper 3 delves into the reading proficiency among children aged 10-14 across eleven African nations, revealing widespread low foundational reading skills. This analysis provides new evidence contributing to discussions around the "Learning Crisis in the Global South." The study identifies significant disparities in reading skills both across countries and between social groups, including CWD, those living in rural areas, and children from poorer or less-educated families, compared to their peers. The findings reveal a noteworthy pattern: countries with higher overall reading proficiency often exhibit larger disparities in reading skills between disadvantaged and non-disadvantaged groups. However, the gaps in reading proficiency between CWD and their peers persist across all countries and socioeconomic contexts analysed in this study. Importantly, despite the persistent disadvantages faced by CWD, they benefit from improved overall reading proficiency in their countries and socioeconomic advancements to the same extent as their non-disabled peers.

Paper 4 ventures into unexplored territory, examining the role of disability and sibling effects on children's educational outcomes in Ghana and Niger. The study is based on primary data collected from selected areas in these countries. It identifies the unique challenges faced by CWD in the local contexts, compared to CWOD. While evidence from the USA and Europe suggests that sibling status influences children's development and education, this study finds that overall sibling effects are relatively small in impoverished African settings. However, negative sibling effects are reported solely for girls with disabilities in Ghana, despite the country's higher economic development, lower fertility rate, and matrilineal tradition. The study sheds light on the developmental risks faced by children with disabilities from a gender perspective.

Collectively, these four papers highlight the generally low levels of basic educational skills acquisition in the selected African countries, alongside significant disparities in school access and learning outcomes among children from disadvantaged backgrounds. The study contributes to a more nuanced understanding of children's diverse challenges due to various functional difficulties in accessing education and acquiring skills. Furthermore, it underscores the critical importance of examining how disability intersects with environmental factors, such as country-level improvements in skills learning and personal and other local contextual factors, including socioeconomic development and gender. This analysis calls for targeted policy interventions and robust support systems to address the specific and multifaceted challenges faced by children with different types of disabilities. Such measures are essential to ensuring equitable access to quality education and fostering opportunities for skill acquisition within inclusive educational settings.

There are several limitations in this study. Data constraints, particularly small sample sizes for specific disability types in MICS6 and EVID surveys, hinder comprehensive analysis of heterogeneous disability effects. The findings of this study apply only to children with certain functional varieties, which cannot cover the broad spectrum of disability. The selection of countries is based on the availability of MICS6 surveys recently conducted in Africa. However, together, these countries give a broad picture of important variation in primary education access and quality in Africa. The limitation with the educational outcome indicators used in this thesis is that it focuses on school access and measurement of children's foundational numeracy and reading skills. The results from these foundational skills tests may not capture advanced competencies of children's skill learning and do not include broader aspects of social and personal development domains for disadvantaged children. Additionally, the study has methodological challenges, such as potential confounding factors, which further affect the generalizability of findings.

Despite these limitations, this study makes a significant contribution by providing important empirical evidence to identify trends and offer valuable insights into educational disparities among children in African countries, highlighting areas that warrant further investigation through complementary research methods. High-quality quantitative data on the learning outcomes of children with disabilities in African contexts remains scarce, and this doctoral research represents an important effort to address this critical gap in the field.

The limitations identified in this PhD thesis highlight the urgent need for high-quality, disability-focused data to enable analysis by specific disability types. Tailored support, assistive technologies, and resources for intellectual and complex disabilities remain underdeveloped, highlighting a need for innovation and equity-driven policies. Future studies should integrate quantitative, qualitative, and mixed methods to explore the nuanced interactions between disabilities, social and environmental factors, and educational outcomes, including the educational outcomes that go beyond school enrolment, including more comprehensive learning outcomes, as well as the role of stigma and discrimination. Expanding these approaches will support inclusive, learner-centred strategies to bridge persistent disparities and foster equitable educational opportunities for CWD.

Norsk sammendrag

Denne doktorgradsavhandlingen undersøker skoleinnmelding og læringsutbytte for barn med funksjonsnedsettelser (CWD) i utvalgte afrikanske land, sammenlignet med barn uten funksjonsnedsettelser (CWOD). Basert på data fra Multiple Indicator Cluster Surveys (MICS) gjennomført i 12 afrikanske land og en prosjektundersøkelse blant skolebarn i Ghana og Niger, analyserer denne studien ulikheter i skoletilgang og ferdighetslæring. Studien undersøker videre påvirkningen av kontekstuelle faktorer, inkludert kjønn, søskenroller, familiens sosioøkonomiske status og et lands makronivå innen utdanningsutvikling.

Artikkel 1 undersøker forskjeller i skoleinnmelding mellom CWD og CWOD på tvers av åtte afrikanske land. Studien avdekker betydelige gap i innmeldingsrater og belyser de mange barrierene CWD møter for å få tilgang til utdanning. Ved å kategorisere funksjonsnedsettelser i funksjonelle domener – syn, hørsel, fysiske, intellektuelle og multiple funksjonsnedsettelser – fremheves de ulike utfordringene knyttet til forskjellige typer funksjonsnedsettelser i grunnskoleinnmelding. Resultatene viser at små barn med fysiske funksjonsnedsettelser har betydelige utfordringer med å starte skolegang i tidlig barndom, men at innmeldingsratene forbedres etter hvert som de blir eldre. Derimot møter barn med intellektuelle funksjonsnedsettelser vedvarende utfordringer både i tidlige og senere stadier, med økt risiko for frafall. Barn med multiple funksjonsnedsettelser opplever de største barrierene for utdanningsdeltakelse, noe som understreker den sammensatte effekten av flere funksjonsnedsettelser.

Artikkel 2 undersøker tilegnelsen av regneferdigheter blant skolebarn i alderen 7–14 i åtte afrikanske land. Generelt er regneferdighetene blant barna bemerkelsesverdig lave, med betydelige variasjoner mellom landene. Resultatene viser systematiske forskjeller i regneferdigheter avhengig av funksjonsnedsettelse. Mens barn med syns- og hørselsnedsettelser viser regneprestasjoner som er sammenlignbare med sine jevnaldrende uten funksjonsnedsettelser, ligger barn med fysiske, intellektuelle eller multiple funksjonsnedsettelser betydelig etter. Studien avdekker to ulike effekter av funksjonsnedsettelse på regneferdigheter ved bruk av Instrumental Variable (IV)-metoder:

én knyttet til totalt antall fullførte skoleår og en annen relatert til regneferdigheter oppnådd per fullførte skoleår. For barn med fysiske og intellektuelle funksjonsnedsettelser skyldes lavere regneferdigheter hovedsakelig færre fullførte skoleår, mens barn med multiple funksjonsnedsettelser møter doble ulemper: redusert skolegang og lavere ferdighetstilegnelse per fullførte skoleår. Videre fremhever studien den avgjørende rollen nasjonale forbedringer spiller i å forme resultater innen numeriske ferdigheter. Den antyder at variasjonene i gjennomsnittlige numeriske ferdigheter mellom land er større enn forskjellene som observeres innenfor land mellom barn med funksjonsnedsettelser (CWD) og barn uten funksjonsnedsettelser (CWOD).

Artikkel 3 utforsker leseferdighetene blant barn i alderen 10–14 år på tvers av elleve afrikanske land og avdekker utbredt lave grunnleggende leseferdigheter. Denne analysen gir nye bevis som bidrar til diskusjonene rundt «læringskrisen i det globale sør.» Studien identifiserer betydelige forskjeller i leseferdigheter både mellom land og mellom sosiale grupper, inkludert barn med funksjonsnedsettelser (CWD), de som bor i landlige områder, og barn fra fattigere eller mindre utdannede familier, sammenlignet med sine jevnaldrende. Funnene avdekker et bemerkelsesverdig mønster: land med høyere samlet leseferdighet viser ofte større forskjeller i leseferdigheter mellom utsatte og ikke-utsatte grupper. Imidlertid vedvarer gapene i leseferdigheter mellom CWD og deres jevnaldrende i alle land og sosioøkonomiske sammenhenger som er analysert i denne studien. Viktig er det at til tross for de vedvarende utfordringene som CWD møter, drar de nytte av forbedret samlet leseferdighet i sine land og sosioøkonomiske fremskritt i samme grad som sine jevnaldrende uten funksjonsnedsettelser.

Artikkel 4 undersøker rollen til funksjonsnedsettelser og søskeneffekter på barns utdanningsresultater i Ghana og Niger. Studien er basert på primærdata samlet inn fra utvalgte områder i disse landene. Den identifiserer de unike utfordringene som barn med funksjonsnedsettelser (CWD) møter i lokale kontekster, sammenlignet med barn uten funksjonsnedsettelser (CWOD). Mens forskning fra USA og Europa antyder at søskenstatus påvirker barns utvikling og utdanning, finner denne studien at søskeneffektene generelt er relativt små i fattige afrikanske settinger. Imidlertid rapporteres negative søskeneffekter utelukkende for jenter med funksjonsnedsettelser i Ghana, til tross for landets høyere økonomiske utvikling, lavere fruktbarhetsrate og matrilineære tradisjon. Studien belyser utviklingsrisikoene som barn med funksjonsnedsettelser står overfor fra et kjønnsperspektiv.

Samlet sett fremhever disse fire artiklene de generelt lave nivåene av grunnleggende utdanningsferdigheter i de utvalgte afrikanske landene, sammen med betydelige ulikheter i tilgang til skole og læringsresultater blant barn fra utsatte bakgrunner. Studien bidrar til en mer nyansert forståelse av barns ulike utfordringer på grunn av funksjonelle vanskeligheter med å få tilgang til utdanning og tilegne seg ferdigheter. Videre understreker den den kritiske viktigheten av å undersøke hvordan funksjonsnedsettelser samspiller med miljøfaktorer, som nasjonale forbedringer i ferdighetstilegnelse og personlige og andre lokale kontekstuelle faktorer, inkludert økonomisk utvikling og kjønn. Denne analysen etterlyser målrettede politiske tiltak og robuste støttesystemer for å møte de spesifikke og sammensatte utfordringene som barn med ulike typer funksjonsnedsettelser står overfor. Slike tiltak er avgjørende for å sikre rettferdig tilgang til kvalitetsutdanning og fremme muligheter for ferdighetstilegnelse innenfor inkluderende utdanningssettinger.

Det er flere begrensninger i denne studien. Databegrensninger, spesielt små utvalgsstørrelser for spesifikke funksjonsnedsettelsestyper i MICS6- og EVID-undersøkelser, hindrer en omfattende analyse av heterogene effekter av funksjonsnedsettelser. Funnene fra denne studien gjelder kun for barn med visse funksjonelle varianter, og dekker derfor ikke det brede spekteret av funksjonsnedsettelser. Valget av land er basert på tilgjengeligheten av MICS6-undersøkelser nylig gjennomført i Afrika. Imidlertid gir disse landene samlet sett et bredt bilde av viktig variasjon i tilgang til og kvalitet på grunnskoleutdanning i Afrika. En begrensning ved de utdanningsmessige resultatindikatorene som brukes i denne avhandlingen, er at det fokuseres på skoletilgang og måling av barns grunnleggende ferdigheter i regning og lesing. Resultatene fra disse grunnleggende ferdighetstestene fanger kanskje ikke avanserte kompetanser i barns ferdighetstilegnelse og inkluderer ikke bredere aspekter ved sosial og personlig utvikling for utsatte barn. I tillegg har studien metodologiske utfordringer, som potensielle forstyrrende faktorer, som ytterligere påvirker generaliserbarheten av funnene.

Til tross for disse begrensningene gjør denne studien et betydelig bidrag ved å levere viktig empirisk evidens for å identifisere trender og gi verdifulle innsikter i utdanningsforskjeller blant barn i afrikanske land, og fremhever områder som krever videre undersøkelser gjennom komplementære forskningsmetoder. Høykvalitets kvantitative data om læringsutbytte blant barn med funksjonsnedsettelser i afrikanske kontekster er fortsatt begrenset, og denne doktorgradsforskningen representerer et viktig forsøk på å adressere dette kritiske gapet i feltet.

Begrensningene som er identifisert i denne avhandlingen understreker det akutte behovet for høykvalitets, funksjonshemmingsfokuserte data for å muliggjøre analyser av spesifikke typer funksjonsnedsettelser. Skreddersydd støtte, hjelpemidler og ressurser for barn med intellektuelle og komplekse funksjonsnedsettelser er fortsatt underutviklet, noe som fremhever behovet for innovasjon og politikk basert på rettferdighet. Fremtidige studier bør integrere kvantitative, kvalitative og blandede metoder for å utforske de nyanserte interaksjonene mellom funksjonsnedsettelser, sosiale og miljømessige faktorer og utdanningsresultater. Disse utdanningsresultatene bør strekke seg utover skoleinnmelding og inkludere mer omfattende læringsutbytter, samt adressere rollene til stigma og diskriminering. Utvidelse av disse metodene vil støtte utviklingen av inkluderende, elevsentrerte strategier for å redusere vedvarende forskjeller og fremme likeverdige utdanningsmuligheter for barn med funksjonsnedsettelser.

1 Introduction

Education is a fundamental human right and a key driver of social and economic development. For children from disadvantaged backgrounds, particularly those with disabilities, access to quality education is crucial for realising their potential and achieving equal opportunities. However, their education is often hindered by significant barriers. Researching the education of children with disabilities is further complicated by unreliable data and the lack of a universally accepted definition and understanding of disability, making it difficult to address their specific needs effectively. Bridging these gaps is essential for fostering inclusivity and ensuring no child is left behind.

1.1 Promote Education for All

Education has long been acknowledged as a crucial tool for breaking the cycle of poverty (Tilak, 2002). Extensive research conducted in developing countries over decades has explored the role of education in reducing poverty (Brown & Park, 2002; Appleton, 2001). The Universal Declaration of Human Rights in 1948 marked the first international protocol outlining norms and standards that recognise the right to education and ensure full participation in schools as a fundamental human right for all children.

Over the past three decades, significant global efforts have been directed towards Universal Basic Education (UBE) and ensuring equitable access to educational opportunities, particularly for children (Nielsen, 2006; Pritchett, 2013). The Education for All 2000-2015 (EfA) movement, initiated by the United Nations and the World Bank, aimed to ensure access to quality basic education for all children, youth, and adults (UNESCO, 2015). The Millennium Development Goals (MDGs), notably Goal 2, emphasised universal primary education, a goal widely adopted by African countries since the late 1990s (UN, 2000). This commitment continues with the Sustainable Development Goals (SDGs), with

Goal 4 advocating for inclusive and equal access to education for every child (UN, 2015). Following the United Nations Convention on the Rights of Persons with Disabilities (CRPD) adopted in 2006, the SDG framework includes 11 specific references to persons with disabilities across various goals, with a particular focus on education, underscoring the commitment to the inclusion of children with disabilities. Such efforts are especially crucial in developing regions like Sub-Saharan Africa (SSA), where educational access and attainment levels significantly lag behind other developing regions (UNESCO, 2015; Bashir et al., 2018).

1.1.1 School Enrolment and Skills Learning in Africa

The advocacy for Universal Primary Education (UPE) has spurred significant progress and achievement in primary school enrolment across most African nations since the late 1990s (Lewin, 2007; UNESCO, 2015). Data from the UNESCO Institute for Statistics confirms this trend, showing a consistent rise in gross enrolment ratios[1] in primary schools within the SSA region. Starting at just over 70 percent in the 1990s, the gross enrolment ratio climbed to 81 percent in 2000, 91 percent in 2004, and reached 99 percent in 2011 (World Bank, 2020). Since then, primary gross enrolment rates in the SSA region have consistently remained close to or even above 100 percent. The 2015 Global Education Monitoring Report highlighted an increase in overall primary net enrolment ratios[2] in Sub-Sahara Africa from 56 percent in 1999 to 79 percent in 2012 (UNESCO, 2015). Countries with historically low school enrolment rates have experienced substantial growth. For instance, within just over a decade, both gross and net school enrolment rates in primary schools in Niger surged from

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[1] Gross enrolment ratio is the total enrolment within a country in a specific level of education, regardless of age, expressed as a percentage of the population in the official age group corresponding to this level of education. The gross enrolment ratio can be over 100 percent.

[2] Net enrolment ratio is the total enrolment of children of official school age in a specific level of education, expressed as a percentage of the population in the official age group corresponding to this level of education. Therefore, the net enrolment ratio excludes overage and underage students.

below 30 percent in the late 1990s to approximately 60 percent in 2010. These rates have continued to rise gradually, reaching 65 percent in the late 2010s and early 2020s (World Bank, 2020).

Despite substantial progress towards achieving universal access to basic education in most African countries since the late 1990s, with gross enrolment rates reaching 99 percent as early as 2011, not all children successfully complete basic or primary education. The Global Education Monitoring Report 2021/22 indicates that as of 2020, primary school completion rates have reached or surpassed 90 percent in most regions worldwide. However, in sub-Saharan Africa, only two out of three children complete primary school, making it an exception in this regard (UNESCO, 2022). In addition, delayed completion is quite a significant phenomenon in Africa. When including late completers, the ultimate primary completion rate in the SSA region is 76 percent, which is 11 percentage points higher than the primary timely completion rate of 65 percent (UNESCO, 2022). In comparison, in other developing areas such as Central and Southern Asia, including late completers increases the completion rate only by four percentage points.

The low primary school completion rate and high delayed completion in primary schools in the SSA region signal poor schooling outcomes. Hanushek and Woessman (2007) highlighted in their review on education’s role in promoting well-being suggested that cognitive skill and school quality, rather than school enrolment, contribute to growth. The primary concern lies in whether schooling effectively fosters learning and the acquisition of essential skills. Some studies indicate that children in low-income African countries often fail to acquire basic skills in reading, mathematics, and other subjects despite many years of schooling (UNESCO, 2016; Johnson, 2008). A regional assessment among grade 6 children in West and Central Africa revealed that nearly 58 percent of children lack sufficient competence in reading or mathematics to continue schooling (World Bank, 2018). The 2018 World Development Report has characterised this situation as a “learning crisis” (World Bank, 2018). This disconnect between school expansion and learning has inspired a global aspiration to improve learning outcomes, as reflected in the Sustainable Development Goal (SDG), specifically calling for quality education in its Goal 4 (UN, 2015).

1.1.2 Measurement Indicators of Educational Outcomes

Empirical studies have employed various indicators to measure children's education outcomes in developing contexts. Commonly used indicators include school enrolment, attendance, and absenteeism at the primary or secondary level due to their ease of reporting and comparison. However, subtle differences in rate calculations exist: some studies focus on the birth cohort (Kan & Klasen, 2021), some refer to the specific school level (İşcan et el., 2015), while other studies report access to school on a broader age range of population (Bakhshi, Babulal & Trani, 2017). Another set of indicators comprises school dropout, completion, or graduation rates. Reported indicators may vary, such as primary school completion (Trani et al., 2012), secondary school completion (Wagner et al., 2005; Takeda & Lamichhane, 2018), or more specific completion rate for grade 5 or 8 (Moyi, 2017). Postsecondary enrolment occasionally serves as an indicator of higher-level school outcomes.

Although years of schooling are less commonly used as an education outcome indicator in empirical comparison studies on school performance, they are referenced in studies on youth (Moshoeshoe, 2023) and more often in adult education and human capital analysis (Kuepié & Nordman, 2016). Since 2010, the Human Development Index (HDI) has substituted the adult literacy rate (UNDP, 2009) with mean years of schooling for the population 25+ in the calculation of HDI (UNDP, 2010), which highlighted the importance of this indicator. However, computing mean years of schooling from a given educational attainment level presents challenges, especially in comparison studies or as a human capital indicator introduced into regression models (Lutz et al., 2007).

While indicators measuring access to school have advantages and are often included in national statistics and used to monitor national planning, policy interventions, and global actions in pursuit of Universal Basic Education (UBE), they fail to capture school learning and basic skills acquired by children, leading to the "hidden" learning crisis suggested by the World Bank (2018). The gap in basic skill learning within and across countries may be more crucial than the quantitative shortage of schooling in developing countries (Van der Berg, 2020).

In response to the "hidden" learning crisis, the 2018 World Development Report emphasizes the urgent need for proper measurements of learning outcomes to complement enrolment indicators (World Bank, 2018). The report suggests that identifying the learning gaps in the classroom and addressing the challenges faced by vulnerable children at risk of social or economic exclusion is crucial. However, as noted by Birdsall, Bruns, and Madan (2016), there are almost no low-income countries that have developed and sustained standardized national assessment systems to measure what children are learning in school. Moreover, existing national or regional standardized testing or alternative academic assessments pose some of the most complicated and controversial challenges for specific groups of children from disadvantaged backgrounds, such as children with disabilities (Yakimowski et al., 2016).

Efforts have been made to include standardized math and reading tests in survey settings to evaluate learning performance during the survey (Singal et al., 2020). However, these tests are costly and subject to significant variations across different surveys. Furthermore, survey questions need to be short and simple, restricting the assessment to children's comprehensive skills.

1.1.3 Disparity in Educational Outcomes among Children with Disadvantaged Backgrounds

The Sustainable Development Goal (SDG) advocates for equal access to education for all children (UN, 2015). Despite advancements in school enrolment, issues such as unequal distribution, disparities in school performance, and the marginalization of the most disadvantaged and vulnerable groups of children persist (Spaull, 2015; Unterhalter, 2013). Current literature has identified factors such as gender (Dickerson et al., 2015; Shabaya & Konadu-Agyemang, 2004; Iddrisu et al., 2018), household wealth or poverty (Lewin & Sabates, 2012), and urban-rural location (Lewin & Sabates, 2012; Hedges et al., 2016) as key drivers of inequality and disparity in educational access and school performance in African contexts.

Ilie and Rose (2016) studied disparities in equal access to higher education across 35 low- and middle-income countries in Sub-Saharan Africa and South Asia, highlighting wealth and gender inequalities as significant factors. They reported that access inequalities were prevalent from primary and secondary education levels in the majority of countries; and countries with higher levels of higher education are equipped with a higher inequality in access to higher education. Reviewing school dropout rates and learning deficits in mathematics, Spaull (2015) warned of a poverty trap resulting from low-quality education in South Africa.

1.1.4 Micro-level Factors and Country-level Development on Children's Skill Learning

Numerous studies have underscored the importance of factors at the social, familial and individual levels in shaping children's skill acquisition in the African context (Taylor & Yu, 2009; Ngandu et al., 2020). Parents with higher social status, greater household income, and higher educational attainment levels tend to provide better support for their children's learning. This support can manifest in various ways, including direct involvement in teaching or guiding children in skill acquisition (Nakijoba et al., 2024; Musengamana, 2023), initiating their learning process at an earlier age (Lee & Burkham, 2002), and indirectly contributing to their education by residing in neighbourhoods with higher-quality schools (Anderson et al., 2001), and actively engaging with the school community, thereby enhancing overall school quality. Children's educational outcomes are greatly influenced by the neighbourhood environment and urban-rural disparities in schooling in the African context (Zhang, 2006), as well as peer effects in the neighbourhood or school context (Epple & Romano, 2011).

Moreover, the country's socioeconomic development and overall school quality play a pivotal role in shaping children's learning performance. With insufficient teaching resources available in economically disadvantaged countries, even for children from relatively advantaged backgrounds, there are limited extra resources they can obtain. According to a study conducted in 29 high- and low-income countries by Heyneman and Loxley (1983), school quality emerges as a paramount factor in children's learning outcomes, which surpasses that of other socioeconomic factors and family characteristics. Notably, this effect is observed to be more pronounced in low-income countries compared to their high-income counterparts. However, recent studies argue that the Heyneman–Loxley effect may be weakening or no longer applicable (Baker et al., 2002; Bouhlila, 2015). These studies suggest that the widespread expansion of basic schooling in recent decades has led to standardized curricula, improved teaching quality, and better provision of essential tools and resources, thereby reducing disparities in public school resources, even in impoverished African contexts. Hence, factors at the micro-level, such as children's family background, play a pivotal role in shaping schooling and learning disparities.

Among various micro-level factors, one important research area, which used to receive less attention but has garnered considerable interest in recent years, is the sibling effect on children's educational outcomes (Nicoletti & Rabe, 2019; Joensen & Nielsen, 2018; Karbownik & Özek, 2023). The sibling relationship is considered to exert a crucial influence during childhood's developmental stages since siblings share the same parents and resources, share life experiences and spend substantial time together at home (Sanders, 2017). The influence of siblings on children's educational outcomes focuses on two main mechanisms: direct sibling spillover effect and indirect sibling spillover effect (Brody, 2004; Karbownik & Özek, 2023; Zang et al., 2023). The former occurs through direct interactions, with older siblings providing assistance and serving as role models. The latter operates through parental differential treatment, where parents redistribute resources among children based on various factors such as age, gender, and perceived potential for success. Existing research, mainly from the United States, indicates that children from disadvantaged backgrounds experience a stronger direct influence from siblings, often encouraged by impoverished families to support each other (Anderson, 2015; McHale et al., 2007; Loury, 2004). Additionally, the negative indirect effect on disadvantaged children, especially children with health challenges, is more pronounced when economic constraints are harsher (Grätz & Torche, 2016; Yi et al., 2015; Parman, 2015).

1.2 Children with Disabilities (CWD)

Disability has long been recognized as a major factor contributing to poverty and socioeconomic disparities (Elwan, 1999). Individuals with disabilities frequently encounter challenges in accessing social services and face restricted employment opportunities (Krahn et al., 2015; Vornholt et al., 2018). However, exclusion from education remains a barrier to breaking the cycle of poverty and disability (Singal, 2011).

To promote and protect the full rights of persons with disabilities, the United Nations Convention on the Rights of Persons with Disabilities (CRPD) was adopted by the UN General Assembly in December 2006 and came into force in 2008 (UN, 2006). This landmark convention builds on a long history of international agreements and initiatives affirming the right to education and full school participation as a fundamental human right. Notably, the CRPD, alongside the United Nations Convention on the Rights of the Child (CRC), explicitly recognises the educational rights of children with disabilities (UN, 1989). As a legally binding instrument, the CRPD further addresses significant gaps in advocating for and implementing inclusive education.

Following the adoption of the CRPD, the 2030 Agenda for Sustainable Development Goals (SDGs) reinforced the principle of "leave no one behind," explicitly integrating the rights of persons with disabilities (UN, 2015). While the CRPD holds legally binding status, the SDGs, although non-binding, have attracted substantial international commitment and support. SDG Goal 4 emphasizes the importance of ensuring inclusive and equitable quality education for all. Among its 10 targets, target 4.1 aims for universal access to primary and secondary education; target 4.5 seeks to eliminate gender disparities in education and guarantee equal access for persons with disabilities; and target 4.6 aims to ensure literacy and numeracy for all children. These objectives represent significant progress compared to the Millennium Development Goals (MDGs), which did not address disability in any of their eight targets (UN, 2000).

Substantial knowledge gaps remain in the availability of quantitative evidence concerning the educational outcomes of children with disabilities (CWD) (World Bank, 2018). While research in developing regions has primarily examined educational disparities related to poverty, gender, ethnic background, and geographical location, studies specifically focusing on disability are comparatively scarce (Bonal, 2016; Ansong et al., 2015; Adugna et al., 2022). The limited scope of quantitative evidence can be attributed to considerable challenges in collecting data on disability.

The collection of data on CWD is essential for several reasons. Firstly, quantifying or estimating the population of CWD is critical for developing effective policies, educational services, and support programs. Secondly, understanding the varied learning experiences of CWD is necessary to design educational strategies tailored to their specific needs. Lastly, identifying the challenges encountered by CWD is vital for developing strategies to eliminate barriers that impede their full participation and success in both education and broader societal contexts.

The gaps in data and knowledge extend beyond the prevalence of disability to include understanding the learning experiences and educational challenges faced by children with disabilities (CWD). These challenges are not limited to disparities in school access but also encompass disparities in learning performance. The complexity of defining and measuring disability, coupled with the limited availability of standardized performance data in African contexts, complicates the development of robust quantitative evidence. While qualitative research has provided valuable insights into the barriers, opportunities, and influencing factors impacting CWD, the absence of comprehensive quantitative data has hindered the development of a complete and generalized understanding of their educational challenges within the African context.

A major obstacle in data collection on CWD is the absence of a universally accepted definition of disability, stemming from its inherent complexity. This challenge extends to designing a standardized measurement tool based on a clear definition to collect comparable data on CWD. This thesis aims to address this gap by offering quantitative evidence related to CWD while also reflecting on the challenges encountered and insights gained throughout the research process. Given the multidimensional, dynamic, and complex nature of disability—and the lack of a universal definition—it is crucial to first examine the concept of disability and the specific definition used in this thesis (section 1.2.1). Section 1.2.2 discusses the disability measurement tools. Section 1.2.3 presents global disability prevalence estimations. Finally, Section 1.2.4 describes the indicators used to evaluate the educational outcomes for CWD.

1.2.1 Framework for Understanding and Measuring Disability

The 2006 CRPD recognises "disability" as an evolving and diverse concept, defining it as “long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder [a person's] full and effective participation in society on an equal basis with others" (UN, 2006).

There has been a longstanding and contentious debate surrounding the concept of disability, fuelled by considerable interest in categorising and collecting data on persons with disabilities (Thomas, 2004; Oliver, 2017; Forstner, 2022). Disability, however, is neither homogeneous nor static; rather, it is multidimensional, dynamic, and complex (Singal et al., 2018).

This debate intersects with various underlying models of disability, each embodying distinct research purposes and academic disciplines concerning assumptions about human differences, interpretations of the "problem" of disability, and strategies for promoting the welfare of individuals with disabilities (Hedlund, 2009). Table 1 outlines key aspects of different disability models. These models vary in their interpretations of the challenges associated with disability, the barriers faced by individuals, potential interventions to improve inclusion or welfare, the critiques associated with each model, as well as their implications for children's education.

Table 1 List of disability models

	Medical model[1]	Social model[2]	Biopsychosocial model[3]	Social relational model[4]	Human rights model[5]	Religious model[6]	Economic model[7]
Interpretation of disability	Personal problem related to health issues	Human-made conditions, constructed through human interaction	Dynamic relationship between health condition, personal, family, and environmental factors	Gap between social demand on individual abilities and individual actual premises	Right-based conditions for persons with impairment	Punishment from God	Non-employability/ Reduced productivity in the capitalist economy
Cause of limitations	Illness or abnormalities within an individual; Persons' differences by nature	Poor organization, response, and adaptations of social environment/ society to individual's needs, discriminatory attitudes	Not constrained by one single factor, but limitations on multilevel factors	Limitations on both individual's ability and social adaptations to individual's reduced function	Denied legal capacity based on the individual impairment	Lack of adherence to social morality and religious proclamations or a test of faith	Impairment to limit a person's labour and employment capabilities
Intervention	Medical treatment or rehabilitation measures to "repair" or maximize remaining functions	Universal design for organizing society so that all can participate	Combined and dynamic measures on multilevel factors	• Bridge the gap through flexibility and instruments to resolve the dilemmas • Combine measures on individual and on reorganizing society	Moral principles or values as a foundation of disability policy	Divine punishment, prayer, blessing	Government labour and poverty support policies
Criticism	• Emphasis on the medical diagnosis and individual factors • Limitation in including types of impairments not clarified in medical terms • Separate persons with disability from the population at large	• Utopian model that demands immense efforts to reorganize the society • Less appropriate for some types of disabilities such as psychiatric or cognitive impairment • Completely ignore the impairments, health condition, and body experiences	Abstract and general without concrete guidelines to define and measure disability	• Limited role in shaping welfare policy • Neglect different values, norms, and priorities in the society	• Risk of cultural imperialism • Lack of operational guidance • Negative consequences of human rights as absolutism	• CWD marginalised • Exclude families from social participation • Negative influence on theological reflection	• Framing disability exclusively in terms of a cost-benefit analysis • Work as the only function considered • Dehumanization of persons with disability
Implication for Education	Information on the scope, nature and magnitude of health care and rehabilitation services needed to support children with specific disabilities	Identify contextual social and environmental factors to improve children's full participation	Current most dominant approach for disability measurement tools in assessing education of CWD	Framework for Learner-centred and flexible approach in inclusive education	Legal foundation of children's equal rights to education	Still predominant in certain cultures and societies dominated by religious thinking	Economic empowerment through education

[1] Marks (1997); [2] Oliver (2013); [3] Simeonsson et al. (2003); [4] Reindal (2008); [5] Degener (2017); [6] Niemann (2005); Henderson and Bryan (2011); [7] Smart (2004)

The medical model of disability, originating in the mid to late 19th century, conceptualizes disability as a personal issue arising from a deviation from typical health status (Marks, 1997). This model emphasizes bodily impairments as attributes of the individual body or mind and advocates for interventions through medical diagnosis. In the educational field, the medical model offers valuable insights into the healthcare and rehabilitation services required to support children with diverse needs in accessing education. However, it overlooks the influence of societal structures and attitudes in shaping the lived experiences of disability.

In contrast, the social model of disability emerged in the 1970s, influenced by organizations of persons with disabilities, as a response to society's failure to meet the needs of individuals with health conditions or impairments. This model posits that disability arises from societal and environmental barriers rather than solely from individual impairments (Oliver, 2013). It emphasizes the disabling factors present in the environment and advocates for changes in societal structures and adaptations to enable the full participation and performance of individuals with disabilities. Within the field of education, the social model underscores the importance of identifying contextual social and environmental factors to better understand the experiences of disabled children and promote their full inclusion in educational settings. Since the 1980s, the social model has gained widespread acceptance and significantly influenced academic discourse in disability studies. However, critics, such as Shakespeare (2006), contend that the model inadequately addresses the role of individuals' underlying impairments, thereby marginalizing their importance.

The biopsychosocial model of disability attempts to integrate both the social and medical models, conceptualizing disability as a dynamic interaction between health conditions or impairments and personal, family, and environmental factors (Simeonsson et al., 2003). This model views disability not as purely a medical issue or solely a social construct but as an umbrella term encompassing impairments, activity limitations, and participation restrictions, framed within a rights-based agenda. It aims to contextualize the needs of individuals with disabilities within a comprehensive framework that accounts for multiple levels of influence, including individual and family-level factors, community-level factors, and macro-level factors. As the foundation of the International Classification of Functioning, Disability, and Health (ICF) framework, the biopsychosocial model has become the dominant approach in the development of influential disability measurement tools, widely used to assess children with disabilities' access to education.

The social relational model is another model that can be considered as a synthesis of both medical and social models, which essentially acknowledges the merits of both models. The social relational model states that people can have reduced function due to impairment related to the body and that society can, in various ways, exert important influences, such as obstructing, oppressing and discriminating against people. A particular impairment is a necessary but not sufficient condition of disability. Disability is seen as a relational phenomenon, with an interaction between personal reduced function and various environmental factors, including not only material but also social relations. Personal experiences of social restrictions due to the reduced function can be distinguished from imposed social restriction (social hindrances) in social settings (Reindal, 2008). Disability can thus be framed as a gap between an individual's personal condition and the social demands or expectations placed on their abilities. This model gained popularity in educational science, which claims that when the environment or social relationship in the shape of a school's resources and approach is not adapted to the needs of children with impairments, it creates disability (Tildeman, 2005).

The human rights model of disability acknowledges individual impairments and identity at multiple levels while emphasising individuals' legal capacity (Degener, 2017). This model asserts that full participation is a universal and fundamental human right, providing a legal and institutional framework for non-discriminatory health policies, inclusive development, and humanitarian aid. As a legal convention, the CRPD incorporates the human rights model, creating legal obligations for countries that have ratified the convention (UN, 2006).

The religious or faith model of disability, deeply rooted in religious traditions, is regarded as the oldest model of disability. It interprets disability either as divine punishment for individual sins, ancestral transgressions, or parental wrongdoing or as a warning against certain behaviours (Henderson & Bryan, 2011). Alternatively, it frames disability as a test of faith, presenting it as an opportunity for spiritual growth through endurance, resilience, and piety, or as a manifestation of divine purpose (Niemann, 2005). While its significance has diminished over time and it has been criticized for marginalizing children with disabilities (CWD) and limiting their families' full social participation, the model retains cultural importance, particularly in low- and middle-income countries (LMICs) where religious beliefs strongly influence societal attitudes. Furthermore, its application varies regionally, shaped by local cultural and religious contexts, and continues to impact the education of children with disabilities in these settings.

The economic model frames disability within an economic context, linking it to a person's capabilities, particularly their ability to work and contribute to the economy (Smart, 2004). Similar to the medical model, it considers the ability to work as normative, with the inability to work viewed as deviance. Originating from values of personal, moral, and social worth, the economic model is heavily dependent on cost-benefit analysis. Unlike the medical model, which views disability as an inherent individual trait applicable in all contexts, the economic model is interactive: an individual is not considered disabled as long as they can work and produce value, regardless of impairment. Government labour policies are often influenced by the economic model, which defines disability in relation to work requirements.

Each model of disability has its limitations, as summarised in Table 1. Disability is a multidimensional, dynamic, and complex concept, and there is no single theory or perspective capable of fully encompassing all its aspects. Different models of disability often reflect specific dimensions of children's disabilities as relevant to particular academic disciplines or research purposes. For instance, the medical model emphasizes biological and health dimensions, the economic model aligns with the principles of economics, the human rights model provides a foundation for legal frameworks, and the social model focuses on the societal organization and the role of society in shaping disability.

These conceptual models can be viewed as complementary, each providing valuable insights into different aspects of children's disabilities. No single disability model takes precedence over others, as different models are suited to specific studies and contexts. Notably, the biopsychosocial model conceptualizes disability as a dynamic interaction within a broader framework, consistent with the ICF framework developed by the WHO (discussed in Section 1.2.2). The Washington Group measurement tools utilized in this study are also grounded in the ICF framework and biopsychosocial model, enabling comparability across African countries while accounting for multi-level factors. In addition, the social-relational model emphasizes the interactions between individuals and society, offering critical insights into inclusive education practices and the complex factors influencing children's learning outcomes. This study largely draws upon these models to understand the educational achievements of children with disabilities.

1.2.2 Measurement Tools for Disability Assessment

Major challenges facing disability studies are the absence of a standardised definition of "disability" (UNESCO, 2018) and internationally comparable data, which are essential for analysing the links between disability and social outcomes. Achieving a consensus on unified and scientifically consistent definitions and measurements of disability categories has been a pressing and lengthy endeavour. The World Health Organization (WHO) framework for measuring health and disability is known as the International Classification of Functioning, Disability and Health (ICF) and was officially endorsed by all 191 WHO member States in 2001. In 2007, the ICF for Children and Youth (ICF-CY) was introduced, providing a standardised classification of individuals' difficulties in performing activities (WHO, 2007).

The CRPD mandates "to collect appropriate information, including statistical and research data, to enable them to formulate and implement policies to give effect to the present Convention" (Article 31, 2006). The *World Report on Disability* recommends to "Develop standardized and internationally comparable data collection methodologies based on the ICF" and "Include disability in national data collection efforts such as Census and administrative data, and consider dedicated disability surveys" (Recommendation 8, 2011). The Sustainable Development Goal (Target 17.18, 2015) urges that "By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts."

Various sets of disability measurement tools developed by different international organizations have been widely accepted and utilized, as outlined in Table 2.

Table 2 Measurement tools focused on functional limitations

		# questions	Functions		Scales
Washington Group (WG)[1]	Short Set (WG-SS)	6	- Vision - Hearing - Mobility	- Self-care - Communication - Remembering & concentrating	Four-severity-scale: - No difficulty - Some difficulty - A lot difficult - Cannot at all
	Short Set Enhanced (WG-SSE)	12	*Same as WG-SS* +	- Upper body - Anxiety - Depression	Four-severity-scale: *Same as WG-SS* + Five-frequency-scale for anxiety and depression: - Never - Rarely - Sometimes - Often - Always
	Extended Set on Functioning (WG-ES)	37	*Same as WG-SSE* +	- Pain - Fatigue	Four-severity-scale: *Same as WG-SS*
	Child Function Module Aged 2-4 (WG-CFM)	16	- Vision - Hearing - Mobility - Dexterity	- Communication - Learning - Playing - Controlling behaviour	Four-severity-scale: Same as WG-SS
	Child Function Module Aged 5-17 (WG-CFM)	24	*Same as WG-SS* + - Learning - Accepting change	- Controlling behaviour - Making friends - Anxiety - Depression	Four-severity-scale: *Same as WG-SS* + Five-frequency-scale: *Same as WG-SSE*
Model Disability Survey (MDS)[2]		48	- Vision - Hearing - Mobility - Self-care - Communication - Hand and arm use - Pain - Energy and drive - Breathing - Affect (depression and anxiety)	- Interpersonal relationships - Handling stress - Cognition - Household tasks - Community and citizenship participation - Caring for others - Work & schooling	Five-severity-scale 1 (None) - 5(Extreme)
Disability Screening Questions (DSQ)[3]		34	- Vision - Hearing - Mobility - Flexibility - Dexterity - Pain	- Learning - Developmental memory - Mental health-related, - Other/ unknown	Four-severity- scale: *Same as WG-SS* + Five-frequency-scale: *Same as WG-SSE*
Ten Question (TQ) (Aged 2-9)[4]		10	- Vision - Hearing - Mobility	- Cognitive - Speech - Epilepsy	None

[1]WG (2020); [2]Sabariego et al. (2021); [3]Trani et al, 2012; Bakhshi et. al, 2017; [4]Moyi, 2017; Durkin et al., 1991

Established in 2001 as a City Group under the United Nations Statistical Commission, the Washington Group on Disability Statistics (WG) aims to develop standardized indicators and instruments that apply common definitions, concepts, standards, and methodologies for disability data collection. Since 2001, the WG has developed several question-sets to assess and measure disabilities, as summarised in Table 2. These include the WG Short Set on Functioning (WG-SS), WG Short Set Enhanced (WG-SSE), WG Extended Set on Functioning (WG-ES), and the Child Functioning Module (WG-CFM), tailored for children aged 2–4 and 5–17 (WG, 2020). Among these tools, the WG-SS has been widely utilized among these tools, particularly in educational studies involving children with disabilities.

The Model Disability Survey (MDS) is a stand-alone instrument developed by the Disability Unit of the World Health Organization (WHO), featuring an extensive and comprehensive set of questions on disability. The primary objective of the MDS is to systematically document all aspects of functioning within a given population. Despite its extensive scope, the MDS requires significant technical expertise for analysis, making it challenging to calculate disability prevalence. As such, the MDS is most suitable for in-depth studies targeting adults, while its integration into national surveys or censuses remains difficult.

The Disability Screening Questions (DSQ-34) were developed by a group of international experts in survey development regarding disability and have been implemented in large-scale national representative surveys across Asia (Trani et al., 2012; Bakhshi, Babulal & Trani, 2017). The DSQ-34 was designed to address concerns that existing measures might not be adaptable to culturally diverse contexts in Low- and Medium-Income Countries or adequately fulfil the requirements of local policy intentions. It emphasizes assessing participation levels, access to services, societal attitudes, individual needs, and overall well-being.

The Ten Question (TQ) screen for child disability was developed by WHO as a component of the *International Pilot Study of Severe Childhood Disability* in 1984 (Belmont, 1984; Moyi, 2017). The TQ was explicitly targeted for screening developmental disabilities among children aged 2-9 years in Low- and Middle-Income Countries (Durkin et al., 1991). However, its narrow focus on a specific age range and limited types of disabilities restricts its application for assessing a broader spectrum of childhood disabilities.

Measurement tools such as those listed in Table 2 assess disability through self-reported or proxy-reported limitations in functioning. Other measurement methods, such as single-question approaches, have been criticized for underestimating childhood disability prevalence. Objective impairment screenings, often based on the medical model, focus on specific impairments and fail to capture the multidimensional nature of disability (Mactaggart and Kuper, 2018). In studies concerning disability and education, school records and student information systems are also utilized to identify students with disabilities, typically defining them as those receiving special education services (Wagner et al., 2005). However, the definitions of disability employed in these studies can vary widely, influenced by local guidelines, criteria, and the conceptual models on which these guidelines are based.

While these measurement tools primarily align with the biopsychosocial model, each has its own focus. For example, the MDS and TQ emphasise individual health conditions, with the TQ specifically targeting developmental challenges in young children. The DSQ-34, in contrast, incorporates cultural and contextual factors, making it particularly relevant in Low- and Middle-Income Countries. Among available tools, the Washington Group question sets are the most influential tools for measuring disability due to their widespread implementation in nationally representative surveys and censuses and their close alignment with the ICF framework and biopsychosocial model. The WG Short Set (WG-SS) and Child Functioning Module (WG-CFM) are probably, so far, the only disability measurement tools widely integrated into large-scale surveys, such as MICS and censuses in many developing countries, whereas the MDS remains confined to specialized studies, restricting broader application.

The WG-SS has been widely utilized in empirical studies (Singal et al., 2020; Lamichhane & Kawakatsu, 2015; Malik et al., 2020; Eide et al., 2021). In November 2016, the Inter-agency and Expert Group on SDG Indicators formally endorsed the WG-SS as a tool for estimating global disability prevalence. However, the WG-SS has notable limitations, particularly its lack of coverage of key developmental and psychological functional domains that are critical for understanding disabilities among children (Groce & Mont, 2017; WG, 2020). To address these limitations, the Washington Group developed the Child Functioning Module (WG-CFM), which expands on the WG-SS by including additional domains, such as learning, memory, communication, and concentration challenges, to better capture the diverse difficulties associated with children's development (Loeb et al., 2018).

Consistent with the ICF framework, WG question sets identify individuals experiencing functional difficulties that limit activities and restrict participation in non-accommodating environments. They employ neutral language and conceptualise disability as a continuum rather than a categorical distinction, as discussed by Madans et al. (2015). For instance, the WG-SS covers six functional domains, while the WG-CFM includes 12 functional domains. Both tools apply a four-severity scale for functional difficulties and a five-frequency scale for anxiety and depression, reflecting a nuanced approach to measuring disability.

1.2.3 Disability Prevalence

Despite the critical importance of reliable data, a lack of consensus persists regarding the definition of disability, resulting in significant gaps in understanding its prevalence. A widely referenced figure from the 2011 World Report on Disability (WHO, 2011) estimated that 1 billion people worldwide, approximately 15 per cent of the global population, have a disability. This estimate was updated to 1.3 billion people, or 16 per cent of the world's population, in the 2022 Global Report on Health Equity for Persons with Disabilities (WHO, 2022). The global increase in both the number and proportion of persons with disabilities is not unexpected, given advancements in medical technology, improved healthcare interventions, and better access to health services. These factors have contributed to lower child mortality rates, increased life expectancy, and a growing elderly population, all of which are associated with higher reported disability rates.

Additionally, the recent WHO report (WHO, 2022) highlighted prevalence rates of 21.2 percent in high-income countries compared to 12.8 percent in low-income countries (Figure 1). While some of this discrepancy can be attributed to an ageing population and a higher prevalence of musculoskeletal or neurological conditions in wealthier nations, underreporting likely plays a significant role in the lower reported prevalence rates of disability in low-income countries. Various factors may contribute to this underreporting, including stigma, cultural perceptions and understanding of disability among respondents, the training and implementation processes for data collection, and methodological differences in the measurement of disability across countries.

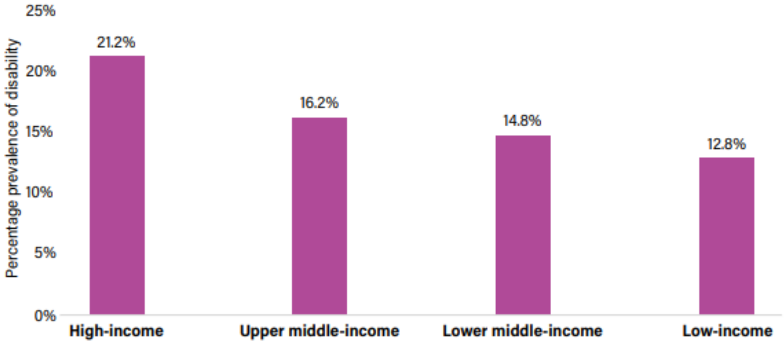

Figure 1 Prevalence of disability by World Bank country income group
Source: Global burden of disease data (2021), Global Report on Health Equity for Persons with Disabilities (WHO, 2022)

UNICEF (2013) estimated that 93 million children globally lived with moderate or severe disabilities, approximately one in twenty children under the age of 14. A more recent WHO report, largely based on the Global Burden of Disease (GDB) database, estimated that by 2021, 5.8 percent of children globally had a disability—equivalent to roughly 116 million children out of the 2 billion aged 0–14 (WHO, 2022). The most recent UNICEF report (2022) provided an even higher estimate among children aged 0-17, suggesting that around 10.1 percent live with a disability, amounting to nearly 240 million children.

Despite substantial efforts in data collection, the prevalence estimates of childhood disability remain unreliable due to inconsistencies in defining disability. WHO (2013) acknowledged these challenges, noting significant variations in reported prevalence, ranging from as low as 1 percent in countries like Kenya and Bangladesh to as high as 20 percent in New Zealand. Olusanya et al. (2022) compared global and regional disability prevalence estimates among children and adolescents reported by UNICEF (2022) and the Global Burden of Disease (GBD, 2019). While the global prevalence rates appear relatively close—10.1% for UNICEF and 11.3% for GBD—these estimates are based on slightly different age groups (0–17 years for UNICEF and 0–19 years for GBD) and are derived from distinct methodological approaches that highlight critical discrepancies.

UNICEF's approach emphasizes functional limitations across specific domains aligned with the ICF framework and the biopsychosocial model, prioritizing the interaction between impairments and contextual factors. Conversely, GBD focuses on diagnostic impairments associated with health conditions and healthcare needs, neglecting the broader environmental and social contexts emphasized by the ICF framework. This divergence is particularly evident in their regional estimates (Figure 2). GBD estimates the prevalence of disability among children at 8.9% in Europe and Central Asia, compared to 5.5% reported by UNICEF. Conversely, in Sub-Saharan Africa, GBD reports a prevalence of 10%, while UNICEF provides a higher estimate of 12.7%. These regional discrepancies likely stem from the differing emphases of the two approaches: GBD focuses on diagnostic incidences, which tend to show smaller regional variations, whereas UNICEF emphasizes functional limitations, which reveal greater disparities between the Global South and the Global North.

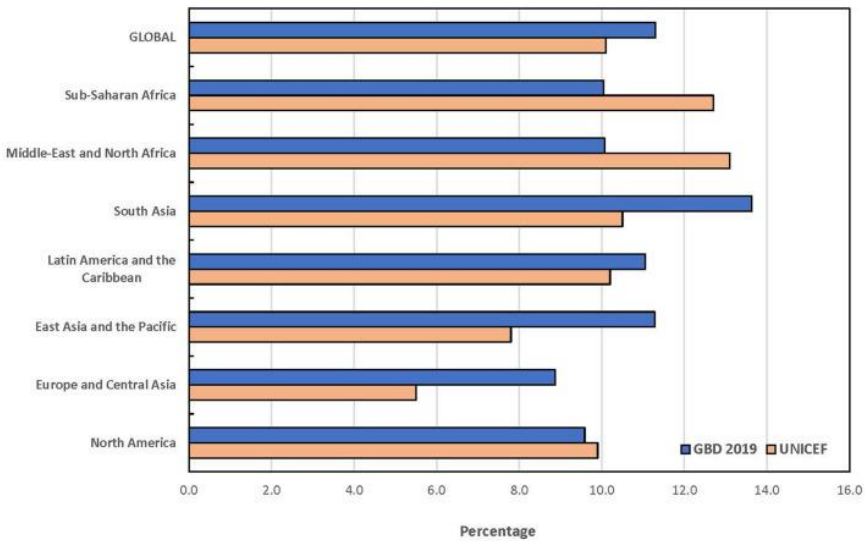

Figure 2 Prevalence of disability among children and adolescents by GBD 2019 (0-19 years) and UNICEF 2022 (0-17 years)
Source: Olusanya et al. (2022)

Furthermore, both approaches are inherently limited in scope. While the UNICEF/WG methodologies capture only a specific range of functional domains, the GBD framework does not encompass all known disabilities. As Olusanya et al. (2022) aptly observed, “No single approach to prevalence estimation is flawless, better, or sufficient by itself to serve the multidimensional interests of children with disabilities.” Neither measurement fully captures the complete spectrum of known disabilities or the multidimensional nature of disability among children and adolescents. Instead, the UNICEF/WG functional approach and GBD’s focus on specific impairments associated with health conditions should be viewed as complementary, each offering valuable insights into different aspects of children’s disabilities.

1.2.4 Educational Outcome Indicators for Children with Disabilities

Due to the inherent complexity of defining and measuring disabilities, as discussed earlier, identifying children with disabilities poses significant challenges. Understanding the specific barriers they encounter in accessing and participating in education, is an even more complex task. A recent report by UNICEF, drawing on MICS data, emphasises that children with disabilities significantly lag behind their peers in terms of school enrolment, numeracy skills, and reading skills proficiency (UNICEF, 2023). However, the report's data is limited, focusing on reporting global or regional estimation, citing only seemingly randomly selected countries as examples to illustrate the disparity in school enrolment and basic skill acquisition among children with disabilities. Consequently, there remains a dearth of information regarding the challenges these children face in accessing education and various factors influencing their educational outcomes in Africa.

Children acquire diverse knowledge and skills primarily through formal school education. There are two pathways through which children may fall behind in their learning. Firstly, if they are not enrolled in school, they miss out on the earning opportunities. Secondly, even if enrolled and attending school regularly, they may struggle to learn as effectively as their peers without support and facilitation, resulting in limited acquisition of new knowledge and skills. In both scenarios, they demonstrate a delay in skill development compared to other children.

To facilitate the skill development of those who are falling behind and promote inclusive education, it is essential to understand the factors that have hindered their learning process, whether due to a lack of school attendance or a shortage of learning in school. Children with disabilities can face various challenges in acquiring skills. For instance, children with physical disabilities may struggle to attend school regularly if transportation, road conditions, or school infrastructure pose obstacles. However, they may not necessarily encounter the challenges in learning skills as children with other disabilities while at school. Conversely, for children with intellectual disabilities, attending school daily may not be especially challenging, but processing and comprehending information during daily instruction may present difficulties for them (Azatyan & Alaverdyan, 2020). On the other hand, children with vision or hearing disability may not face difficulties in developing numeracy competencies or may even excel in representing numbers (Zarfaty et al., 2004; Crollen et al., 2021; Morgan et al., 2011). However, they may encounter challenges in developing language-related or reading skills.

Beyond the challenges associated with school enrolment, it is equally critical to examine how children with disabilities lag in skill acquisition and to identify the underlying factors contributing to these disparities. This thesis provides quantitative evidence on a range of educational outcome indicators, including school enrolment, numeracy and reading skills, and overall academic performance (measured through school records in major subjects), by comparing children with disabilities (CWD) to children without disabilities (CWOD).

1.3 Research Gaps to be Addressed in Africa

In 2018, the out-of-school population in Sub-Saharan Africa (SSA) exceeded that of Central and Southern Asia, making it the region with the highest percentage globally, at 38 percent (UNESCO, 2020). A study by Lewin (2009), analysing data from 44 SSA countries in the 2008 Global Monitoring Report (World Bank, 2008), found significant increases in gross and net enrolment in primary schools across several countries in SSA. However, this increase was accompanied by high dropout rates in later grades, highlighting the insufficiency of primary school enrolment as an indicator for measuring the basic education progress in African contexts (Lewin, 2009). Although the primary school gross enrolment rate has reached 100% and above in many SSA countries, Figures 3 and 4 indicate that SSA countries still lag significantly behind South Asia in terms of primary school net enrolment and primary school completion rates.

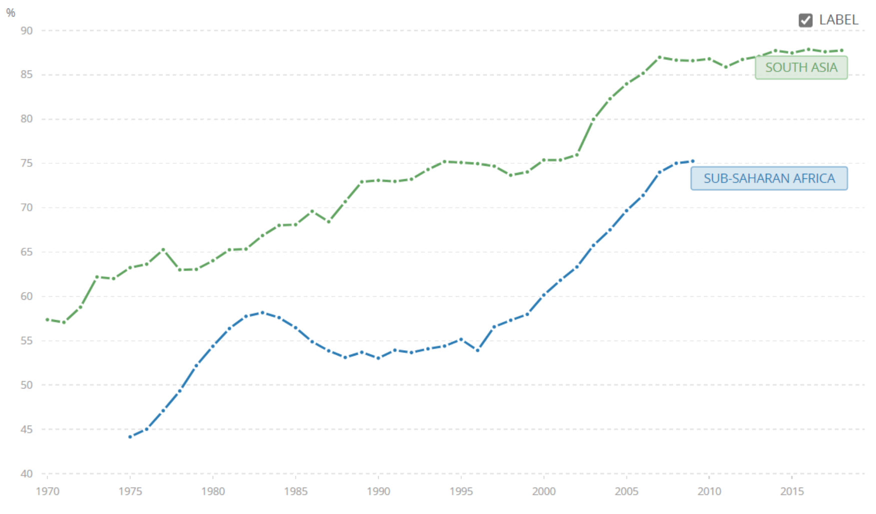

Figure 3 Primary school net enrolment in Sub-Saharan Africa and South Asia (World Bank, 2024a)

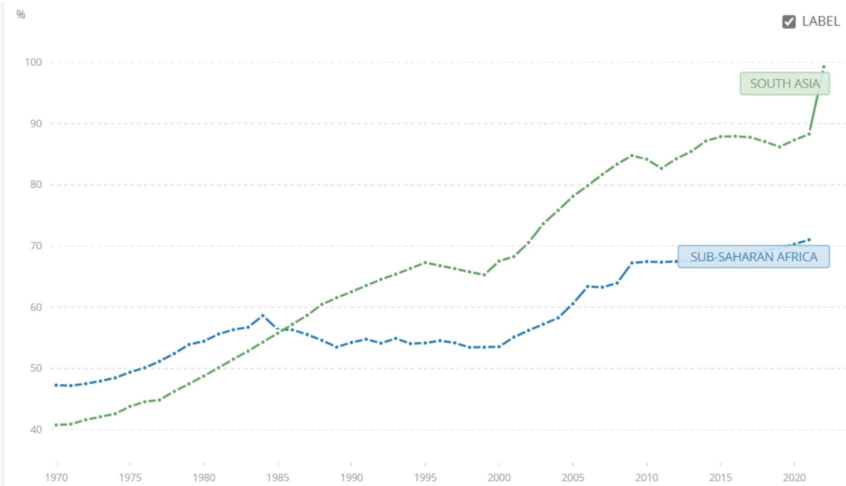

Figure 4 Primary school completion rate (% of relevant age group) in Sub-Saharan Africa and South Asia (World Bank, 2024b)

Over the past three decades, most African countries have implemented Universal Basic Education (UBE) (Agbaire & Musa, 2013). However, a recent review by Nkrumah and Sinha (2020) notes that this focus on Universal Basic Education (UBE) has led to a research culture focused on quantitative indicators like school enrolment and completion rates, which may overlook the complexities of education progress. While these indicators offer valuable insights into education access, measurements of school learning outcomes are notably absent from public education data. The 2018 World Development Report describes this learning crisis as "hidden" due to the lack of data on learning outcomes in developing countries (World Bank, 2018).

The 2018 World Development Report emphasized the role of family socioeconomic factors, teachers' quality, and school resources as crucial determinants in shaping children's learning outcomes (World Bank, 2018), underscoring the need for such knowledge to bridge equity gaps and ensure equitable access for all. There is an urgent call for empirical studies on evaluating children's school learning, especially among those from disadvantaged backgrounds in the Africa context (Bashir et al., 2018; Johnson, 2008; Pritchett, 2013).

Among disadvantaged groups, children with disabilities face even greater research gaps in terms of reliable and systematic studies on their education outcomes, particularly in Sub-Saharan Africa and West Africa (Jolley et al., 2018). The International Centre for Evidence in Disability reported a scarcity of evidence in this area, with existing evidence often of poor quality (Kuper et al., 2018). Data limitations, including small sample sizes and inconsistencies in disability definitions, categorizations, and measurements, pose significant challenges for systematic studies and cross-country comparisons (Loeb & Eide, 2006). Current studies addressing the schooling gap among children with disabilities in Africa are scarce, with only a few exceptions (Adugna et al., 2020; Adugna et al., 2022; Gregorius, 2016).

Much of the empirical evidence on disabled children's educational outcomes originates from studies conducted in developed contexts, predominantly focusing on micro-level factors. Comparative research encompassing multiple African countries remains scarce. A notable exception is the work of Gruijters and Behrman (2020), which analysed children's mathematics and reading competencies across 10 Francophone African countries. Their study revealed that the direct influence of family socioeconomic status within the same school was relatively limited, emphasizing the critical role of school quality and macro-level factors. To comprehensively address the complexities of educational inequality among children from disadvantaged backgrounds, it is essential to integrate micro-level evidence with cross-country comparative analyses. This includes investigating how overall improvements in basic skills learning can mitigate disparities between children with disabilities (CWD) and children without disabilities (CWOD) in the African context.

Inclusive education emerged in the mid-1980s as a political goal and framework, initially endorsed by UNESCO through the Salamanca Statement in 1994 (UNESCO, 1994). The transition towards inclusive schools was underpinned by educational, social, and economic justifications (Ainscow et al., 2019). Thirty years after the adoption of the Salamanca Statement, the literature on inclusive education predominantly emphasises the placement of children with disabilities in mainstream schools rather than in separate institutions. Significant progress has been made in this regard; however, the transformation of teaching practices within inclusive education has been comparatively slow (Haug et al., 2024). A persistent gap remains in teachers' knowledge and competence required to effectively support the learning of children with disabilities. Furthermore, empirical evidence on the influence of various contextual factors is necessary to harmonise the core principles of inclusive education with local values and traditions.

Educational inequality in Africa, influenced by environmental, household, and individual factors, requires a deeper exploration (Nkrumah & Sinha, 2020; Unterhalter, 2013; Bashir et al., 2018). Moreover, findings from studies on micro-level factors in developed contexts may not readily translate to developing contexts. For example, the extensive body of research from developed countries on sibling effects on education—particularly for children from disadvantaged backgrounds—has yet to undergo rigorous evaluation in African settings. While disability is often conceptualized in individualistic terms in Western contexts, traditional and collective values hold greater influence in African societies. The role of community, family, and siblings plays a crucial part in the relational and interconnected social fabric of the African context. Such research is crucial for designing effective interventions aimed at achieving the Sustainable Development Goal (SDG) commitment to "leave no one behind" and promoting inclusive education for marginalized children across Africa.

1.4 Conceptual Framework and Research Questions

1.4.1 Conceptual Framework

This study aims to investigate the educational outcomes of children in basic education across African countries, with a particular focus on children with disabilities. Building on the expansion of Universal Primary Education and the steady rise in primary school enrolment across Africa since the late 1990s, the study analyzes the progress in children's learning outcomes using the most recent data available. These outcomes include school enrolment levels, foundational skills acquisition, and academic achievements, both within and across countries.

To address the research gaps identified earlier, this PhD study is grounded in the ICF framework, as illustrated in Figure 5. It aims to provide quantitative evidence on children's **participation** in education, with a particular focus on disparities in learning outcomes between disadvantaged and non-disadvantaged children in African countries. This study specifically examines disparities in educational outcomes among children with different types of **impairments**, including vision, hearing, physical, intellectual, and multiple impairments. Additionally, the thesis explores the impact of **contextual factors** on educational outcomes. These include environmental influences such as urban versus rural settings and national levels of numeracy and reading proficiency, as well as personal factors such as gender, household income, parental education, and the presence of siblings.

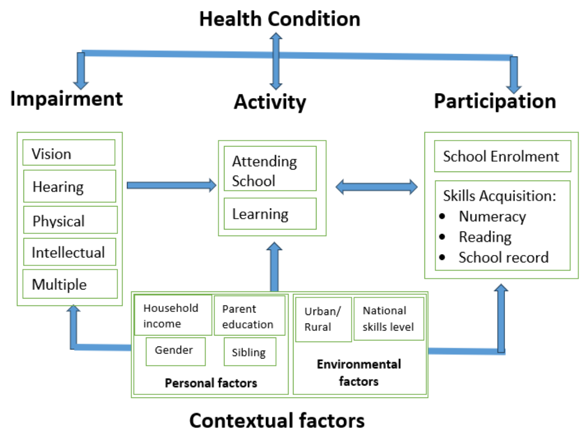

Figure 5 Conceptual framework

The ICF framework conceptualizes disability as a multidimensional construct encompassing body functions and structures, individual activities, participation in life, and the environmental factors that influence these experiences. This framework serves as a foundation for this study, which focuses on children's participation in education and the impact of contextual factors on this participation. As visualized in Figure 5, this conceptual framework integrates the interconnected dimensions of disability and contextual influences, providing a structured lens through which to analyze disparities in educational outcomes among children from diverse backgrounds. The overarching objective and research questions that connect all four studies in this thesis are outlined in the next section.

1.4.2 Overarching Objective and Research Questions

This study aims to enhance understanding of educational disparities and the influence of contextual factors on children's learning outcomes through evidence-based analysis. The four papers included in the thesis address this overarching objective by offering a comprehensive examination of the barriers to equitable education and the factors that support or hinder inclusion, thereby aligning with the study's central aim.

Overarching objective:

To investigate the challenges and underlying factors that hinder equitable access to education for children from disadvantaged backgrounds in African countries, with a particular emphasis on children with disabilities (CWD).

Research Questions:

RQ1: How much heterogeneity exists in basic educational outcomes within and across African countries, particularly among children from diverse socioeconomic backgrounds and those experiencing various disabilities?

In line with the conceptual framework, the first research question focuses on measuring children's **participation** in educational systems, specifically through school enrollment and skill acquisition. This analysis places particular emphasis on children from diverse backgrounds, with a focus on those with disabilities. Key educational outcomes—school enrollment, numeracy, and reading skills—are assessed, and disparities in these outcomes are examined both across African countries and among children from different backgrounds, such as those from low-income or less-educated families, rural areas, or with disabilities, compared to those from higher-income or more-educated families, urban areas, or without disabilities. Paper 1 investigates differences in school enrollment among children with disabilities across various ages and stages of school. Papers 2 and 3 examine numeracy and reading skill levels across selected African countries, focusing on disparities between children with and without disabilities. Finally, Paper 4 explores within-class disparities in performance of main school subjects between children with and without disabilities, with a specific focus on Ghana and Niger as case studies.

RQ2: How do disparities in children's educational outcomes vary among children with different types of disability in selected African countries?

The second research question aims to investigate whether and to what extent children's **participation** in education is influenced by different types of **impairments**. Paper 1 examines school enrolment among children with various impairments compared to their peers without impairments across eight African countries. Papers 2 and 3 investigate the distinct challenges faced by children with different types of impairments in acquiring numeracy and reading skills.

RQ3: What roles do contextual factors, including environmental and personal factors, play in basic skills acquisition and in shaping disparities between children with and without disabilities in selected African countries?

This thesis examines the role of various contextual factors in children's basic skill learning across three papers. Papers 2 and 3 investigate whether children with disabilities benefit equally from national improvements in basic numeracy and reading skills compared to their peers without disabilities across selected African countries. Paper 3 further investigates the influence of micro-level factors on reading skills development among children with disabilities. Lastly, Paper 4 provides empirical evidence of effects of sibling on educational outcomes, analysing whether these effects differ by gender and disability status in Ghana and Niger.

2 Methodology

This PhD thesis draws on two data sources: secondary MICS6 survey data from 12 African countries and primary survey data collected in Ghana and Niger. To investigate the impact of disability on children's educational outcomes, all four papers in this study classify children with disabilities (CWD) using the Washington Group Child Functioning Module (WG-CFM) (see Table 2). The classification of disability is based on data reported by households in the MICS6 survey and by both households and teachers in the EVID research project.

This chapter outlines the two data sources, the disability types, and the disability terms utilized in the study. It also addresses potential sample biases, ethical considerations, and the empirical strategies employed in the analysis.

2.1 Research Project

This PhD thesis is part of the research project titled «Education Outcome Variability in Children with Disabilities: Structure, Institution, or Agency?» (EVID) funded by the Research Council of Norway (Project Number 300635). The primary objective of this project is to enhance understanding of the factors influencing the enrolment, attendance, performance, and achievements of children with disabilities (CWD) in mainstream primary schools in Ghana and Niger.

In addition to my PhD position in Norway, the project includes two PhD candidates based in Niger and Ghana, as well as a Post-Doctoral researcher in Norway. The work of these two PhD candidates and the Post-Doctoral researcher is entirely focused on the data collected in Ghana and Niger. The two PhD candidates employ a mixed-methods approach that combines quantitative survey findings with exploratory and in-depth qualitative interviews conducted with teachers and parents, alongside classroom observations. Their research focuses on the experiences and challenges related to school access and educational outcomes, as well as contextual factors such as family support, perceptions of teaching CWD held by parents and teachers, differentiated instruction, religious support, and support from authorities and NGOs – all aimed at identifying the barriers to learning for CWD. The Post-Doctoral researcher employs qualitative methods and seeks to identify potential sources of resilience, encompassing children's characteristics, family dynamics, local community support, school environment, civil society contributions, and spiritual resources.

This project strategically selected two distinct regions for conducting both quantitative surveys and qualitative fieldwork: the Ashanti region of Ghana and urban Niamey, the capital of Niger. Niger, which ranked among the lowest on the Human Development Index in 2022 (UNDP, 2022), is one of the most impoverished and fragile countries globally. In contrast, Ghana has experienced considerable economic growth over the past decades and is progressing towards a middle-income country within Africa. Culturally, Niger is characterized by patrilineal inheritance traditions influenced by Islamic traditions. In contrast, the Ashanti, the largest ethnic group among the Akan in Ghana, represents one of the few societies in West Africa that practice matrilineal inheritance. The selection of these two countries facilitates a comparative analysis of the various situations and challenges faced by children with disabilities in African nations with diverse economic conditions and cultural traditions.

While the research conducted by two PhD candidates in Niger and Ghana, along with the Post-Doctoral researcher in Norway, provided valuable insights into the challenges and contextual factors impacting the education of CWD through mixed-methods and qualitative approaches, my PhD research is solely based on a quantitative approach.

The project, which commenced in 2020, experienced delays in initiating and completing quantitative survey activities due to the COVID-19 pandemic. Mapping activities in both countries started by the end of 2021, with follow-up surveys concluded by the summer of 2023. The collection of school performance data finalized by fall 2023. While the two PhD candidates in Ghana and Niger managed to conduct qualitative fieldwork during the pandemic, it was not feasible for me to begin work with the quantitative survey data. During the first year of my PhD studies, I turned my attention to exploring a valuable secondary data source: the sixth round of the Multiple Indicator Cluster Surveys (MICS6, detailed in Section 2.1), a global project initiated by the United Nations Children's Fund (UNICEF). This relatively new and largely under-explored dataset from nationally representative surveys in African countries has recently incorporated the Washington Groups' Child Functional Form (WG-CFM; see section 1.2.2 for further details).

While the postponement of the EVID survey for this research project due to the COVID-19 pandemic was unfortunate and constrained the time available for data analysis during my PhD, the integration of MICS data has substantially enriched the understanding of challenges faced by CWD in African contexts. The MICS survey data, characterized by its nationally representative household samples, the application of WG-CFM measurements, and standardized numeracy and reading assessments consistently conducted across countries, provides a unique foundation for this thesis to provide valuable quantitative evidence and essential insights from a wider, comparative perspective that spans multiple African countries. This evidence not only sheds light on educational outcome disparities among CWD and other disadvantaged groups but also assesses the potential influence of national-level educational improvements and microeconomic factors on these disparities. In comparison, the project-specific survey data, due to its limited and non-representative sample size, was unable to offer the same scope of comprehensive, nationally representative findings.

Nonetheless, the EVID survey data offers a unique contribution by enabling the exploration of the causal effects of specific contextual factors that are not included in the MICS data. For example, Paper 4 in this thesis examines the sibling effect on school learning related to gender and disability status. While outside the scope of this thesis, I continued analysing the survey data. For example, based on the survey data, I wrote another paper that investigates disparities between CWD and CWOD within classes of varying sizes in Ghana and Niger[3].

Although the children selected for the survey were identified only based on teachers' reports using the WG-CFM for all children in the class – a practical approach given the constraints of time and funding – additional data on children's functional difficulties was

[3] The paper is currently under review with the journal *Comparative Education Review*.

collected during subsequent phases. During the baseline survey interviews, families were asked to respond to the WG-CFM questions and report their children's functional difficulties. In the follow-up surveys, both families and teachers were requested to complete the WG-CFM again to provide updated reports on children's functional difficulties. This unique approach allowed for the collection of data from both teachers and families on the same child's functions over a two-year period. An ongoing co-authored paper with colleagues involved in this research project highlights interesting findings on the WG-CFM disability measurement over time and across different respondents, which highlights the dynamic and complex nature of disability.

The analysis of the valuable data collected in this research project is ongoing, even though not all findings are included in my PhD study. This thesis represents not the conclusion but the beginning of further exploration in this compelling research field. I look forward to continuing an exciting journey of further research on this topic.

2.2 MICS6 Survey Data

The MICS6 surveys encompass questions related to household and individual children on a large-scale and nationally representative sample. The aim of the MICS surveys is to collect data on SDG globally agreed indicators related to the well-being of children and women in developing countries. Furthermore, the sixth round of MICS surveys integrates WG-CFM, as well as standard numeracy and reading assessment tools, to assess children's disability status and educational outcomes.

The sixth round of MICS stands out as the first, and likely the only, large-scale implementation of Washington Group (WG) disability measurement tools (UNICEF, 2017), which align with the biopsychosocial model and ICF standards. Since 2017, 72 countries and regions have conducted surveys using the sixth round of the Multiple Indicator Cluster Surveys (MICS), with an additional approximately 40 countries and regions having either conducted or planned surveys under the seventh round of the MICS. This thesis utilizes data from all African countries where MICS6 surveys were conducted between 2017 and 2020, and for which data was publicly available at the time of writing, excluding one country due to poor-quality education data. Consequently, the study includes data from 12 African countries: Central African Republic, Chad, DR Congo, Ghana, Lesotho, Madagascar, Malawi, Sierra Leone, The Gambia, Togo, Tunisia, and Zimbabwe (Table 3). The sample is a nationally representative household sample in each individual country. Table 3 lists the number of children sampled in each country, along with the age groups and countries used in each paper.

Table 3 Sample size of interviewed households and children aged 5-17 in MICS6 surveys[1] by countries

	Total number of interviewed households	Total number of interviewed children 5-17	Paper 1 (Children 6-17)	Paper 2 (Children 7-14)	Paper 3 (Children 10-14)
Central African R.	8 994	6 167			X
Chad	19 217	14 865			X
DRCongo	20 810	14 027	X	X	X
Gambia	7 750	5 716	X	X	X
Ghana	13 202	8 946	X	X	X
Lesotho	10 413	5 000	X	X	X
Madagascar	20 117	12 429			X
Malawi	26 882	17 976			X
Sierra Leone	15 605	11 033	X	X	
Togo	8 404	4 969	X	X	X
Tunisia	11 996	4 934	X	X	X
Zimbabwe	12 012	7 034	X	X	X

[1]UNICEF (2017); Khan & Hancioglu (2019), https://mics.unicef.org/surveys

The MICS6 survey incorporates standardized performance assessments in numeracy and reading skills, providing valuable insights into foundational competencies across diverse countries. The numeracy assessment for children aged 7-14 includes four tasks—number reading, number comparison, addition, and logical pattern recognition—comprising a total of 21 questions. There are two sets of reading assessment tests in MICS survey, and the reading test for younger children aged 7-9 is not included in this study. The reading assessment for children aged 10-14 involves three tasks: word recognition, a short narrative of approximately 60–80 word4, and comprehension questions, including three

[4] MICS6 survey reading tests mainly use same text with primary official teaching languages in these countries, which are English in The Gambia, Ghana, Lesotho, Malawi, and Zimbabwe; French in

literal and two inferential questions based on the narrative's content. Details of the numeracy and reading tests are provided in Appendix I.

The response rates for numeracy and reading skills, disaggregated by disability type and school attendance status, are presented in Table 4a and Table 4b. The assessment tests were voluntary. Among children aged 7–14 across eight countries, the response rate for the numeracy test was relatively high at 97 percent. However, the response rate for the reading test, administered to children aged 10–14 across twelve countries, was significantly lower, with only two-thirds of children completing the test.

A key difference was that numeracy tests were administered to all selected children, while reading tests were typically required only for children enrolled in school in most survey countries. As a result, 16 percent of out-of-school children did not participate in the reading test. Among school-enrolled children, 97 percent completed the numeracy test, while only 85 percent participated in the reading test. Several factors contributed to the lower response rate for the reading test: approximately 5 percent of parents declined participation, 3 percent of children were unable to take the test due to the unavailability of test materials in their language, and 9 percent of children refused to participate.

The response rates also varied by disability status. While the numeracy test response rate was slightly lower among children with disabilities, particularly those with multiple disabilities (75 percent), the disparity was more pronounced for the reading test. Children with disabilities, especially those with physical and multiple disabilities, had notably lower participation rates, largely due to higher rates of school non-attendance. Additionally, families of children with multiple disabilities had a higher rate of refusal, with 32 percent declining participation. These findings highlight challenges in administering skill tests to children with disabilities.

Central African Republic, Chad, DR Congo, Madagascar, Togo, and Tunisia. The story is same across all countries, but total number of words vary depending on the language used.

Table 4a Response rate of numeracy tests by disability types and school attendance

	Total sample	% Total took numeracy test	Ever-In-School Children (EISC)	% EISC took numeracy test	Never-In-School Children (NISC)	% NISC took numeracy test
Non-disabled	30,013	97.0	27,305	97.3	2,708	94.6
Vision disability	168	94.6	163	94.5	5	100.0
Hearing disability	96	90.6	87	93.1	9	66.7
Physical disability	422	95.0	357	97.2	65	83.1
Intellectual disability	1,366	95.8	1,236	96.6	130	87.7
Multiple disabilities	241	74.7	170	85.9	71	47.9
Total	32,306	96.7	29,318	97.1	2,988	92.9

Table 4b Response rate of reading tests by disability types and school attendance

	Total sample	Missing due to Family refusal(%)	Missing due to Out of school (%)	Missing due to Language (%)	Missing due to Child refusal (%)	Done reading test (%)
Non-disabled	33,505	4.4	15.9	2.7	8.8	68.2
Vision disability	204	8.3	5.9	1.0	7.4	77.5
Hearing disability	118	9.3	11.0	2.5	11.9	65.3
Physical disability	354	5.1	22.0	4.2	15.0	53.7
Intellectual disability	1,409	5.7	16.9	2.8	12.1	62.5
Multiple disabilities	204	31.9	25.5	2.9	8.3	31.4
Total	35,794	4.7	16.0	2.7	8.9	67.7

2.3 EVID Survey Data

Paper 4 is based on the EVID project surveys (see chapter 2.1), conducted in two African countries, Ghana and Niger, cooperated by Kwame Nkrumah University of Science and Technology (KNUST) in Ghana, Abdou Moumouni University in Niger, SINTEF research institute and Fafo Institute for Labour and Social Research in Norway. I have taken the primary responsibility for organizing the surveys in Ghana and Niger. My tasks during the surveys included contacting local partners, coordinating the fieldwork in both countries, drafting the questionnaire, drawing the sample, training the fieldworkers, collecting, cleaning, finalizing the data, and conducting preliminary analysis.

The quantitative EVID survey was conducted in both regions following a mapping activity that included all children in 27 schools in the Ashanti region in Ghana and 18 schools in Niamey in Niger. The schools were selected from a comprehensive list of inclusive schools provided by local authorities, based on the registered number of children with disabilities in each school. Schools with the highest number of CWD are selected. An inclusive school is an educational institution that supports and accommodates all students, including those with disabilities and diverse needs, ensuring equitable access to education. This mapping activity provided the sample frame for selecting a sample of both children with disabilities (CWD)[5] and children without disabilities (CWOD).

In January 2022, all the teachers responsible for Grades 1, 3, and 5 in the selected schools were visited and filled out the teacher version of Washington Group Child Functional Module (WG-CFM) forms for all the children in their classes. Based on these forms, all mapped children in these schools are classified as either CWD or CWOD. For each child with a disability (as defined in this study), one child without a disability (CWOD) was randomly selected from the same class as the child with a disability. The sampling procedure after mapping to select children is provided in Appendix II.

We conducted two rounds of surveys and interviewed teachers and families of 594 children in Niger and 429 children in Ghana between February and May 2022, followed by 573 children in Niger and 387 children in Ghana between March and May 2023 (Table 5). Children's teachers and family members were interviewed in both rounds of surveys to collect information on children's individual and family background, such as disability status and sibling status, as well as their school performance.

Table 5 Sample size of interviewed children by sibling status in Ghana and Niger

	Ghana		Niger	
	CWD	CWOD	CWD	CWOD
Without sibling	70	111	77	124
With sibling	82	124	150	222
Total	***152***	***235***	***227***	***346***

CWOD: Children without disabilities; CWD: Children with disabilities.

The disability status of each selected child in the EVID survey was evaluated four times using the WG-CFM forms. The first evaluation by the responsible teachers in all the selected

[5] The definition of disability in identifying CWD follows the discussions in Section 2.3.1

schools was conducted during the mapping. A second evaluation by the responsible teachers was carried out during the second survey one year later. Parents also made two rounds of evaluations on the selected children's functional difficulties during two rounds of surveys by filling out the parents' version of WG-CFM forms. Based on the four evaluations, we made a new classification of disability status for each selected child (criteria for defining children in the survey analysis as CWD and CWOD are outlined in Appendix III). The disability status used in the analysis in Paper 4 was not the original classification during mapping, but the final classification based on four evaluations, which is considered more accurate. Finally, 152 children in the Ghana sample and 227 children in the Niger sample are categorised as children with disabilities (Table 6).

Table 6 Sample size of interviewed children by grade in Ghana and Niger

	Ghana			Niger		
	CWD	CWOD	CC	CWD	CWOD	CC
Grade 2	46	79	818	74	110	2 116
Grade 4	57	86	980	85	132	1 965
Grade 6	49	70	1 126	68	104	1 607
Total	***152***	***235***	***2 924***	***227***	***346***	***5 688***

CWOD: Children without disabilities; CWD: Children with disabilities.
CC: Counterfactual Classmates, not selected for survey interview, only school records collected

Quarterly school grades in mathematics, natural science, French reading, and French writing in Niger, as well as annual school records in mathematics, natural science, English, and the local Akan language in Ghana, were collected for all students in the classes of the selected children in EVID survey[6]. Paper 4 is based on the data from the second survey round, as school performance data were only collected in 2023. These records were collected not only for the children sampled for interviews but also for all other children in the same classes as

[6] Due to the COVID-19 pandemic, the school year structure in Ghana was reorganized, with academic year beginning at the start of the calendar year. Therefore, during the survey conducted in early 2023, data were collected on the final school records from the 2022 academic year in Ghana. Niger maintained its traditional school calendar, with the academic year commencing in October 2022. For most schools in Niger, school records were collected for the first two semesters, while some schools provided school records for the first three semesters. The average quarterly school grades for each child were used for analysis in Niger.

the sampled children. In addition to the selected children, school records of 2924 counterfactual classmates (CC) in Ghana and 5688 CC children in Niger were collected. Sample sizes for various groups of children in the two countries are presented in Table 6.

2.4 Disability Terms and Sample Bias

2.4.1 Disability and Disability Types

Children's disabilities encompass a broad spectrum of attributes and developmental experiences during childhood. Children with disabilities exhibit significant differences in their impairments and activity limitations. The factors that hinder their school attendance and skill acquisition vary considerably, often depending on specific functional difficulties. Beyond individual activity variations, challenges associated with vision, hearing, physical, and cognitive impairments each present unique obstacles that must be addressed to promote inclusive education (Lederberg et al., 2013; Tedla et al., 2015; McIntyre et al., 2006). Understanding these distinct challenges is essential for analysing their educational experiences.

The CFM measurement tool used in this study aims to identify various functional variations or difficulties among children. However, it is limited in defining disability without considering its interaction with contextual factors. In this study, the terms "disability" and "disability types" refer to the potential risk of disability due to functional difficulties in specific domains. The following simplified terms are, throughout this study, used to represent these potential risks of disability associated with particular functional difficulties:

- **Vision disability** refers to children who cannot see or have significant difficulty seeing, even with corrective lenses.
- **Hearing disability** refers to children who cannot hear or have significant difficulty hearing, even with hearing aids.
- **Physical disability** included children who cannot perform self-care or walk, or have significant difficulty in these activities, such as walking 500 meters on level ground.

- **Intellectual disability** encompasses children who cannot or have significant difficulty with communication, learning, remembering, or concentrating.
- **Multiple disabilities** represent children who experience more than one functional difficulty among the four groups listed above.

To provide quantitative evidence, it is often practical to define disability in binary terms. This necessitates critical decisions regarding the selection of cut-off points for identifying target populations for analysis, enabling the disaggregation of educational outcomes by disability status. One of the key strengths of the WG question sets lies in their consistency across surveys, allowing for meaningful cross-country comparisons when identical cut-off points are applied. It is important to acknowledge that disability status can be defined across a spectrum of severity and functional domains. The selection of cut-off points in this study is aligned with its specific research objective.

2.4.2 Data Sources and Sample Bias

Disability represents just one aspect of a child's identity or experience (Shakespeare, 2006). It is important to acknowledge that conceptual variability can significantly affect disability measurement and estimation, ultimately influencing conclusions about how disability impacts children's educational outcomes. The data used in this thesis is derived from two primary sources: nationally representative household samples (MICS6 survey data, detailed in Section 2.1) and mainstream inclusive schools (EVID survey data, detailed in Section 2.2). Disability in this study is defined based on the WG-CFM measurement tool and is constrained to a limited range of functional domains.

Specifically, in Papers 1-3, using MICS survey data, disability is defined as children reported to have "a lot of difficulty" or "cannot do at all" in at least one of eight functional domains: vision, hearing, mobility, self-care, communication, learning, remembering, and concentrating. Four behavioural and psychosocial domains (e.g., accepting changes, behaviour control, making friends, anxiety or depression) are excluded from MICS data analysis. Prevalence rates for these functional domains vary significantly across the countries included in the study, potentially reflecting cultural or linguistic differences in interpreting terms that describe these functions within local contexts. This large variability suggests that analysing these functional domains within their specific cultural and contextual environments may provide more meaningful insights than combining data across countries, as done in this thesis. As a result, Paper 1-3 focus on the eight functional domains from MICS data, which are less prone to ambiguity across local contexts, for cross-country comparisons within the African context. Consequently, the disability status reported in these papers does not capture all functional domains in CFM, but rather focuses on those with specific functional difficulties.

In Paper 4, using the WG-CFM framework in the EVID survey, four evaluations of children's functional difficulties were conducted by teachers and parents during two survey rounds (details can be found in Section 2.2). Disability is defined as children reported to experience "a lot of difficulty" or "cannot do at all" in at least one of 12 functional domains: vision, hearing, mobility, self-care, communication, learning, remembering, concentrating, accepting changes, controlling behaviour, and making friends. Additionally, children who are reported to feel anxious, nervous, worried, or sad/depressed daily, as well as those who experience "some difficulty" in vision, hearing, walking, or self-care, are included (see Appendix III for details). This approach includes children with severe difficulties in all 12 functional domains, as well as those with moderate difficulties in physical and sensory function domains.

It is important to note that the EVID project specifically targets CWD in inclusive mainstream schools in Ghana and Niger, while MICS surveys often involve national representative samples of all households. As a result, children with extremely severe impairments—such as those who are deaf, blind, or unable to walk—are underrepresented in EVID surveys. Although the MICS survey features a large, nationally representative sample, children with severe difficulties remain rare cases within the dataset. Most children included in the data exhibit moderate difficulties, such as being hard of hearing, having low vision, or experiencing challenges with mobility. While the underrepresentation of children with the most severe conditions is a limitation, the data likely captures a larger subgroup of children with moderate functional difficulties. Therefore, the quantitative evidence presented in this thesis is limited to assessing the educational outcomes of children categorized as having "a lot of functional difficulty" in specific domains, such as sensory, physical, and cognitive functions.

2.5 Ethical Approval

The MICS6 survey data is publicly available and can be downloaded from the MICS website (https://mics.unicef.org/surveys). These surveys are conducted by UNICEF (United Nations International Children's Emergency Fund), which adheres to the ethical requirements outlined in its ethical document (https://www.unicef.org/media/54796/file). While data collection involves human participation, the MICS team ensures confidentiality. Informed consent is discussed in each country's survey report and included in the individual questionnaires.

The surveys conducted in Ghana and Niger have obtained approval from NSD in Norway (Norsk Senter for Forskningsdata), which conducted the Data Protection Impact Assessment (DPIA, project number 819931). Additionally, ethical approval for the surveys has been granted by the research directorate in the Ministry of Higher Education and Research in Niger, as well as the Ashanti Regional Director of Education in Ghana.

2.6 Empirical Strategy

Since only cross-sectional data is available for this study, papers rely on the natural experiment assumption to elicit various disability and sibling effects. The natural experiment assumes that subjects are exposed to a random treatment determined by nature or uncontrollable factors. This assumption hinges on the belief that the treatments (disability status and sibling status of any kind) are not concentrated in specific segments of the population or driven by ecological, economic, or social processes. Consequently, it is assumed that a subgroup of the population exposed to a specific treatment (i.e. the treatment – children with disabilities or children with siblings) should be otherwise similar to those not exposed to the treatment (i.e. the control – children without disabilities or children without siblings), allowing for causal inference of the effect of treatments.

However, potential correlations between disability and socioeconomic factors, such as poverty, cannot be completely excluded, as noted in some previous studies (Banks et al., 2017). It is conceivable that individuals may have a higher chance of becoming disabled due to a lack of access to nutritious food, health facilities, sanitation, and housing (Hosseinpoor et al., 2013). Nevertheless, the nature of this connection is complex. Other studies have reported that differences in socioeconomic characteristics between people with and without disabilities may be limited, with the correlations being very small and not statistically significant, especially in impoverished environments (Trani et al., 2010; Groce & Kett, 2013). No universal conclusion can be made due to the complexity and continuum of disability as discussed in Section 1.2, the correlations between disability and socioeconomic factors are highly dependent on the definition of disability pertained to each study. We cannot disregard the possibility that disability and sibling status may not be random treatments.

Potential correlations between disability and socioeconomic factors, such as poverty, cannot be entirely ruled out, as highlighted in previous studies (Banks et al., 2017). Limited access to nutritious food, healthcare, sanitation, and housing may increase the likelihood of individuals becoming disabled (Hosseinpoor et al., 2013). However, this relationship is complex. Some studies suggest that socioeconomic differences between individuals with and without disabilities may be minimal, with weak and statistically insignificant correlations, particularly in impoverished settings (Trani et al., 2010; Groce & Kett, 2013).

Given the multidimensional and evolving nature of disability, as outlined in Section 1.2, the observed correlations depend heavily on the specific definitions and methodologies applied in each study. Thus, no overarching conclusion can be drawn. It is essential to recognize that disability and sibling status may not occur as entirely random treatments, necessitating further assessment.

To address this, the papers evaluate the natural experiment assumption to support the hypothesis. Treatment variables are regressed on various control variables, including individual and family characteristics, family wealth, and geographical variables. The natural experiment assessments of disability treatment using MICS6 data consistently support the validity of this assumption, reinforcing the reliability of the analytical framework applied.

In Paper 4, the natural experiment assessment with the EVID survey data reveals some significant findings. It shows that there are statistically more children with disabilities (CWD) in urban areas and from wealthier families in Ghana, and more boys with disabilities in Niger. This may be attributable to the fact that the survey sample only includes school children from inclusive schools in both countries, which may skew the sample toward children from more advantaged backgrounds. This could potentially lead to an underestimation of the disability effect, as children from marginalized communities or those with more severe disabilities might be underrepresented. Additionally, the analysis in both Ghana and Niger reveals that a mother's education is correlated with a child's sibling status, which highlights the influence of family background on disability and educational outcomes.

To address these complexities, Paper 4 employs both non-parametric and parametric analyses to estimate the effects of disability and sibling status. For the parametric analysis, the models are run with and without the main variables of interest to test the robustness of the findings and ensure the reliability of the results. This approach allows for a deeper exploration of the disability and sibling effects while accounting for potential biases in the data.

The specific analytical (empirical) strategies in the four papers are summarized as follows:

The first paper analyses the diverse effects on school attainment among children with different types of disabilities in eight African countries. Despite the large sample size of the national representative MICS6 surveys conducted in these countries, the sample size of CWD is relatively small. When the sample of CWD is further divided into different types of disabilities, the sample size becomes even more limited. For instance, out of 9166 children aged 6-17 interviewed in the Democratic Republic of Congo (DRC), only 17 children had a vision disability, and 16 children had a hearing disability. The advantage of the MICS6 surveys lies in their standardized approach, as all surveys utilize the same WG-CFM forms to measure children's disability status. Consequently, the data from eight African countries are merged, creating a unique dataset that enhances statistical power and allows for a more robust analysis of the effects of disability on children's access to education across various disability types in the study countries. Paper 1 constructs three indicators of school enrolment – Young Not-Enrolled (YoungNE), Older Never-Enrolled (OlderNE), and school dropout (Dropout) – to identify the challenges of school access for CWD at different stages of schooling.

The second paper explores numeracy skills learning among children aged 7-14 in eight African countries and examines the gaps between CWD and CWOD, using data from the MICS6 survey. The standardized numeracy skills test is presented in Appendix I. Two potential mechanisms contributing to the potentially lower numeracy skills learning among CWD are considered. Firstly, CWD may lag in learning these skills if they do not attend school or drop out earlier. Secondly, their functional difficulties may impede skill learning in school despite their full school attainment. To measure children's school attainment, completed school years are calculated based on their reported level of educational attainment in the surveys, considering the varying durations of education at different levels within each country's school system. To control for the endogeneity of completed school years when assessing children's numeracy skills learning in school, instrumental variable (IV) models are employed. Age and gender are used as instruments to satisfy the theoretical validity of IV models. They are not expected to affect numeracy skills learning (exclusion restriction) directly but are correlated with completed school years. To ensure the validity of the two instrument variables, standard IV tests are included: tests for endogeneity (Robust Wu-Hausman test), instrument strength (first stage F test), and overidentification (Sargan IV validity test). ln(age) is selected since it performs best in satisfying the Sargan overidentification test. The heterogeneous disability effects are first estimated across children with different types of disabilities. Subsequently, IV models are constructed on split samples of countries categorized by low- and high-numeracy skills groups to assess the role of school system quality in the disparities of numeracy skills learning between CWD and CWOD.

The third paper focuses on the learning of reading skills among school children aged 10-14 in 11 African countries, utilizing data from the MICS6 survey. The standardized reading skills test is presented in Appendix I. During analysis, significant data missing in reading tests was detected. In the selected sample of children, 32 percent did not take the reading test. Half of these children were out-of-school, while the other half did not take the test either because their minority language was not available for the reading tests or due to refusal for unknown reasons. Since the majority of out-of-school children (99.6 percent of children who never attended school and 78.5 percent of school dropouts) did not take the reading test, the analysis is conducted only on the in-school children. However, even among the in-school children, there is a potential risk of selection bias. Inverse probability weighting (IPW) least square regressions are implemented by assigning higher weights to school children with similar family and individual characteristics as those who did not do the reading test. The study employs the percentage of school children with reading ability exceeding a threshold score of 0.85 as indicators of educational outcomes. This threshold is chosen because the distribution of reading test scores exhibits a large number of extreme values, with children either unable to read at all or proficient in reading.

The fourth paper estimates the sibling effect on school learning, particularly examining the sibling effect related to gender and disability status. The final school records of four main subjects reported by selected schools were reported in a survey conducted in Niamey, the capital city in Niger, and in the Ashanti region of Ghana in 2023. As national standardized tests are unavailable in this context, we normalize the school records using z-score techniques for each school subject at the class level. The non-parametric tests are first conducted by estimating Cohen's *d*s and running Kolmogorov-Smirnov (KS) tests as additional robustness checks to evaluate the sizes and significance of the treatment effects. Thereafter, random effect models are employed by analysing four school subject records from each child as a panel. Disability effects, sibling effects, and gender-related sibling effects across CWD and CWOD samples are estimated by using disability and sibling status as treatments.

3 Paper Summaries: Main Findings

This section provides a summary of the findings from the four papers discussed in Sections 3.1 to 3.4. Additionally, Section 3.5 highlights supplementary findings that emerged across these papers, offering a broader perspective on the themes and patterns identified in the study.

3.1 Paper 1: Disability Types and Children's Schooling in Africa

Despite international agreements promoting education for all, particularly for children with disabilities, there remains a significant gap in the evidence concerning their educational outcomes in the African context. Paper 1 seeks to address this gap by examining disparities in school access for children with disabilities (CWD) (RQ1) and the variations in access related to specific disability types—vision, hearing, physical, intellectual, and multiple disabilities—across eight African countries (RQ2). The analysis utilizes data from nationally representative household surveys conducted as part of the MICS surveys. The study employs the WG-CMF questionnaire set to categorize the various disability types, as outlined in Section 1.2.2.

This study introduces a novel approach by utilizing three indicators to measure the risk of school access among children across different age groups. We define three school enrolment indicators: Children below the age cut-off of ten[7] and not yet enrolled in school are categorised as "Young Not-Enrolled" (YoungNE), representing the risk of starting school late. Children above the age cut-off are classified as "Older Never-Enrolled"

[7] The age cut-off was set at ten, since of the first-grade children in the sample, 97.4 Percent are 10 years old or younger

(OlderNE), indicating the risk of never attending school. Lastly, children who were previously enrolled but are no longer attending school, despite not having completed compulsory junior high school, are categorized as “School Dropout” (Dropout), reflecting the risk of premature school departure.

The analysis not only confirms substantial gaps in school enrolment between CWD and CWOD, but also reveals varying effects on different groups of children with disabilities. Children with physical disabilities tend to experience a delayed school start but generally catch up over time. They do not show a significant risk of school dropout, suggesting that with time and support, they are able to remain enrolled and progress in their education. Children with intellectual disabilities do not face significant challenges in early school enrolment, but they experience notable difficulties as they grow older. This group shows an elevated risk of school dropout, highlighting the increasing challenges they face as the school years advance. Children with multiple disabilities face the most severe barriers to school enrolment at all stages. These children encounter persistent obstacles, making it harder for them to access education. The study underscores the importance of classifying disability types to better understand the varied educational needs of these children.

3.2 Paper 2: Numeracy skills learning of children in Africa: - Are disabled children lagging behind?

Paper 2 examines numeracy skills as an additional indicator of children's educational outcomes, drawing on MICS6 data from eight African countries. Using a standardized assessment, the study evaluates numeracy skills among children aged 7–14, focusing on disparities across countries and disability status (RQ 1), differences by disability type (RQ 2), and whether CWD benefit equally from national improvements in numeracy skills (RQ 3). The findings reveal consistently low overall scores, significant variations in average numeracy performance between countries, and enduring inequalities between CWD and CWOD.

The paper applies Instrumental Variable (IV) models to explore two mechanisms explaining the disparities between CWD and CWOD: differences in completed school years and variations in numeracy skill returns per completed year. The numeracy skill returns per completed year measure the additional numeracy skills children acquire after completing one year of schooling. Children with vision and hearing disabilities perform comparably to their non-disabled peers. Children with physical or intellectual disabilities exhibit a gap in numeracy scores. However, no significant disparity remains for children with physical disabilities in the country-fixed effects model, suggesting cross-country variations in the impact of physical disabilities on numeracy outcomes. Furthermore, the findings from the IV models indicate that the numeracy gap for children with physical or intellectual disabilities primarily stems from limited school attendance. Finally, children with multiple disabilities face compounded disadvantages, with both lower school attendance and diminished numeracy returns per school year, leading to the highest gaps in numeracy skills.

IV regressions conducted on split samples of low- and high-numeracy countries further underscore these patterns: children with vision, hearing, physical, or intellectual disabilities experience similar gains in numeracy skills as CWOD, whereas children with multiple disabilities have lower gains per completed year. Moreover, returns in numeracy skills per completed year are generally higher in high-numeracy countries compared to low-numeracy countries.

Combining the effects of school attendance and returns to schooling, the predicted mean numeracy scores for 14-year-old children with intellectual disabilities are 13 and 17 percentage points lower than those for CWOD in low- and high-numeracy countries, respectively. For children with multiple disabilities, the gap widens further, to 34 and 30 percentage points. By comparison, the predicted difference in numeracy skills for a 14-year-old CWOD between low- and high-numeracy countries is even higher, reaching approximately 40 percentage points. Moreover, CWD in higher-performing countries often outperform CWOD in lower-performing countries.

3.3 Paper 3: Disparity in School Children's Reading Skills in 11 African Countries

Paper 3 also utilises nationally representative data from the MICS6 surveys, incorporating new data from additional countries. Expanding upon the approach of Paper 2, it evaluates reading skills and disparities among school children aged 10-14 across countries, social groups, and children with different disability statuses (RQ 1), as well as disparities across disability types (RQ 2). The paper also investigates whether CWD benefits equally from national improvements in reading skills and how other socioeconomic factors interact with a disability to influence reading outcomes (RQ 3).

The study reveals consistently low overall reading proficiency with significant variations. Substantial disparities are observed among social groups and across countries. Children from poor families, families with lower educational levels, or rural areas experience lower reading skills compared to their peers from more advantaged backgrounds. Family income emerges as a strong predictor of reading skills, highlighting the need to address socioeconomic inequalities to improve educational outcomes.

Disparities across social groups are often more pronounced in countries with higher overall reading proficiency. For instance, differences between children from poor and non-poor families are most significant in mid-level proficiency countries like Ghana and Madagascar (23 percentage points), but negligible in low-proficiency countries such as the Central African Republic and The Gambia. Similar patterns emerge for urban-rural disparities, with gaps being largest in countries like Ghana (24 percentage points), Togo (22 percentage points), and Zimbabwe (21 percentage points), while remaining insignificant in several low-proficiency countries. Disparities between CWD and CWOD, however, are significant (ranging from 7 to 22 percentage points) across all 11 countries, as confirmed by the country group analysis.

Additionally, a cross-effect analysis between disability and other social factors (urban/rural residence, wealth index, and family educational attainment) reveals that disparities between CWD and CWOD remain relatively stable at approximately 15 percentage points across most social groups. These disparities are slightly higher in urban areas (19 percentage points) and among children from families with no schooling (21 percentage points). Due to sample size limitations, this cross-effect analysis combines all disability types into a single group. Encouragingly, the analysis shows that CWD benefits from improved socioeconomic conditions at rates generally comparable to CWOD.

3.4 Paper 4: Disability, Gender, and Sibling Impacts on Learning Outcomes in Ghana and Niger

Paper 4 investigates disparities in children’s overall academic performance based on disability status, using primary data collected in Ghana and Niger (RQ1). A unique aspect of this primary data is that it includes information about the siblings of children with disabilities (CWD) as well as the academic performance, measured by grades, of all classmates of the CWD. Additionally, the paper explores the influence of sibling relationships and examines how these dynamics interact with both disability and gender (RQ3). The study was conducted in the Ashanti region of Ghana and urban Niamey, Niger, which differ significantly in terms of socioeconomic development, fertility rates, and cultural contexts. Niger represents a country with extreme poverty, high fertility rates, and a patrilineal tradition. In contrast, Ghana, a middle-income country, has experienced a sharp decline in fertility rates in recent decades, with the survey area following a matrilineal tradition.

Based on the random effects models applied to pooled school subjects, Paper 4 first identified gender advantage for girls and a significantly lower performance gap among CWD compared to CWOD on academic performance in core subjects in both Ghana and Niger.

Despite growing interest in this area, research on how sibling relationships impact educational outcomes remains limited and mainly conducted in the developed context. To our knowledge, this is the first study to explore the sibling effect on children's learning performance in Africa, specifically concerning gender and disability. Drawing from theories and literature in developed contexts, the study investigates how siblings, sharing common resources and experiences, may influence each other’s education through both direct and indirect effects (Brody, 2004; Karbownik & Özek, 2023; Zang et al., 2023). The study finds no significant sibling effect on children’s school performance in Niger or among CWOD in Ghana, contrasting with evidence from more developed contexts.

Notably, the study reveals gender-specific sibling effects for CWD in Ghana: younger siblings negatively impact the performance of only girls with disabilities, while older sisters positively influence both boys and girls with disabilities. This gender bias persists despite Ghana’s lower fertility rates and its matrilineal tradition.

3.5 Summarizing Findings across Papers

While the four papers employ different educational indicators to measure children's educational outcomes, they reveal several comparable findings. These include insights into average learning skills across countries, disparities in learning outcomes among children with different types of disabilities, and the influence of various contextual factors and their interactions with children's disability status. This section examines these comparable findings in greater detail, addressing the key research questions of the study.

3.5.1 Educational Outcomes

Table 7 presents the mean numeracy skills test scores across 8 African countries and the mean proficiency rate of reading skills across 11 African countries, along with the gross and net primary school enrolment rates in these countries[8]. The average score of the numeracy skills tests among the eight African countries was only 57 out of a total score of 100, with Tunisia having the highest score at 87 and the lowest score recorded in DR Congo at 35 (***Paper 2***). The mean proficiency rate in reading skills among the 11 African countries was only 45 percent, with Tunisia recording the highest proficiency rate at 88 percent and Central Africa Republic (CAR) reporting the lowest at 18 percent (***Paper 3***).

[8] The gross and net enrolment rates for primary schools are obtained from the World Bank open data for the years proximate to the MICS6 surveys conducted in each respective country. Notably, primary net enrolment rates for DR Congo have not been reported by the World Bank in recent years.

Table 7 School enrolment and average numeracy and reading skills across countries

	Gross enrol-ment[1]	Year	Net enrol-ment[2]	Year	Primary Com-pletion[3]	Year	Numeracy skills[4] Mean score	Sample size	Reading skills[4] Mean (%)	Sample size	Year of survey
CAR	111	2017	66.3	2012	49	2017			17.8	1,080	2019
Chad	87	2019	73.2	2016	44	2021			21.2	1,548	2019
DR Congo	114	2018			83	2021	34.8	6,663	18.9	2,730	2017
Ghana	99	2017	86.2	2019	92	2022	69.0	4,914	47.0	2,916	2017
Lesotho	110	2017	93.3	2017	71	2023	67.0	2,708	58.4	1,568	2018
Madagascar	137	2018	95.6	2018	59	2022			51.2	2,477	2018
Malawi	127	2021	97.7	2009	87	2021			49.4	4,883	2020
Sierra Leone	122	2017	98.1	2016	95	2021	41.0	5,085			2017
The Gambia	86	2018	76.8	2018	76	2023	49.9	3,232	34.6	1,213	2018
Togo	123	2017	90.7	2018	89	2022	62.9	2,454	37.9	1,574	2017
Tunisia	106	2018	97.8	2013	97	2021	86.6	2,303	87.7	1,607	2018
Zimbabwe	97	2019	94.2	2013	86	2022	74.6	3,895	56.3	2,056	2019
Total							**56.5**	**31,254**	**44.7**	**23,652**	

1 The World Bank. School gross enrolment, primary (%); Https://data.worldbank.org/indicator/SE.PRM.ENRR
2 The World Bank. School net enrolment, primary (%); Https://data.worldbank.org/indicator/SE.PRM.NENR
3 The World Bank. School completion, primary (%); https://data.worldbank.org/indicator/SE.PRM.CMPT.ZS
4 Calculated from MICS6 survey data

Most of the countries analysed in this study report a primary gross enrolment rate close to or over 100. The primary gross enrolment rate is calculated based on all children enrolled in primary school, regardless of age, as a percentage of the official primary-school-age population. Therefore, the gross enrolment rate can exceed 100 percent. On the other hand, the primary net enrolment rate, which reflects the percentage of official primary-school-age children enrolled in primary school, is often unavailable for recent years and may not be reported annually. The primary school completion rate ranges between 44 and 97 percent in the studied countries.

While a general trend suggests that countries with higher primary net enrolment and completion rates tend to perform better in skills learning, these correlations are inconsistent. For example, Malawi and Sierra Leone both had a primary net enrolment rate of around 98 percent and high primary completion rates (87 and 95 percent), similar to Tunisia. Yet, Sierra Leone had mean numeracy skills score of only 41, and Malawi had an average reading skills proficiency rate of 49 percent, compared to mean score of 86.6 in numeracy skills and 88 percent in reading skills in Tunisia. Despite Ghana's lower primary net enrolment rate, its completion rate is as high as 92 percent, and its mean numeracy skills score of 69 is much higher than that in Malawi and Sierra Leone. Furthermore, despite very high school enrolment in Madagascar, the primary completion rate is very low at 59 percent, while the reading skills proficiency rate among children in school is relatively high, with an average score of 51 percent. There are also variations in different skills areas; for example, in Togo, although the mean numeracy skills score is 63, the proficiency rate in reading skills is only 38 percent.

3.5.2 Disability Types and Educational Outcomes

Table 8 presents the estimated gaps in educational outcomes between CWD and CWOD as reported in Papers 1–3, based on MICS survey data. All three papers examine disparities across children with various types of disabilities.

Table 8 Estimated gaps in school enrolment, numeracy, and reading skills across disability types[1]

	School Enrolment Gaps (Paper 1)[2]			Numeracy Skills (Paper 2)		Reading Skills (Paper 3)[6]
	YoungNE[3]	**OlderNE[3]**	**Dropout[3]**	**Disability Gap in Numeracy Skills[4]**	**Return to each completed school year[5]**	**Disability Gap in Reading Skills**
CWOD					0.146***	
Vision disability	Non-Sig	Non-Sig	Non-Sig	Non-Sig	0.147***	Non-Sig
Hearing disability	Non-Sig	Non-Sig	Non-Sig	Non-Sig	0.143***	0.105* ~0.145**
Physical disability	0.033 ~0.066***	Non-Sig	Non-Sig	0.019 ~0.068***	0.151***	Non-Sig
Intellectual disability	Non-Sig	0.008 ~0.027***	0.026*** ~0.038***	0.072*** ~0.109***	0.145***	0.150*** ~0.157***
Multiple disabilities	0.191*** ~0.212***	0.235*** ~0.245***	0.072*** ~0.109***	0.205*** ~0.213***	0.121***	0.128* ~0.174***

Significance levels: * $p<0.10$; ** $p<0.05$; *** $p<0.01$

1 All the gaps between children with various types of disability and CWOD are negative but only differences are presented in this table
2 Gaps measured as differences in school enrolment rates
3 YoungNE: Young Not-Enrolled; OlderNE: Older Never-Enrolled; Dropout: school dropout
4 Gaps measured as differences in percentage points of numeracy test score
5 Percentage points in numeracy test score gained by one more completed school year
6 Gaps measured as the proportion of children with satisfactory reading skills. Note that Paper 3 is based only on children enrolled in school

Findings by Disability Type:

- **Vision Disability:** Children with vision disabilities show no significant lag in school enrolment, numeracy skills, or reading skills proficiency.
- **Hearing Disability:** While children with hearing disabilities do not lag in school enrolment or numeracy skills, they exhibit a 10.5–14.5 percentage point deficit in reading skills proficiency.
- **Physical Disability:** Children with physical disability are 3.3–6.6 percentage points less likely to start school before the age of 10 but eventually enrol later at similar rates as CWOD. While they achieve numeracy skill gains comparable to CWOD for each completed school year, they are at risk of lower overall numeracy skills due to fewer completed school years. No significant gaps in reading skills proficiency are observed among children with physical disabilities.
- **Intellectual Disability:** Although children with intellectual disabilities begin school at similar ages as CWOD, a significantly higher proportion of them (0.8–2.7 percentage points) never attend school. They are also 2.6–3.8 percentage points more likely to drop out. Like children with physical disabilities, they gain numeracy skills at rates comparable to CWOD for each completed school year but face an overall numeracy skills gap of 7.2–10.9 percentage points due to fewer years of schooling. The gap in reading skills proficiency is larger for this group, estimated at 15–15.7 percentage points.
- **Multiple Disabilities:** Children with multiple disabilities face the highest risk of exclusion from education, with school attendance gaps of 19.1–21.2 percentage points in early age, a 24-percentage-point gap in later school enrolment, and a dropout rate 7.2–10.9 percentage points higher than their peers. They acquire numeracy skills significantly more slowly (2.5 percentage points lower per completed school year) and exhibit an overall lag of about 21 percentage points in numeracy skills. Among those enrolled, children with multiple disabilities experience reading skill deficits of 12.8–17.4 percentage points.

3.5.3 Contextual Factors and Intersection with Disability

Table 9 highlights selected findings from Paper 3, focusing on disparities in reading skills proficiency among children from various disadvantaged groups. These include CWD, children from low-income or less-educated families, and those residing in rural areas. The findings reveal that CWD faces notable challenges, with an estimated overall gap of 13.1–16.9 percentage points in reading skills proficiency compared to CWOD. Urban children outperform their rural counterparts in reading skills proficiency, with an advantage of 9 to 22.5 percentage points. Similarly, children from families with stronger economic standing exhibit higher reading proficiency. Compared to the poorest families in the lowest wealth quintile, children in the second quintile show a 4.4–5.9 percentage point advantage, while those in the highest wealth quintile demonstrate a substantially higher proficiency by 25.7–36.7 percentage points. Finally, children from families where the highest educational attainment is senior secondary or higher outperform those from families with no schooling by 8.5 to 21.1 percentage points.

Table 9 Estimated gaps in reading skills proficiency across different social groups

Estimated gaps in reading skills proficiency (Paper 3)	Pooled Sample
CWD VS. CWOD	-0.169*** ~ -0.131***
Rural VS. Urban	-0.225*** ~ -0.090***
Wealth index	
Second VS. Lowest quintile	0.044*** ~ 0.059***
Middle VS. Lowest quintile	0.076*** ~ 0.109***
Fourth VS. Lowest quintile	0.145*** ~ 0.209***
Highest VS. Lowest quintile	0.257*** ~ 0.367***
Family Education	
Primary VS. No school	0.033*** ~ 0.059***
Junior secondary VS. No school	0.098*** ~ 0.210***
Senior secondary or higher VS. No school	0.085*** ~ 0.211***

Significance levels: * p<0.10; ** p<0.05; *** p<0.01
Gaps are measured as the proportion of children with satisfactory reading skills.

Furthermore, Papers 2 and 3 examine disparities in skill acquisition between children with and without disabilities across countries with varying national levels of basic skill proficiency. Table 10 presents the estimated gaps in annual returns to numeracy skills, defined as the additional numeracy skills gained with each completed year of schooling. The results are based on split samples of countries, categorised into low-numeracy and high-numeracy skill groups, as reported in Paper 2.

Table 10 Estimated gaps in return to numeracy skills by disability status

	Return to numeracy skills per each completed school year[1]	
	Low-numeracy skills country	High-numeracy skills country
Children without disabilities	0.132***	0.155***
Physical disability	0.141***	0.166***
Intellectual disability	0.138***	0.148***
Multiple disabilities	0.107***	0.129***

Significance levels: * p<0.10; ** p<0.05; *** p<0.01
1 Percentage points in numeracy test score gained by one more completed school year

Table 11 presents the estimated gaps in reading proficiency among various groups, including children from poor and non-poor families, children from families with and without schooling, urban and rural children, and children with and without disabilities, as reported in Paper 3. The results are disaggregated and compared across country groups categorised by low, mid, and high levels of reading proficiency.

Table 11 Estimated gaps in reading skills proficiency in social groups

	Low-reading skills country	Mid- VS. Low-reading skills country	High- VS. Low-reading skills country
Poor VS. Non-poor	-0.043***	-0.083***	-0.045*
No school VS. Other	0.054***	-0.083***	-0.045*
Urban VS. Rural	-0.043***	Non-Sig	-0.117***
CWD VS. CWOD	-0.131***	Non-Sig	Non-Sig

Significance levels: * p<0.10; ** p<0.05; *** p<0.01
Gaps are measured as the proportion of children with satisfactory reading skills.

Paper 2 utilises an instrumental variable (IV) model to estimate the returns to numeracy skills in split samples of CWOD and children with specific disability types. This approach assumes that annual returns to numeracy skills vary across children with different types of disabilities, making it impractical to conduct such estimations in a pooled sample encompassing CWOD and all disability types. In contrast, Paper 3 estimates the differences in reading skills proficiency between CWD and CWOD without disaggregating by specific disability types. Due to sample size limitations among children with specific disability types across country groups, cross-country group analyses in Paper 3 aggregate all disability types and do not provide separate estimates for individual disability categories.

The findings from Paper 2 indicate that children with physical and intellectual disabilities benefit more from education in high-numeracy-skill countries, achieving higher numeracy skill gains per completed school year compared to their counterparts in low-numeracy-skill countries. Similarly, while children with multiple disabilities exhibit lower average numeracy skill gains in both contexts, they still achieve an additional 2.2 percentage points per completed school year in high-numeracy-skill countries compared to those in low-numeracy-skill countries[9].

Paper 3 findings presented in Table 11 for children in low-reading-skill countries align with those summarised in Table 9 for the pooled sample. These results highlight significant disparities in reading skills proficiency among disadvantaged groups. Specifically, children from poor families lag by 4.3 percentage points, rural children by 7.5 percentage points, and CWD by 13.1 percentage points, compared to their counterparts from non-poor families, urban areas, and CWOD. An exception is observed among children from no-school families, where parents' education does not significantly influence children's reading skills proficiency in low-reading-skill countries.

In mid-reading-skill countries, compared to low-reading-skill countries, the gap between children from poor and non-poor families increases by 8.3 percentage points, and the disparity between children from no-school and educated families widens by 16.3 percentage points. However, the urban-rural gap and the gap between CWD and CWOD remain unchanged.

In high-reading-skill countries, relative to low-reading-skill countries, the gap between children from poor and non-poor families expands by 4.5 percentage points. In comparison, the disparity between children from families with none of the family members ever in school and families with educated members increases by 10.2 percentage points. Additionally, the urban-rural gap grows by 11.7 percentage points. Yet, the gap between CWD and CWOD does not significantly differ across low-, mid-, and high-reading-skill country groups.

Table 12 summarizes the key findings from Paper 4, which examines sibling effects on school performance among CWD and CWOD based on average scores across three core school subjects in Ghana and Niger.

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[9] Due to limitations in sample size, the split-sample analysis for children with vision and hearing disabilities in low- and high-numeracy skill countries was not conducted.

Table 12 Estimated gaps of average scores in three main school subjects across sibling and disability status

Estimated gaps in average score in three main school subjects (Paper 4)		Ghana	Niger
Disability effect	CWD vs. CC	-0.184***	-0.357***
	CWD vs. CWOD	-0.301*** ~ -0.332***	-0.424*** ~ -0.446***
Sibling effect (VS. No sibling) (CWOD)	Sibling effect	Non-Sig	Non-Sig
	Older brother		
	Older brother##Girl		
	Older sister		
	Older sister##Girl		
	Younger sibling		
	Younger sibling##Girl		
Sibling effect (VS. No sibling) (CWD)	Older brother	Non-Sig	
	Older brother##Girl	Non-Sig	
	Older sister	0.359** ~ 0.373**	
	Older sister##Girl	Non-Sig	
	Younger sibling	Non-Sig	
	Younger sibling##Girl	-0.759** ~ -0.673**	

Significance levels: * $p<0.10$; ** $p<0.05$; *** $p<0.01$
Gaps are measured as standard deviations of average scores.

First, the disparities in academic performance between CWD and CWOD are highlighted. CWD performed 0.3–0.33 standard deviations below their non-disabled peers in Ghana and 0.42–0.45 standard deviations lower in Niger. Additionally, the analysis estimates the performance gap between CWD and their counterfactual classmates—defined as the other students in the same classes who were not part of the survey sample. Using school records collected for all students in the visited classes, the study estimates these gaps to be 0.18 standard deviations in Ghana and 0.36 standard deviations in Niger.

No sibling effect is found either in Niger or among CWOD in Ghana. However, in Ghana, among CWD, there is a positive sibling effect with older sister. That means that CWD with older sister performs 0.22-0.37 standard deviations higher in school performance than CWD without older sister. The positive sibling effect has no significant differences between CWD boys and CWD girls. Furthermore, there is a negative sibling effect with younger siblings, meaning CWD with younger siblings performs worse in school performance. However, the result is not stable.

No sibling effect is identified either in Niger or among CWOD in Ghana. However, in Ghana, a positive sibling effect is observed among CWD who have an older sister. Specifically, CWD with an older sister performs 0.22-0.37 standard deviations higher in school performance compared to CWD without an older sister. This positive sibling effect does not significantly differ between CWD boys and girls. Conversely, the presence of a younger sibling is associated with a negative sibling effect exclusively for girls with disabilities, whereas this effect is not observed among boys with disabilities.

3.5.4 Role of Gender

Gender has been incorporated as an explicit control variable in all the regression results of the four papers. In both Paper 1 and Paper 2, no significant gender effects on school enrolment and acquisition of math skills are identified. Consequently, the gender effects are not explicitly addressed in these two papers. Paper 3 indicates a four-percentage point advantage for girls in reading skills proficiency in almost all models. However, as splitting the sample by both disability and gender can lead to relatively small samples, especially at the country level, which limits statistical power. Therefore, gender was only included as a control variable in a pooled sample of all children in the study countries, and the interaction of gender with disability was not explored in Papers 1, 2, and 3.

Only Paper 4 specifically estimated the gender effect on school performance and analysed the interaction between disability and gender effects. The findings of Paper 4 suggest a notable gender advantage for girls, amounting to 0.21–0.22 standard deviations in Niger, whereas no such gender-based advantage is found in Ghana. Furthermore, as discussed in Section 3.5.3, while the results do not indicate any sibling effects across gender in Niger, a significant positive effect of older sisters on the school performance of CWD and a negative effect of younger siblings on the school performance of girls CWD were found in Ghana.

4 Discussion

The four papers in this study collectively contribute to understanding the persistent disparities and underlying contextual factors that hinder access to equitable educational outcomes—specifically school enrolment, numeracy and reading skills acquisition, and overall school performance—among children from disadvantaged backgrounds (including those from poor or less educated families, rural areas, or with disabilities) in the African context. Grounded in the ICF framework of disability, the conceptual framework of this thesis focuses on three components: ensuring children's full **participation** in equitable and quality education (4.1 Educational Outcomes and Disparities); understanding the limitations to education associated with different types of **impairment** (4.2 Educational Disparities across Disability Types); and assessing the impact of **contextual factors** (4.3 Intersection of Disability and Contextual Factors on Education).

4.1 Educational Outcomes and Disparities

The first research question of this thesis is to assess the heterogeneity in children's educational outcomes in multidimensional perspectives within and across African countries. This is assessed through four key indicators: school enrolment, numeracy skills, reading skills, and overall academic performance across core school subjects, as utilised in the four papers of this study.

National statistics and results from this study across 12 African countries reveal substantial inconsistencies between high primary enrolment rates, low completion rates, and varied national numeracy and reading skills levels, as presented in Section 3.5.1. These inconsistencies, in line with UNESCO's (2022) observations on the exceptionally low primary completion rate in sub-Saharan Africa, are partially attributable to poor numeracy and reading skills, as reported in this study. Despite the rapid expansion of Universal Basic Education across African countries, the overall numeracy and reading skills among African children remain alarmingly low, with huge variations across countries and social groups. These findings echo studies (UNESCO, 2016; Johnson, 2008; World Bank, 2018) that point to a disconnect between school expansion efforts and actual skill acquisition in many African nations. For instance, countries such as Malawi and Sierra Leone demonstrate alarmingly low basic skill levels despite high enrolment and completion rates, highlighting concerns about school quality. In contrast, Ghana and Madagascar report comparatively stronger skill performance, even without high school enrolment or completion rates. As supported by findings from Lewin (2009) and Nkrumah and Sinha (2020), this study confirms that primary school enrolment alone is an insufficient measure of educational progress in African contexts.

The MICS surveys test basic numeracy and reading skills, as shown in Appendix I. Alarmingly, both my study and UNICEF (2022) reveal very low skill levels in these African countries. For numeracy, UNICEF (2022) defines foundational skills as answering all four tasks correctly, with only 17% of children meeting this standard. Paper 2 instead measures the average number of correct answers out of 21 questions, showing that children aged 7–14 in eight African countries answered just over half correctly on average. For reading, UNICEF (2022) considers children proficient if they recognise 90% of words and answer all five comprehension questions correctly, with 32% of CWOD meeting this standard. Paper 3 uses a less strict measure, counting children scoring over 85% as proficient. For instance, recognising 90% of words and answering four out of five questions qualifies as proficient. Using this method, Paper 3 finds that 44.7% of children aged 10–14 in 11 African countries are proficient, though only 17.8% meet this level in the lowest-performing country.

Another notable distinction between the UNICEF report and my study is the age group reported for reading skills. MICS6 surveys administer two reading tests: a simpler version for younger children aged 7–9 and a more advanced test for children aged 10–14. My study focuses exclusively on the latter age group, analysing results from the advanced test, while UNICEF (2022) combines results from both tests and age groups.

It is important to note that the reading test predominantly assessed children enrolled in school, resulting in a biased sample, as most out-of-school children were excluded from the MICS6 surveys. This limitation likely overestimates overall reading proficiency. However, even among tested children aged 10–14—who are expected to have attended school for several years—less than half achieved satisfactory reading proficiency, despite the relaxed criteria used in my study.

Tunisia, the sole North African country included in the sample, demonstrates significantly better performance compared to other countries. Tunisian children achieved an average score of 86.6% on the numeracy test, with 87.7% meeting the criteria for satisfactory reading proficiency. These results probably indicate a comparatively decent level of foundational skills among children in this age group.

Despite differences in age groups, criteria, and calculations for reporting numeracy and reading skills between the UNICEF report and my study, the findings are largely consistent. Both studies highlight stark disparities and the generally low quality of schools in skill acquisition across African countries. These results provide robust empirical evidence for the hidden learning crisis highlighted in the 2018 World Development Report.

4.2 Educational Disparities across Disability Types

This study examines challenges and disparities in educational outcomes for children with different functional difficulties, addressing the second research question. It tackles a critical gap highlighted by the International Centre for Evidence in Disability, which noted the lack of high-quality evidence in this area (Kuper et al., 2018). Existing studies often face issues like small sample sizes for CWD, inconsistent definitions of disabilities, and varied measurement methods (Loeb & Eide, 2006).

To address these challenges, the WG-CFM has been used across all MICS6 surveys to consistently measure disability, ensuring standardised definitions and enabling cross-country comparisons. By pooling data from multiple countries, this study builds a robust sample of CWD, allowing an analysis of how different types of impairments affect educational outcomes. This approach overcomes sample size limitations in individual studies and provides strong evidence of educational disparities among CWD in the region.

A recent UNICEF report (2022) used a similar approach to this study, comparing children’s skill learning outcomes across multiple African countries using standardised MICS tests. Both studies use the same MICS data, and the UNICEF report has a broader focus.

Several distinctions are critical for interpreting our different results from UNICEF (2022). Unlike UNICEF (2022), our study classifies multiple children with one or more than one functional difficulty as having multiple disabilities. Consequently, vision, hearing, physical, and intellectual disabilities in this study are confined exclusively to these specific domains without significant challenges in other areas. This narrower definition may partly explain the higher incidence of difficulties in various educational outcomes reported by UNICEF (2022) compared to my findings. Furthermore, it is important to note that all findings from UNICEF (2022) in the following sections are based on global estimates, while my findings are specific to the African countries included in the analysis.

Other cross-country comparison studies frequently focus on readily available education indicators, such as school enrolment rates. Table 13 lists several studies that have undertaken cross-country comparisons of children's educational outcomes. However, apart from the UNICEF (2022) report, these studies often rely on data from various sources that use differing methods to measure children's disability status. For instance, while Mizunoya et al. (2018) attempted to select surveys employing the WG-SS, many surveys had altered the standard questions to varying degrees. Kuper et al. (2014) conducted multinational surveys that relied on a single self-reported question to identify disability status, which carried a risk of underreporting and provided no information about specific types of disabilities.

Table 13 Literature of cross-country comparison studies on educational outcomes

	Data sources	Countries	Countries included in this study	School outcome indicators	Disability types reported
Filmer (2008)	14 survey data collected 1992-2004	13 developing countries	Chad	Current school enrollment (6-17 years)	None
Gottlieb et al. (2009)	Third round of MICS survey data between 2005-2006	18 countries with low and middle incomes	Central African Republic, Ghana	School attendance (6-9 years)	None
Ilie and Rose (2016)	Demographic and Health Surveys (DHS) 2007-2014	35 low- and middle-income countries in sub-Saharan Africa and South Asia	DRC, Ghana, Gambia, Lesotho, Malawi, Madagascar, Sierra Leone, Togo, Zimbabwe	Higher education net attendance rate (below 25)	None

UNESCO (2018)	DHS, School-to-Work Transition Surveys (SWTS), and population census 2005-2015	49 countries in Africa, Asia, Latin America and the Caribbean, Europe and Northern America	DRC, Ghana, Madagascar, Malawi, The Gambia, Togo, Tunisia	School attendance and completion rate for primary and lower secondary level; Mean years of schooling (25+); Adult literacy rate	None
Mizunoya et al. (2018)	Surveys used WGSS (selected from 2500 surveys) 2005-2013	18 surveys in 15 developing countries	Malawi	Primary and secondary school attendance rate	None
Luo et al. (2020)	8 population censuses that used WGSS 2006-2011	8 developing countries	None	Adjusted net attendance and completion rate at primary, lower secondary, upper secondary level	Hearing, seeing, mobility remembering, concentrating, self-care
Kuper et al. (2014)	Own survey with participants in the Plan International Sponsorship Programme in 2012	30 countries in Africa, Asia, and South America	Zimbabwe	School attendance at primary and secondary level	Hearing, vision, physical, learning, and communication
UNICEF (2022)	MICS, 2017-2021	36 developing countries	All except Malawi	School enrolment, numeracy and reading skills, use of communication technology, parental involvement, education support	All 12 functional domains

Earlier cross-country studies have consistently reported lower school attendance (Filmer, 2008; Mizunoya et al., 2018; Luo et al., 2020; Kuper et al., 2014), lower school completion rates, and higher dropout rates among children with disabilities (UNESCO, 2018; Luo et al., 2020). ***Paper 1*** of this study corroborates these findings. Moreover, it emphasises the critical need to understand the distinct challenges faced by children with different functional difficulties.

Apart from UNICEF (2022), only two cross-country studies (Luo et al., 2020; Kuper et al., 2014) have examined the effects of different types of disabilities. However, neither study included children with multiple disabilities as a separate category. Luo et al. (2020) found that children with self-care and remembering difficulties had the lowest school enrolment and completion rates, while Kuper et al. (2014) identified physical disabilities as the greatest barrier. Both studies reported relatively smaller challenges in school attainment for children with vision and hearing difficulties, consistent with Paper 1. However, UNICEF (2022) noted much higher out-of-school rates for children with vision and hearing disabilities compared to CWOD. The school enrolment indicators used in this study differ from those in UNICEF (2022), limiting direct comparisons.

One limitation of this study is the small sample size for children with vision and hearing difficulties, which reduces statistical power and increases variability. Despite the MICS survey's large-scale, nationally representative design, children with low-incidence disabilities remain underrepresented. Among 44,532 children sampled in the eight countries in Paper 1, only 10–61 children per country (0.2–1.5%) were reported to have significant seeing difficulties, and 6–25 children per country (0.1–0.6%) had significant hearing difficulties. Cases of complete blindness or deafness were even rarer. UNICEF (2022) similarly estimated global prevalence rates of 0.3% for hearing difficulties and 0.5% for seeing difficulties, closely aligning with this study's findings.

Global prevalence estimates vary. Yekta (2022) reported that blindness among individuals under 20 years old was 0.17%, with visual impairment ranging from 1.67% to 7.26%. Stevens et al. (2013) found hearing impairment in 1.4% of children aged 5–14. These diagnostic estimates highlight likely underreporting in the MICS data, which rely on parents' observations. Parents may either fail to recognise their children's seeing or hearing difficulties or report them as having multiple functional challenges. In such cases, these children are categorised as having multiple disabilities.

This PhD study utilises three indicators of school attendance to highlight that different functional difficulties are associated with distinct challenges in accessing school at various stages. For instance, transportation barriers and environmental obstacles within schools or classrooms pose significant challenges for children with physical disabilities, particularly when they are young and beginning school, as reported in ***Paper 1***. However, their enrolment rates tend to catch up with those of older children, and they face a lower risk of dropping out, provided they manage to start school. It is important to note that in highly inaccessible environments, children with physical disabilities may be enrolled but struggle to attend school regularly. Since this study does not register daily school attendance, it cannot fully capture these attendance constraints, which may ultimately impact their skill acquisition.

In contrast, ***Paper 1*** also suggests that children with intellectual disabilities may not face substantial challenges related to mobility or transportation but often struggle to keep up with learning tasks over time. These children typically start school at the same age as children without disabilities (CWOD), but stigma and frustration can accumulate, especially for those with difficulties in learning, remembering, concentrating, and communicating. This increases their risk of dropping out, with some never attending school at all. Finally, children with multiple functional difficulties encounter compounded barriers. They are more likely to delay school entry, drop out early, and face a significantly higher risk of never attending school.

Furthermore, our study provides new evidence on the often-overlooked disparities in skills learning. ***Paper 2*** explores two key mechanisms driving disparities in numeracy skills: differences in completed years of schooling and variations in numeracy skill acquisition per completed year. While UNICEF (2022) found that 4–15% of children with various functional difficulties demonstrated foundational numeracy skills compared to 17% of children without disabilities (CWOD), Paper 2 reported no significant difference in the mean numeracy scores between CWOD and children with vision difficulties. This finding aligns to some extent with UNICEF (2022), which highlighted children with vision difficulties as the group performing best among CWD, with 15% attaining foundational numeracy skills compared to 17% of CWOD. However, UNICEF (2022) did not report foundational numeracy skills specifically for children with hearing difficulties.

Paper 2 identifies poorer performance in numeracy skills among children with physical and intellectual disabilities, largely attributed to fewer completed school years. Children with intellectual disabilities performed worse than those with physical difficulties due to their dual disadvantages: a higher likelihood of never enrolling in school and a greater risk of dropping out. Nevertheless, for children with intellectual disabilities who do attend school, their learning progress per completed year is comparable to that of CWOD. UNICEF (2022) similarly reported that only 4–7% of children with concentrating, learning, and communicating difficulties and only 5–6% of children with walking or self-care difficulties achieved foundational numeracy skills.

Paper 2 highlights the compounded disadvantages faced by children with multiple disabilities. These children experience both reduced school attendance and lower returns in numeracy skills despite attending school. Their gap in numeracy skills score is approximately 21 percentage points, compared to gaps of 7.2–10.9 percentage points for children with intellectual disabilities.

My studies further report the gaps in reading skills between CWD and CWOD by disability types in ***Paper 3***. The paper finds that children with vision difficulties do not significantly lag behind in reading skills, which aligns with UNICEF (2022), reporting that 31% of children with vision difficulties, compared to 32% of children without disabilities (CWOD), achieved foundational reading skills. Children with hearing difficulties are reported to lag by 10.5-14.5 percentage points in reading skills in this study, which is not reported in UNICEF (2022). Additionally, ***Paper 3*** does not report a significant lag in reading skills for children with physical disabilities, while UNICEF (2022) identifies a notable difference. This discrepancy may be attributed to several factors. First, as previously discussed, the two studies follow slightly different criteria for defining reading proficiency. Second, this study focuses exclusively on children aged 10-14 using the same reading test, whereas UNICEF (2022) includes findings for both younger children (aged 7-9) and older children. As highlighted in ***Paper 1***, children with physical disabilities are more likely to start school later. Consequently, younger children with physical disabilities may experience a larger deficit in reading skills, which they may gradually overcome in later years.

Finally, ***Paper 3*** reports a gap in reading skills proficiency for children with multiple disabilities ranging from 12.8 to 17.4 percentage points, and for children with intellectual disabilities, the gap ranges from 15.0 to 15.7 percentage points, compared to CWOD. Both this study and UNICEF (2022) likely underestimate the disparities in reading skills, as the reading tests are only administered to children enrolled in school, excluding out-of-school children in many countries. This exclusion does not apply to the numeracy test, which is administered to all children, regardless of their school status. Furthermore, since participation in both the numeracy and reading tests is voluntary, many children refuse to take the reading test for unreported reasons. Children with disabilities are notably over-represented among both out-of-school children and those who refused to take the reading tests, suggesting that the true gap in reading skills for children with disabilities may be even larger.

The key implication and contribution of this study is to highlight that the effects of different functional disabilities on children's skill learning outcomes can be highly heterogeneous. This underscores the importance of tailoring school adjustments and interventions to the specific needs of children with different functional difficulties, ensuring equitable access to education for all children.

4.3 Intersection of Disability and Contextual Factors on Education

To achieve the objective of "Education for All" and foster equitable education for children from disadvantaged backgrounds, it is imperative to gather empirical evidence on various factors influencing children's educational outcomes at the country, household, and individual levels, as highlighted in the third research question. This evidence is crucial for designing effective programs, planning interventions, and implementing policies aimed at promoting equitable access to education. As discussed in the literature review section, the extensive evidence from developed contexts may not be directly applicable to developing contexts. Therefore, it is crucial to establish empirical evidence of both personal and household-level factors and environmental factors on the acquisition of basic skills learning among CWD in Africa. This study represents an initial effort to explore these factors.

Paper 2 examines the numeracy skills performance across high- and low-performing country groups and reveals that between-country gaps in numeracy skills exceed the within-country disparities between CWD and CWOD. Notably, CWD in high-performing countries demonstrates better numeracy skills than CWOD in low-performing countries, underscoring the critical influence of national educational contexts. The findings highlight that CWD benefits significantly from both increased school enrolment and broader national improvements in numeracy skills. These results emphasize the dual necessity of prioritizing school access for CWD and enhancing overall school quality to improve educational outcomes for this group in African countries.

Similar findings are presented in ***Paper 3***, which studied disparities in reading skills proficiency between CWD and CWOD in a split sample of high-, mid-, and low-performing countries. The result reveals the consistency of disparities in reading skills between CWD and CWOD across all three country groups, despite socioeconomic development and improvements in national reading skills. This finding reinforces the conclusion from ***Paper 2***: CWD benefit from national improvements in skills development similar to CWOD.

Together, these findings highlight the importance of raising overall national numeracy and reading skills to promote children's educational outcomes. However, while national improvements can enhance learning outcomes, they have not resolved the substantial and persistent gaps in skills acquisition between CWD and CWOD.

Furthermore, my PhD study explores the role of micro-level factors on children's skills learning. Research on disparities in children's learning outcomes in African contexts has extensively explored the influence of gender, socioeconomic status, and urban-rural divides (Zhang, 2006; Clercq, 2020; Chmielewski, 2019). These factors are also commonly examined in cross-country studies on children's reading performance (León, 2022; Chiu and McBride-Chang, 2010). However, these cross-country studies primarily focus on developed countries or a broad range of global contexts, leaving a gap in understanding how contextual factors affect learning outcomes in African countries specifically. This study appears to be the only cross-country analysis examining the effects of contextual factors on children's reading skills within African contexts.

Paper 3 reveals significant disparities in reading skills for children from disadvantaged backgrounds, including those from rural areas, poor households, and families with limited education. Crucially, these gaps across social groups tend to widen as national reading skills improve—a pattern distinct from the consistent gaps observed between CWD and CWOD across different country groups, as discussed in RQ3. For instance, compared to low-performing countries, disparities in reading skills between children from poor and non-poor families, as well as those from families with and without schooling backgrounds, are more pronounced in high-performing countries and largest in mid-performing countries. Urban-rural disparities are particularly significant in high-performing countries. These widening disparities underscore the need for targeted interventions to address inequities extending beyond disability status.

While several studies have highlighted the dominant effect of disability on children's schooling, often surpassing the impact of other individual and household factors (Filmer, 2008; Mizunoya et al., 2018), ***Paper 3*** delves deeper into the interplay between micro-level factors and disability in shaping educational disparities in African contexts. It underscores the unique challenges faced by CWD, which are not fully mitigated by broader social improvements. Similar to findings related to national development in RQ3, while CWD can benefit from favourable social conditions and make progress comparable to their peers, a persistent skills gap between CWD and CWOD remains.

Finally, ***Paper 4*** examines the interplay between gender and disability in shaping educational outcomes in Ghana and Niger, revealing mixed effects. Prior research underscores the significance and mixed gender effect in the educational experiences. For instance, UNESCO (2018) reports that women with disabilities in developing contexts derive fewer benefits from education than men, while Luo et al. (2020) highlight higher school attendance and completion rates among girls compared to boys. ***Paper 4*** identifies a general advantage for girls in school performance in Niger, where socio-economic constraints are more pronounced. However, among CWD this "girl advantage" is absent in Niger,

The current literature on the educational outcomes of CWD has largely focused on the roles of teachers and parents, with limited attention to the influence of peer relationships on their school opportunities. ***Paper 4*** addresses this gap by exploring sibling effects on school performance and uncovering significant contextual differences. Among children without disabilities (CWOD), no significant sibling effect was observed in both countries, suggesting minimal gender bias and limited familial influence on education in extremely impoverished African settings. This finding contrasts with studies in developed contexts, where familial and gender-based influences on education are more pronounced (Conley, 2008; Yi et al., 2015; Parman, 2015).

A notable divergence emerges when comparing Ghana, a middle-income African country with low fertility rates, and Niger, a low-income fragile economy with high fertility rates. Gender bias in sibling effects is evident only for CWD in Ghana but not in Niger. Interestingly, older sisters consistently benefit CWD, regardless of the CWD's gender, suggesting that sibling dynamics may help mitigate educational disparities. Conversely, in Ghana, CWD girls with younger siblings face heightened risks of poor school performance, indicating that macroeconomic development may exacerbate disparities for girls with disabilities.

Bhalotra and Heady (2003) found that children from land-rich households are at greater risk of child labour and school exclusion, while CWD, often unable to participate in labour, are more likely to attend school. In such contexts, educational disparities between CWD and CWOD may be narrower. However, as African countries expand educational access and experience economic growth, the dynamics shift. School expansion is likely to reduce child labour, creating more opportunities for CWOD. Yet, as societal recognition of education's value grows and economic resources remain constrained, disparities in school enrolment and performance between CWD and CWOD may widen. These findings emphasize the complex interaction between macroeconomic development, household dynamics, and individual characteristics in shaping educational outcomes for CWD.

These findings offer valuable empirical evidence regarding the critical role of specific environmental factors in shaping the learning outcomes of children with disabilities. Furthermore, our study highlights the necessity of adopting a learner-centred approach to promote inclusive education within African countries. Tailored strategies must address both disability-specific barriers and broader social inequities to ensure equitable learning opportunities for all children.

4.4 Limitations

It is important to recognize important limitations in my four papers on educational disparities among children in African countries.

There are inherent challenges associated with secondary data analysis (Smith, 2008), as exemplified in this doctoral study. The research relies heavily on data from the Multiple Indicator Cluster Surveys (MICS), originally designed for broader purposes, primarily to provide internationally comparable data on the conditions of children and women in developing countries. While education is a key focus of the MICS surveys, they are not specifically tailored to CWD. As a result, the nationally representative sample design, combined with the low proportion of CWD in the general population, presents significant limitations related to sample size. Furthermore, survey questions—designed to address more general objectives—may not comprehensively capture all aspects relevant to this research. These limitations are elaborated in this section.

First, it is important to note that secondary data analysis shares many of the challenges faced by primary data collection and qualitative studies in the field of disability research. For instance, data quality often relies on respondents' self-reports or the perspectives of proxies such as parents, caregivers, or teachers. These perspectives may not fully align with the lived experiences of CWD. Parents, for example, may interpret their children's functional challenges differently than the children themselves (Ólafsdóttir et al., 2019), and stigma may result in underreporting of disabilities (Cox & Marshall, 2020). In the context of secondary data, researchers have limited control over the data collection process, making such challenges more pronounced. Nevertheless, MICS surveys, coordinated by UNICEF and implemented across more than 100 countries, have established rigorous standards and extensive experience, contributing to a generally high level of data quality, albeit with some country-specific variability.

The second data constraint arises from the limited sample size per disability type. Despite the MICS6 survey's effort to interview a large number of nationally representative households, its design does not specifically target disability studies, resulting in inadequate sample sizes for specific disability groups. While this study attempts to leverage MICS6 data by pooling information from multiple countries to generate a larger CWD sample, this approach is insufficient for analysing disability effects within individual countries or for specific disability categories. Similarly, the EVID project survey data in Ghana and Niger face challenges in analysing the heterogeneous effects of disability types due to constrained sample sizes of CWD. This limitation often leads to treating disability as a broad, catch-all category, hindering the ability to capture the full spectrum of disability experiences.

The third constraint is the omission of out-of-school children from the analyses of skill acquisition, which represents a notable gap in understanding educational disparities. For example, the MICS6 reading test is not administered to out-of-school children in many countries, requiring Paper 3 to rely on reading skill proficiency data exclusively from children enrolled in school. A similar limitation applies to the EVID project survey, which samples CWD from inclusive schools in Ghana and Niger. This sample bias likely excludes children with disabilities who do not attend school or are enrolled in special education institutions. These out-of-school children, particularly those with disabilities, may face distinct challenges that are overlooked when analyses focus solely on enrolled children.

The fourth constraint concerns the limited ability of the data to capture the full range of disabilities. Relying on the WG-CFM, this study primarily focuses on children reported to have “a lot of difficulty” or “not at all” in various functional domains. Consequently, children identified as having milder disabilities (“some difficulty”) are excluded from the analysis. Furthermore, the MICS6 survey, as a nationally representative household survey, may underrepresent or entirely miss children with extremely severe functional difficulties (e.g., blindness or deafness) due to their low prevalence in the population. The voluntary nature of skill learning tests in MICS6, without special arrangements for children with severe disabilities, may further bias the representation of this group. Similarly, as the EVID survey samples children from schools, the inclusion rate for children with severe functional difficulties is likely much lower. As a result, the findings from this study are more relevant for children with “a lot of difficulty” in one or more functional domains, as defined by the WG-CFM. Finally, the cross-country analyses in Papers 1 through 3, based on MICS6 data, do not include children with behavioural and psychosocial functional difficulties, as discussed in Section 2.3.2. This exclusion limits the scope of the findings and their applicability to the broader population of CWD.

The concept of disability itself is inherently complex and multidimensional, which poses additional challenges for quantitative research. Capturing the interaction between disability and children’s educational outcomes often necessitates reducing socially constructed phenomena into simplified statistical formats (Vulliamy & Webb, 2001). While this process facilitates analysis, it risks failing to capture the nuanced and multifaceted nature of disability. Moreover, quantitative approaches, while valuable for identifying broad patterns and mechanisms, are limited in their ability to provide in-depth insights into the experiences of CWD. In contrast, qualitative methods, through direct observation and interviews, often excel in uncovering the intricate social and cultural contexts shaping these experiences. Thus, quantitative approaches as utilised by this doctoral study may struggle to address the complex interactions within local sociocultural contexts that influence educational outcomes.

Fifthly, the selection of African countries in this study is largely arbitrary and based on the availability of publicly accessible MICS6 surveys. As a result, the selection process lacks predefined criteria, potentially limiting the broader applicability of the findings. Nonetheless, despite this arbitrary selection, the chosen countries exhibit considerable diversity, offering valuable insights across different socioeconomic contexts. The sample includes an upper-middle-income North African country, Tunisia; lower-middle-income West and Southern African countries, such as Ghana, Lesotho, and Zimbabwe; and low-income Central African countries, such as DRCongo and the Central African Republic. Tunisia, as the only upper-middle-income African country included in this study, serves as a useful reference point, illustrating a relatively high level of foundational numeracy and reading skills among children in certain age groups.

Sixthly, there are notable limitations associated with the educational outcome indicators used in this study. As a multi-indicator survey, MICS6 offers only a limited set of essential school performance indicators. Papers 2 and 3 rely on standardized performance tests embedded in MICS6 surveys, allowing for comparisons across social groups and countries. However, the numeracy and reading skills tests primarily assess foundational competencies, potentially overlooking more advanced skills. Children from disadvantaged backgrounds are likely to face deeper inequities due to the higher complexities they encounter in meeting advanced skill requirements. Paper 4 uses school records for four main subjects as reported by schools, which are not standardized across classes and schools, limiting the study to analysing relative within-class performance differences between CWD and CWOD.

The limitations associated with the educational outcome indicators also stem from the narrow focus of this study on academic performance. Biesta (2019) emphasizes the need to view educational outcomes through three interconnected domains: qualification, socialization, and subjectification. Qualification encompasses academic knowledge, skills, and credentials critical for children’s future opportunities; socialization pertains to the integration of children into social, cultural, and political traditions and practices; and subjectification addresses personal development and self-determination fostered through education. A comprehensive evaluation of educational outcomes must consider these domains to fully understand how children's functional difficulties affect their academic, social, and personal development.

Finally, methodological considerations pose significant limitations. The assumption of a natural experiment in these papers requires careful validation due to potential confounding factors, emphasizing the need for robust study designs. Additionally, the limited sample size of children with each specific disability type in both nationally representative and country-level surveys may affect the accuracy of estimates and the generalizability of findings.

Despite its limitations, secondary data analysis offers significant advantages. It provides a cost-effective means of conducting large-scale, population-representative research that enables cross-country comparisons. For instance, this study utilizes quantitative MICS survey data to explore the prevalence of disability, the average educational performance of CWD and CWOD, developmental trends in learning, and the effects of specific contextual factors on educational outcomes. Additionally, EVID survey data enables an in-depth exploration of the role of specific family and individual factors in promoting the educational outcomes of CWD.

The standardization of data collection methods, disability measurement tools, and statistical analysis techniques across countries enhances the comparability of findings and the robustness of inferences. While quantitative research has inherent limitations, it is indispensable for quantifying the scale and importance of factors such as educational system performance and progress toward achieving the Sustainable Development Goals (SDGs). It also enables the assessment of temporal changes and spatial heterogeneity in educational outcomes.

This study highlights the importance of connecting empirical data with specific social contexts and theoretical frameworks to better understand the social world. Although quantitative analysis alone cannot fully capture the complexity of disability and educational outcomes, it plays a crucial role in identifying trends and providing valuable insights into educational disparities among children and exploring the potential role of contextual factors in children's education in African countries.

By laying the groundwork for further investigation, this approach emphasizes the need for complementary research methods to explore the mechanisms underlying observed inequities. Ultimately, such research contributes to the development of effective policy interventions aimed at supporting marginalized children and promoting educational equity.

4.5 Identified gaps for future study

This study explores the educational landscape for children in Africa, with a particular focus on CWD, and highlights avenues for future research.

A significant gap in research is the lack of high-quality, tailored data for studying children's educational outcomes in Africa, particularly for CWD. The development of the WG-CFM question set and its integration into MICS surveys represents progress in addressing data needs for disability studies. However, despite the high population representativeness of MICS surveys, they often struggle to include children with severe functional difficulties due to their low prevalence. This is particularly concerning, as these children are likely among the most disadvantaged in accessing education.

Given the diverse needs of CWD, no single survey can fulfil all research objectives. This study highlights the need for disability-focused surveys with sufficiently large sample sizes in African countries to enable data disaggregation by specific disability types and provide a comprehensive understanding of these children's needs. However, the declining international development support for African countries poses a significant challenge to funding such surveys.

This study underscores the importance of moving beyond enrolment rates to assess school performance. Future data collection must include advanced learning indicators, as well as measures of socialization and subjectification, to provide a holistic understanding of the challenges CWD face. MICS surveys currently fail to capture performance information for out-of-school children, highlighting the need for targeted studies focusing on these populations.

A key finding of this study is the persistent gap between CWD and CWOD across countries and social groups. Addressing these challenges requires a learner-driven approach in inclusive education. Children with functional diversity require tailored support, materials, and pedagogies to ensure inclusion (Marschark et al., 2015). Examples include tools like braille and eyeglasses for children with visual impairments, hearing aids and sign language for those with hearing impairments and walking aids or ramps for children with physical impairments. However, resources for supporting children with intellectual and complex functional difficulties remain underdeveloped and inaccessible to disadvantaged families in African countries, exacerbating disparities (Adugna et al., 2020). Advances in assistive technologies hold promise for improving access and equity in education and warrant further exploration.

The social environment of education varies significantly across contexts. Learner-centred approaches must adapt to local circumstances, prioritizing inclusivity and equity. Broader examinations of personal, household, community, and country-level factors are necessary to address persistent gaps and inform policies. Disability is often treated as a singular identity in research, neglecting intersections with other identities. This study innovatively explores sibling effects interacting with gender and disability in Paper 4, but further research is needed to understand how contextual factors and their interactions with disabilities influence CWD's societal participation. Moreover, although this study does not examine stigma and discrimination experienced by CWD, future research should investigate these factors and their impact on educational outcomes (Baffoe, 2013; Mantey, 2017).

Future studies should expand their methodological approaches. New quantitative methods, such as social experiments, can better establish causal links between educational outcomes and influencing factors while minimizing confounding variables. While quantitative methods are effective for measuring gaps and statistical significance, qualitative and mixed methods are essential for understanding the complexities of CWD's experiences. These approaches are particularly valuable for studying underrepresented groups, such as children with severe functional difficulties or those out of school. Combining qualitative and quantitative methods can provide a more nuanced understanding of the contextual factors influencing and interacting with disability.

By addressing these gaps and adopting a holistic approach to educational outcomes, researchers can better understand the barriers faced by disadvantaged children, including CWD, and develop strategies to enhance their academic success and inclusive engagement in educational environments.

4.6 Conclusions

Education for all is a cornerstone of sustainable development, with the potential to break cycles of poverty and inequality—an imperative particularly critical in African contexts. However, limited data exist on the educational outcomes of marginalized groups, and the ways in which personal, socioeconomic, and cultural factors shape access to quality education remain underexplored. Given the challenges of conducting systematic and cross-country comparative studies on CWD in Africa (Loeb & Eide, 2006)—including inconsistencies in disability definitions, categorizations, and measurements, as well as data limitations and small sample sizes—this study provides evidence on learning outcomes and the multifaceted challenges faced by disadvantaged children, particularly those with disabilities. By addressing factors such as gender, socioeconomic status, school quality, and the varied impacts of different disability types on educational access and outcomes, this research emphasizes the need to close knowledge gaps to inform policies promoting equitable access to education. Furthermore, as economies grow and educational quality improves, targeted interventions for children with disabilities and develop learner-centred inclusive education—particularly for girls—become increasingly critical.

5 References

Adugna, M., Ghahari, S., Merkley, S., & Rentz, K. (2022). Children with disabilities in Eastern Africa face significant barriers to access education: a scoping review. International Journal of Inclusive Education, 1-17.

Adugna, M. B., Nabbouh, F., Shehata, S., & Ghahari, S. (2020). Barriers and facilitators to healthcare access for children with disabilities in low and middle income sub-Saharan African countries: a scoping review. BMC health services research, 20, 1-11.

Agbaire, J., & Musa, C. (2013). A global assessment of the implementation levels of the Education For All (EFA) initiative and the millennium development goals (MDGs) on education in sub-Saharan Africa: A focus on Nigeria. Sokoto Educational Review, 14(2), 83-96.

Ainscow, M., Slee, R., & Best, M. (2019). The Salamanca statement: 25 years on. International Journal of inclusive education, 23(7-8), 671-676.

Anderson, E. (2015). The white space. Sociology of race and ethnicity, 1(1), 10-21.

Anderson, K. G., Case, A., & Lam, D. (2001). Causes and consequences of schooling outcomes in South Africa: Evidence from survey data. Social dynamics, 27(1), 37-59.

Ansong D, Ansong EK, Ampomah AO, Afranie S. A spatio-temporal analysis of academic performance at the Basic Education Certificate Examination in Ghana. Applied Geography. 2015; 65:1–12.

Appleton, S. (2001). Education, Incomes and Poverty in Uganda in the 1990s (No. 01/22). CREDIT research paper.

Azatyan, T., & Alaverdyan, A. (2020). Children with intellectual disabilities: Challenges in education. Armenian Journal of Special Education, 4(1), 77-85.

Baffoe, M. (2013). Stigma, discrimination & marginalization: Gateways to oppression of persons with disabilities in Ghana, West Africa. Journal of Educational and Social Research, 3(1), 187-198.

Baker, D. P., Goesling, B., & LeTendre, G. K. (2002). Socioeconomic status, school quality, and national economic development: A cross-national analysis of the "Heyneman-Loxley effect" on mathematics and science achievement. Comparative Education Review, 46(3), 291-312.

Bakhshi, P., Babulal, G. M., & Trani, J.-F. (2017). Education of Children with Disabilities in New Delhi: When Does Exclusion Occur? PloS one, 12(9), e0183885.

Banks, L. M., Kuper, H., & Polack, S. (2017). Poverty and disability in low-and middle-income countries: A systematic review. PloS one, 12(12), e0189996.

Bashir, S., Lockheed, M., Ninan, E., & Tan, J.-P. (2018). Facing Forward: Schooling for Learning in Africa. In: Washington, DC: World Bank.

Belmont, L. (1984). The International Pilot Study of Severe Childhood Disability. Final Report: Screening for Severe Mental Retardation in Developing Countries.

Bhalotra, S., & Heady, C. (2003). Child farm labor: The wealth paradox. The World Bank Economic Review, 17(2), 197-227.

Birdsall, N., Bruns, B., & Madan, J. (2016). Learning data for better policy: A global agenda. Center for Global Development Working Paper Series.

Bonal X., Education Poverty, and the "Missing Link". The Handbook of Global Education Policy: John Wiley & Sons, Ltd; 2016. p. 97–110.

Bouhlila, D. S. (2015). The heyneman–loxley effect revisited in the Middle East and North Africa: analysis using TIMSS 2007 database. International Journal of Educational Development, 42, 85-95.

Brody, G. H. (2004). Siblings' direct and indirect contributions to child development. Current directions in psychological science, 13(3), 124-126.

Brown, P. H., & Park, A. (2002). Education and poverty in rural China. Economics of education review, 21(6), 523-541.
Chiu MM, McBride-Chang C. Family and reading in 41 countries: Differences across cultures and students. Scientific Studies of Reading. 2010 Nov 4;14(6):514-43.
Chmielewski AK. The global increase in the socioeconomic achievement gap, 1964 to 2015. American sociological review. 2019 Jun;84(3):517-44.
Clercq Fd. The persistence of South African educational inequalities: The need for understanding and relying on analytical frameworks. Education as Change. 2020;24(1):1-22.
Conley, D., & Lareau, A. (2008). Bringing sibling differences in: Enlarging our understanding of the transmission of advantage in families. Social class: How does it work, 179-200.
Cox, F. M., & Marshall, A. D. (2020). Educational engagement, expectation and attainment of children with disabilities: Evidence from the Scottish Longitudinal Study. British Educational Research Journal, 46(1), 222-246.
Crollen, V., Warusfel, H., Noël, M.-P., & Collignon, O. (2021). Early visual deprivation does not prevent the emergence of basic numerical abilities in blind children. Cognition, 210, 104586.
Degener, T. (2017). A new human rights model of disability. Paper presented at the The United Nations convention on the rights of persons with disabilities.
Dickerson, A., McIntosh, S., & Valente, C. (2015). Do the maths: An analysis of the gender gap in mathematics in Africa. Economics of Education Review, 46, 1-22.
Durkin, M., Zaman, S., Thorburn, M., Hasan, M., Shrout, P., Davidson, L., & Stein, Z. (1991). Screening for childhood disability in less developed countries: rationale and study design. Int J Ment Health, 20(2), 47-60.
Eide, A. H., Lamichhane, K., & Neupane, S. (2021). Gaps in access and school attainments among people with and without disabilities: a case from Nepal. Disability and rehabilitation, 43(14), 1995-2000.
Elwan, A. (1999). Poverty and disability: a survey of the literature (Vol. Vol. 9932). Washington, DC: Social Protection Advisory Service.
Epple, D., & Romano, R. E. (2011). Peer effects in education: A survey of the theory and evidence. In Handbook of social economics (Vol. 1, pp. 1053-1163): Elsevier.
Filmer, D. (2008). Disability, Poverty, and Schooling in Developing Countries: Results from 14 Household Surveys. The World Bank Economic Review, 22(1), 141-163.
Forstner, M. (2022). Conceptual models of disability: the development of the consideration of non-biomedical aspects. Disabilities, 2(3), 540-563.
GBD (2019). Diseases and Injuries Collaborators . Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: a systematic analysis for the global burden of disease study 2019. Lancet. (2020) 396:1204–22. 10.1016/S0140-6736(20)30925-9
Gottlieb, C. A., Maenner, M. J., Cappa, C., & Durkin, M. S. (2009). Child disability screening, nutrition, and early learning in 18 countries with low and middle incomes: data from the third round of UNICEF's Multiple Indicator Cluster Survey (2005–06). The Lancet, 374(9704), 1831-1839.
Gregorius, S. (2016). Exploring narratives of education: disabled young people's experiences of educational institutions in Ghana. Disability & society, 31(3), 322-338.
Groce, N., & Kett, M. (2013). The Disability and Development Gap. Leonard Cheshire Disability and Inclusive Development Centre Working Paper Series No 21. In: London, UK: LCDIDC.
Groce, N. E., & Mont, D. (2017). Counting Disability: Emerging Consensus on the Washington Group Questionnaire. The Lancet Global Health, 5(7), e649-e650.
Gruijters, R. J., & Behrman, J. A. (2020). Learning inequality in Francophone Africa: School quality and the educational achievement of rich and poor children. Sociology of Education, 93(3), 256-276.
Grätz, M., & Torche, F. (2016). Compensation or reinforcement? The stratification of parental responses to children's early ability. Demography, 53(6), 1883-1904.

Hanushek, E. A., & Woessmann, L. (2008). The role of cognitive skills in economic development. Journal of Economic Literature, 46(3), 607-668.

Haug, M., Fasting, R., & Hausstätter, R. (2024). Approaches to inclusive education A review of the literature on inclusive education for children and youth with disabilities in low-income countries in Africa and Asia.

Hedges, S., Mulder, M. B., James, S., & Lawson, D. W. (2016). Sending children to school: rural livelihoods and parental investment in education in northern Tanzania. Evolution and human behavior, 37(2), 142-151.

Hedlund, M. (2009). Understandings of the Disability Concept: A Complex and Diverse Concept. Disabilities: Insights from across fields and around the world, 1, 5-18.

Henderson, G. & Bryan, W., 2011, Psychosocial aspects of disability, Charles C. Thomas, Springfield, IL.

Heyneman, S. P., & Loxley, W. A. (1983). The Effect of Primary-School Quality on Academic Achievement Across Twenty-nine High- and Low-Income Countries. American Journal of Sociology, 88(6), 1162-1194. doi:10.1086/227799

Hosseinpoor, A. R., Stewart Williams, J. A., Gautam, J., Posarac, A., Officer, A., Verdes, E., . . . Chatterji, S. (2013). Socioeconomic Inequality in Disability Among Adults: A Multicountry Study Using the World Health Survey. American journal of public health, 103(7), 1278-1286.

Iddrisu, A. M., Danquah, M., Quartey, P., & Ohemeng, W. (2018). Gender bias in households' educational expenditures: Does the stage of schooling matter? World Development Perspectives, 10, 15-23.

Ilie, S., & Rose, P. (2016). Is equal access to higher education in South Asia and sub-Saharan Africa achievable by 2030? Higher Education, 72, 435-455.

İşcan, T. B., Rosenblum, D., & Tinker, K. (2015). School fees and access to primary education: Assessing four decades of policy in sub-Saharan Africa. Journal of African Economies, 24(4), 559-592.

Joensen, J. S., & Nielsen, H. S. (2018). Spillovers in education choice. Journal of Public Economics, 157, 158-183.

Johnson, D. (2008). The changing landscape of education in Africa: Quality, equality and democracy.

Jolley, E., Lynch, P., Virendrakumar, B., Rowe, S., & Schmidt, E. (2018). Education and social inclusion of people with disabilities in five countries in West Africa: a literature review. Disability and rehabilitation, 40(22), 2704-2712.

Kan, S., & Klasen, S. (2021). Evaluating universal primary education in Uganda: School fee abolition and educational outcomes. Review of Development Economics, 25(1), 116-147.

Karbownik, K., & Özek, U. (2023). Setting a Good Example?: Examining Sibling Spillovers in Educational Achievement Using a Regression Discontinuity Design. Journal of Human Resources, 58(5), 1567-1607.

Khan, S., & Hancioglu, A. (2019). Multiple indicator cluster surveys: delivering robust data on children and women across the globe. Studies in family planning, 50(3), 279-286.

Krahn, G. L., Walker, D. K., & Correa-De-Araujo, R. (2015). Persons with disabilities as an unrecognized health disparity population. American journal of public health, 105(S2), S198-S206.

Kuepié, M., & Nordman, C. J. (2016). Where does education pay off in Sub-Saharan Africa? Evidence from two cities of the Republic of Congo. Oxford Development Studies, 44(1), 1-27.

Kuper H, Monteath-van Dok A, Wing K, Danquah L, Evans J, et al. (2014) The Impact of Disability on the Lives of Children; Cross-Sectional Data Including 8,900 Children with Disabilities and 898,834 Children without Disabilities across 30 Countries. PLOS ONE 9(9): e107300. https://doi.org/10.1371/journal.pone.0107300

Kuper, H., Saran, A., White, H., Kumar, S. T., Tolin, L., Muthuvel, T., & Wapling, L. (2018). Rapid Evidence Assessment (REA) of What Works to Improve Educational Outcomes for People with Disabilities in Low- and Middle-Income Countries. International Centre for Evidence in Disability, London School of Hygiene and Campbell Collaboration.

Lamichhane, K., & Kawakatsu, Y. (2015). Disability and determinants of schooling: A case from Bangladesh. International Journal of Educational Development, 40, 98-105.

Lederberg, A. R., Schick, B., & Spencer, P. E. (2013). Language and Literacy Development of Deaf and Hard-of-Hearing Children: Successes and Challenges. Developmental psychology, 49(1), 15.

Lee, V. E., & Burkam, D. T. (2002). Inequality at the starting gate: Social background differences in achievement as children begin school: ERIC.

Lewin, K. M. (2007). Diversity in convergence: Access to education for all. Compare, 37(5), 577-599.

Lewin, K. M. (2009). Access to education in sub-Saharan Africa: patterns, problems and possibilities. Comparative Education, 45(2), 151-174. doi:10.1080/03050060902920518

Lewin, K. M., & Sabates, R. (2012). Who gets what? Is improved access to basic education pro-poor in Sub-Saharan Africa? International Journal of Educational Development, 32(4), 517-528.

León J, Álvarez-Álvarez C, Martínez-Abad F. Contextual effect of school SES on reading performance: A comparison between countries in the European Union. Compare: A Journal of Comparative and International Education. 2022 May 19;52(4):674-88.

Loeb, M., Mont, D., Cappa, C., De Palma, E., Madans, J., & Crialesi, R. (2018). The Development and Testing of a Module on Child Functioning for Identifying Children with Disabilities on Surveys. I: Background. Disability and Health Journal, 11(4), 495-501.

Loeb, M. E., & Eide, A. H. (2006). Paradigms lost: The changing face of disability in research. In International views on disability measures: Moving toward comparative measurement (pp. 111-129): Emerald Group Publishing Limited.

Loury, L. D. (2004). Siblings and gender differences in African-American college attendance. Economics of Education Review, 23(3), 213-219.

Luo, Y., Zhou, R. Y., Mizunoya, S., & Amaro, D. (2020). How Various Types of Disabilities Impact Children's School Attendance and Completion-Lessons Learned from Censuses in Eight Developing Countries. International Journal of Educational Development, 77, 102222.

Lutz, W., Goujon, A., KC, S., & Sanderson, W. (2007). Reconstruction of populations by age, sex and level of educational attainment for 120 countries for 1970-2000. Vienna yearbook of population research, 193-235.

Mactaggart, I., & Kuper, H. (2018). What Gets Measured Gets Done: Collecting Data to Support Inclusive Education for Children with Disabilities. Education and Disability in the Global South: New Perspectives from Africa and Asia, 59.

Malik, R., Raza, F., Rose, P., & Singal, N. (2020). Are children with disabilities in school and learning? Evidence from a household survey in rural Punjab, Pakistan. Compare: A Journal of Comparative and International Education, 52(2), 211-231. doi:10.1080/03057925.2020.1749993

Mantey, E. E. (2017). Discrimination against children with disabilities in mainstream schools in Southern Ghana: Challenges and perspectives from stakeholders. International Journal of Educational Development, 54, 18-25.

Marks, D. (1997). Models of disability. Disability and rehabilitation, 19(3), 85-91.

Marschark, M., Shaver, D. M., Nagle, K. M., & Newman, L. A. (2015). Predicting the Academic Achievement of Deaf and Hard-of-Hearing Students from Individual, Household, Communication, and Educational Factors. Exceptional Children, 81(3), 350-369.

McHale, S. M., Whiteman, S. D., Kim, J.-Y., & Crouter, A. C. (2007). Characteristics and correlates of sibling relationships in two-parent African American families. Journal of Family Psychology, 21(2), 227.

McIntyre, L. L., Blacher, J., & Baker, B. L. (2006). The Transition to School: Adaptation in Young Children with and without Intellectual Disability. Journal of Intellectual Disability Research, 50(5), 349-361.

Mizunoya, S., Mitra, S., & Yamasaki, I. (2018). Disability and School Attendance in 15 Low-and Middle-Income Countries. World Development, 104, 388-403.

Morgan, P. L., Farkas, G., & Wu, Q. (2011). Kindergarten children's growth trajectories in reading and mathematics: Who falls increasingly behind? Journal of learning disabilities, 44(5), 472-488.

Moshoeshoe, R. (2023). LONG-TERM EFFECTS OF PRIMARY EDUCATION EXPANSION ON EDUCATIONAL ACHIEVEMENT. Annals of Economics and Statistics(149), 3-38.

Moyi, P. (2017). School Enrolment and Attendance for Children with Disabilities in Kenya: An Examination of Household Survey Data. Paper presented at the FIRE: Forum for International Research in Education.

Musengamana, I. (2023). A Systematic Review of Literature on Parental Involvement and Its Impact on Children Learning Outcomes. Open Access Library Journal, 10(10), 1-21.

Nakijoba, R., Biirah, J., Akullo, T., & Mugimu, C. B. (2024). Parental Involvement and Children Acquisition of Literacy and Numeracy Skills in Uganda. Futurity Education, 4(1), 53-70.

Ngandu, C. B., Momberg, D., Magan, A., Chola, L., Norris, S. A., & Said-Mohamed, R. (2020). The association between household socio-economic status, maternal socio-demographic characteristics and adverse birth and infant growth outcomes in sub-Saharan Africa: a systematic review. Journal of developmental origins of health and disease, 11(4), 317-334.

Nicoletti, C., & Rabe, B. (2019). Sibling spillover effects in school achievement. Journal of applied econometrics, 34(4), 482-501.

Nielsen, H. D. (2006). From schooling access to learning outcomes, an unfinished agenda: an evaluation of World Bank support to primary education: World Bank Publications.

Niemann, S., 2005, 'Persons with disabilities', in M. Burke, J. Chauvin & J. Miranti (eds.), Religious and spiritual issues in counseling: Applications across diverse populations, pp. 105–134, Brunner-Routledge, New York.

Nkrumah, R. B., & Sinha, V. (2020). Revisiting global development frameworks and research on universal basic education in Ghana and Sub-Saharan Africa: a review of evidence and gaps for future research. Review of Education, 8(3), 733-764. doi:10.1002/rev3.3205

Ólafsdóttir, L. B., Egilson, S. T., Árnadóttir, U., & Hardonk, S. C. (2019). Child and parent perspectives of life quality of children with physical impairments compared with non-disabled peers. Scandinavian Journal of Occupational Therapy, 26(7), 496-504.

Oliver, M. (2013). The social model of disability: Thirty years on. Disability & society, 28(7), 1024-1026.

Oliver, M. (2017). Defining impairment and disability: Issues at stake. In Disability and equality law (pp. pp. 3-18): Routledge.

Olusanya, B. O., Kancherla, V., Shaheen, A., Ogbo, F. A., & Davis, A. C. (2022). Global and regional prevalence of disabilities among children and adolescents: analysis of findings from global health databases. Frontiers in public health, 10, 977453.

Parman, J. (2015). Childhood health and sibling outcomes: Nurture Reinforcing nature during the 1918 influenza pandemic. Explorations in Economic History, 58, 22-43.

Pritchett, L. (2013). The rebirth of education: Schooling ain't learning: CGD Books.

Reindal, S. M. (2008). A social relational model of disability: A theoretical framework for special needs education? European Journal of Special Needs Education, 23(2), 135-146.

Sabariego, C., Fellinghauer, C., Lee, L., Posarac, A., Bickenbach, J., Kostanjsek, N., . . . Cieza, A. (2021). Measuring functioning and disability using household surveys: metric properties of the brief version of the WHO and World Bank model disability survey. Archives of Public Health, 79, 1-11.

Sanders, R. (2017). Sibling relationships: Theory and issues for practice: Bloomsbury Publishing.

Shabaya, J., & Konadu-Agyemang, K. (2004). Unequal access, unequal participation: some spatial and socio-economic dimensions of the gender gap in education in Africa with special reference to Ghana, Zimbabwe and Kenya. Compare: A Journal of Comparative and International Education, 34(4), 395-424.

Shakespeare, T. (2006). The social model of disability. The disability studies reader, 2(3), 197-204.

Simeonsson, R. J., Leonardi, M., Lollar, D., Bjorck-Akesson, E., Hollenweger, J., & Martinuzzi, A. (2003). Applying the International Classification of Functioning, Disability and Health (ICF) to measure childhood disability. Disability and rehabilitation, 25(11-12), 602-610.

Singal, N. (2011). Disability, Poverty and Education: Implications for Policies and Practices. International Journal of Inclusive Education, 15(10), 1047-1052. doi:10.1080/13603116.2011.555065

Singal, N., Sabates, R., Aslam, M., & Saeed, S. (2020). School enrolment and learning outcomes for children with disabilities: findings from a household survey in Pakistan. International Journal of Inclusive Education, 24(13), 1410-1430. doi:10.1080/13603116.2018.1531944

Singal, N., Taneja Johansson, S. and Lynch, P. (2018) Education of children with disabilities: changing landscape of new opportunities and challenges. In: Singal, N., Lynch, P. and Taneja Johansson, S. (eds.) *Education and Disability in the Global South: New perspectives from Africa and Asia.* Bloomsbury Academic, pp. 1-18. ISBN 9781474291224

Smart, J. (2004). Models of disability: The juxtaposition of biology and social construction. Handbook of rehabilitation counseling, 25-49.

Smith, E. (2008). Pitfalls and promises: The use of secondary data analysis in educational research. British Journal of Educational Studies, 56(3), 323-339.

Spaull, N. (2015). Schooling in South Africa: How low-quality education becomes a poverty trap. *South African child gauge*, *12*(1), 34-41.

Stevens, G., Flaxman, S., Brunskill, E., Mascarenhas, M., Mathers, C. D., & Finucane, M. (2013). Global and regional hearing impairment prevalence: an analysis of 42 studies in 29 countries. The European Journal of Public Health, 23(1), 146-152.

Takeda, T., & Lamichhane, K. (2018). Determinants of schooling and academic achievements: Comparison between children with and without disabilities in India. International Journal of Educational Development, 61, 184-195. doi:10.1016/j.ijedudev.2018.01.003

Taylor, S., & Yu, D. (2009). The importance of socio-economic status in determining educational achievement in South Africa. Unpublished working paper (Economics). Stellenbosch: Stellenbosch University, 33-47.

Tedla, T. A., & Ababa, A. (2015). The Challenge of Inclusion of Children with Physical Impairment: Absenteeism in Focus—A Case Study. Open Access Library Journal, 2(11), 1.

Thomas, C. (2004). How is disability understood? An examination of sociological approaches. Disability & society, 19(6), 569-583.

Tilak, J. B. (2002). Education and poverty. Journal of human development, 3(2), 191-207.

Tildeman, M. (2005). A relational perspective on disability: An illustration from the school system. Í A. Gustavsson, J. Sandvin, R. Traustadóttir og J. Tøssebro (ritstj.). Resistance, reflection and change. Nordic disabiltiy research, 219-232.

Trani, J.-F., Bah, O., Bailey, N., Browne, J., Groce, N., & Kett, M. (2010). Disability in and around Urban Areas of Sierra Leone. Retrieved from

Trani, J.-F., Bakhshi, P., & Nandipati, A. (2012). 'Delivering'education; maintaining inequality. The case of children with disabilities in Afghanistan. Cambridge Journal of Education, 42(3), 345-365.

UN. (1989). Convention on the Rights of the Child. Retrieved from https://downloads.unicef.org.uk/wp-content/uploads/2010/05/UNCRC_united_nations_convention_on_the_rights_of_the_child.pdf

UN. (2000). Millennium Development Goals. Retrieved from https://www.un.org/millenniumgoals/

UN. (2006). Convention on the Rights of Persons with Disabilities (CRPD). Retrieved from https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html

UN. (2015). Sustainable Development Goals. Retrieved from https://sdgs.un.org

UNDP. (2009). Human development report 2009. Overcoming barriers: Human mobility and development. Overcoming Barriers: Human Mobility and Development (October 5, 2009). UNDP-HDRO Human Development Reports.

UNDP. (2010). Human Development Report 2010: The Real Wealth of Nations-Pathways to Human Development: UN.

UNDP (2022) Human Development Report 2021-22. Retrieved from https://hdr.undp.org/content/human-development-report-2021-22

UNESCO (1994). Final Report: World Conference on Special Needs Education: Access and Quality. Paris: UNESCO.
UNESCO. (2015). EFA Global Monitoring Report. Education for all 2000–2015: Achievements and challenges Retrieved from Paris: https://unesdoc.unesco.org/ark:/48223/pf 0000232205
UNESCO. (2016). Teaching policies and learning outcomes in Sub-Saharan Africa: issues and options.
UNESCO. (2018). Education and Disability: Analysis of Data from 49 Countries. United Nations Educational, Scientific and Cultural Organization.
UNESCO. (2020). Global Education Monitoring Report 2020: Inclusion and Education-All Means All. UN.
UNESCO. (2022). Global Education Monitoring Report 2021/2: Non-state actors in education: Who chooses? Who loses?
UNICEF (2013). The state of the world's children 2013: children with disabilities. Retrieved from https://www.unicef.org/media/84886/file/SOWC-2013.pdf
UNICEF. (2017). Module on Child Functioning Concept Note. Retrieved from https://data.unicef.org/resources/module-child-functioning-concept-note
UNICEF (2022) . Seen, counted, included: using data to shed light on the well-being of children with disabilities. New York: United Nations Children's Fund. Available online at: https://data.unicef.org/resources/children-with-disabilities-report-2021/
UNICEF. (2023). Children with Disabilities in Eastern and Southern Africa: A statistical overview of their well-being. Retrieved from https://data.unicef.org/resources/children-with-disabilities-in-eastern-and-southern-africa-a-statistical-overview-of-their-well-being/
Unterhalter, E. (2013). Education targets, indicators and a post-2015 development agenda: Education for All, the MDGs, and human development. The power of numbers: A critical review of MDG targets for human development and human rights.
Van der Berg, S. (2020). Education Access and "Learning Poverty" in Seven Southern African Countries. NO POVERTY, 6(17), 199.
Vornholt, K., Villotti, P., Muschalla, B., Bauer, J., Colella, A., Zijlstra, F., . . . Corbière, M. (2018). Disability and employment–overview and highlights. European journal of work and organizational psychology, 27(1), 40-55.
Vulliam, G. and Webb, R. (2001) The social construction of school exclusion rates: implications for evaluation methodology, Educational Studies, 27 (3), 358-370.
Wagner, M., Newman, L., Cameto, R., & Levine, P. (2005). Changes over Time in the Early Postschool Outcomes of Youth with Disabilities. A Report of Findings from the National Longitudinal Transition Study (NLTS) and the National Longitudinal Transition Study-2 (NLTS2). Online Submission.
WG. (2020). An Introduction to Washington Group on Disability Statistics Question Sets. Retrieved from https://www.washingtongroup-disability.com/fileadmin/uploads/wg/The_Washington_Group_Primer_-_English.pdf
WHO (2007). International Classification of Functioning, Disability, and Health: Children & Youth Version: ICF-CY: World Health Organization.
WHO (2011). WHO World Report on Disability: a review. Disability and health journal, 4(3), 141-142.
WHO (2022). Global report on health equity for persons with disabilities. World Health Organization.
World Bank. (2008). Global monitoring report 2008: MDGs and the environment: Agenda for inclusive and sustainable development:
World Bank. (2018). World development report 2018: Learning to realize education's promise (T. W. Bank Ed.).
World Bank. (2020). School enrollment, primary (% gross), World Development Indicators.
World Bank. (2024a). School enrollment, primary (% net), World Development Indicators.
World Bank. (2024b). Primary completion rate, total (% of relevant age group), World Development Indicators.

Yakimowski, M. E., Faggella-Luby, M., Kim, Y., & Wei, Y. (2016). Reading achievement in the middle school years: A study investigating growth patterns by high incidence disability. Journal of Education for Students Placed at Risk (JESPAR), 21(2), 118-128.

Yekta, A., Hooshmand, E., Saatchi, M., Ostadimoghaddam, H., Asharlous, A., Taheri, A., & Khabazkhoob, M. (2022). Global prevalence and causes of visual impairment and blindness in children: a systematic review and meta-analysis. Journal of current ophthalmology, 34(1), 1-15.

Yi, J., Heckman, J. J., Zhang, J., & Conti, G. (2015). Early health shocks, intra-household resource allocation and child outcomes. The Economic Journal, 125(588), F347-F371.

Zang, E., Tan, P. L., & Cook, P. J. (2023). Sibling spillovers: Having an academically successful older sibling may be more important for children in disadvantaged families. American Journal of Sociology, 128(5), 1529-1571.

Zarfaty, Y., Nunes, T., & Bryant, P. (2004). The performance of young deaf children in spatial and temporal number tasks. Journal of Deaf Studies and Deaf Education, 9(3), 315-326.

Zhang, Y. (2006). Urban-rural literacy gaps in Sub-Saharan Africa: The roles of socioeconomic status and school quality. Comparative Education Review, 50(4), 581-602.

6 Appendices

Appendix I Example of numeracy and reading tests in MICS6 surveys

Numeracy test

Read numbers	Compare numbers	Addition	Pattern
9	7 & 5	3 + 2	5, 6, 7, ?
12	11 & 24	8 + 6	14, 15, ?, 17
30	58 & 49	7 + 3	20, ?, 40, 50
48	65 & 67	13 + 6	2, 4, 6, ?
74	146 & 154	12 + 24	5, 8, 11, ?
731			

Reading test

Text:
Moses is in class two. One day, Moses was going home from school. He saw some red flowers on the way. The flowers were near a tomato farm. Moses wanted to get some flowers for his mother. Moses ran fast across the farm to get the flowers. He fell down near a banana tree. Moses started crying. The farmer saw him and came. He gave Moses many flowers. Moses was very happy.

Question

What class is Moses in?

What did Moses see on the way home?

Why did Moses start crying?

Where did Moses fall

Why was Moses happy?

Appendix II EVID project sampling procedure

Selection of schools and mapping

School selection for the mapping is conducted in two stages:

First stage, schools selected for the mapping were based on a complete list of inclusive schools with registered numbers of CWD both in Ghana and Niger. Schools with more registered CWD are prioritized. 6 schools in each country were selected in the first stage. In Ghana, both public and private schools in both urban and rural areas were selected. In Ghana, one additional school with a similar name to one of the sampled schools was also mapped; therefore, altogether 7 schools were mapped in Ghana in the first stage. In Niger, a sample of public schools was allocated in the urban area of the Capital city, Niamey.

In the second stage, 20 schools in Ghana and 12 schools in Niger based on the same list were selected.

In Ghana, 27 schools 100 teachers 4214 children were mapped. 3 schools, 9 teachers, and 268 children were used in the pretest and, therefore, not included in the final sample selections. Finally, 24 schools, 91 teachers, 3946 children, are used for sample selection in Ghana.

In Niger, 18 schools 118 teachers 5173 children are mapped. Finally, excluding 1 school which was used for pretest, 17 schools 113 teachers 5032 children were used for sample selection in Niger.

Selection of children with disability (CWD)

1. All children with severe seeing difficulties (not at all, a lot of difficulty) were selected.
2. All children with severe hearing difficulties (not at all, a lot of difficulty) were selected.
3. All children with both severe and moderate walking difficulties (some difficulty, not at all, a lot of difficulty) were selected. The number of children reported to have walking difficulties are quite few in both Ghana and Niger. To get some children with walking difficulty, all the children with moderate walking difficulties are included.

4. All children reported as “not at all” in any of the four intellectual functional difficulties (understanding, learning, remembering, concentrating) were selected.

5. For children selected in step 1-4, we call them “sample 1” for each country. In “sample 1”, 104 CWD were selected in Ghana, 92 CWD were selected in Niger.

6. After the first four groups of children were selected (some of these children have only one functional difficulty, while many have more than one functional difficulty), among the rest of children not sampled yet, children with multiple functional challenges in the following functional types and severity are listed:

   a. Moderate seeing (some difficulty)
   b. Moderate hearing difficulties (some difficulty)
   c. Severe (a lot of difficulty) functional difficulty in understanding
   d. Severe (a lot of difficulty) functional difficulty in learning
   e. Severe (a lot of difficulty) functional difficulty in remembering
   f. Severe (a lot of difficulty) functional difficulty in concentrating

7. If more than one functional difficulty listed in 5 is reported, the child was selected

For children we selected in step 6, we call them “**sample 2**” for each country. With “sample1+sample2”, we selected 306 CWD in Ghana, and 369 CWD in Niger.

However, we found that some teachers reported far too many children with functional difficulties (as defined by the selection). Some even reported that 50%- 100% of children in the class have functional difficulties, as defined above. We suspect that these teachers evaluated children with quite different ideas about functional difficulty. Therefore, a benchmark was set up for adjusting the number of children selected as having functional difficulties for these classes.

8. In Niger, the average percentage of children being reported as functional difficulties (as defined by the selection in the first 6 steps) is 7.3%, and it is 8.3% in Ghana. So we set the benchmark as 20% in Niger and Ghana. That means in all the classes where 20% or more children are reported as having functional difficulty, we readjust the number of children to be sampled.

   a. The new criteria for excluding the children in these classes in Niger: only children selected in step 1-4 + children officially registered as CWD are included. Those selected in step 6 are not included.

b. The new criteria for excluding the children in these classes in Ghana: children selected in step 1-4 + children officially registered as disabled are included + those who have three or more severe difficulties listed in step 5 are included.

Sample 3: After the adjustment in step 7, 213 CWD in Ghana and 200 CWD in Nige were sampled.

9. We relax the inclusion criteria in the classes where the teacher has reported few children with functional difficulty (4% or fewer children in the class):

a. If one functional difficulty listed in 5 is reported, the child is included.

Sample 4: After the adjustment in step 8, 260 CWD in Ghana and 275 CWD in Niger were selected.

10. Finally, we found that there is slightly imbalanced sample between grade in Ghana and Niger, so we select more from grade 3 and 5. For the classes in Grade 3 and 5 with 10% or fewer children reported with functional difficulties, the relaxed criteria is:

a. If one functional difficulty listed in 5 is reported, the child is included

Sample 5: After the adjustment in step 9, 288 CWD in Ghana and 309 CWD in Niger were selected.

Selection of children without disability (CWOD) as control

We list children who are qualified as CWOD control sample.

1. **Control1**: We list all the children who reported as "no difficulty" for seeing, hearing, walking, understanding, learning, remembering, concentrating, accepting changes, controlling behavior, making friends, and reported to be "never" or "a few times a year" anxious/nervous/worried or sad/depressed.
2. **Control2**: In some classes, those who are reported as 1 are too few. For the classes where fewer than 30% of the children who are listed as no difficulty, we relaxed the criteria for selecting the control sample. For these classes, we include children who

a. Some difficulty in understanding, learning, remembering, concentrating, accepting changes, controlling behavior, making friends

b. "Monthly" anxious/nervous/worried or sad/depressed

3. In the list of children who are qualified as control children in step 1 and 2, one control child is then selected for each CWD selected in the same class. The principle is that

control child with the same age and gender are selected, if no child with the same age and gender as the selected CWD, control children with one-year age difference and same gender, or the child with same age but different gender will be selected. Furthermore, children on the list of control 1 is prioritized than those on the list of control 2.

Appendix III Data Collection and Definition of Children's Disability Status in Paper 4

Children's functional difficulties (disability) are measured based on the question sets in the Child Functioning Module (WG-CFM) for children aged 5–17 developed by Washington Group on Disability Statistics (WG, 2020). We applied WG-CFM in two rounds of surveys by interviewing teachers and parents of the same selected children in different time period. The analysis is conducted on data of all the children who have completed both surveys and hence we have four rounds of evaluation on disability status of each child sampled for the surveys.

Mapping: In Dec 2021, the responsible teachers in Grades 1, 3, 5 filled in the WG-CFM forms for all the children in their classes. Children with disabilities and control children were sampled for survey based on the WG-CFM forms filled by the teachers and the selection procedure is described in Appendix I.

Baseline household survey: Right after the mapping, the households and teachers of the selected children were interviewed and the parents or household members of these children filled in WG-CFM form to report their disability status.

Follow-up household survey: One year later in March-May 2023, households were interviewed again, and they filled in WG-CFM form again to report the disability status of the child.

Follow-up teacher survey: Teachers were interviewed during follow-up survey and filled in WG-CFM for the selected children again.

There can be same or different household members or teachers who were interviewed during mapping/baseline survey and follow-up surveys. After collecting these data, although based on the same WG-CFM forms, there are large disparities related to children's disability status reported by different people at different time points for the same child. Therefore, we decide to apply certain criteria to redefine the disability of these children for the analysis.

Severe disability is defined as "Not at all" or "lot of difficulty" in vision, hearing, walking, self-care, communication, learning, remembering, concentrating, accepting changes, controlling, and making friends, or reported to be anxious/ nervous/ worried or sad/ depressed on a daily basis.

Moderate disability includes “Some difficulty” in vision, hearing, walking, and self-care.

Then, a child is classified as a child with disability (**CWD**) if reported to have:

Severe or moderate disability for at least three times in mapping and three surveys;

Severe disability for at least two times in the three surveys;

Severe or moderate disability in both household surveys

A child is classified as a child without disability (**CWOD**) if reported to have:

Severe or moderate disability for at most once in mapping or the three surveys

No severe disability and at most once moderate disability in the three surveys

If a child cannot be classified as CWD or CWOD, the original classification of disability status of the child from the mapping is used.

7 Enclosed Papers

I Disability Types and Children's Schooling in Africa

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Disability Types and Children's Schooling in Africa

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ABSTRACT

The Sustainable Development Goals (SDGs) on inclusive and equitable quality education aim to ensure equal access to education for children with disabilities. Our study enhances understanding of school enrolment patterns among children with different types of disabilities, using the first large-scale application of the Washington Group Child (WGC) function module in Multiple Indicator Cluster Surveys (MICS) nationally representative surveys across eight African countries. We analyze early school enrolment for children below ten years old, school enrolment for older children aged 10– 17, and school dropout rates, treating different types of disabilities as random treatments in a natural experiment. Our findings indicate that children with vision and hearing disabilities have comparable enrolment rates to their non-disabled peers. In contrast, children with physical disabilities are more likely to start school late, while those with intellectual disabilities face significant challenges, including lower enrolment rates, higher dropout rates, and diffi- culty remaining enrolled. Children with multiple disabilities experi- ence the most severe obstacles to school enrolment at all ages. Future research on educational policies and their implementation should focus on addressing the diverse challenges faced by chil- dren with various disabilities to promote their educational inclusion effectively.

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1. Introduction

For several decades, researchers have considered the critical role of disability in poverty and unequal access to education and other social services (Banks et al., 2017; Singal, 2011). The first legally binding instrument to promote education for children with dis- abilities was the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD), published in 2006 (UN, 2006). Since then, many international agreements and protocols on disabled children's rights to education have been established, including the United Nations' 2030 Agenda for Sustainable Development Goals (SDGs) (UN, 2015).

To measure the performance of countries and stakeholders concerning disabled chil- dren's schooling, there is an urgent need to develop knowledge- and evidence-based

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monitoring systems on how school attendance and children's educational performance are related to children's disability status. In 2018, Sub-Saharan Africa surpassed Central and Southern Asia as the region with the largest out-of-school population, comprising 38% of the global total (UNESCO, 2020). However, a recent report from the International Centre for Evidence in Disability (ICED) concluded that there was still little evidence of and information on the educational outcomes for people with disabilities in developing countries (Kuper et al., 2018). Further, the quality of existing evidence is also poor.

This study focuses on eight African countries and aims to answer: 1) whether and how much children with disabilities differ from their peers without disabilities in terms of school enrolment, and 2) whether and to what extent there are heterogeneous disability effects on children's school enrolment according to their disability type. We aim to provide evidence on the extent of heterogeneity of such disability effects by disability types.

The Washington Group on Disability Statistics (WG) has developed several question sets for measuring disabilities since 2001, including the WG Short Set on Functioning (WG-SS), WG Short Set Enhanced (WG-SSE), WG Extended Set on Functioning (WG-ES), Child Functioning Module (WG-CFM) for children aged 2–4, and WG-CFM for children aged 5–17 (WG, 2020). The WG-SS has so far been the most widely used and the only WG tool used in education studies for children with disabilities. However, the WG-SS does not include several important devel- opmental and psychological functional domains that reflect key aspects and challenges during child development (N. E. Groce & Mont, 2017; WG, 2020). Disability prevalence by adopting WG-SS can be considerably underestimated for children. In contrast, the WG-CFM includes questions on several important functional challenges for children, such as learning, remembering, being understood, and concentrating (Loeb et al., 2018).

Our study is based on the sixth round of Multiple Indicator Cluster Surveys (MICS), which adopted the WG-CFM (UNICEF, 2017). Since 2017, about 70 countries and regions have completed or have planned surveys utilising the sixth round of the MICS WG-CGM survey tool. It is one of the few large-scale surveys that include WG disability measure- ment tools and is the first, and probably the only, large-scale application of the WG-CFM measurement tool across countries to date.

There are many challenges related to studying disabled children's schooling, including the limited data availability, diversified conceptual models of disability (Hedlund, 2009), and limited and inconsistent use of various measurement tools to classify children with disabilities. Earlier studies comparing the school performance of children with disabilities often relied on incompatible disability definitions and measurements, and many suffered from data quality issues (Filmer, 2008; UNESCO, 2018). Mizunoya et al. (2018) and Luo et al. (2020) deliberately selected surveys adopting the Washington Group Short Set on Functioning to identify people with functional difficulties (WG, 2020). However, some survey sources they used had modified the standard questions to varying degrees, which made direct comparisons questionable.

There is considerable heterogeneity in how disability is characterised and its impact on schooling outcomes (Anastasiou & Kauffman, 2011). At the same time, the fact that disability is not a widespread phenomenon makes it challenging to disaggregate dis- ability by type, especially among children and youth. Therefore, most current studies have focused on the studies on disabilities as a catch-all category in the cross-country compar- isons between non-disabled children and disabled children (Filmer, 2008; Mizunoya et al., 2018; UNESCO, 2018). Luo et al. (2020) were among the first to explore the disability gaps in school enrolment and completion rates by considering the heterogeneity in disability type and gender. However, the eight national censuses they deliberately selected between 2006 and 2012 only used part of WG-SS questions, which were less comprehen- sive than intended by the WG-SS. Following the work of David Card, Joshua Angrist, and Guido Imbens, 2021 Nobel Prize winners in economics, we frame our analysis as a natural experiment where disabilities are considered random treatments. We aim to measure the impacts/causal effects of various disability types on children's school enrolment rate before and after age ten and the children's school dropout rate. We first inspect the heterogeneity and frequency of the disability types across countries. After that, we check the school enrolment and dropout rates according to five disability types (vision, hearing, physical, intellectual, and multiple disabilities). Children with different types of disabilities face potentially heterogeneous barriers in the school environment, leading to diversified school outcomes related to their disabilities. Our study findings indicate that classifying the disability types of children can be an essential first step in studying the disability effects on education and can provide a sound basis for developing policies to promote the education of disabled children.

2. Concepts, Measurement, and Research Framework

2.1. Disability Concepts and Measurement Tools

The World Health Organization (WHO) developed the International Classification of Functioning, Disability, and Health (ICF) as a framework for classifying functional limita- tions. The ICF adopted a biopsychosocial model, emphasising the dynamic interaction between health conditions and individual and environmental factors. The Multiple Indicator Cluster Surveys (MICS) conducted by UNICEF generate data on globally agreed indicators on the well-being of children and women related to the SDGs in developing countries. The question sets in the WG-CFM follow conceptually both the biopsychosocial model of disability and ICF standards, focusing on functional outcomes.

To date, there is no widely acknowledged categorisation of disability type. Table A1 lists several widely adopted disability measurement tools. Most tools are gen- erally not directly comparable, and none is superior to others. Different categorisations of disability types have been reported in various studies, with low international compar- ability and external validity (Filmer, 2008; UNESCO, 2018). The comparability challenges also lie in the diversified sub-categories and the subtle differences among the same disability types. For example, the deaf or blind are often included in the category of hearing or vision disabilities in many studies but may be defined as stand-alone cate- gories in some other studies (Wagner et al., 2005) or defined together with multiple disabilities as a low incidence disability (Schifter, 2016). Due to the typical limitation in the sample size, hearing, vision, and physical disabilities may be merged as one broad sensory category in some studies (Schifter, 2016). However, other studies have defined hearing and vision disabilities as sensory disabilities but left physical disabilities as separate (Bakhshi et al., 2017). Intellectual disability is more complicated and may contain hetero- geneous disability sub-categories.

The sixth round of the MICS data has the outstanding advantage of combining large- scale and nationally representative samples with the standard WG-CFM disability measurement tool. The MICS WG-CFM data also have limitations. First, the question sets in WG-CFM only capture the most common functional problems. Second, as a multi- indicator survey, MICS includes a limited number of crucial school performance indicators. Third, there are limitations with utilising school enrolment since the simple binary indicator cannot fully reflect children's school involvement regarding school attendance and skill learning. Even if enrolled in school, children might be under-attending or attending school but not learning. Suppose school attendance and school performance are considered. In that case, the effect of disability can be much more significant than what has been reported by this paper only based on school enrolment. However, the variation in school enrolment by disability type, country, and age may also reveal significant contextual and cultural variations and differences in school systems of rele- vance for the degree of inclusion of disabled children in school. It can be instructive for future studies, educational policies, and assessments of the SDGs.

2.2. Research Framework

The various barriers hinder children with different disability types in the school learning environment. While lack of proper materials such as braille or eyeglasses, children with vision disabilities are hindered from receiving information through vision, while mathe- matics depends on complex visual knowledge (Rosenblum & Herzberg, 2011). Due to the visual and abstract nature of mathematical concepts, students with vision difficulties lag in simultaneously taking in pieces of information (Palmer, 2013). The main challenge for children with hearing disabilities is language-related, primarily spoken language. Earlier studies demonstrated that teaching them sign language at an early stage is crucial. Otherwise, they will be significantly challenged in grammar development, reading and writing skills, communication, and participation in social activities (Lederberg et al., 2013). For those with moderate hearing disabilities, hearing aid equipment is crucial but often not affordable for vision-disabled children in African countries.

Unlike vision and hearing disabilities, children with physical disabilities are typically constrained in travelling to school, moving around in school, or participating in physical activities. At the same time, lack of walking equipment or assistance with poor roads and school infrastructure, children with physical disabilities are restricted in school atten- dance, which can lead to high school absences and early dropout from school at a later stage (Tedla & Ababa, 2015). Intellectual (cognitive or mental) disability is probably the most complex disability type. It can include a wide range of limitations in cognitive ability and behavioural functions, which may affect the children's communication, attention, social, self-regulation, or adaptive skills, as well as logic and reasoning, and language processing. Lack of proper adaptive teaching and pedagogical interventions in the school environment, children facing these challenges may have difficulties in school adaptation, which may constrain their school attendance (McIntyre et al., 2006).

It is evident from the above examples that the social barrier related to school enrol- ment are heterogeneous. Furthermore, perceptions, attitudes and expectations towards children with different disability types can also be diversified. Stigma hierarchies (Huskin et al., 2018) and lowered expectations (Sanders, 2006) towards children with specific disability types can have essential implications for children's schooling.

With one type of disability, subjects may be able to compensate by substitution, i.e. by gaining more experiences via their other senses. Such substitution, however, may be more complicated or impossible for subjects with multiple disabilities. In that case, such subjects need more social support and face even more substantial challenges, with multiplicative effects of disability (Marschark et al., 2015).

We chose three school performance indicators to assess the different challenges for children with disability to enrol in school. Late enrolment is quite common in most African countries for young-age children. Young children who never attended school early might still have an opportunity to start school later, but older children who are not yet in school are unlikely ever to start school (Van der Berg, 2020). We define an age cut-off for starting school. Children under the age cut-off and not yet enrolled in school are considered under the category 'Young Not-Enrolled' (YoungNE), representing the risk of a late school start- up. Children above the age cut-off are regarded under the Older Never-Enrolled (OlderNE) category, representing a risk of never attending school. Children who manage to start school also have a high risk of school dropout in African countries (Momo et al., 2019). The third school performance indicator evaluates the risk of school dropout (Dropout), defined as a child who was enrolled in school before but is not continuing in school despite not having yet completed compulsory junior high school.

To answer the overarching research question as to the evidence of the disability effects on children's school performance and of the heterogeneous disability effects by disability type, we aim to test the following hypotheses based on the three school performance indicators:

Hypotheses H1a-c: Children with vision disabilities do not have challenges in early school enrolment (H1a), are not significantly more likely to enrol late in school (H1b), but have a significantly higher risk of dropping out than children without disabilities (H1c).

Hypotheses H2a-c: Children with hearing disabilities do not have challenges in early school enrolment (H2a), are not delayed in school enrolment (H2b), but have a significantly higher risk of dropping out than children without disabilities (H2c).

Most vision- and hearing-disabled children in our national representative samples have some vision/hearing capability, while blind/deaf children are rare. Hypotheses H1a-c and H2a-c build on the assumption that children with limited vision/hearing capability may not be particularly hindered from attending school but may face more barriers in receiv- ing information from school learning.

Hypotheses H3a-c: Children with physical disabilities have a significantly higher risk of failing in early school enrolment (H3a), significantly more likely to enrol in school at an older age (H3b), and not significantly more likely to drop out than non-disabled children if they can attend school (H3c). Hypotheses H3a-c build on the assumption that children with physical disabilities can be more constrained by the distance to school, weak school infrastructure, and limited transportation facilities for their school start-up and participa- tion. Furthermore, children with physical disabilities can face higher risk in rural areas where the physical barriers can be more severe. As long as it is feasible for them to start school, they should not be significantly more likely to drop out than children without disabilities.

Hypotheses H4a-c: Children with intellectual disabilities are not particularly hindered in early school enrolment (H4a), are not significantly more likely to start school late (H4b), but are significantly more likely to drop out than children without disabilities (H4c). These hypotheses build on the assumption that such children may have difficulties in school adaptation due to the lack of inclusive teaching methods to handle their cognitive and behavioural functional challenges, which can constrain their school progress.

Hypothesis H5a-c: Children with multiple disabilities lag more behind in school perfor- mance (all indicators) than children with a single disability. These hypotheses build on the assumption that barriers for children with multiple disabilities are more diverse and manifold than for singly disabled children.

We assess these hypotheses based on the pooled data from the eight African countries to ensure we have a large enough sample size for each disability type.

3. Data and Descriptive Analysis

3.1. Data

Our sample includes data from eight African countries (DR Congo, Gambia, Ghana, Lesotho, Sierra Leone, Togo, Tunisia, and Zimbabwe) where MICS surveys were conducted in 2017–2019. The MICS children survey instrument comprises 26 questions from the WG- CFM with four severity scales. The questions relate to 13 functional difficulties in a child aged 6–17 (Table A1). Severe disability refers to those with many functional problems or no function at all. This paper prescribes vision disability as severe difficulty in vision even with glasses or contact lenses, hearing disability as severe difficulty in hearing even with a hearing aid, physical disability as severe difficulty in self-care or walking 500 metres on level ground without equipment or assistance, and intellectual or cognitive disability as severe difficulties in communication, learning, remembering, or concentrating on activ- ities that the child enjoys doing. Finally, those who reported more than one co-occurring severe functional difficulty are categorised as having multiple disabilities.

This study focuses on eight out of the 13 functional domains (categorised into four types of disabilities) included in the WG-CFM. The descriptive data in Table A2 show that the prevalence rates across the eight African countries vary greatly in five behavioural and psychological functional domains: accepting change, controlling behaviour, making friends, anxiety, and depression. The large variations may indicate a huge disparity in interpreting and understanding these functional challenges locally. These functional domains should be analysed with their contextual meaning in these countries. Our analysis, therefore, does not include these five functional domains. The total sample size is 32,248, consisting of 29,218 (90.6%) non-disabled children and 3026 (9.4%) disabled children.[1]

3.2. Descriptive Statistics

Table 1 shows that the sample sizes for the specific severe disability types for the individual countries are small, especially for the severe vision and hearing disability types. The share of children with disabilities varies from 16.3% in Ghana (highest) to 5.6% in the Gambia (lowest). Our data, however, do not allow us to investigate the reasons for this variation.

Table 1. Sample size by country.

Non-disabled		Seeing disability	Hearing disability	Physical disability	Intellectual disability	Multiple disabilities	Total
DRCongo	8630 (94.2)	17 (0.2)	16 (0.2)	146 (1.6)	283 (3.1)	74 (0.8)	9166 (100.0)
The Gambia	4316 (95.7)	15 (0.3)	6 (0.1)	54 (1.2)	102 (2.3)	16 (0.4)	4509 (100.0)
Ghana	6323 (89.2)	32 (0.5)	16 (0.2)	95 (1.3)	565 (8.0)	56 (0.8)	7087 (100.0)
Lesotho	3978 (94.6)	61 (1.5)	25 (0.6)	19 (0.5)	97 (2.3)	26 (0.6)	4206 (100.0)
Sierra Leone	6610 (93.8)	10 (0.1)	11 (0.2)	157 (2.2)	196 (2.8)	62 (0.9)	7046 (100.0)
Togo	3077 (91.3)	44 (1.3)	18 (0.5)	21 (0.6)	187 (5.6)	23 (0.7)	3370 (100.0)
Tunisia	3237 (93.1)	39 (1.1)	6 (0.2)	50 (1.4)	106 (3.1)	39 (1.1)	3477 (100.0)
Zimbabwe	5343 94.2)	30 (0.5)	20 (0.4)	20 (0.4)	223 (3.9)	35 (0.6)	5671 (100.0)
Total	**41514 (93.2)**	**248 (0.6)**	**118 (0.3)**	**562 (1.3)**	**1759 (4.0)**	**331 (0.7)**	**44532 (100.0)**

The number in parenthesis is the percentage of the total column sum.

In our sample of first-grade children, 52.2% are six years old, 5.8% are nine years old, and only 2.6% are ten years old (see Table A3 for details). Therefore, we set the age cut-off for classifying the first two school performance indicators (young and older group) at age ten, under which each age group comprises over 5% of the first-grade students. The results for the three school performance indicators among the children with different disability types are presented in Figure 1. The descriptive data indicate that young children under age ten with physical disabilities have specific challenges in terms of school enrolment. Moreover, children with multiple disabilities have a much lower school enrolment rate in young and older age groups than children with a single disability. At the same time, children with multiple and intellectual disabilities have the highest risk of school dropout. These findings generally align with our hypotheses H3a-c, H4a-c, and H5a-c. On the other hand, surprisingly, children with vision and hearing disabilities have higher school enrolment and lower dropout than non-disabled children, which does not support our hypotheses H1a-c and H2a-c. However, higher school enrolment and lower dropouts only mean that they manage to stay in school and do not mean that they do not have other challenges in school learning and other activities.

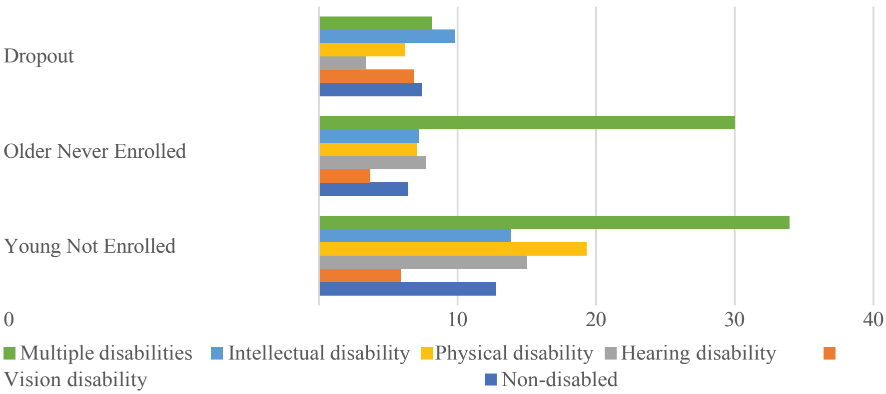

Figure 1. School performance indicators for children with different disabilities (%). Note: Young Not Enrolled is calculated as the % of the total number of young children; the rate of Older Never Enrolled is calculated as the % of the total number of older children; the dropout rate is calculated as the % of all the children who have ever been enrolled in school.

4. Model and Estimation Strategy

We frame our econometric analysis as a natural experiment (Rosenzweig & Wolpin, 2000). The assumption is that disability of any kind is not concentrated in certain parts of the population or driven by ecological, economic, or social processes. Therefore, a subgroup of the population exposed to a specific treatment (treatment-disabled group) should be otherwise similar to those not exposed to the treatment (control non-disabled group).

Although recent studies indicate that poor people might have a higher chance of becoming disabled due to a lack of housing, nutritious food, basic health facility, sanita- tion, and so on (Hosseinpoor et al., 2013), other studies suggest that in an impoverished environment, the differences between people with and without disabilities in socioeco- nomic characteristics are also limited and not statistically significant (N. Groce & Kett, 2013; Trani et al., 2010). To further inspect our assumption, we regressed each disability type on individual, family, wealth, and geographical variables, see Table A4. Such analysis supports our natural experiment assumption.[2] Based on this assumption (given that it is plausible), causal inferences can be made where the differences in outcomes may be ascribed to the disability (Leatherdale, 2019).

We include all the children in one of the five severe disability types in the 'treatment' sample and those who did not report any severe or moderate disabilities in the 'control' sample. The disability effects of the various disability types on schooling are estimated from the disparities in the rates of the three selected school performance indicators between the 'treatment' and 'control' samples. We next run regressions with the three indicators (Young Not-Enrolled, Older Never-Enrolled, and Dropout) as dependent vari- ables. The model includes a dummy of disability types D_{ij} as a treatment variable. As Angrist (2001) proposed, a simple ordinary least squares (OLS) approach can measure the causal effects of these limited dependent variables. These models provided unbiased estimates of the average marginal treatment effects in the whole sample compared with the non-disabled children as the control group.

$$YoungNE_i = \beta_0 + \beta_{1j}D_{ij} + X_i\beta_2 + u_i \quad (1)$$

$$OlderNE_i = Y_0 + Y_{1j}D_{ij} + X_iY_2 + v_i \quad (2)$$

$$Dropout_i = \alpha_0 + \alpha_{1j}D_{ij} + X_i\alpha_2 + \varepsilon_i \quad (3)$$

Here, subscript i represents each child in the sample, j indicates the disability type, X_i represents a list of the control variables, and ε_i, u_i and v_i are the error terms. We run models (1)–(3) on the pooled sample from the eight African countries. We draw general conclusions for the parts of the region these countries represent. α_0, β_0 and Y_0 estimate the average rates of the three school performance indicators (YoungNE, OlderNE, Dropout) for our control group (non-disabled children). α_{1j} is the marginal treatment effect of disability type j on dropout., while β_{1j} and Y_{1j} estimate the marginal disability treatment effects for disability type j on children's school enrolment at an earlier and later stage.

We start with a parsimonious specification with the pooled data that includes only the disability types. To inspect the robustness of the findings in the parsimonious model, we run additional models where we stepwise include macro-level (country and urban/rural dum- mies) and micro-level (individual and household characteristics) control variables. Ideally, we would have liked to split the samples to more thoroughly investigate the heterogene- ities in school performance by the macro variables; however, as shown in Table 1, there were too few observations for some disability types, which limits the statistical power.

5. Results

5.1. Disability Effect on School Enrolment by Disability Type

The regression models for the three school performance indicators: Young Not-Enrolled (YoungNE), Older Never-Enrolled (OlderNE), and school dropout (Dropout), are presented in Tables 2–4. The first regression for each model is a parsimonious model. The constant terms represent the estimated mean rates for the counterfactual non-disabled children, while the coefficients on the disability categories represent the deviation from the counterfactual non-disabled children.

The estimated average rate of Young Not-Enrolled (YoungNE) for the non-disabled children in the parsimonious model is 12.8% (Table 2), indicating that late school enrol- ment among young children in African countries is common. The coefficients on the disability types for the YoungNE rate show that young children with vision or hearing disabilities start school no later than their peers.

Young children with physical disabilities are about 6.5% points less likely to attend school, according to the model without additional controls. The introduction of macro country controls reduces this effect to 3.8% points. On the other hand, the disability effect is robust to introducing macro urban/rural control and micro controls. Furthermore, we run the models in urban and rural areas, respectively. The estimated effect for children with physical disabilities in rural areas is significant at 4.9%, while it is lower and insignif- icant in the urban subsample. It indicates that poor facilities in rural areas are an even more significant barrier for young children with physical challenges to attend school.

The intellectual disability effect is insignificant in the parsimonious model and most other models when adding the macro and micro controls, except in the model where only country dummies are included as controls. Finally, children with multiple disabilities are most affected in their school enrolment and are close to 20% points less likely to attend school than their counterfactual non-disabled children. This finding is robust with the introduction of the macro and micro controls.

Table 3 presents the results for the school enrolment of the Older Never-Enrolled (OlderNE) children. In the parsimonious model, the OlderNE rate for non-disabled children is 6.4% (Table 3). Unexpectedly, in the parsimonious model, the OlderNE rate for children with vision disabilities is significantly lower than that for the counterfactual non-disabled children. However, this effect becomes insignificant after controlling for the controls. For older children with hearing and physical disabilities, their school enrolment rates are not significantly different from their peers without disabilities. These findings are robust to the inclusion of the macro and micro controls. For children with physical disabilities, the effect is also insignificant for both urban and rural subsamples.

Again, the estimated intellectual disability effect for older children is insignificant but becomes significant after including the macro controls. The disability effect stays at a 2.4–2.7% points higher likelihood of not attending school than the non-disabled children in the alternative model specifications with the macro and micro controls

Table 2. Regression results for disability effects on Young Not Enrolled[3].

	YoungNE1	YoungNE2	YoungNE3	YoungNE4	YoungNE5	YoungNE6
Disability types (base category: none-disabled)						
Vision disability	−0.069***	−0.008	−0.059	−0.061**	0.000	0.005
	(0.026)	(0.035)	(0.036)	(0.026)	(0.023)	(0.023)
Hearing disability	0.022	0.054	0.014	0.030	0.053	0.038
	(0.057)	(0.051)	(0.053)	(0.060)	(0.058)	(0.060)
Physical disability	0.065***	0.035**	0.063***	0.066***	0.033	0.038*
	(0.022)	(0.017)	(0.018)	(0.022)	(0.021)	(0.021)
Intellectual disability	0.011	0.024**	0.004	0.010	0.017	0.014
	(0.013)	(0.012)	(0.012)	(0.013)	(0.012)	(0.012)
Multiple disabilities	0.211***	0.203***	0.205***	0.212***	0.197***	0.191***
	(0.036)	(0.025)	(0.025)	(0.036)	(0.036)	(0.035)
Control variables (X=included)						
Area (1=rural, 0=urban)			X		X	X
Country dummy (base category: DRCongo)		X			X	X
Gender (1=girl, 0=boy)				X	X	X
Family structure (base category: live together with both mother and father)				X	X	X
Number of siblings				X	X	X
Highest completed educational level of household head (base category: No schooling)						X
Wealth index (base category: first quintile)						X
Constant	0.128***	0.246***	0.050***	0.068***	0.152***	0.286***
	(0.004)	(0.005)	(0.004)	(0.007)	(0.011)	(0.015)
Sample size	18319	18319	18319	18135	18135	18092
R2	0.005	0.094	0.035	0.017	0.117	0.147

Significance levels: *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$. Cluster robust standard errors are in parentheses. Young Not-Enrolled (YoungNE) is calculated as a proportion of the total number of young children.
YoungNE: 1 = Not in school, 0 = In school.

included. The multiple disability effect for the older group is significant. They are about 24% points less likely to enrol in school than their counterfactual children, close to the younger group. This finding is also robust to the inclusion of additional controls. Table 4 presents the results for model 3 based on the dropout rate. The estimated average school dropout rate for the counterfactual non-disabled children is 8.1% for children aged 6–17. The coefficients on the disability categories suggest no adverse disability effect on the school dropout rate for children with vision, hearing, and physical disabilities in the models without control variables. These findings are all robust when introducing various controls.

The intellectual disability effect on the school dropout rate is significant and about one percentage point higher in the parsimonious model. The disability effect is robust with the micro controls but increases to over three percentage points after introducing the macro country dummy. For children with multiple disabilities, the disability effect is insignificant in the parsimonious model. Still, it becomes significant in the second model specifications after controlling for the macro country dummy. In this case, these children have about four percentage points higher likelihood of dropping out.

We will now assess our hypotheses. Hypothesis H1 states that children with vision disabilities do not have challenges in early school enrolment (H1a), are not significantly more likely to enrol late in school (H1b), but have a significantly higher risk of dropping out (H1c) than children without disabilities. Our models support hypotheses H1a and H1b but not H1c and the conclusions are robust with all the model specifications.

Table 3. Regression results for the disability effects on the Older Never-In-School (OlderNE) rate[4].

	OlderNE1	OlderNE2	OlderNE3	OlderNE4	OlderNE5	OlderNE6
Disability types (base category: none-disabled)						
Vision disability	−0.027*	0.007	−0.024	−0.022	0.013	0.015
	(0.014)	(0.019)	(0.019)	(0.014)	(0.013)	(0.013)
Hearing disability	0.013	0.036	0.001	0.016	0.028	0.029
	(0.030)	(0.027)	(0.028)	(0.031)	(0.029)	(0.030)
Physical disability	0.006	−0.011	0.006	0.005	−0.011	−0.010
	(0.019)	(0.017)	(0.017)	(0.020)	(0.020)	(0.020)
Intellectual disability	0.008	0.024***	0.009	0.008	0.024***	0.027***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Multiple disabilities	0.236***	0.245***	0.235***	0.238***	0.245***	0.241***
	(0.036)	(0.019)	(0.019)	(0.036)	(0.036)	(0.036)
Control variables (X=included)						
Area (1=rural, 0=urban)			X		X	X
Country dummy (base category: DRCongo)		X			X	X
Gender (1=girl, 0=boy)				X	X	X
Family structure (base category: live together with both mother and father)				X	X	X
Number of siblings				X	X	X
Highest completed educational level of household head (base category: No schooling)						X
Wealth index (base category: first quintile)						X
Constant	0.064***	0.075***	0.026***	0.032***	0.015**	0.074***
	(0.002)	(0.003)	(0.002)	(0.004)	(0.006)	(0.009)
Sample size	26213	26213	26213	25895	25895	25837
R2	0.006	0.071	0.021	0.012	0.090	0.113

Significance levels: **p* < 0.10; ***p* < 0.05; ****p* < 0.01.
The rate of Older Never-Enrolled (OlderNE) is calculated as a proportion of the total number of older children. OlderNE: 1 = Never in school, 0 = In school.

Hypothesis H2 states that children with hearing disabilities do not have challenges in early school enrolment (H2a), are not delayed in school enrolment (H2b), but have a significantly higher risk of dropping out than children without disabilities (H2c). Again, our models support hypotheses H2a and H2b but not H2c. These findings indicate that compared with non-disabled children, children with vision and hearing disabilities in African countries may not face specific challenges in school enrolment or dropouts. However, even if they are equally enrolled in school as other children, we do not know whether they attend school daily or have learned and been involved in other school activities as much as others. This is outside the scope of this paper.

Hypothesis H3 states that children with physical disabilities have a significantly higher risk of failing in early school enrolment (H3a), significantly more likely to enrol in school at an older age (H3b), and not significantly more likely to drop out than non-disabled children if they can attend school (H3c). The regression results on the physical disability effect support hypotheses H3a and H3c but not H3b, indicating that children with physical disabilities are significantly more likely to be late starters in school. They are more likely to enrol in the later stage and do not have a higher dropout risk if they start school. However, it does not mean that they do not have daily challenges in school attendance or learning, which we do not have information about. There are variations in the late start effect for children with physical disabilities depending on the macro and micro controls, which may signal the room for improving their school enrolment.

Hypothesis H4 states that children with intellectual disabilities are not particularly hindered in early school enrolment (H4a), are not significantly more likely to start school

Table 4. Regression results for the disability effects on the dropout rate.

	Dropout1	Dropout2	Dropout3	Dropout4	Dropout5	Dropout6
Disability types (base category: none-disabled)						
Vision disability	−0.01	−0.005	−0.006	−0.003	0.004	0.007
	(0.017)	(0.018)	(0.018)	(0.017)	(0.017)	(0.017)
Hearing disability	−0.044**	−0.043	−0.052*	−0.043**	−0.046**	−0.049**
	(0.018)	(0.027)	(0.027)	(0.020)	(0.020)	(0.020)
Physical disability	−0.008	−0.003	−0.009	−0.005	−0.003	−0.003
	(0.011)	(0.013)	(0.013)	(0.012)	(0.011)	(0.011)
Intellectual disability	0.028***	0.038***	0.027***	0.026***	0.034***	0.033***
	(0.008)	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)
Multiple disabilities	0.039	0.043**	0.036*	0.040*	0.040*	0.032
	(0.024)	(0.018)	(0.018)	(0.023)	(0.023)	(0.023)
Control variables (X=included)						
Area (1=rural, 0=urban)			X		X	X
Country dummy (base category: DRCongo)		X			X	X
Gender (1=girl, 0=boy)				X	X	X
Family structure (base category: live together with both mother and father)				X	X	X
Number of siblings				X	X	X
Highest completed educational level of household head (base category: No schooling)						X
Wealth index (base category: first quintile)						X
Constant	0.081***	0.129***	0.052***	0.053***	0.080***	0.161***
	(0.002)	(0.003)	(0.002)	(0.003)	(0.006)	(0.008)
Sample size	40400	40400	40400	39906	39906	39811
R2	0.001	0.014	0.008	0.010	0.03	0.039

Significance levels: *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.
The dropout rate is calculated as a proportion of all the children who have ever been enrolled in school. Dropout: 1 = drop out of school, 0 = In school.

late (H4b), but are significantly more likely to drop out (H4c) than children without disabilities. The results for hypothesis H4b were not robust to the inclusion of alternative controls. After including the macro controls, older children with intellectual disabilities were less likely to be enrolled in school, and we, therefore, reject hypothesis H4b. However, hypotheses H4a and H4c are supported, indicating a higher risk of school dropout for children with intellectual disabilities.

Finally, hypothesis H5 states that children with multiple disabilities lag more behind in school performance (all indicators (H5a-c)) than children with a single disability. Hypothesis H5a-c cannot be rejected because they lag most in all the school performance indicators. However, if they have managed to be enrolled, they are not much more likely to drop out of school than other children.

6. Discussion and Conclusion

Based on the unique MICS survey with nationally representative data from eight African countries, this paper provides evidence about the gaps in school enrolment for children with different disabilities. We assessed the likelihood of school enrolment before and after age ten and the possibility of school dropout. We found heterogeneous disability effects in the African context in school enrolment and dropout by disability types. Despite the potential language-related and communication challenges and constraints for children with vision and hearing disabilities, children with vision and hearing disabilities have similar school enrolment as non-disabled children.

The challenges faced by physical-disabled children prevail in school enrolment among the young age group with a higher risk of being enrolled late. Still, they eventually manage to start school when they grow older, and they also do not have a higher risk of school dropout than non-disabled children. However, our study shows some variations in the physical disability effect of late school start depending on the macro and micro controls. This finding may signal that the local facilities and infrastructure can be crucial for improving the school situation for physical-disabled children.

Based on the WG-CFM, this study presents the particular challenges in school enrol- ment for children with intellectual disabilities, which the commonly used WG-SS did not capture well. They are less likely to be or remain enrolled in school and significantly more likely to drop out than their counterfactual peers. Again, there were variations in the intellectual disability effects on school enrolment when introducing a macro country dummy, suggesting heterogeneous regional effects on school enrolment for children with intellectual disabilities. Finally, children with multiple disabilities experienced the most severe challenges in school enrolment among all the children with disabilities. When the enrolment rate for children with multiple disabilities was already very low (about 20% points lower than non-disabled children), those who managed to enrol were not found to have a higher risk of school dropout than other children.

On the other hand, besides the challenges caused by disabilities, the reasons for children not being enrolled or dropping out of school can be manifold in the African context (Sabates et al., 2010). Household-level factors such as poverty and child labour, school-level factors such as quality of education, school location and availability, teacher absenteeism, and system of educational provision can all contribute to children's school enrolment. Among all these driving factors, the child can be involved in either income- generating activities or household duties. Child labour affects the schooling of disabled and non-disabled children differently, depending on the type of disability. Many disabled children are constrained in contributing to work and therefore have more chance of going to school. The mean dropout rate across the eight countries in this study is 7.5%, which is relatively high. The disability effect of school dropout between disabled and non-disabled children can be potentially higher in countries where child labour is uncommon.

Several earlier multicountry studies have also reported considerable gaps in school enrolment between children with and without disabilities (Filmer, 2008; Luo et al., 2020; UNESCO, 2018). However, disabilities are often defined in a catch-all category, and little effort is paid to compare the disability effects across disability types. The exceptions are the studies by Kuper et al. (2018) and Luo et al. (2020), who reported children with difficulties in seeing or hearing have the least risk of lagging in school. They also found children with difficulty in learning, communication, or remembering suffered most from lower school enrolment. Kuper et al. (2018) suggested considerable variations in the school attainment gap for children with physical disabilities in the 30 countries they analysed. The results from these studies are in line with our findings.

These studies were based on surveys from various sources with different disability mea- surements and definitions. None of these studies differentiated the multiple disabilities children, who were found to be the most challenging group in our study, from those with a single disability. Also, the studies often include countries spread over vast regions, including Asia, Africa, Latin America, and even Europe. To the best of our knowledge, our study is the first multicountry comparison study that follows the new standard WG-CFM disability measurement with recent nationally representative data, focusing on the schooling of children with different disability types in Africa.

It is worth mentioning that the majority of the vision, and hearing-disabled children in our sample are not blind or deaf. Our study concludes that vision or hearing-disabled children are not hindered from school enrolment, which may not apply to children in more extreme conditions. Intellectual disability can be related to different heterogeneous disability sub-categories. This study only includes children with severe difficulties in communication, learning, remembering or concentrating on activities children enjoy doing. Although our study did not find a significant correlation between disability and other factors in our data, the natural experiment assumption should always be validated for such analyses since many studies suggest that the incidence of disability can be correlated with geographic, economic, health and social processes in various contexts.

To further inspect our assumption, we regressed each disability type on individual, family, wealth, and geographical variables, see Table A4. The results from this analysis support our natural experiment assumption.

School enrolment is a crude indicator of children's school performance, which may not fully represent the complicated school challenges faced by children with disabilities. The fact that disabled children are enrolled in school does not mean that they are not facing other barriers associated with their disabilities that can affect learning when in school. The disability effect on the likelihood of dropout is controversial and should be complemen- ted with an assessment of school attendance. This is probably most relevant for children with a physical disability who are vulnerable to external conditions in everyday' s school attendance. However, as a nationally representative survey, MICS surveys are not specially tailored to education issues or disability studies. Indicators such as school attendance are not available, which makes it challenging to study the likely differences in school atten- dance for disabled versus non-disabled children. Finally, the limited sample size of disabled children in MICS data also limits the accuracy of the estimates of the disability effects on school performance indicators at the country level.

In future studies, other indicators of school performance and skill learning should be introduced. Intellectually disabled children are probably the most heterogeneous dis- ability group who may need more personalised school adjustments. To fully understand their different functions, more work is required to break them into more sub-categories with standard definitions. Critical macro heterogeneous effects on some disability types should also be studied in local contexts.

The heterogeneous disability effects among children with diversified disabilities suggest a crucial need to classify children's disability types in understanding the impact of disability on education, which the current studies have so far overlooked. Donohue and Bornman (2014) illustrated the poor implementation and enforce- ment of inclusive education policy in South Africa due to the lack of specificity and detail in catering to diverse learners. This paper highlights the importance of understanding the heterogeneous challenges and needs of children with diversified disabilities. Future studies on formulating and implementing educational policy and constructing local education services for children with disabilities should address their heterogeneous needs.

8 Notes

1. We excluded 6 children who did not report any schooling information and 1259 children whose reported difference between their age and the reported school year was too small, indicating a data quality issue.
2. We examine whether each type of disability is correlated with key factors, we regress each disability type on individual factors (children's age, gender, relationship to the household head, number of siblings, and school status of siblings), household factors (gender and educational level of the household head, family structure, and wealth index), and geo- graphical factors (urban/rural, and country dummy). Table A2 presents the results. We find that these variables explain less than 1% of the likelihood of disability for all but one disability type. For the intellectual disability class, the model explains 3.5% of the varia- tion, which is still low. We therefore consider our assumption to be sufficiently statistically correct to use it as a basis for our analysis.
3. The coefficient estimations for all the control variables are available upon request.
4. The base category for the OlderNE model is children in the age group of 10–11, otherwise they have the same characteristics as those for the regression on the YoungNE.
5. The Model Disability Survey (MDS) is a stand-alone instrument developed by the Disability Unit of the World Health Organization (WHO). The Disability Screening Questions (DSQ-34) was initiated by a group of international experts and has been applied in several large national representative surveys in Asia (WHO, 2017).

9 Disclosure Statement

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12 Data Statement

The data we use in this paper were gathered in the 6th round of Multiple Indicator Cluster Surveys (MICS6), which can be downloaded from https://mics.unicef.org/surveys. The MICS6 surveys are conducted by UNICEF (United Nations International Children's Emergency Fund). The UNICEF surveys follow the ethical requirements as stated in their ethical document: https://www.unicef. org/media/54796/file. The data collection involves human participation; however, the information was concealed by the MICS team. The informed consent is also discussed in each country's survey report and included in the individual questionnaires.
The Stata user data and do-files are available from the authors for verification of the results upon request.

13 References

Anastasiou, D., & Kauffman, J. M. (2011). A social constructionist approach to disability: Implications for special education. *Exceptional Children*, *77*(3), 367–384. https://doi.org/10.1177/ 001440291107700307

Angrist, J. D. (2001). Estimation of limited dependent variable models with dummy endogenous regressors: Simple strategies for empirical practice. *Journal of Business & Economic Statistics*, *19*(1), 2–28. https://doi.org/10.1198/07350010152472571

Bakhshi, P., Babulal, G. M., Trani, J.-F., & Federici, S. (2017). Education of children with disabilities in New Delhi: When does exclusion occur? *PLOS ONE*, *12*(9), e0183885. https://doi.org/10.1371/ journal.pone.0183885

Banks, L. M., Kuper, H., & Polack, S. (2017). Poverty and disability in low-and middle-income countries: A systematic review. *PLOS ONE*, *12*(12), e0189996. https://doi.org/10.1371/journal. pone.0189996

Donohue, D., & Bornman, J. (2014). The challenges of realising inclusive education in South Africa. *South African Journal of Education*, *34*(2), 1–14. https://doi.org/10.15700/201412071114

Filmer, D. (2008). Disability, poverty, and schooling in developing countries: Results from 14 household surveys. *The World Bank Economic Review*, *22*(1), 141–163. https://doi.org/10.1093/wber/lhm021

Groce, N., & Kett, M. (2013). *The disability and development gap. Leonard Cheshire disability and inclusive development centre working Paper Series No 21*. LCDIDC.

Groce, N. E., & Mont, D. (2017). Counting Disability: Emerging Consensus on the Washington Group Questionnaire. *The Lancet Global Health*, *5*(7), e649–e650. https://doi.org/10.1016/S2214-109X(17) 30207-3

Hedlund, M. (2009). Understandings of the disability concept: A complex and diverse concept. In Marshall (Ed.), *Disabilities: Insights from across fields and around the world* (Vol. 1, pp. 5–18).

Hosseinpoor, A. R., Stewart Williams, J. A., Gautam, J., Posarac, A., Officer, A., Verdes, E., Kostanjsek, N., & Chatterji, S. (2013). Socioeconomic inequality in disability among adults: A multicountry study using the world health survey. *American Journal of Public Health*, *103*(7), 1278–1286. https://doi. org/10.2105/AJPH.2012.301115

Huskin, P. R., Reiser-Robbins, C., & Kwon, S. (2018). Attitudes of undergraduate students toward persons with disabilities: Exploring effects of contact experience on social distance across ten disability types. *Rehabilitation Counseling Bulletin*, *62*(1), 53–63. https://doi.org/10.1177/ 0034355217727600

Kuper, H., Saran, A., White, H., Kumar, S. T., Tolin, L., Muthuvel, T., & Wapling, L. (2018). Rapid evidence assessment (REA) of what works to improve educational outcomes for people with disabilities in low-and middle-income countries. *International Centre for Evidence in Disability, London School of Hygiene and Campbell Collaboration*. https://assets.publishing.service.gov.uk/ media/5b8ea83040f0b67d9a6fe669/Education_Rapid_Review_full_report.pdf

Leatherdale, S. T. (2019). Natural experiment methodology for research: A review of how different methods can support real-world research. *International Journal of Social Research Methodology*, *22* (1), 19–35. https://doi.org/10.1080/13645579.2018.1488449

Lederberg, A. R., Schick, B., & Spencer, P. E. (2013). Language and literacy development of deaf and hard-of-hearing children: Successes and challenges. *Developmental Psychology*, *49*(1), 15. https:// doi.org/10.1037/a0029558

Loeb, M., Mont, D., Cappa, C., De Palma, E., Madans, J., & Crialesi, R. (2018). The development and testing of a module on child functioning for identifying children with disabilities on surveys. I: Background. *Disability and Health Journal*, *11*(4), 495–501. https://doi.org/10.1016/j.dhjo.2018.06.005

Luo, Y., Zhou, R. Y., Mizunoya, S., & Amaro, D. (2020). How various types of Disabilities Impact Children's School Attendance and completion-lessons learned from censuses in eight developing countries. *International Journal of Educational Development*, *77*, 102222. https://doi.org/10.1016/j. ijedudev.2020.102222

Marschark, M., Shaver, D. M., Nagle, K. M., & Newman, L. A. (2015). Predicting the academic achievement of deaf and hard-of-hearing students from Individual, household, communication, and educational factors. *Exceptional Children*, *81*(3), 350–369. https://doi.org/10.1177/0014402914563700

McIntyre, L. L., Blacher, J., & Baker, B. L. (2006). The transition to school: Adaptation in young children with and without intellectual disability. *Journal of Intellectual Disability Research*, *50*(5), 349–361. https://doi.org/10.1111/j.1365-2788.2006.00783.x

Mizunoya, S., Mitra, S., & Yamasaki, I. (2018). Disability and school attendance in 15 low-and middle-income countries. *World Development*, *104*, 388–403. https://doi.org/10.1016/j.worlddev. 2017.12.001

Momo, M. S., Cabus, S. J., De Witte, K., & Groot, W. (2019). A systematic review of the literature on the causes of early school leaving in Africa and Asia. *Review of Education*, *7*(3), 496–522. https://doi. org/10.1002/rev3.3134

Palmer, C. (2013). Mathematical connections: Making it happen for students with vision impairment in inclusive classrooms. *Journal of the South Pacific Educators in Vision Impairment*, *6*(1), 17–24.

Rosenblum, L. P., & Herzberg, T. (2011). Accuracy and techniques in the preparation of mathematics worksheets for tactile learners. *Journal of Visual Impairment & Blindness*, *105*(7), 402–413. https:// doi.org/10.1177/0145482X1110500703

Rosenzweig, M. R., & Wolpin, K. I. (2000). Natural "Natural Experiments" in economics. *Journal of Economic Literature*, *38*(4), 827–874. https://doi.org/10.1257/jel.38.4.827

Sabates, R., Akyeampong, K., Westbrook, J., & Hunt, F. (2010). *School drop out: Patterns, causes, changes and policies*.

Sanders, K. Y. (2006). Overprotection and lowered expectations of persons with disabilities: The unforeseen consequences. *Work*, *27*(2), 181–188.

Schifter, L. A. (2016). Using survival analysis to understand graduation of students with disabilities. *Exceptional Children*, *82*(4), 479–496. https://doi.org/10.1177/0014402915619418

Singal, N. (2011). Disability, poverty and education: Implications for policies and practices. *International Journal of Inclusive Education*, *15*(10), 1047–1052. https://doi.org/10.1080/ 13603116.2011.555065

Tedla, T. A., & Ababa, A. (2015). The challenge of inclusion of children with physical impairment: Absenteeism in focus—A case study. *Open Access Library Journal*, *2*(11), 1. https://doi.org/10. 4236/oalib.1102009

Trani, J.-F., Bah, O., Bailey, N., Browne, J., Groce, N., & Kett, M. (2010). *Disability in and around Urban Areas of Sierra Leone*.

UN. (2006). *Convention on the rights of persons with disabilities (CRPD)*. https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html

UN. (2015). *Sustainable development goals*. https://sdgs.un.org

UNESCO. (2018). *Education and disability: Analysis of data from 49 countries*. United Nations Educational, Scientific and Cultural Organization.

UNESCO. (2020). *Global education monitoring report 2020: Inclusion and education–all means all.* Unesco Paris.

UNICEF. (2017). *Module on child functioning concept note*. https://data.unicef.org/resources/module- child-functioning-concept-note

Van der Berg, S. (2020). Education access and "Learning Poverty" in seven Southern African Countries. *NO POVERTY*, *6*(17), 199.

Wagner, M., Newman, L., Cameto, R., & Levine, P. (2005). *Changes over time in the early postschool outcomes of youth with disabilities. A report of findings from the national longitudinal transition study (NLTS) and the national longitudinal transition study-2 (NLTS2)*. Online Submission.

WG. (2020). *An introduction to Washington Group on disability statistics question sets*. https://www.washingtongroup-disability.com/fileadmin/uploads/wg/The_Washington_Group_Primer_-_ English.pdf

WHO. (2017). *Model disability survey(MDS): Survey manual*. Geneva: World Health Organizatio: World Health Organization. https://iris.who.int/bitstream/handle/10665/258513/?sequence=1

14 Appendix

Table A1. Disability measurement tools[5].

Tools	Number of questions	Disability types	Severity scales
WG-SS	6	Vision, hearing, mobility, communication, remembering and concentrating, self- care.	'No difficulty', 'Some difficulty', 'A lot of difficulty', and 'Cannot do at all'.
WG-SSE	12	Vision, hearing, mobility, communication, remembering and concentrating, self- care, upper body, anxiety, depression.	'No difficulty', 'Some difficulty', 'A lot of difficulty', and 'Cannot do at all'. (Five- level scale for anxiety and depression)
WG-ES	37	Vision, hearing, mobility, communication, remembering and concentrating, self- care, upper body, anxiety, depression, pain, fatigue.	'No difficulty', 'Some difficulty', 'A lot of difficulty', and 'Cannot do at all'.
WG-CFM (Aged 2–4)	16	Vision, hearing, mobility, communication, dexterity, learning, playing, controlling behaviour.	'No difficulty', 'Some difficulty', 'A lot of difficulty', and 'Cannot do at all'.
WG-CFM (Aged 5–17)	24	Vision, hearing, mobility, communication, remembering, concentrating, self-care, learning, accepting change, controlling behaviour, making friends, anxiety, depression.	'No difficulty', 'Some difficulty', 'A lot of difficulty', and 'Cannot do at all'. (Five- scale for anxiety and depression)
Model Disability Survey (MDS)	48	Vision, hearing, mobility, communication, self-care, hand and arm use, pain, energy and drive, breathing, affect (depression and anxiety), interpersonal relationships, handling stress, cognition, household tasks, community and citizenship participation, caring for others, work and schooling.	1 (None)–5 (Extreme)
Disability Screening Questions (DSQ)	34	Vision, hearing, mobility, flexibility, dexterity, pain, learning developmental memory, mental health-related, other/ unknown.	'No difficulty', 'Some difficulty', 'A lot of difficulty', and 'Cannot do at all'. 'Never', 'Rarely', 'Sometimes', 'Often', 'Always'.
Ten Question (TQ) (Aged 2–9)	10	Vision, hearing, mobility, cognitive, speech, epilepsy.	None

Table A2. Prevalence rates of functional difficulties for behavioural and psychological domains among children aged 6-17 in each country (%).

	Accepting change		Controlling behaviour		Making friends		Anxious, nervous or worried		Sad or depressed	
Country	Some difficulty	A lot of difficulty/ Cannot at all	Some difficulty	A lot of difficulty/ Cannot at all	Some difficulty	A lot of difficulty/ Cannot at all	Weekly	Daily	Weekly	Daily
DRCongo	19.39	1.39	20.40	1.32	6.47	0.55	27.93	1.27	23.73	0.74
The Gambia	9.12	0.40	9.27	0.31	1.89	0.16	5.56	0.16	5.34	0.18
Ghana	17.57	1.51	18.74	1.78	8.55	0.63	4.71	0.47	3.80	0.40
Lesotho	5.92	0.31	4.18	0.52	3.40	0.38	2.07	0.19	1.57	0.12
Sierra Leone	15.81	1.36	15.99	1.08	6.83	0.37	12.61	1.13	10.78	1.11
Togo	26.29	2.40	20.68	0.83	8.16	0.47	17.75	1.01	13.20	0.63
Tunisia	14.58	1.29	13.60	1.47	6.07	1.04	25.40	2.56	8.12	1.12
Zimbabwe	9.91	0.39	7.65	0.65	2.87	0.37	5.92	0.39	5.59	0.26
Total	15.16	1.14	14.65	1.07	5.74	0.49	13.33	0.87	10.23	0.59

Table A3. Proportion of children in each age group among the first-grade children in each country (%).

Age	DRCongo	Gambia	Ghana	Lesotho	Sierra Leone	Togo	Tunisia	Zimbabwe	All
6	41.2	34.5	40.4	73.2	54.4	61.4	93.3	65.6	52.2
7	29.1	34.9	31.0	18.7	24.4	20.9	5.3	27.6	26.4
8	12.6	16.8	14.9	5.5	9.7	10.0	0.4	5.3	10.7
9	8.7	8.8	7.4	0.7	6.3	5.0	0.0	1.0	5.8
10	4.7	2.7	3.2	1.0	2.3	1.4	0.7	0.6	2.6
11	2.6	0.9	1.6	0.0	1.8	0.5	0.0	0.0	1.3
12	0.5	1.1	0.6	0.0	0.4	0.9	0.0	0.0	0.5
13	0.4	0.2	0.7	0.0	0.7	0.0	0.0	0.0	0.4
14	0.1	0.0	0.1	1.0	0.0	0.0	0.4	0.0	0.1
15	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
16	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Sample size	977	559	693	310	733	220	283	511	4286
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Numbers in red indicate the age groups that comprise over five per cent of the first-grade students.

Table A4. Regression results for estimating the determinant factors of each disability type.

	Vision disability (1=yes, 0=no)	Hearing disability (1=yes, 0=no)	Physical disability (1=yes, 0=no)	Intellect disability (1=yes, 0=no)	Multi disability (1=yes, 0=no)
Age	0.000*	0.000	−0.002***	−0.001	−0.001**
Gender (1=girl, 0=boy)	0.000	0.000	0.003	−0.007*	−0.001
Area (1=rural, 0=urban)	0.001	0.001	0.004	0.002	0.000
Gender of household head (1=female, 0=male)	0.000	−0.002	0.004	−0.001	−0.002
Highest completed educational level of household head (base category: primary)					
Never in school	0.002	0.001	−0.009**	−0.01	0.000
Lower secondary	0.003	0.001	−0.001	−0.004	0.001
Upper secondary	0.000	0.000	0.001	−0.006	−0.003
Higher education	0.002	0.002	−0.003	−0.014*	0.004
Family structure (base category: live together with both mother and father)					
Only mother	0.004	0.003	−0.003	0.007	0.002
Only father	−0.002	0.000	0.002	0.002	−0.002
None of the parents	0.000	0.003	−0.020*	0.001	0.004
Relationship of the child to the household head (base category: son/daughter of the household head)					
Grandchild	−0.001	0.001	0.017*	0.005	0.000
Adopted/foster/stepchild	−0.002	−0.004***	0.011	0.017	−0.004
Relative	−0.002	−0.001	0.011	0.011	−0.002
Non-relative	−0.004	−0.001	0.016	0.019	−0.007**
Wealth index (base category: first quintile)					
Second	0.001	0.000	−0.004	0.001	0.001
Middle	0.001	−0.001	−0.005	−0.001	−0.001
Fourth	0.003	0.001	0.001	0.001	−0.002
Highest	0.003	−0.002	0.003	−0.010	−0.003
School status of siblings (base category: no sibling)					
All siblings aged 6–17 currently enrolled in school	0.000	0.001	−0.011*	−0.007	0.000
Some siblings 6–17 not currently enrolled in school	0.001	−0.001	−0.008	−0.018	−0.001
None of sibling currently in school	−0.001	0.000	−0.005	−0.006	0.002
Number of sibling	0.000	0.000	0.001	0.001	0.000
Country dummy (base category: DRCongo)					
The Gambia	−0.001	−0.001	−0.007	0.003	−0.004
Ghana	−0.001	0.000	−0.007	0.067***	0.001
Lesotho	0.012***	0.004*	−0.017***	−0.010	−0.002
Sierra Leone	−0.002	−0.001	0.009*	0.000	0.001
Togo	0.010**	0.003	−0.009*	0.033***	−0.001
Tunisia	0.009***	0.001	−0.001	0.010	0.004
Zimbabwe	0.001	0.002	−0.018***	0.015**	−0.003
Constant	−0.003	0.001	0.040***	0.046***	0.015***
Sample size	41167	41034	41479	42657	41250
R2	0.005	0.003	0.010	0.018	0.002

*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

II Numeracy skills learning of children in Africa: - Are disabled children lagging behind?

PLOS ONE

RESEARCH ARTICLE

Numeracy skills learning of children in Africa:—Are disabled children lagging behind?

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Abstract

Significant progress has been achieved in universal basic education in African countries since the late 1990s. This study provides empirical evidence on the within- and across-coun- try variation in numeracy skills performance among children based on nationally representa- tive data from eight African countries (DR Congo, The Gambia, Ghana, Lesotho, Sierra Leone, Togo, Tunisia, and Zimbabwe). We assess whether and to what extent children with disabilities lag in numeracy skills and how much it depends on their type of disabilities. More specifically, we explore whether disabled children benefit equally from better school system quality. The assessment is analysed as a natural experiment using the performance of non- disabled children as a benchmark and considering the different types of disabilities as ran- dom treatments. We first evaluate the variation in average numeracy skills in the eight Afri- can countries. They can roughly be divided into low- and high-numeracy countries. We apply Instrumental Variable (IV) methods to control the endogeneity of completed school years when assessing subjects' school performance and heterogeneous disability effects. Children with vision and hearing disabilities are not especially challenged in numeracy skills performance. The low numeracy skills among physically and intellectually disabled children are mainly attributable to their limited school attendance. Children with multiple disabilities are constrained both by low school attendance and by poor numeracy skills return to school- ing. The average differences in school performance across the high- versus low-numeracy skill country groups are larger than the within-group average differences for disabled versus non-disabled kids. This indicates that school enrolment and quality are crucial for children's learning of numeracy skills, and that disabled children benefit equally from better school quality across these African countries.

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1. Introduction

The Sustainable Development Goal (SDG) 4 aims at inclusive and equal access to education for all children [1]. Significant progress has been achieved [2] since the adoption of several development frameworks, such as Education for all [3] and the Millennium Development Goals [4]. Data from UNESCO Institute for Statistics suggests that since the late 1990s and

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early 2000s, most African countries have increased the gross enrolment in primary schools from about 75% to almost 100%. Even countries with low school enrolment historically, such as Niger, also witnessed their primary school gross enrolment to grow from 30% in the late 1990s to about 60–70% in recent years [5].

Although universal basic education has achieved great success, recent studies are concerned about poor school performance among children across African countries [6]. Many children did not gain basic skills in reading and mathematics even after many years of schooling [6–8]. Furthermore, the achievement gained in school enrolment has masked problems related to unequal distribution and disparity in school performance, as well as the marginalisation of the most disadvantaged and vulnerable groups of children [9–12]. Children with disabilities are possibly among those exposed to such limitations and risks [13, 14].

This paper aims to investigate the learning outcome in form of numeracy skills for children with and without disabilities in eight African countries. Based on the sixth round of Multiple Indicator Cluster Surveys (MICS), we aim to answer the following research questions: 1) To what extent do the average numeracy skills vary across African countries? 2) To what extent does the average performance differ between children with and without disabilities? 3) To what extent is the numeracy skills return to schooling dependent on children's disability status and types of disabilities? 4) Are disabled children able to benefit from better school system quality to the same extent as non-disabled children? To answer these questions, we first evalu- ate the variation in the numeracy skills across the eight African countries in our study and esti- mate the disability effects on numeracy skills returns to schooling by using non-disabled children as the counterfactual. Afterwards, we assess the relative performance between dis- abled and non-disabled children in countries with low- and high-numeracy skills. The coun- try-level school quality is measured by the mean numeracy score of non-disabled children in these countries.

There is a growing research interest in timely and reliable empirical evidence on school enrolment and learning performance for children with disabilities in developing countries to measure the across-region variation [15, 16]. Several comparative studies based on data from multiple countries provided evidence on disabled children's overall low school attendance, enrolment, and school completion [15, 17–21]. However, none of these comparative studies has assessed disabled children's school performance.

Earlier studies based on Western experiences have presented evidence for learning chal- lenges among disabled children since they are often limited in cognitive, behavioural, motor, and emotional abilities [22, 23]. However, the evidence on disability gaps in learning skills in the developing context is limited and primarily through simple tests embedded in surveys in individual countries. For example, studies in India [24] and Pakistan [25, 26] suggest a signifi- cant disability gap in numeracy skills. These studies do not indicate whether the low numeracy skills among disabled children have been merely correlated with their low school attendance or have originated from their challenges in learning in school. Takeda and Lamichhane (2018) notice that when the interaction between disability status and school status is included in the model, the disability dummy becomes insignificant [24]. They conclude that once disabled children access education, they become less likely to fall behind in school performance. We suggest that the endogeneity of selection into schooling should be considered when estimating the disability gap in learning.

Due to the challenges in sample size for disabled children, many studies in the developing context used the catch-all category for disability. There are a few exceptions. Singal et al. (2018) evaluated Pakistani children's basic numeracy skills among those with three types of disabilities and varying severity: sensory (walking, seeing and hearing); self-caring (difficulty in dressing and washing all over); and cognitive [26]. They only found significant disability gap in learning outcomes among those with moderate or severe sensory disabilities but not among those with mild disabilities or other disability types.

Another study that also differentiates disability types is Bakhshi, Babulal and Trani (2018), who predicted school access and literacy in Western Darfur in Sudan for children with four types of disabilities: sensory (physical, seeing and hearing), mental and cognitive, behavioural and mood, and multiple disabilities [6]. They found no difference in skills performance either with the catch-all disability category or with different disability types. However, the authors further argue that in the conflict setting in Darfur, where all children are exposed to a high risk of being excluded and not taught in school, the differences in school performance might have disappeared. More evidence is needed to understand the heterogeneous effects of disability types and the potential correlation between the disability effect and school quality.

To the best of our knowledge, our study is the first comprehensive study evaluating disabled children's achievement in numeracy skills based on the standardised WG-CFM and numeracy tests in African countries. Our analysis uses the natural experiment framework by using the sample of non-disabled children as a benchmark (counterfactual). When assessing subjects' numeracy skills returns to schooling and heterogeneous disability effects, we apply Instrumen- tal Variable (IV) methods to control the endogeneity of completed school years, since the dis- ability status may directly affect children's likelihood of being in school.

2. Conceptual framework

This paper explores whether children with disabilities lag in numeracy skills compared to non- disabled children and to what extent such a lag varies with their disability status, school enrol- ment and country-level numeracy performance. Children with disabilities might lag in numer- acy skills if they do not attend school as much as their non-disabled peers. Earlier studies found that children with disabilities are exposed to a higher risk of not attending school, enrolling late, or dropping out of school early [15, 17, 18, 27]. The factors constraining disabled children from school attendance can be diverse due to their varied functional difficulties.

On the other hand, disabled children can also be constrained in learning numeracy skills due to diversified challenges in the learning process, even if they are equally enrolled in school. Some literature indicates that children with developmental delay in motor coordination, severe delay in motor skills, and visual-motor integration skills have challenges in learning math [28, 29]. "Embodied cognition" theory argues that the mathematical cognitive process is grounded in the simulations of sensorimotor processes through the interaction of the body with the world [15].

Earlier studies have not supported that children's seeing or hearing abilities are prerequi- sites for developing essential numeracy competencies. Zarfaty et al. (2004) conclude that deaf children in their early years do not have a problem with representing numbers and are particu- larly good at representing numbers when sets are presented as spatial arrays [30]. Morgan et al. (2011) also find that children with speech-language impairments do not lag behind non- disabled children in their math skills growth [31]. Crollen et al. (2021) have reported that blind children might even outperform their non-blind peers in numeracy abilities [32]. However, Zhang et al. (2019) demonstrate that children with seeing or auditory perception challenges struggle to learn numeracy skills related to visual Arabic or verbal modules [33].

Numerous studies have also presented evidence that children's development in various abil- ities, such as information processing, cognitive abilities, and attentive behaviours, is critical for their learning process [22, 34]. Children with intellectual disabilities are often characterised by cognitive, behavioural, and emotional difficulties [35], which can constrain children's ability to learn numeracy skills [34].

Finally, a lack of teaching materials (such as braille or eyeglasses, hearing aids equipment, walking equipment, and sign language) and proper pedagogical interventions for children with disabilities may also constrain their skill learning. Other potential challenges in school can be stigma and negative perceptions, attributions, and expectations of their teachers [36]. Children with multiple disabilities have higher risks related to all the challenges discussed ear- lier than children with single disabilities. The question is whether or to what extent disabled children's numeracy skills are influenced by factors other than their school attendance and how these factors correlate with their disability status and disability types.

Another concern in investigating children's learning outcomes is school quality [37, 38].

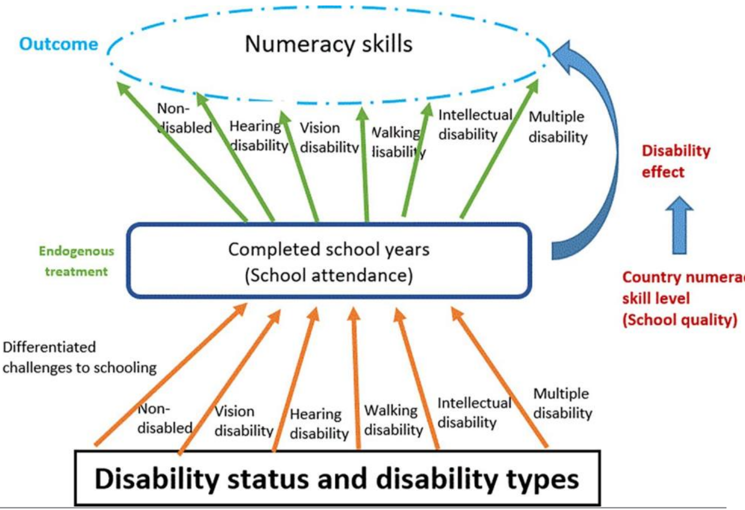
Heyneman & Loxley (1983) studied 29 high- and low-income countries and concluded that in low-income countries, the effect of school quality on primary school children's academic achievement was more prominent than the effect of family socioeconomic status [39]. Bakhshi, Babulal, and Trani (2018) report that when the overall school learning is poor in a conflict set- ting, there is no difference in learning performance as everybody may lag in poor-quality schools [6]. So far, little evidence in African countries has indicated whether children with dis- abilities might benefit more or less from high school quality and whether the gap between chil- dren with and without disabilities will expand or stabilise when school quality improves. We suggest testing this by comparing the disability effects on children's numeracy skills perfor- mance across countries with low- and high-numeracy skills.

Our framework is presented in Fig 1. This paper will estimate the heterogeneous disability effect on the return to schooling regarding numeracy skills with IV models. S1 Table presents the sample size for the split samples. We will estimate the disability effect in the low- and high- numeracy skills country groups for the three disability types, respectively. Ideally, we would have included all five disability types. However, the sample is too small for vision and hearing disabilities in the split sample of sub-groups.

We aim to test the following hypotheses:

H1. *There is a considerable variation in average school performance*, *measured by the average numeracy skills of children across African countries*.

Fig 1. Framework on numeracy skills performance for children with and without disability.



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H2. *Children with disabilities perform significantly worse than their non-disabled peers of the same age in learning numeracy skills*.

H3. *There are heterogeneous disability effects in numeracy skills return to schooling for children with different disabilities*. More specifically, we hypothesise that:

H3a. *Children with vision and hearing disabilities perform well in numeracy skills return to schooling compared to non-disabled children*. This hypothesis is based on earlier evidence [30, 32], suggesting that vision and hearing abilities might not be crucial in developing numeracy skills. Although learning numeracy skills related to visual or verbal modules might be relevant [33], the numeracy tests involved in this survey are pretty basic.

H3b. *Children with physical disabilities have a lower return to schooling in numeracy skills learning than non-disabled children*. This hypothesis is based on the embodied cognition theory [40] that motor skills can constrain children's numeracy skills learning.

H3c. *Children with intellectual disabilities have a lower return to schooling in numeracy skills learning than non-disabled children*. This hypothesis follows various research findings [22, 34, 35] that children's cognitive and behavioural abilities development is crucial for their numeracy learning.

H3d. *Children with multiple disabilities have the lowest numeracy skills return to schooling among all disability types*. Children with multiple disabilities are exposed to higher challenges [27] because they have fewer opportunities of substituting across senses and functions in their learning processes.

H4a. *The gap in numeracy skills between non-disabled and disabled children is larger in high-numeracy skills countries*. It is based on the assumption that children with disabilities are less capable of benefiting from the better quality of the school system than non-disabled children. Disabled children likely need to give extra effort to the senses and functions that work well to compensate for their disability constraints. More resources and teaching skills are needed to cater for the unique needs of disabled children.

H4b. *The within-group average differences in the numeracy skills between non-disabled and disabled children are smaller than the between-group average differences between the low- and high-numeracy skills country groups*. This is based on the assumption that despite the functional challenges among disabled children, schooling with good quality may greatly contribute to the school performance of children both with and without disabilities.

3. Data, methods, and estimation strategy

The MICS surveys aim to provide internationally comparable data about the education status of children and women. Our sample is a national representative sample from eight African countries (DR Congo, The Gambia, Ghana, Lesotho, Sierra Leone, Togo, Tunisia, and Zimbabwe) that conducted the sixth round of the MICS surveys in 2017–2019, conducted by United Nations International Children's Emergency Fund (UNICEF). The survey includes a standard learning assessment test for children aged 7–14 [41].

The MICS survey adopts Washington Group Child Functioning Module (WG-CFM), which aims to capture the most common functional problems related to child development for children aged 6–17 [42, 43]. WG-CFM include 26 questions (related to 13 functional domains) with four severity scales. This paper formulates vision disability as severe difficulty in vision even with glasses or contact lenses; hearing disability as extreme difficulty in hearing even with a hearing aid; physical disability as severe difficulty in self-care or walking 500 metres on level ground without equipment; intellectual disability as severe difficulties in communication, learning, remembering or concentrating on activities that the child enjoys doing; and multiple disabilities as more than one co-occurring severe functional difficulties as prescribed earlier. Here, severe functional difficulty refers to a lot of functional difficulties or no function at all. The study only uses eight (categorised as four disability types) out of the 13 functional domains captured by WG-CFM. The remaining five functional domains (accepting change, controlling behaviour, making friends, anxiety, and depression) are not included since their prevalence rates vary greatly across the eight African countries, possibly indicating a challenge in inter- preting these functional challenges in the local context.

The sample includes currently-in-school, dropout, and never-in-school children. Table 1 shows the total sample size is 32,306, including 30,013 non-disabled children as the counterfac- tual and 2,293 disabled treatment sample. School enrolment is lower among disabled children (87.8%) than non-disabled children (91.0%) and lowest among multiple disabled children (70.5%). The response rates to the numeracy test among different groups of Ever-In-School children are generally quite high (about 95% or higher) but much lower among the Never-In- School disabled sample (76.1%).

We frame our econometric analysis as a natural experiment, which assumes that the sub- jects are exposed to a random disability treatment determined by nature or factors outside the control of the subjects or researchers [44]. Disability can be considered an exogenous treat- ment variable since it is most likely not determined by the characteristics of the population or geographic, economic or social aspects. Despite the potential correlation between poverty and childhood disability declared by some studies [45], the nature of this connection has been complicated. Two mechanisms coexist: children in poor households can be exposed to a higher risk of being disabled, while families with disabled children might experience social depriva- tion due to the high costs related to their healthcare needs [46]. Moreover, some studies sug- gest that the gaps in socioeconomic characteristics between people with and without disabilities might be limited and are not statistically significant in a poor environment [47, 48]. To critically assess our natural experiment assumption, we further regress each disability type on a set of individual, family, wealth, and geographical variables (S2 Table). It supports our natural experiment assumption if we find no or very low correlation between these. S2 Table shows that the natural experiment assumption is supported.

Table 1. Sample size by school status and disability status.

	A	B	C	D	E	F	G	H	I
	Total sample	**Ever-In-School Children (EISC)**	**% EISC (B/A)**	**EISC took numeracy test**	**% EISC took numeracy test (D/B)**	**Never-In-School Children (NISC)**	**% NISC (F/A)**	**NISC took numeracy test**	**% NISC took numeracy test (H/F)**
Non-disabled	30,013	27,305	91.0	26,556	97.3	2,708	9.0	2,563	94.6
Disabled	2,293	2,013	87.8	1,922	95.5	280	12.2	213	76.1
Vision disability	168	163	97.0	154	94.5	5	3.0	5	100.0
Hearing disability	96	87	90.6	81	93.1	9	9.4	6	66.7
Physical disability	422	357	84.6	347	97.2	65	15.4	54	83.1
Intellectual disability	1,366	1,236	90.5	1,194	96.6	130	9.5	114	87.7
Multiple disabilities	241	170	70.5	146	85.9	71	29.5	34	47.9
Total	32,306	29,318	90.8	28,478	97.1	2,988	9.2	2,776	92.9

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Our outcome variable in this study is children's performance in a numeracy skills test, which is measured as the mean numeracy test score based on four sets of altogether 21 numer- acy test questions on symbols reading, quantity comparison, addition and, logical sequence.

Our exogenous "treatment" sample consists of children classified in one of the five severe dis- ability types (seeing, hearing, physical, intellectual, and multiple disabilities). The counterfac- tual sample includes those who did not report severe or moderate disabilities. The disparities in the numeracy test between treatment and control children are assumed to be the treatment impacts or causal disability effects.

The majority of our sample consists of non-disabled children; therefore, we can test hypoth- esis H1 by assessing the variation in numeracy skills within and across countries. The non-dis- abled children's performance also serves as a good benchmark to evaluate the numeracy performance of disabled children that are much fewer in number. The fact that we found size- able across-country variation in numeracy scores among non-disabled children caused us to split our sample into low- and high-numeracy skill countries. We assess the relative perfor- mance of non-disabled children versus disabled children within these country groups. This split also serves as a proxy measurement of school quality across the two groups to evaluate the role of school system quality on numeracy skills for disabled children and the gaps between disabled and non-disabled children.

Most studies on disabled children's education apply bivariate or multivariate logistic or probit models to evaluate their access to education (such as school enrolment, school comple- tion, dropout, highest grade achieved) for children with and without disability [17–19, 26].

Some studies simply use univariate analysis while including the disability status [15, 21]. Some studies dichotomise the indicators (able to read or write) for school performance and use logis- tic or probit models [6, 25]. Takeda and Lamichhane (2018) use an OLS model to estimate school performance as a continuous score [24]. These studies assess the correlation between children's disability status and their school performance without considering the cause-effect of disability on children's schooling. A few studies use household fixed-effect models to esti- mate the disability effect by controlling for unobserved and observed household characteristics [17, 18]. However, such kind of studies require a sample of children both with and without dis- abilities from the same household, which may not always be available.

Children's numeracy skills are primarily learnt through school attendance. Disabled chil- dren may fall behind other children in numeracy skills for two reasons. First, they may fall behind because they cannot attend school and complete fewer school years. Second, their dis- ability may limit their numeracy skill learning ability while in school. Children's educational attainment (completed school years) can be considered as both the outcome of disability and, at the same time, an endogenous treatment on skill learning. Therefore, to estimate the disabil- ity effect of numeracy skills, we suggest using the instrumental variable (IV) method to control for the potential bias associated with endogenous completed school years of disabled versus non-disabled children.

In the first set of regressions (Eq (1) below), we test hypothesis H2, which states that chil- dren with disabilities perform significantly worse than their non-disabled peers of the same age in learning numeracy skills. We first test a reduced-form model which ignores the causal mechanisms with a parsimonious specification. The first model includes only age and the treatment variable D_{ij}, indicating children as non-disabled or with disability type j. We then run additional models, first including the country dummies and then gender. Without consid- ering endogenous treatment and possible interaction effects, the first set of regressions allows us to assess the variation in numeracy skills by age and disability types.

$$Numeracy_i = \beta_0 + \beta_{1j} D_{ij} + \beta_2 Age_i + \beta_3 Gender_i + \beta_{4k} Country_{ik} + u_{ijk} \quad (1)$$

Here, the subscript i represents each individual child, j represents a type of disabilities (including children without disability, children with vision, hearing, physical, intellectual, and multiple disabilities), k represents countries, and u_{ijk} is the error term. In the models, β_0 esti- mates the average score rates of numeracy tests for the 7-year-old non-disabled control chil- dren in DRCongo (the country used as the base). β_{1j} estimates the marginal disability treatment effects of disability type j on children's performance of numeracy skills.

In the second set of regressions, we want to test hypothesis H3, which suggests heteroge- neous disability effects in learning numeracy skills for children with different disabilities. The type of disability may affect each step in the causal mechanisms in different ways; therefore, we run the IV models on the split samples by various disability statuses:

$$\text{Outcome equation: } Numeracy_{ij} = \Upsilon_{1j} * CSY_{ij} \quad (2)$$

$$\text{Selection equation: } CSY_{ij} = \pi_{0j} + \pi_{1j}\ln\,(Age_{ij}) + \pi_{2j}Gender_{ij} + \varepsilon_{ij} \quad (3)$$

Here, U_{1j} estimates the average numeracy skills return to each completed school year among the children with disability type j. This is the parameter of interest. We want to test whether the return to education per school year in numeracy skills is homogeneous or depends on disability types. In the first stage of regressions, π_{1j} and π_{2j} capture the effect of age and gen- der on the number of school years completed by children with disability type j. ln(age) is included since it performs best in satisfying the Sargan overidentification test. The constant term π_{0j} is included in the first stage but not the second one since we assume that children learn numeracy skills mainly from school and therefore have no numeracy skills when they start school. We apply the *ivregress 2SLS* estimator in Stata 15.

In the IV model, to satisfy the theoretical validity of our identification strategy, we use age and gender as instruments, as these variables affect completed school years. They do not directly affect numeracy skills learning (exclusion restriction). For children's age and gender to be strong instruments, they must be strongly correlated with the completed school years. For these instruments to be statistically valid, they must be uncorrelated with the error term in the numeracy skills (outcome) model. These properties are also statistically testable in the overidentified case. We present standard IV instrument tests of endogeneity (Robust Wu- Hausman test), the strength of the instruments (first stage F test), and the overidentification (Sargan IV validity test). We also present results from Ordinary Least Square (OLS) regres- sions if the IV tests are not satisfied.

In the third set of regressions, we want to test hypotheses H4a and H4b, which evaluate the role of school system quality on the numeracy skills of disabled children and the gaps between disabled and non-disabled children. We run all IV split-sample models in the low- and high- numeracy skills country groups for the non-disabled children and children with physical, intel- lectual, and multiple disabilities, respectively.

4. Results

4.1 Descriptive analysis

The descriptive statistics of outcome and control variables are presented in S3 Table. We calcu- late children's overall numeracy test scores as the mean value of 21 numeracy questions (0 = wrong, 1 = correct). We show the mean test scores by children's age (left figure) and by completed school years (right figure) in Fig 2. The figure draws vertical box plots, which show the median, 25th and 75th percentile (upper and lower hinge) and lower and upper adjacent values of the mean test scores in each group. The outside values are plotted as dots. The figure

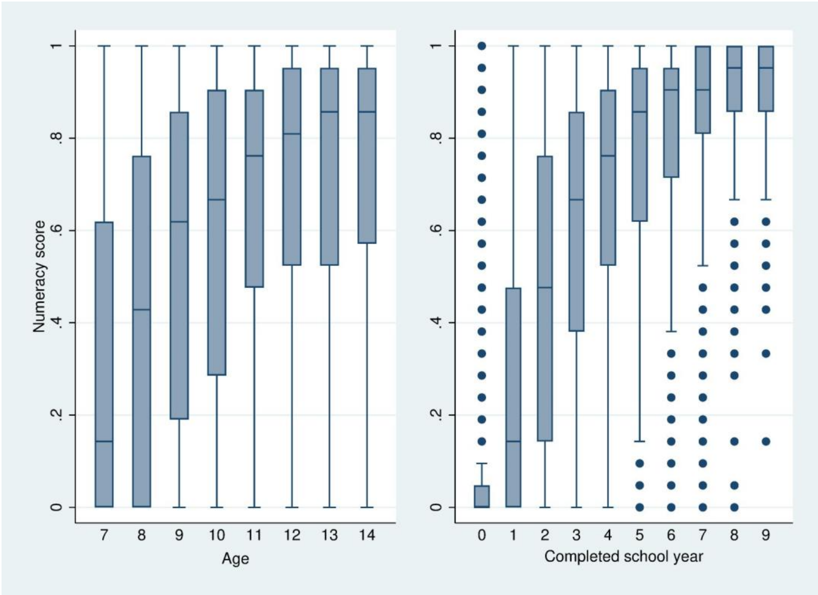

Fig 2. Numeracy test scores by children's age or by completed school years (median, 25th and 75th percentile).

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suggests that children perform better in numeracy skills when they grow older. The disparity in numeracy skills performance by completed school years is higher than the age disparity. It is in line with the earlier assumption that age does not directly affect numeracy skills and only involves exposure to schooling.

Table 2 shows the mean numeracy score by countries for non-disabled and disabled children, respectively. The overall mean numeracy score for the non-disabled is 0.57, which is relatively low in DRCongo (0.35), Sierra Leone (0.41) and The Gambia (0.50). In the remaining five countries (Ghana, Lesotho, Togo, Tunisia, and Zimbabwe), the mean numeracy score is between 0.63 and 0.88. The average numeracy skills in these countries are about double those

Table 2. Mean numeracy score by countries.

	Non-disabled		Disabled		Sample size		
	Mean	**Std. err.**	**Mean**	**Std. err.**	**Non-disabled**	**Disabled**	**Total**
DRCongo	0.35	0.004	0.25	0.014	6268	395	6,663
The Gambia	0.50	0.007	0.37	0.033	3104	128	3,232
Ghana	0.70	0.005	0.59	0.015	4372	542	4,914
Lesotho	0.68	0.006	0.57	0.029	2567	141	2,708
Sierra Leone	0.41	0.005	0.36	0.019	4761	324	5,085
Togo	0.63	0.007	0.57	0.023	2252	202	2,454
Tunisia	0.88	0.004	0.73	0.025	2135	168	2,303
Zimbabwe	0.75	0.005	0.63	0.025	3660	235	3,895
Total	**0.57**	**0.002**	**0.49**	**0.008**	**29,119**	**2,135**	**31,254**

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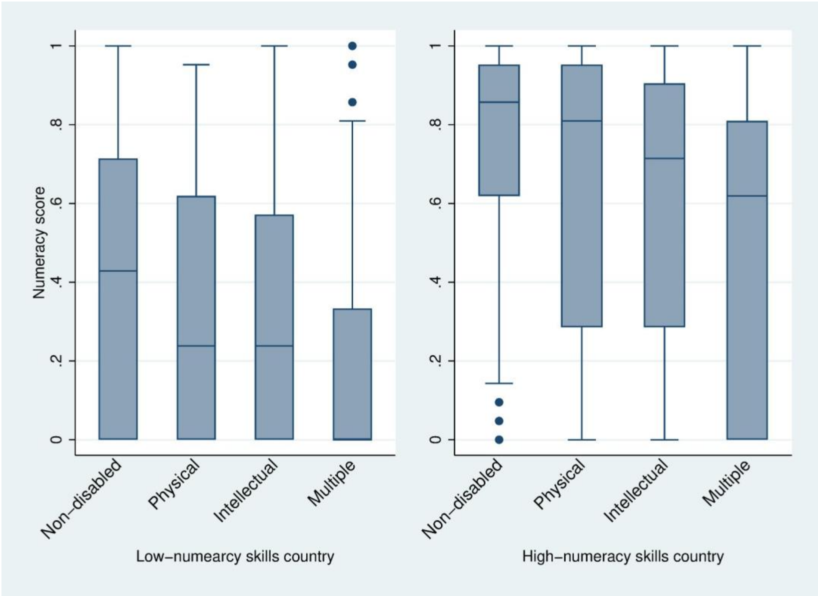

Fig 3. Numeracy test scores in low- and high-numeracy skills countries (median, 25th and 75th percentile).

https://doi.org/10.1371/journal.pone.0284821.g003

in DRCongo. The mean numeracy scores in DRCongo and Sierra Leone are significantly lower than all the five countries with higher scores. Hypothesis H1 on the large variation in average numeracy skills performance among children across African countries is supported. We suggest dividing our sample into two groups: the low-numeracy countries group (DRCongo, Sierra Leone, and The Gambia) and the high-numeracy country group (Ghana, Lesotho, Togo, Tunisia, and Zimbabwe).

Table 2 shows that non-disabled children answered 57% of the questions correctly, and the disabled sample answered 49% correctly. The descriptive statistics in S3 Table demonstrate that children with hearing and vision disabilities answered more questions correctly than non- disabled children. In contrast, the correct response rates for children with other disabilities are much lower. We present the test score distributions (median, p25, and p75) for the low- numeracy countries (left figure) versus the high-numeracy countries (right figure) by disability types as vertical box plots in Fig 3. The mean test scores with 95% confidence intervals by dis- ability type are presented in Fig 4. With the split sample, the sample size is too small for reliable statistical analysis for children with vision and hearing disabilities, as shown in S1 Table.

Therefore, we restrict our split sample analysis to children with physical, intellectual, and mul- tiple disabilities.

Figs 3 and 4 indicate the significant disparities in numeracy tests not only between the two groups of countries but also between children with and without disabilities. Disabled children lag in numeracy skills performance in both groups of countries. However, descriptive data sug- gest that disabled children benefit from improved school quality since disabled children in high-numeracy skills countries perform even better than non-disabled children in low-numer- acy skills countries. The question is whether disabled children gain as much as non-disabled children in learning numeracy skills when the learning environment has improved.

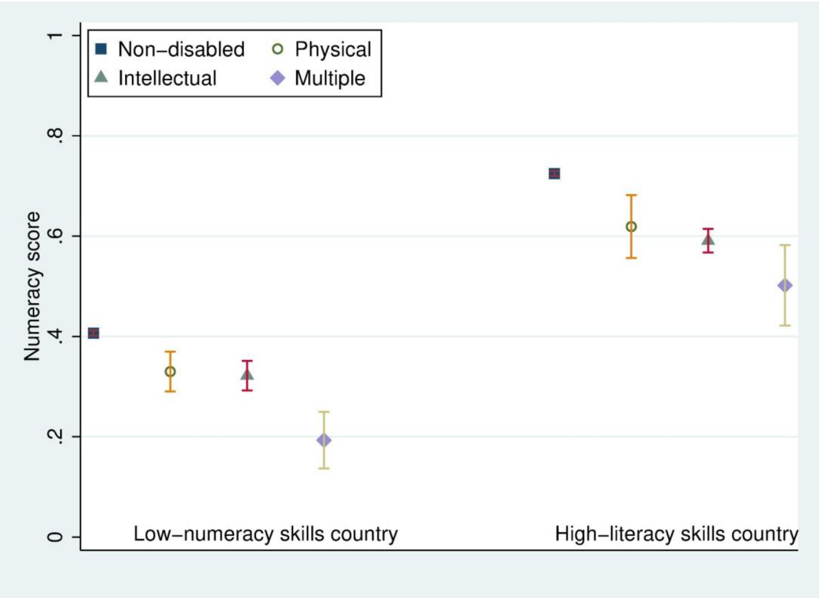

Fig 4. Mean numeracy test scores with 95% confidence intervals for the means in low- and high-numeracy skills countries.

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4.2 Disability effect with age control

The first set of regressions aims to test hypothesis H2, which states that children with disabili- ties perform significantly worse than their non-disabled peers of the same age in learning numeracy skills. Without considering the causal mechanisms, we start with a parsimonious specification, including age, country and gender dummy variables stepwise as control vari- ables. The regression results are presented in Table 3.

The constant term in Model 1 suggests that the estimated average score is 0.31 for 7-year- old control children. Children's numeracy skills improve with age, probably related to their access to schooling. Model 2 shows effective numeracy skills variation across countries. To evaluate the numeracy skills gap over countries, we run separate regressions with age dummies for non-disabled children in each country (S4 Table). DRCongo is the country with the lowest numeracy skills, where the average numeracy score is only 0.106 for 7-year-old children, while Tunisia has the highest average numeracy score of 0.77 for 7-year-old children. The country dummy variable parameters and their significance levels illustrate large variations in school quality across countries in their performance in enhancing children's average numeracy skills. Finally, gender is not significantly correlated with children's numeracy skills performance. It indicates that girls are not discriminated against in the school systems in a way that affects their basic numeracy skills.

The coefficients on the disability status in model 1 in Table 3 show a significant and nega- tive disability effect on children's numeracy skills for children with physical, intellectual, and multiple disabilities. However, the estimated disability effect for children with physical disabili- ties turns insignificant after controlling for the macro country dummy (models 2 and 3). In

Table 3. Regression results for disability effects on the mean numeracy test score.

	Model 1	Model 2	Model 3
Disability status			
Vision disability	0.121***	0.028	0.029
	(0.024)	(0.021)	(0.021)
Hearing disability	-0.002	-0.049	-0.049
	(0.036)	(0.031)	(0.031)
Physical disability	-0.068***	-0.019	-0.019
	(0.020)	(0.017)	(0.017)
Intellectual disability	-0.072***	-0.109***	-0.109***
	(0.010)	(0.009)	(0.009)
Multiple disabilities	-0.213***	-0.205***	-0.205***
	(0.026)	(0.024)	(0.024)
Age			
8	0.128***	0.127***	0.127***
	(0.007)	(0.006)	(0.006)
9	0.242***	0.231***	0.231***
	(0.007)	(0.007)	(0.007)
10	0.284***	0.277***	0.277***
	(0.007)	(0.006)	(0.006)
11	0.355***	0.337***	0.337***
	(0.008)	(0.007)	(0.007)
12	0.382***	0.371***	0.371***
	(0.007)	(0.007)	(0.007)
13	0.420***	0.398***	0.398***
	(0.007)	(0.006)	(0.006)
14	0.439***	0.415***	0.415***
	(0.007)	(0.006)	(0.006)
Country (base category: DRCongo)			
The Gambia		0.147***	0.147***
		(0.012)	(0.012)
Ghana		0.327***	0.327***
		(0.010)	(0.010)
Lesotho		0.298***	0.298***
		(0.009)	(0.009)
Sierra Leone		0.066***	0.066***
		(0.010)	(0.010)
Togo		0.274***	0.274***
		(0.011)	(0.011)
Tunisia		0.501***	0.501***
		(0.008)	(0.008)
Zimbabwe		0.396***	0.396***
		(0.008)	(0.008)
Gender (1 = girl, 0 = boy)			0.003
			(0.003)
Constant	0.305***	0.106***	0.105***
	(0.005)	(0.007)	(0.007)
Sample size	31254	31254	31254

(*Continued*)

Table 3. (Continued)

	Model 1	Model 2	Model 3
R2	0.171	0.373	0.373

Significance levels: * p<0.05; ** p<0.01; *** p<0.001

https://doi.org/10.1371/journal.pone.0284821.t003

contrast, it becomes larger for children with intellectual disabilities after controlling for the country dummy. The country effect might be important for evaluating the disability effect for children with physical and intellectual disabilities. The first set of regressions supports hypoth- esis H2 that children with physical, intellectual, and multiple disabilities perform significantly worse than their non-disabled peers of the same age in learning numeracy skills. However, hypothesis H2 is not supported for children with vision and hearing disabilities.

4.3 IV models with endogenous completed school years

We will now more closely study the causal mechanisms for the links between the exogenous disability (treatment) variables and the outcome. The disability effect on numeracy skills may come from reduced school participation or a lower ability to acquire numeracy skills while in school. To analyse this, we run IV models with completed school years as the endogenous exposure to schooling on the split samples for each disability type.

We run IV models with age and gender as instruments. To test the strength of the two instruments and assess the endogeneity of completed school years in the model, we first run a set of regressions, presented in S5 Table. All the models in S5 Table suggest that age and gender are significantly associated with the completed school years. Moreover, the disability effects on completed school years vary a lot across disability types, which suggests potentially high endo- geneity of the completed school years. Furthermore, the regressions in section 4.2 suggest that gender does not directly affect children's numeracy skills.

The regression results and IV tests are shown in Table 4. The OLS model results are pre- sented for the non-disabled when the IV tests are invalid. For the models that satisfy the tests, we find the following results. The first-stage regression indicates that children with vision or hearing disabilities do not lag in completed school years compared to non-disabled children. However, children with physical, intellectual, or multiple disabilities have completed signifi- cantly fewer school years than non-disabled children per year of age.

The return to each completed school year in numeracy skills score is estimated at 0.146 units for non-disabled children in the IV model and 0.142 in the OLS model, noting that the overidentification test failed for this IV model. For the other IV models, the statistical validity could not be rejected. For children with vision, hearing, physical, and intellectual disabilities, there is no significant disability effect on numeracy skills returns to completed school years. Hypothesis H3a, which states that children with vision and hearing disabilities perform well in numeracy skills return to schooling compared to non-disabled children, cannot be rejected.

However, H3b and H3c, which state that children with physical or intellectual disabilities have a lower return to schooling in numeracy skills than non-disabled children, are not supported.

The estimated return to each completed school year is 0.142 (CI:0.140–0.144) for non-dis- abled children and 0.121 (CI:0.105–0.137) for children with multiple disabilities. Significant disability effects of 0.121–0.142 = -0.021 score points for each completed school year are reported for children with multiple disabilities. Hypothesis H3d that children with multiple disabilities have the lowest return to schooling regarding numeracy skills cannot be rejected.

Table 4. Regressions on the mean numeracy score by disability types.

	OLS for non-disabled	IV (separate model for each disability type)					
		Non-disabled	Vision disabled	Hearing disabled	Physical disabled	Intellectual disabled	Multiple disabled
Completed school years (base category: 1)	0.142***	0.146***	0.147***	0.143***	0.151***	0.145***	0.121***
	(0.000)	(0.001)	(0.005)	(0.009)	(0.006)	(0.002)	(0.008)
Sample size	29119	29119	159	87	401	1308	180
First stage regressions (Dep: Completed school year)							
Ln(age)		7.599***	8.440***	7.970***	6.523***	6.731***	5.637***
		(0.044)	(0.376)	(0.641)	(0.379)	(0.209)	(0.637)
Gender (1 = girl, 0 = boy)		0.021	0.108	0.340	0.106	-0.025	-0.020
		(0.019)	(0.193)	(0.336)	(0.136)	(0.090)	(0.287)
Constant		-13.954***	-15.371***	-15.064***	-11.902***	-12.268***	-10.203***
		(0.092)	(0.838)	(1.444)	(0.789)	(0.450)	(1.374)
IV test							
Robust Wu-Hausman test (p value)		0.000	0.000	0.000	0.000	0.000	0.060
Sargan IV validity test (p-value)		0.000	0.960	0.989	0.560	0.349	0.126
Strength (First stage F test)		21324.1	381.4	145.54	302.73	1497.77	149.46

Instrumented: Completed school year. Instruments: ln(age) and gender dummy.

Significance levels: * p<0.05; ** p<0.01; *** p<0.001, based on the standard errors which allow for intragroup correlation

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4.4 IV models for low- and high-numeracy skills countries

The results in Table 3 show that there might be a country effect when evaluating the overall disability effect for children with physical and intellectual disabilities. This might indicate het- erogeneous disability effects across the eight African countries. To further explore the disabil- ity effects for different disability types, we run IV regressions after dividing the sample into low- and high-numeracy skills country groups as defined in section 4.1. The sample sizes of the split samples by country numeracy skills level and disability status only allow for the analy- ses of three disability types (physical, intellectual, and multiple disabled). The regressions are run on the split samples of the non-disabled and disabled for each of the three specific disabil- ity statuses in the countries with low and high numeracy skills, respectively. The results are presented in Table 5.

We then graph the regression coefficients with 95 per cent confidence intervals to present the first stage estimated completed school year by age (Fig 5) and the second stage estimated numeracy skills return to completed school years (Fig 6) over different disability types in low- and high-numeracy skills country groups. Fig 5 indicates that in both groups of countries, the mean estimated completed school years by age for intellectually disabled children and multiple disabled children are significantly lower than those for non-disabled children. Children with physical disabilities have also completed fewer school years than non-disabled children, but the differences are not significant. The gap in completed school years in the low-numeracy skills country group is higher than in the high-numeracy skills group.

Fig 6 suggests that the mean estimated numeracy skills return to each completed school year in low-numeracy skills countries is 0.132 (CI: 0.130–0.134) score points for non-disabled children. In contrast, it is estimated to be 0.152 (CI: 0.150–0.154) score points in the high- numeracy skills country group. Children with physical or intellectual disabilities are not signif- icantly different from non-disabled children in numeracy skills return to schooling. In con- trast, the mean estimated numeracy returns are 0.107 (CI: 0.082–0.132) and 0.129 (CI: 0.111–

Table 5. Regressions on the mean numeracy score in low- and high-numeracy skills country group.

	Low-numeracy skills group					High-numeracy skills group				
	OLS for intellectual disabled	IV (separate model for each disability type)				OLS for non-disabled	IV (separate model for each disability type)			
		Non-disabled	Physical disabled	Intellectual disabled	Multiple disabled		Non-disabled	Physical disabled	Intellectual disabled	Multiple disabled
Completed school years (base category: 1)	0.128***	0.132***	0.141***	0.138***	0.107***	0.152***	0.155***	0.166***	0.148***	0.129***
	(0.005)	(0.001)	(0.009)	(0.005)	(0.013)	(0.001)	(0.001)	(0.009)	(0.003)	(0.009)
Sample size	435	14133	268	435	93	14986	14986	133	873	87
First stage regressions (Dep: Completed school year)										
Ln(age)		6.580***	5.782***	4.738***	3.664***		8.330***	7.731***	7.376***	6.977***
		(0.075)	(0.479)	(0.364)	(0.983)		(0.046)	(0.542)	(0.222)	(0.778)
Gender (1 = girl, 0 = boy)		-0.042	0.096	-0.014	-0.030		0.135***	0.349	0.098	-0.154
		(0.029)	(0.163)	(0.150)	(0.358)		(0.021)	(0.209)	(0.098)	(0.332)
Constant		-12.183***	-10.581***	-8.523***	-6.530***		-15.142***	-14.054***	-13.434***	-12.378***
		(0.156)	(0.988)	(0.762)	(2.159)		(0.097)	(1.119)	(0.487)	(1.647)
IV test										
Robust Wu-Hausman test (p value)		0.000	0.000	0.000	0.568		0.000	0.000	0.000	0.004
Sargan IV validity test (p-value)		0.656	0.655	0.004	0.694		0.000	0.465	0.452	0.123
Strength (First stage F test)		5193.02	159.57	334.46	40.59		24230.81	191.2	1483.36	143.04

Instrumented: Completed school year. Instruments: Ln(age) and gender

Significance levels: * p<0.05; ** p<0.01; *** p<0.001, based on the cluster-robust standard errors

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0.147) for children with multiple disabilities in countries with low- and high-numeracy skills. The gap between non-disabled children and children with multiple disabilities in the low numeracy countries -0.025 (= 0.107–0.132) is marginally higher than that -0.023 (= 0.129– 0.152) in the high numeracy countries. Furthermore, numeracy skills return to schooling for children with physical 0.166 (CI: 0.148–0.184) or intellectual disabilities 0.148 (CI: 0.142– 0.154) in high-numeracy skills countries are significantly higher than that of the non-disabled children 0.132 (CI: 0.130–0.134) in low-numeracy skills countries. It indicates that disabled children benefit as much from higher school quality as non-disabled children do.

Finally, the numeracy skills performance is predicted for a 14-year-old child by disability status in both low- and high-numeracy skills groups in Fig 7. The endogenous school year dif- ferences, as well as differences in return to each endogenous school year in both stages, are taken into consideration. The total effects of disability on numeracy skills for 14-year-old chil- dren are negative and significant for both intellectual and multiple disabled children in coun- tries with low- and high-numeracy skills. The predicted mean numeracy skill for children with intellectual disability is 0.547 (CI: 0.504–0.590) in low-numeracy skills countries and 0.899 (CI: 0.869–0.930) in high-numeracy skills countries, which is significantly lower than that for non-disabled children of 0.679 (CI: 0.669–0.688) and 1.073 (CI: 1.065–1.081) in low- and high-numeracy skills countries.

The disability effect for children with intellectual disability are -0.13 (= 0.547–0.679) and -0.17 (= 0.899–1.073) in low- and high-numeracy skills countries, and that for children with multiple disabilities are -0.34 and -0.30, respectively. For those with physical disabilities, there is no significant disability effect in low- or high-numeracy skills groups.

The cross-country difference in predicted numeracy skills for a 14-year-old non-disabled child is about 0.4 points between low- and high-numeracy skills country groups, which is

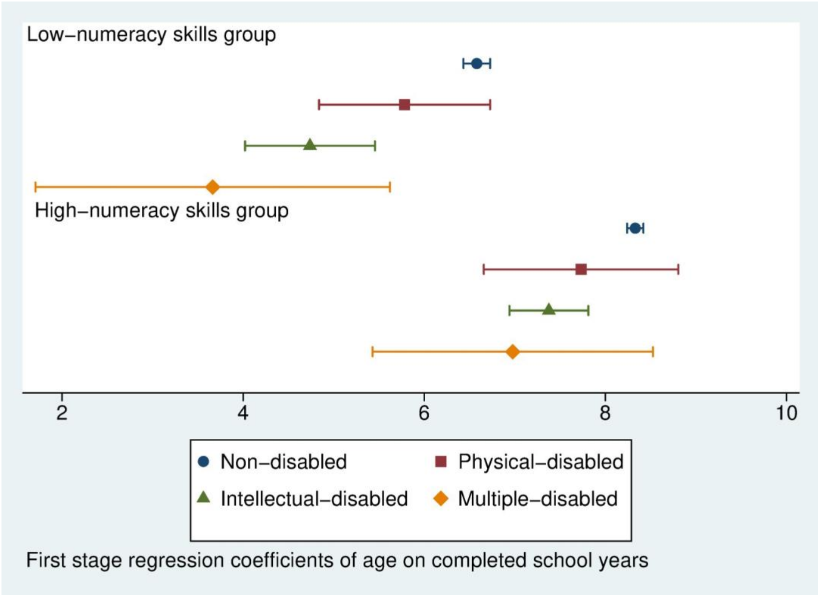

Fig 5. First-stage regression coefficients of age on completed school years with 95% confidence intervals (IV regression on numeracy skill return to each completed school year, separate IV models for three disability types in low- and high-numeracy skills country groups).

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marginally higher than the estimated numeracy skills gaps across disability types, as discussed above.

Furthermore, 14-year-old children with intellectual disabilities in high-numeracy skills countries show significantly better numeracy skills performance (0.90) than the non-disabled children in the low-numeracy skills group (0.68). The average score of non-disabled children in the low-numeracy skills countries (0.68) is even below the average numeracy score for the most challenged multiple-disabled children in high-numeracy skills countries (0.77).

These findings do not support hypothesis H4a, that children with disabilities are less capa- ble of benefiting from the better quality of the school system than non-disabled children. Dis- abled children do benefit substantially from improved school quality. The gap between non- disabled and disabled children in numeracy skills is smaller than the variation across countries, which supports hypothesis H4b.

5. Discussion

We will now summarise our findings for the key hypotheses and discuss our results related to the relevant literature and earlier studies. The first hypothesis (H1) states a considerable varia- tion in average numeracy skills across the eight African countries we have studied. Our analy- ses reveal large variations in average numeracy skills across countries based on nationally representative data; thus, we cannot reject this hypothesis. The large sample sizes provide accu- rate estimates of mean numeracy skill scores by country since they have confidence intervals in the range of 0.01–0.015 around the mean numeracy skills scores, ranging from the lowest

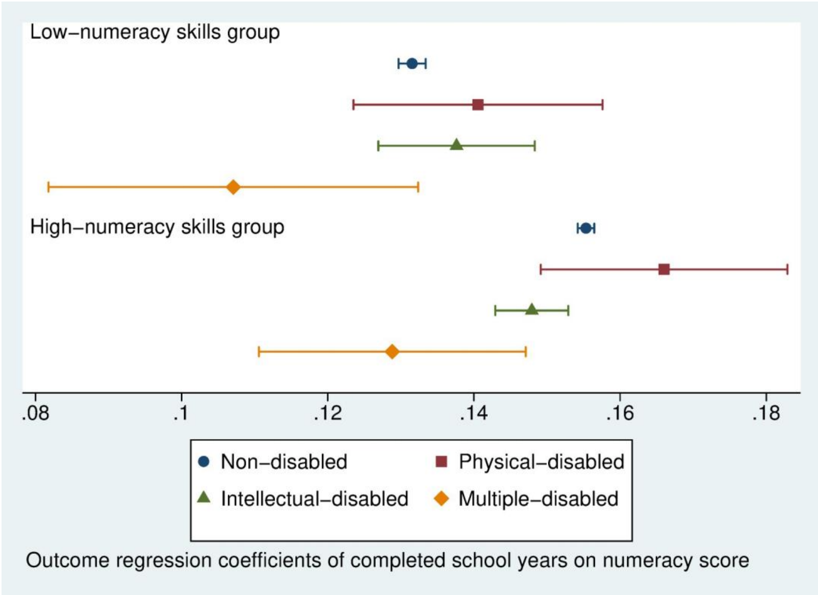

Fig 6. Outcome regression coefficients of completed school years on numeracy scores with 95% confidence intervals (IV regression on numeracy skill return to each completed school year, separate IV models for three disability types in low- and high-numeracy skills country groups).

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0.35 in DRCongo to the highest 0.88 in Tunisia. It indicates considerable variation in the aver- age quality of school systems across these eight countries regarding their ability to teach chil- dren numeracy skills.

Our second hypothesis (H2) that disabled children perform worse than their non-disabled peers in numeracy skills was supported for children with physical, intellectual, and multiple disabilities but not those with vision and hearing disabilities. To our knowledge, almost no similar study has evaluated disabled children's numeracy skills in the African context. The only exception is the study by Bakhshi, Babulal, and Trani (2018) from Sudan [6]. The other few earlier papers in the developing context are mainly from Asia, with the study of Takeda and Lamichhane (2018) from India [24], Malik et al. (2020) and Singal et al. (2020) from Paki- stan [25, 26]. Most studies have applied the Washington Group definition of disabilities. Bakh- shi, Babulal, and Trani (2018) used a disability screening questionnaire (DSQ-35), and Takeda and Lamichhane (2018) revised the WG module to a large extent. The age range of children included in the learning assessment test also varies. The two studies in Pakistan use the ASER (Annual Status of Education Report) test on reading and math. Takeda and Lamichhane (2018) use reading, math and writing test in the Indian Human Development Survey (IHDS). Bakhshi, Babulal, and Trani (2018) use simple self-reporting assessments. Despite the dispari- ties of these studies, most studies reported a performance gap between disabled and non-dis- abled children, except the study by Bakhshi, Babulal, and Trani (2018). Our findings provide evidence in the African context, suggesting a gap in numeracy skills between disabled and non-disabled children, which varies across disability types.

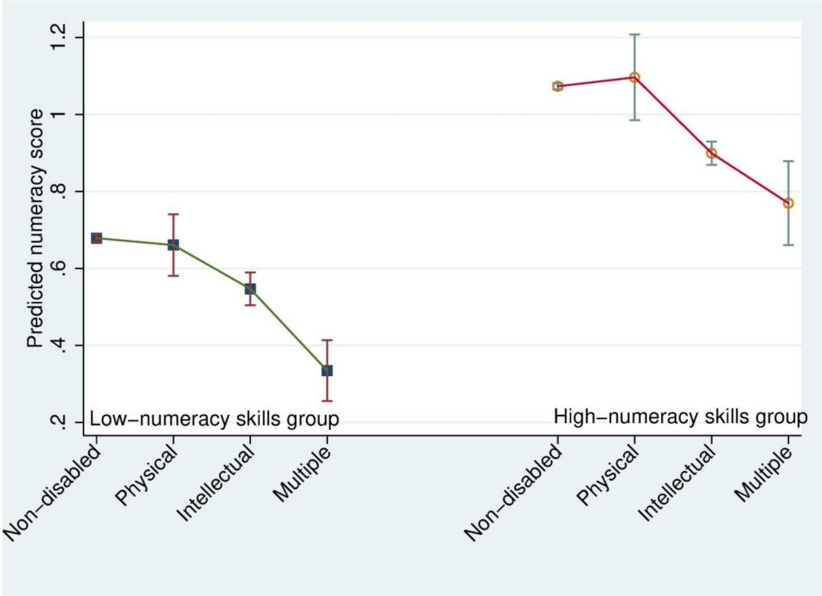

Fig 7. Predicted numeracy skills performance by disability status for an average 14-year-old child in both low- and high-numeracy skills groups.

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Little empirical evidence has been available for heterogenous disability effects on school performance by disability types in the African context. Our results suggest that children with vision and hearing disabilities do not have lower numeracy skills than non-disabled children, which supports our hypothesis H3a. It is not the case for children with other disabilities. Also, based on the WG definition of disabilities, a study in Pakistan by Singal et al. (2020) is one of the few studies differentiating the disability types, which uses the ASER (Annual Status of Edu- cation Report) test [26]. They report that children with moderate or severe sensory disabilities (walking, seeing and hearing) have the lowest level of basic numeracy skills. Singal et al. (2018) transferred the test scale to a very low threshold dichotomy variable and only evaluated whether children could identify one-digit numbers. It might explain the special challenges for children with sensory disabilities compared to children with other disabilities. Our study does not find challenges for children with vision and hearing disabilities, but it does not mean they are not exposed to additional risks in school performance. The numeracy test embedded in the MICS survey might not fully capture the potential risk for those with vision and hearing dis- abilities to learn more advanced numeracy skills.

Earlier studies on the numeracy skills differences have not specifically differentiated the mechanisms behind possible disability effects. Such effects could simply be caused by the lack of school attendance, or they could be related to disabled children's low returns to schooling in numeracy skills. We separate the two types of disability effects by IV models to control for the endogeneity of completed school years for each disability type. In their study in India, Takeda and Lamichhane (2018) suggest that disabled children are less likely to fall behind in skills once they access education [24]. They made this conclusion because they noticed that when the interaction between disability status and school status is included in the model, the disabil- ity dummy becomes insignificant. However, they did not consider the potential endogeneity of schooling.

Our IV model shows that low numeracy scores among the physical- and intellectually dis- abled children are mainly attributable to the low school years they manage to complete but are not constrained by their numeracy skills returns to schooling. Hypotheses H3b and H3c state that children with physical or intellectual disabilities have a lower return to schooling in numeracy skills (after controlling for differences in completed school years) compared to non- disabled children. Our results do support the two hypotheses. These findings suggest that school enrolment is especially crucial for children with disabilities to gain equal access to edu- cation. On the other hand, children with multiple disabilities have not only completed the least school years but also have the lowest numeracy skill returns per completed school year among children with various disability types, which supports hypothesis H3d.

Finally, hypothesis H4a states that the gap in numeracy skills between non-disabled and dis- abled children is larger in high-numeracy skills countries. However, our study shows that the overall gap between children with and without disabilities in terms of numeracy skills, consid- ering both effects of endogenous school year differences and differences in school return to each school year, is not significantly different between low- and high-numeracy skills coun- tries. It does not provide evidence of a broader gap in school performance for disabled children when the school quality is improved. Therefore, we reject hypothesis H4a.

Bakhshi, Babulal, and Trani (2018) found in their study in West Darfur of Sudan that when all the children are exposed to low-quality schools in a conflict context, there is no difference in numeracy skills between the disabled and non-disabled children [6]. By controlling the endogeneity of completed school years, we find that in low- and high-numeracy skills coun- tries, most children with disabilities (except children with multiple disabilities) do not lag sig- nificantly in gaining numeracy skills if they complete the same schooling as the non-disabled children. Their main challenge is low school enrollment, especially in countries with poor school quality.

The estimated numeracy skills return to schooling among children with physical or intellec- tual disabilities in high-numeracy skills countries are significantly higher than that of the non- disabled peers in low-numeracy skills countries. The variation in numeracy skills performance is higher across countries than over disability types. We cannot reject hypothesis H4b, that the average numeracy skills of non-disabled children vary more across countries with different school system quality than the gap between non-disabled and disabled children. The variation across countries can be even higher if more countries are included, which suggests the quality of the school system is the key to improving school performance in Africa.

6. Conclusion

Based on large-scale nationally representative samples in the eight African countries, we assess the within- and across-country variation in numeracy skills and the gap between children with and without disabilities. The Washington Group Child Functional Module (WG-CFM) and standard numeracy test are applied to all the countries and ensure the credibility of this com- parison study. We identify two types of disability effects using IV models to control for the endogeneity of completed school years. These models allow us to divide the numeracy skill dif- ferences into the difference in completed school years and the difference in numeracy skill returns per completed school year. Combining these two effects results in systematic variations in the overall numeracy skill performance across disability types.

First, we find a considerable variation in average numeracy skills across the eight African countries (hypothesis H1 is supported). Second, there is systematic variation in numeracy skills across disability types (hypothesis H2 is supported). More specifically, children with vision and hearing disabilities perform as well as non-disabled children, while children with physical, intellectual and multiple disabilities lag behind. Third, the reason why children with different disability types lag behind varies (hypotheses H3a and H3d are supported; hypotheses H3b and H3c are rejected). Those with physical and intellectual disabilities lag because they, conditional on age, have completed fewer school years. Those with multiple disabilities lag both due to fewer completed school years and due to lower numeracy skill returns per school year.

Furthermore, based on average performance, we find that the within-group average differences in numeracy skill returns to school between non-disabled and disabled children are similar between the low- and high-numeracy country groups (hypothesis H4a is rejected). More importantly, the difference in average performance between high-performing and low-performing countries is larger than the within-country group difference in performance between non-disabled and disabled children categories (hypothesis H4b is supported). Disabled chil- dren in the high numeracy skill countries perform even better than the non-disabled children in the low numeracy skill countries.

Except for children with multiple disabilities characterised by low enrolment and low numeracy skill returns to completed school years, the main challenge for most children with disabilities is the low school enrolment. This is especially the case for children in low-numeracy skill countries. This suggests that the priority for the education policy in low-income African countries is to improve children's school enrolment, especially for children with disabilities. The fact that the within-group differences between children with and without dis- abilities are similar between the low- and high-numeracy skill country groups suggests that disabled children benefit equally when the school quality improves. It demonstrates substantial room for improvement in the school system, and such enhancements also benefit disabled children. Disability effects in numeracy skills across country groups are more fundamental than the within-group gaps. Therefore, improving overall school quality and promoting school attendance for disabled children are crucial for better school performance among disabled children in the African context.

We acknowledge several limitations of this study. First, the study is limited to numeracy skills and may not be correlated with other benefits from schooling. Second, the study assesses fundamental numeracy skills and may have failed to capture substantial variation in more advanced numeracy skills that may vary more, especially among the older children that the test can identify. The test may be more appropriate in low-numeracy countries and for younger children. In high-numeracy countries, about 40% of all children answered over 90% of the questions correctly. It might lead to a potentially underestimated disability effect in high-numeracy countries. Third, while the MICS surveys are nationally representative samples aim- ing to provide data on the general population of children, the incidence of severe disability is very low in the population. Therefore, we have merged some categories to achieve sufficient sample sizes for statistical analysis. Last, the eight African countries included in this study are the countries that recently conducted the sixth round of the MICS survey. We do not know the external validity of the conclusions drawn based on the data from these eight countries.

For future research, we recommend studies with a broader range of skills, such as reading and science skills, and tests with more advanced numeracy skills for older children. Covering more countries with large samples may also be possible to do more statistical analyses for more disaggregated samples with rare forms of disabilities.

Supporting information

S1 Table. The sample size of children who have done the numeracy test by disability status and country.
(PDF)
S2 Table. Regression results for estimating the determinant factors of each disability type.
(PDF)
S3 Table. Sample characteristics.
(PDF)
S4 Table. Regressions on the mean numeracy score with age dummy by countries (non-dis- abled children).
(PDF)
S5 Table. Regression on the completed school years.
(PDF)

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References

1. UN. Sustainable Development Goals: Department of Economic and Social Affairs; 2015 [Available from: https://sdgs.un.org.
2. Lewin KM. Access to education in sub-Saharan Africa: patterns, problems and possibilities. Compara- tive Education. 2009; 45(2):151–74.
3. UNESCO. Education for All 2000–2015: Achievements and Challanges. Paris: UNESCO, 2015. Ke´pze´s e´s gyakorlat. 2016; 14(1–2):283–7.
4. UN. Millennium Development Goals. 2000.
5. UNESCO. Global Education Monitoring Report 2020: Inclusion and Education–All Means All. Unesco Paris; 2020.
6. Bakhshi P, Babulal GM, Trani J-F. Education and disability in a conflict affected context: Are children with disabilities less likely to learn and be protected in Darfur? World Development. 2018; 106:248–59.

7. UNESCO. Teaching policies and learning outcomes in Sub-Saharan Africa: issues and options; Sum- mary. 2016.

8. Johnson D, editor The changing landscape of education in Africa: Quality, equality and democracy 2008: Symposium Books Ltd.

9. Spaull N, Taylor S. Effective enrolment–Creating a composite measure of educational access and edu- cational quality to accurately describe education system performance in sub-Saharan Africa. Stellen- bosch EconomicWorking Papers. 2012; 21(12):1–25.

10. Unterhalter E. Education targets, indicators and a post-2015 development agenda: Education for All, the MDGs, and human development. The power of numbers: A critical review of MDG targets for human development and human rights. 2013.

11. Bonal X., Education Poverty, and the "Missing Link". The Handbook of Global Education Policy: John Wiley & Sons, Ltd; 2016. p. 97–110.

12. Ansong D, Ansong EK, Ampomah AO, Afranie S. A spatio-temporal analysis of academic performance at the Basic Education Certificate Examination in Ghana. Applied Geography. 2015; 65:1–12.

13. Adugna M, Ghahari S, Merkley S, Rentz K. Children with disabilities in Eastern Africa face significant barriers to access education: a scoping review. International Journal of Inclusive Education. 2022:1–17.

14. Gregorius S. Exploring narratives of education: disabled young people's experiences of educational institutions in Ghana. Disability & Society. 2016; 31(3):322–38.

15. UNESCO. Education and Disability: Analysis of Data from 49 Countries. United Nations Educational, Scientific and Cultural Organization. 2018.

16. Stromquist NP. The Learning Generation: Investing in Education for a Changing World; A Report by the International Commission on Financing Global Education Opportunity. September 2016. 176 pp. Free distribution online at http://report.educationcommission.org/report. Comparative Education Review. 2017;61(1):214–7.

17. Filmer D., Disability Poverty, and Schooling in Developing Countries: Results from 14 Household Sur- veys. The World Bank Economic Review. 2008; 22(1):141–63.

18. Mizunoya S, Mitra S, Yamasaki I. Disability and School Attendance in 15 Low-and Middle-Income Countries. World Development. 2018; 104:388–403.

19. Kuper H, Saran A, White H, Kumar ST, Tolin L, Muthuvel T, et al. Rapid Evidence Assessment (REA) of What Works to Improve Educational Outcomes for People with Disabilities in Low-and Middle-Income Countries. International Centre for Evidence in Disability, London School of Hygiene and Campbell Col- laboration. 2018.

20. Lewis E, Mitra S, Yap J. Do Disability Inequalities Grow with Development? Evidence from 40 Coun- tries. Sustainability. 2022; 14(9):5110.

21. Luo Y, Zhou RY, Mizunoya S, Amaro D. How Various Types of Disabilities Impact Children's School Attendance and Completion-Lessons Learned from Censuses in Eight Developing Countries. Interna- tional Journal of Educational Development. 2020; 77:102222.

22. Tolar TD, Fuchs L, Fletcher JM, Fuchs D, Hamlett CL. Cognitive Profiles of Mathematical Problem Solv- ing Learning Disability for Different Definitions of Disability. J Learn Disabil. 2016; 49(3):240–56. https://doi.org/10.1177/0022219414538520 PMID: 24939971

23. Murphy MM, Mazzocco MM, Hanich LB, Early MC. Cognitive characteristics of children with mathemat- ics learning disability (MLD) vary as a function of the cutoff criterion used to define MLD. J Learn Disabil. 2007; 40(5):458–78. https://doi.org/10.1177/00222194070400050901 PMID: 17915500

24. Takeda T, Lamichhane K. Determinants of schooling and academic achievements: Comparison between children with and without disabilities in India. International Journal of Educational Develop- ment. 2018; 61:184–95.

25. Malik R, Raza F, Rose P, Singal N. Are children with disabilities in school and learning? Evidence from a household survey in rural Punjab, Pakistan. Compare: A Journal of Comparative and International Education. 2020; 52(2):211–31.

26. Singal N, Sabates R, Aslam M, Saeed S. School enrolment and learning outcomes for children with dis- abilities: findings from a household survey in Pakistan. International Journal of Inclusive Education. 2020; 24(13):1410–30.

27. Zhang H, Holden S. Disability Types and Children's Schooling in Africa. SSRN Electronic Journal. 2022.

28. Pieters S, Desoete A, Roeyers H, Vanderswalmen R, Van Waelvelde H. Behind mathematical learning disabilities: What about visual perception and motor skills? Learning and Individual Differences. 2012; 22(4):498–504.

29. Pieters S, Roeyers H, Rosseel Y, Van Waelvelde H, Desoete A. Identifying Subtypes Among Children With Developmental Coordination Disorder and Mathematical Learning Disabilities, Using Model- Based Clustering. J Learn Disabil. 2013; 48(1):83–95. https://doi.org/10.1177/0022219413491288 PMID: 23757349

30. Zarfaty Y. The Performance of Young Deaf Children in Spatial and Temporal Number Tasks. Journal of Deaf Studies and Deaf Education. 2004; 9(3):315–26. https://doi.org/10.1093/deafed/enh034 PMID: 15304434

31. Morgan PL, Farkas G, Wu Q. Kindergarten children's growth trajectories in reading and mathematics: who falls increasingly behind? J Learn Disabil. 2011; 44(5):472–88. https://doi.org/10.1177/ 0022219411414010 PMID: 21856991

32. Crollen V, Warusfel H, Noe¨l M-P, Collignon O. Early visual deprivation does not prevent the emergence of basic numerical abilities in blind children. Cognition. 2021; 210:104586. https://doi.org/10.1016/j. cognition.2021.104586 PMID: 33477011

33. Zhang S, Xia X, Li F, Chen C, Zhao L. Study on Visual and Auditory Perception Characteristics of Chil- dren with Different Type of Mathematics Learning Disability. International Journal of Disability, Develop- ment and Education. 2019; 68(1):78–94.

34. Chan LKS, Dally K. Learning disabilities and literacy & numeracy development. Australian Journal of Learning Disabilities. 2001; 6(1):12–9.

35. Jimenez BA, Stanger C. Math Manipulatives for Students with Severe Intellectual Disability: A Survey of Special Education Teachers. Physical Disabilities: Education and Related Services. 2017; 36(1):1–12.

36. Shifrer D. Stigma and stratification limiting the math course progression of adolescents labeled with a learning disability. Learning and Instruction. 2016; 42:47–57.

37. Bernal P, Mittag N, Qureshi JA. Estimating effects of school quality using multiple proxies. Labour Eco- nomics. 2016; 39:1–10.

38. Singh R, Sarkar S. Does teaching quality matter? Students learning outcome related to teaching quality in public and private primary schools in India. International Journal of Educational Development. 2015; 41:153–63.

39. Heyneman SP, Loxley WA. The Effect of Primary-School Quality on Academic Achievement Across Twenty-nine High- and Low-Income Countries. American Journal of Sociology. 1983; 88(6):1162–94. https://doi.org/10.1086/227799 PMID: 6614303

40. Soylu F, editor Mathematical cognition as embodied simulation. Proceedings of the Annual Meeting of the Cognitive Science Society; 2011.

41. UNICEF. Module on Child Functioning concept note. 2017.

42. Groce NE, Mont D. Counting Disability: Emerging Consensus on the Washington Group Questionnaire. The Lancet Global Health. 2017; 5(7):e649–e50. https://doi.org/10.1016/S2214-109X(17)30207-3 PMID: 28619216

43. WG. An Introduction to Washington Group on Disability Statistics Question Sets. 2020.

44. Rosenzweig MR, Wolpin KI. Natural"Natural Experiments" in Economics. Journal of Economic Litera- ture. 2000; 38(4):827–74.

45. Banks LM, Kuper H, Polack S. Poverty and Disability in Low-and Middle-Income Countries: A System- atic Review. PloS One. 2017; 12(12):e0189996. https://doi.org/10.1371/journal.pone.0189996 PMID: 29267388

46. Blackburn CM, Spencer NJ, Read JM. Prevalence of childhood disability and the characteristics and cir- cumstances of disabled children in the UK: secondary analysis of the Family Resources Survey. BMC Pediatrics. 2010; 10(1). https://doi.org/10.1186/1471-2431-10-21 PMID: 20398346

47. Trani J-F, Bah O, Bailey N, Browne J, Groce N, Kett M. Disability in and around Urban Areas of Sierra Leone. 2010.

48. Groce N, Kett M. The Disability and Development Gap. Leonard Cheshire Disability and Inclusive Development Centre Working Paper Series No 21. London, UK: LCDIDC; 2013.

III Disparity in School Children's Reading Skills in 11 African Countries

Disparity in School Children's Reading Skills in 11 African Countries

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Abstract

To promote SDG Goal 4 and "education for all", this study investigates children's basic reading skills in 11 low-income and lower-middle-income African countries, using standardized reading tests from the Multiple Indicator Cluster Surveys (MICS). Research specifically examining children's reading skills and disparities across socioeconomic groups in African contexts remains scarce. This study addresses a critical knowledge gap by providing comparative evidence on reading skills disparities across diverse social backgrounds, including children with disabilities.

Our study provides new evidence on the "Learning Crisis in the Global South", revealing alarmingly low levels of reading skills but with considerable variation across the 11 African countries studied. Substantial reading skills differences exist between children with disabilities or from disadvantaged backgrounds—those living in rural areas, and from poorer, less educated families—and their non-disabled and non-disadvantaged peers. Notably, these disparities are often more pronounced in countries with higher overall reading proficiency.

Moreover, there are persistent gaps between children with and without disabilities across the countries and socioeconomic groups in this study. Encouragingly, strengthening education systems is a promising way of improving the reading skills of children with disabilities. These findings underscore the diverse challenges faced by children from different backgrounds in varying contexts.

Keywords

Africa, Children with disabilities (CWD), Educational inequality, Poverty, Reading skills, Socioeconomic background, Urban-rural disparity

JEL codes

I24: Education and Inequality

1. Introduction

The UN Sustainable Development Goal 4 underscores the importance of achieving inclusive and equitable quality education for all [1,2]. There is a growing interest in understanding the educational outcomes of children from disadvantaged backgrounds and identifying the factors contributing to variations in these outcomes, which can inform the development of effective educational policies [3,4,5]. In recent years, following the debate on the "Learning Crisis in the Global South" [6,7], reading proficiency has emerged as a crucial focus in sub-Saharan Africa, recognised as a key indicator of learning outcomes and the success of formal education. The percentage of students attaining the minimum proficiency level in reading skills is a key indicator for achieving SDG Goal 4, given the emphasis on reading skills by the UNESCO Global Education Monitoring Report (2014) [7].

Previous research in developed contexts has emphasised the persistent differences in reading skills between children from disadvantaged and non-disadvantaged backgrounds [8,9,10]. In developing countries, efforts have traditionally centred on socioeconomic factors such as gender, education, income, and geographical location [11,12,13]. Numerous cross-country studies on children's reading performance have offered valuable insights into the role of gender, home environment, school socioeconomic status, and literacy interventions in shaping children's reading [14-19]. However, these studies often rely on international standard learning assessments, such as PIRLS (the Progress in International Reading Literacy Study) and PISA (Programme for International Student Assessment). These assessments primarily target developed or OECD countries, with limited participation from African nations. Of the 102 countries that have ever participated in PISA, only eight are from Africa, including just four from Sub-Saharan Africa. PIRLS has even fewer African participants.

Due to data constraints, research specifically examining children's learning performance, such as reading or numeracy skills, and the disparities in these outcomes across socioeconomic groups in African contexts remain limited. Some studies rely on data from the Confemen Programme for the Analysis of Educational Systems (PASEC), which surveyed 10 and 14 African countries in 2014 and 2019, respectively. Using PASEC, reading skills were reported as significantly lower among children from poor or disadvantaged families [20,21]. Furthermore, Kadio (2023) highlighted that gender disparities in educational outcomes are correlated with socioeconomic status, with children from disadvantaged backgrounds experiencing disproportionally higher gender-based disparities [22]. The challenges faced by children with disabilities (CWD) and their low learning performance have only recently garnered attention, particularly following the adoption of the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) in 2006 [23]. Recent studies have made efforts to understand the schooling challenges faced by CWD, focusing on differences in school access, attendance and enrolment in developing countries [24,25,26]. However, studies specifically addressing how much CWDs are falling behind in reading skills learning are rare in the context of developing countries, with a few from individual studies in Asia [27].

While none of these PASEC-based studies explicitly focused on children with disabilities, Wodon et al. (2018) reported large disparities in reading and numeracy learning between children with hearing or vision disabilities and their peers without disabilities in 10 African countries [28]. Other cross-country comparative studies have utilized MICS survey data, as in the present study. UNICEF (2022) reported different disparities in reading and numeracy skills across different disability types [29]. However, the report primarily provided global estimates or findings from a limited number of countries, without a specific focus on African countries. Zhang and Holden (2023), also using MICS data, found that barriers to numeracy skills among children with disabilities vary by disability type: some children are hindered primarily by lack of school access; while others face dual barriers related to school access and skill acquisition within schools [30].

Using nationally representative data across 11 low-income and lower-middle-income African countries, we evaluate the reading skills of children aged 10 to 14 years old and investigate variations in reading skills across rural versus urban areas, between children with disabilities (CWD) versus children without disabilities (CWOD), as well as between children from poorer and less educated families versus better-off and more educated families. More specifically, this study provides unique insights into how these disparities differ across 11 African countries and highlights the relative performance of CWD compared to CWOD within various social groups and across different national contexts.

Our research aims to answer the following research questions: 1) To what extent do children with disabilities or from disadvantaged backgrounds (e.g., children from poorer or less educated families, rural areas) lag behind their peers (children without disabilities or from better off or educated families, urban areas) in acquiring basic reading skills? 2) Do children with disabilities or from disadvantaged backgrounds benefit equally from higher national-level reading proficiency? 3) Can better micro-level social conditions help mitigate the learning constraints faced by children with disabilities?

This paper is unique in its exclusive focus on school children's reading skills performance across low-income and lower-middle-income African countries, all of which were included in the sixth round of Multiple Indicator Cluster Surveys (MICS) between 2017 and 2020. First, we present comprehensive, nationally representative evidence of the substantial variation in basic reading skills among children from different socioeconomic backgrounds. We employ consistent, standardised tests and measurements of reading skills both within and across countries. We identify substantial differences in reading skills across the 11 countries, as well as across socioeconomic groups within each country.

Second, we utilise the standardised identification of children with disabilities in the MICS survey to assess their reading skills, using children without disabilities in each country as a counterfactual. Overall, children with disabilities lag behind children without disabilities. However, an interesting finding is that children with disabilities in better-performing countries outperform children without disabilities in other countries. This suggests that strengthening education systems is a promising way of improving the reading skills of children with disabilities.

2. Conceptual framework

Reading skills are crucial for the development of various other academic skills in school and can greatly impact children's likelihood of repeating grades or dropping out [31]. Several social, familial and individual factors influence children's learning, and the mechanisms through which these factors influence learning are multifaceted (Taylor [Unpublished]). Pace et al. (2017) identify three potential pathways by which socioeconomic status might influence children's language development, which are child characteristics, parent-child interaction, and the availability of learning resources [32].

This paper aims to evaluate children's reading skills performance in any of the three potential pathways as suggested by Pace et al. (2017). First, children who have functional challenges in one of the four main functional domains – vision, hearing, physical, intellectual – or with multiple functional challenges. Second, children from families in the lowest quintile of the asset index, and children from families without schooling. These children quite often have little access to critical learning resources and parental engagement for language development. Finally, children living in rural areas, where learning resources are constrained and school quality is often lower.

Families with higher social status, including better income and higher education levels, tend to provide better support for their children's learning. Children from more advantaged backgrounds often begin their learning process earlier than their peers from disadvantaged families [33]. Additionally, they may indirectly benefit from residing in neighbourhoods with higher-quality schools [34]. Parents with higher social status are also more likely to actively engage with the school community, thereby contributing to overall school quality.

The neighbourhood environment can influence children's learning outcomes. In the African context, although not extensively studied, there is evidence of urban-rural disparities in schooling [11]. Rural areas often face challenges related to school quality due to a lack of infrastructure, educational resources, and qualified teachers. Furthermore, in neighbourhoods characterised by high levels of poverty in rural areas, various social issues affecting disadvantaged families can be exacerbated. Children are also exposed to the influences of their peers in the same neighbourhood or school [35].

The challenges related to learning reading skills vary greatly across different disability types due to the diverse nature of functional difficulties [36,37]. Children with vision disabilities may have the same capability to develop reading skills as their peers, but the real challenges often stem from the availability of aids, such as corrective lenses, optical devices, and glasses [38], as well as access to consultative instructional services [39]. For children with hearing disabilities, the challenge of learning to read often arises from a lack of exposure to their first language before the critical period [40]. This puts them at high risk of linguistic deprivation [41]. Children with physical disabilities may not face apparent functional challenges in learning reading skills, but they frequently experience high rates of school absenteeism due to factors like long distances to school and lack of infrastructure, materials, and support [42]. Children with intellectual disabilities struggle with developing reading skills due to challenges in various abilities, including information processing, cognitive abilities, and attentive behaviours [43,44]. Children with multiple disabilities are exposed to higher risks related to several different functional challenges. Moreover, the availability of appropriate teaching materials and pedagogical interventions for CWD can enhance their skill development.

We set up the first hypothesis concerning the role of factors related to child characteristics, parent-child interaction, and the availability of learning resources:

H1. The percentages of school children aged 10-14 with satisfactory reading skills among children with a) families in the lowest quintile of the asset index, b) families without schooling, c) rural residence, d) disabilities (vision, hearing, physical, intellectual, and multiple disabilities) are significantly lower than that among their peers.

Several cross-country studies focusing on school enrolment have shown that disparities in enrolment and attendance for disadvantaged children are more pronounced in countries with higher overall enrolment rates and better socio-economic development [23,24,45]. We formulate the second hypothesis to explore whether children from different backgrounds benefit equally from their country's overall reading proficiency level:

H2. The differences in the percentage of school children with satisfactory basic reading skills are more pronounced in countries with higher overall reading proficiency when comparing a) children from families in the lowest asset quintile vs. those in the upper quintiles, b) children from families without vs. with schooling, c) rural vs. urban children, and d) CWD vs. CWOD.

Another question revolves around whether CWD, when raised in families with a more advantageous social background (urban residence, higher income, higher education), can successfully bridge the academic performance gap compared to CWOD. Can better micro-level socioeconomic conditions help mitigate the learning constraints faced by children with disabilities? We set up the third hypothesis related to the reading skills associated with children's disabilities across different social groups:

H3. The differences in the percentage of school children with satisfactory basic reading skills between CWD and CWOD are smaller in a) urban, b) higher-income, c) more educated families.

Our H3a-c hypotheses are based on the notion that families with advantageous conditions can better support CWD in overcoming learning challenges. Finally, due to data limitations, our assessment is confined to children enrolled in school during the survey period.

3. Materials and methods

3.1 Data description

We use publicly available data from the sixth round of MICS national representative surveys conducted by the United Nations International Children's Emergency Fund (UNICEF) between 2017 and 2020 in 11 African countries: Central Africa Republic, Chad, DRCongo, Ghana, Lesotho, Madagascar, Malawi, The Gambia, Togo, Tunisia, Zimbabwe. The sixth round of MICS adopted the Washington Group Child Functioning Module (WG-CFM) to assess functional difficulties among children aged 6-17 [46,47]. Out of the 13 functional domains covered by WG-CFM, this paper focuses on eight domains that include four severity scales, categorised into five types of disabilities: vision, hearing, walking, intellectual and multiple disabilities [48].

Our analysis primarily relies on the reading test designed for children aged 10-14 in the MICS survey. This reading test is highly standardised and consistently applied across countries. It consists of an oral reading fluency test, where children read a short story of approximately 60-80 words [49], followed by a comprehension test containing five questions related to the story's content. From this test, we derive two key indicators: Q1, representing the proportion of correctly read words (ranging from 0 to 1), and Q2, indicating the proportion of correctly answered questions (with values of 0, 0.2, 0.4, 0.6, 0.8, 1). The reading test score is subsequently computed as the average of Q1 and Q2.

The distribution of these test scores shows a substantial number of extreme values, with children either reading fluently and answering all comprehension test questions correctly or being unable to read at all. The reading test in the MICS survey assesses foundational skills, and given the sample age of 10-14, after several years of schooling, all children should theoretically reach this basic level of reading. Children who struggle to achieve satisfactory proficiency in these tests face notable challenges in reading. Rather than treating the reading test score as a continuous measure, this study focuses on identifying children who are struggling with reading. We use the percentage of school children who surpass the threshold score of 0.85 as the primary outcome variable. Additionally, we include sensitivity analysis (reported in Table S2.3, S2.5, and S2.7) using continuous outcome variables. These results are consistent with the findings based on the threshold-based outcome measure.

Furthermore, although the 0.85 threshold is somewhat arbitrary, it allows a maximum of one incorrect comprehension question and a limited number of errors in reading the story (up to 10 percent of words). However, the threshold at 0.9 might be a little bit too strict because the child will have to read all the words 100% correctly if one question is wrong, or the child has to answer all 5 questions correctly. To ensure robustness, we conduct sensitivity analyses using alternative cutoff points (0.8, 0.9) to assess whether they would significantly change our primary findings. The results of these sensitivity analyses are detailed in Supporting Information Table S2.1, S2.2, S2.4, and S2.6. The sensitivity test shows no large sensitivity to the selection of different cutoff thresholds.

In the MICS survey, one child aged between 6 and 17 is selected from the participating households to take the reading test. Table 1 provides an overview of the total sample size by country and the size of non-response.

Table 1 Sample size and non-response by countries

Country	Missing due to Out of school[1]		Missing due to Language		Missing due to refusal[2]		Done reading test		**Total**
	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)	
Central African Repub	361	17.8	145	7.1	444	21.9	1081	53.2	**2,031**
Chad	2,568	54.1	107	2.3	490	10.3	1582	33.3	**4,747**
DRCongo	769	16.6	305	6.6	754	16.2	2813	60.6	**4,641**
Ghana	176	5.0	112	3.2	267	7.6	2937	84.1	**3,492**
Lesotho	42	2.2	0	-	287	14.9	1598	82.9	**1,927**
Madagascar	958	22.3	1	0.0	656	15.3	2686	62.5	**4,301**
Malawi	204	3.0	69	1.0	1498	22.4	4930	73.6	**6,701**
The Gambia	366	18.7	190	9.7	179	9.2	1220	62.4	**1,955**
Togo	119	6.6	5	0.3	110	6.1	1576	87.1	**1,810**
Tunisia	20	1.1	0	-	77	4.4	1651	94.5	**1,748**
Zimbabwe	137	5.6	43	1.8	105	4.3	2156	88.3	**2,441**
Total	**5,720**	**16.0**	**977**	**2.7**	**4,867**	**13.6**	**24,230**	**67.7**	**35,794**

Note 1 including children never-in-school and dropouts
2 including family and child refusal

In many countries, the majority of children who have never attended school (99.6 percent) or have dropped out (78.5 percent) did not take the reading test, accounting for 16.0 percent of the sample. Additionally, 2.7 percent of children did not take the reading test because the test was not available in their primary teaching language. In most countries, the test is administered in an official foreign language, such as English or French [50]. Finally, 13.6 percent of non-responses were due to refusals, with 4.7 percent attributed to families refusing to involve their child, and 8.9 percent to children themselves refused to take the reading test.

The sample size of the children who completed the reading tests is presented in Table 2, categorized by urban vs. rural location, CWD vs. CWOD, children from the lowest asset quintile vs. those in the upper quintiles), as well as children from families with vs. without schooling, across the 11 African countries.

Table 2 Number of tested children by location, disability status, socioeconomic factors and country, ages 10-14

Country	Location		Disability Status		Poverty Status		Family Schooling	
	Rural	Urban	CWD	CWOD	Lowest quintile	Upper quintiles	No school	Other
Central African Repub	472	609	66	1,015	108	973	190	888
Chad	994	588	41	1,541	163	1,419	662	918
DRCongo	1,673	1,140	45	2,768	625	2,188	335	2,477
Ghana	1,502	1,435	219	2,718	664	2,273	912	2,018
Lesotho	1,142	456	39	1,559	421	1,177	212	1,377
Madagascar	1,871	815	138	2,548	372	2,314	505	2,166
Malawi	4,124	806	153	4,777	697	4,233	654	4,256
The Gambia	582	638	21	1,199	386	834	761	454
Togo	1,031	545	83	1,493	340	1,236	532	1,031
Tunisia	514	1,137	49	1,602	326	1,325	197	1,448
Zimbabwe	1,518	638	90	2,066	428	1,728	131	2,024
Total	15,423	8,807	944	23,286	4,530	19,700	5,091	19,057

"Lowest quintile" refers to children from families in the lowest quintile of the asset index, while "Upper quintiles" includes all children not in the lowest quintile.
"No school" refers to children from families without any schooling, while "Other" includes all children from families with some level of formal education.

3.2 Ethics Methods

MICS surveys data were publicly available online data base, with all the surveys conducted by UNICEF. These surveys underwent review and received approvals from ethics committees in each respective country. Furthermore, participants in these surveys were provided with information about the surveys and informed consent process was conducted during all the MICS surveys, following the MICS protection protocol. Detailed information is provided in section 2.4 in the survey report for each country and publicly available on MICS website.

3.3 Estimation strategy

The MICS data is a national sample of children aged 6-17. However, the non-response rate in the MICS reading tests is as high as 32 percent. The majority of out-of-school children and all children taught in minority languages are excluded from the reading tests. As a result, our analysis can only confidently speak about in-school children taught in the main language.

We are able to address one of the selection problems in the data, non-participation due to refusal. To address this potential selection issue due to refusals, we employ inverse probability weighting (IPW). IPW relies on estimating the probability of exposure (in this case, taking the reading test) for each person in the sample by using probit regression models.

We first use a probit model to evaluate the likelihood of children in the sample taking the reading test in each respective country in the following :

$$Selection_i^m = \alpha_0^m + \alpha_{1j}^m D_{ij}^m + \alpha_3^m UR_i^m + \alpha_{2k}^m EDU_i^m + \alpha_{2k}^m ASS_i^m + \alpha_4^m Age_i^m + \alpha_5^m Gender_i^m + \varepsilon_i \quad (1)$$

To address potential sample selection, we include variables that could be correlated with a child's probability of taking the reading tests. Several factors may have contributed to children's participation rates in the reading tests. Children with lower reading abilities may have felt reluctant or ashamed to participate, potentially due to fear of embarrassment or negative judgment. To address this concern, we account for key factors that are commonly associated with children's reading skills in the selection model, including age, gender, and the family's socioeconomic status [51,52].

Additionally, children may have missed the test due to health-related issues or because they were engaged in household duties or other work responsibilities, factors that are particularly prevalent in low-resource settings. To account for these dynamics, we include children's disability status, urban or rural residence, and socioeconomic indicators, as these variables are often linked to the likelihood of children participating in domestic or economic labour [53,54].

Therefore, the control variables in the selection model encompass: 1) asset index indicator quintiles (ASS_i), constructed using weighted assets owned by the household through the first principal component based on principal component analysis (PCA) at the household level [55]; 2) the highest completed educational level among the household members (EDU_i); 3) location variable UR_i, indicating urban or rural residence; 4) disability status (D_{ij}), represented by dummy variables indicating no disability, vision, hearing, physical, intellectual, or multiple disabilities; and 5) children's age and gender. Here, subscript *i* represents each individual child, m represents countries, *j* represents different disability statuses.

If the coefficients for these variables are statistically significant, it indicates evidence of sample selection. The predicted probability of selection from the full model (1) is $\widehat{Selection}1_i^m$. Next, we rerun a reduced probit model with covariates that are insignificant in (1) and the predicted probability from the reduced model is $\widehat{Selection}2_i^m$. The inverse probability weight is calculated as the ratio between the two predicted probabilities:

$$Weight_i^m = \widehat{Selection}2_i^m. \;/\; \widehat{Selection}1_i^m. \quad (2)$$

The inverse probability weight is used on the sample consisting of children who have completed the reading test. The approach helps adjust for potential selection bias related to family and individual characteristics since children with similar characteristics to those who refused the reading test will receive higher weights [56].

In the second stage model, only school children with reading test scores will be included, weighted by IPW.

We first test hypothesis H1, which states that the percentages of school children aged 10-14 with satisfactory reading skills among children with a) families in the lowest quintile of the asset index, b) families without schooling, c) rural residence, d) disabilities (vision, hearing, physical, intellectual, and multiple disabilities) are significantly lower than that among their peers.

We employ country-fixed effects models and include Asset index quintile (ASS_i), Families' educational level (EDU_i), urban/ rural residence (UR_i), disability status (D_{ij}), as well as additional control variables such as age and gender in the models. Initially, we run four separate models, each including only one of these factors alongside the control variables, to test the treatment effect of each factor individually. Then, we run the model with all factors and control variables included, using the following model specification:

$$Reading_i = \beta_0 + \beta_{1j}D_{ij} + \beta_2 UR_i + \beta_3 ASS_i + \beta_4 EDU_i + \beta_5 Age_i + \beta_6 Gender_i + \beta_7 Country_i + u_i \quad (3)$$

Here, subscript *i* represents each individual child.

To test hypothesis H2, which states that the differences in the percentage of school children with satisfactory reading skills between disabled and non-disabled as well as between disadvantaged and non-disadvantaged backgrounds are more pronounced in countries with higher overall reading proficiency, we include interaction terms between different factors and country variable. Similarly, we run four separate models, each including the interaction term between the country and one factor F_{ij} (j represents one of the factors: poverty status, family schooling, urban/ rural residence, and disability status). The model specification is as follows:

$$Reading_i = \pi_{10} + \pi_{11}F_{ij} + \pi_{12}Country_i + \pi_{13}F_{ij} * Country_i + \pi_{14}UR_i + \pi_{15}ASS_i + \pi_{16}EDU_i + \pi_{17}Age_i + \pi_{18}Gender_i + u_{1i} \quad (4)$$

The sample size is relatively small for some groups in certain countries, particularly for children with disabilities, resulting in a high variance in the estimations. Therefore, we also categorise the 11 countries in the sample into three country groups (CGrp): low-reading country, mid-reading country, and high-reading country. We run separate models again, similar to (4) with the country group variable. The new set of regressions follows the model specification:

$$Reading_i = \pi_{10} + \pi_{11}F_{ij} + \pi_{12}CGrp_i + \pi_{13}F_{ij} * CGrp_i + \pi_{14}UR_i + \pi_{15}ASS_i + \pi_{16}EDU_i + \pi_{17}Age_i + \pi_{18}Gender_i + u_{1i} \quad (5)$$

To test hypothesis H3, which states that the differences in the percentage of school children with satisfactory reading skills between CWD and CWOD are smaller in a) urban, b) higher-income, c) more educated families, we include interaction terms between disability status and other micro-level indicators:

$$Reading_i = \pi_{20} + \pi_{21}D_i + \pi_{22}UR_i + \pi_{23}ASS_i + \pi_{24}EDU_i + \pi_{25}D_i * UR_i + \pi_{26}D_i * ASS_i + \pi_{27}D_i * EDU_i + \pi_{28}Age_i + \pi_{29}Gender_i + \pi_{30}Country_i + u_{2i} \quad (6)$$

Due to the limitations in the size of samples for some disability types, we will not estimate the treatment effect of different disability types but include disability status D_i as a catch-all category.

4. Results

4.1 Reading skills across 11 African countries

The percentage of school children aged 10-14 with satisfactory reading skills (reading score 0.85 or above) in each country is displayed in Table 3, showing substantial variation. This percentage ranges from a low of 17.8% in the Central African Republic to a high of 87.7% in Tunisia. Seven countries have more than 50% of children with unsatisfactory reading skills. In our combined sample from 11 countries, fewer than half (45 per cent) of school children have achieved a satisfactory reading level. Namely, they can read the basic text properly. As shown in Table 3, the reading proficiency levels among school children highlight not only the generally low overall reading skills but also substantial variations across the 11 African countries.

Table 3 Percentage of tested children with satisfactory reading skills (score > 85%) by countries, ages 10-14

	Mean (%)	Std. Err.	[95% Conf.	Interval]	Sample size	Year of survey
Central Africa R.	17.8	0.012	0.155	0.201	1,080	2019
Chad	21.2	0.010	0.192	0.232	1,548	2019
DRCongo	18.9	0.008	0.175	0.204	2,730	2017
Ghana	47.0	0.009	0.452	0.488	2,916	2017
Lesotho	58.4	0.012	0.559	0.608	1,568	2018
Madagascar	51.2	0.010	0.492	0.531	2,477	2018
Malawi	49.4	0.007	0.480	0.508	4,883	2020
The Gambia	34.6	0.014	0.319	0.373	1,213	2018
Togo	37.9	0.012	0.355	0.403	1,574	2017
Tunisia	87.7	0.008	0.861	0.893	1,607	2018
Zimbabwe	56.3	0.011	0.542	0.585	2,056	2019
Total	**44.7**	**0.003**	**0.441**	**0.454**	**23,652**	

Based on the overall reading skills proficiency of these countries, we can categorize them into three groups: low-reading countries, which include the Central Africa Republic, Chad, DRCongo, and The Gambia; mid-reading countries, which include Ghana, Madagascar, Malawi, and Togo; and high-reading countries, which include Lesotho, Tunisia, and Zimbabwe.

4.2 Reading skills across micro-level factors

In the first set of regressions, we run inverse probability weighted pooled least squares regression models by including one of the four micro factors in each of the four models: 1) household asset index quintile, 2) family members' highest educational level, 3) location (rural vs. urban), and 4) disability status. The outputs for the first stage of the selection model are presented in the Supporting Information S1 Table. The final regression, labelled as Model 5, includes all the micro-level factor variables and control variables (Table 4).

Table 4 IPW least squares regressions on the proportion of children with satisfactory reading skills (score > 85%), by urban/rural and micro-level factors

	Model1	Model2	Model3	Model4	Model5
Asset index (base category=Lowest quintile)					
Second quintile	0.059***				0.044***
	(0.009)				(0.009)
Middle	0.109***				0.076***
	(0.009)				(0.010)
Fourth quintile	0.209***				0.145***
	(0.010)				(0.011)
Richest	0.367***				0.257***
	(0.010)				(0.013)
Highest Educational level in the household (base category=No school)					
Primary		0.059***			0.033***
		(0.009)			(0.009)
Junior secondary		0.210***			0.098***
		(0.010)			(0.010)
Senior secondary or higher		0.211***			0.085***
		(0.011)			(0.011)
Location (base category: urban)			-0.225***		-0.090***
			(0.008)		(0.009)
Disability status (base category: non-disabled)					
Vision disability				0.05	0.039
				(0.036)	(0.035)
Hearing disability				-0.145**	-0.105*
				(0.049)	(0.047)
Physical disability				0.037	0.073*
				(0.035)	(0.036)
Intellectual disability				-0.157***	-0.150***
				(0.016)	(0.015)
Multiple disabilities				-0.174***	-0.128*
				(0.051)	(0.050)

Gender	X	X	X	X	X
Age	X	X	X	X	X
Country FE	X	X	X	X	X
Sample size	23591	23572	23591	23591	23572
R2	0.214	0.176	0.19	0.153	0.226

Table 4 indicates large differences in the share of school children with satisfactory reading skills across various groups. Children from the highest quintile of the asset index outperform those from the lowest quintile by 37 percentage points (Model 1). Children in families with primary education show a 6 percentage-point advantage over those from families without any schooling, while those from families with a member who has completed junior secondary education or higher achieve a 21 percentage-point advantage (Model 2). In the full model incorporating all factors, the coefficients for wealth and education from Models 1 and 2 are reduced, likely reflecting a correlation between these factors.

Urban children outperform their rural counterparts by 23 percentage points in satisfactory reading skills before accounting for micro-level factors (Model 3) and by 9 percentage points after these factors are controlled for (Model 5).

Compared to CWOD, children with hearing disabilities (15 percentage points lower), intellectual disability (16 percentage points lower) and multiple disabilities (17 percentage points lower) exhibit lower proficiency rates (Model 4). The finding remains consistent with or without controlling for other factors (Models 4 and 5).

4.3 Disparities in reading skills across 11 African countries

To test hypothesis H2, we include country-specific dummy variables and interaction terms between micro-level factors and individual countries. Fig 1 presents the estimated proportion of 14-year-old children with satisfactory reading skills across various groups: rural children, children with disabilities (CWD), children from families in the lowest quintile of the asset index, and children from families without schooling. The figure also includes data on children who do not belong to these groups, offering a comparative analysis across the 11 African countries in our sample.

Fig 1 Here

Disparities in reading skills between children from families in the lowest asset quintile and upper asset quintiles are significantly larger in countries with mid-level reading proficiency, such as Ghana (23 percentage points), Madagascar (23 percentage points), Togo (15 percentage points), and Zimbabwe (14 percentage points), and Lesotho (10 percentage points). In contrast, these disparities are much smaller in countries with low reading proficiencies, such as Chad (8 percentage points) and DRCongo (6 percentage points), or even no significant disparities, such as in the Central Africa Republic and The Gambia. In Tunisia, where most children have high basic reading proficiency, the differences are also insignificant. An exception is Malawi, which, despite having mid-level reading proficiency, shows no significant disparity between children from families in the lowest asset quintile and those from upper asset quintiles. Disparities in reading skills between children from families with and without schooling have largely mirrored those from the lowest versus upper asset quintiles, with much lower disparities in countries with overall low reading proficiency.

Urban-rural disparities in reading skills are the most pronounced in Ghana (24 percentage points), Togo (22 percentage points) and Zimbabwe (21 percentage points), while they are significant but small in DRCongo (12 percentage points), Lesotho (12 percentage points), and Madagascar (8 percentage points). For other countries, the urban-rural disparities are not significant. Disparities in reading skills for children with disabilities (CWD) are significant across all 11 African countries, ranging from 7 to 22 percentage points. The largest disparity is observed in the Gambia, while countries with lower reading proficiency show smaller differences.

Despite significant disparities in reading proficiency across social groups within these countries, the cross-country differences are even more pronounced. For example, children from the lowest quintile of asset index in mid-proficiency countries such as Lesotho, Zimbabwe, Madagascar, Malawi, Ghana, Togo, and The Gambia outperform those from the top four asset quintiles in low-proficiency countries like Chad, DRCongo, and the Central African Republic.

The sample size for CWD is quite limited in several countries, resulting in a large variance in the estimated outcomes for CWD. Consequently, we further analyse the data across the three country groups defined in Section 4.1 (Fig 2). The results from group-level analysis are similar to those from the country-level analysis. Disparities in reading skills between children from families in the lowest and upper asset quintiles and between children from families with and without schooling are not significant in low-reading countries but are much larger in mid-reading and high-reading countries. The urban-rural disparity is especially high in the high-reading countries. However, disparities between CWD and CWOD remain consistently significant across countries with different levels of reading proficiency.

Fig 2 Here

4.4 Disparities in reading skills related to disabilities

To test hypothesis H3, we include all micro-level indicators, as well as the interaction terms between disability status and other micro-level indicators (urban/rural residence, asset index, and family's highest educational level) in the country fixed effect model. The regression results at various cutoff points are presented in the Supporting Information S2 Table. Sensitivity test.

Fig 3 displays the estimated proportion of 14-year-old children with satisfactory reading skills. These predictions are made with covariates set at their means for both CWD and CWOD in different social groups (urban vs. rural, high vs. low socio-economic status, more vs. less educated families). These disparities in reading skills between CWD and CWOD in schools are visually represented as lines connecting two estimated reading skill proficiency rates in various social groups. A steeper incline in the line indicates a higher disparity between CWD and CWOD, while a flatter line suggests a smaller disparity.

Fig 3 Here

Fig 3 suggests that disparities in reading skills proficiency between CWD and CWOD do not vary significantly across different social groups. These disparities remain relatively constant at around 15 percentage points in various groups. The most significant disparities are observed in urban areas (19 percentage points) and among families without any schooling (21 percentage points).

Furthermore, it is noteworthy that CWD in social groups with advantaged backgrounds (urban, rich and more-educated families) have achieved similar levels of reading skill proficiency as their CWOD peers in social groups with disadvantaged backgrounds (rural, economically disadvantaged, and less-educated families).

5. Discussion and study limitations

5.1 Discussion

In this section, we will discuss the findings related to the key hypotheses. We will also discuss important limitations of our study and provide some suggestions for future research.

Utilizing a standardized reading test, the paper reveals particularly low overall reading skills and considerable variations among school children across the 11 African countries. It is important to note that there is substantial variation in the level of school attendance across these countries, with rates ranging from 43 percent in Chad to 69 percent in Madagascar, and reaching as high as 95 percent in Lesotho, Malawi, and Tunisia. Since we expect a much lower reading skill level for children not enrolled in school, the overall reading skill level and the actual gap in learning across these countries are likely higher when differences in school attendance are considered. For instance, while the average reading skill proficiency rate is 21 percent among schoolchildren in Chad, school attendance is only 43 percent.

The first set of models supports hypothesis H1, showing that children from 1a) impoverished backgrounds, 1b) less-educated households, and 1c) rural areas exhibit significantly lower reading skills than their peers from affluent families, more educated households, or urban areas. Hypothesis H1d) is only partially supported: the percentage of school children with satisfactory reading skills is significantly lower among those with hearing, intellectual, and multiple disabilities compared to their CWOD peers [57]. However, it is important to note that children with vision or physical disabilities do not significantly lag behind, and the conclusion regarding children with hearing disabilities does not remain statistically significant when all control variables are included in the analysis.

As demonstrated by numerous studies in developed contexts [29], children from disadvantaged backgrounds tend to lag behind in reading abilities. Notably, our analysis shows that family poverty has the strongest correlation with children's reading skills. The proportion of school children in the richest quintile group who have achieved satisfactory reading skills is approximately 24-35 percentage points higher than those in the lowest quintile group.

What is particularly notable in our study is the observation that a substantial proportion of school children obtain extreme values in their reading test scores, either very low or very high scores. The concern here is primarily for school children who, at their current age, continue to achieve very low scores in basic reading tests. This underscores the substantial challenges they may have encountered in developing proficient reading skills in the long future. Children from disadvantaged backgrounds are particularly representative.

Furthermore, our study indicates that school children with vision and physical disabilities do not exhibit significant differences in their reading skills compared to non-disabled children. It is plausible that they have managed adequately with basic reading skills. However, if more extensive reading tests were to be introduced, these children might also encounter challenges and potential difficulties in meeting advanced reading skill requirements.

Our findings support Hypothesis H2a, H2b, and H2c, indicating that disparities in reading proficiency rates across socioeconomic groups and urban-rural disparities are more pronounced in countries with higher overall reading proficiency. In countries with very low reading proficiency, such as the Central African Republic (average reading skills score of 18 percent), Chad (21per cent), and DRCongo (19 percent), disparities in reading skills across socioeconomic groups are either insignificant or much smaller compared to other countries.

The largest disparities across socioeconomic groups are observed in countries with mid-level reading proficiency, such as Ghana (47 percent), Madagascar (51 percent), Togo (38 percent), and Zimbabwe (56 percent). Urban-rural disparities are also most pronounced in countries with relatively high reading proficiency. However, in Tunisia, which boasts the highest level of socio-economic development and the highest reading proficiency (88 percent) among the 11 countries, no significant disparities in reading skills are found among children from different disadvantaged backgrounds.

Our findings do not support Hypothesis H2d, which posits that disparities in reading proficiency rates between children with and without disabilities are more pronounced in countries with higher overall reading proficiency. Meanwhile, Tunisia, the country with the highest reading proficiency (88 percent), exhibits relatively high disparities in reading skills between CWD and CWOD. However, a closer analysis reveals that the 20-percentage-point gap in Tunisia is not particularly large when viewed as a proportion of the country's overall reading proficiency level. This contrasts with the 7–12 percentage-point gaps observed in countries with significantly lower reading proficiency levels, such as the Central African Republic, Chad, and the Democratic Republic of Congo, where overall proficiency levels range from 18% to 21%. In countries with mid-level reading proficiency (35-58 percent), disparities between CWD and CWOD range from 12 to 25 percentage points, further suggesting that disability-related disparities are not significantly different across countries with different reading proficiency.

Our findings do not support Hypothesis H3 that disparities in the percentage of school children with satisfactory reading skills between CWD and CWOD would be less pronounced in households with more advantaged backgrounds. Instead, these disparities have remained relatively constant across different social groups. It is worth emphasising that these results are based on children who are currently enrolled in school. When we consider out-of-school children, recognising the overrepresentation of CWD in this group, it becomes apparent that disparities across social groups ay have been underestimated. However, as long as children are enrolled in school, a consistent gap between CWD and CWOD appears to persist.

5.2 Study limitations

Several limitations should be considered when interpreting the findings of this study.

First, there are some limitations associated with the reading test used in the MICS survey. Given the age range of children tested (10-14 years), the MICS reading test focuses primarily on foundational reading skills and may not assess more advanced reading skills. However, even with the basic test, the prevalence of satisfactory reading skills among children aged 10-14 in most of these countries is notably low, indicating limited reading abilities across many African countries. Introducing a more extensive reading test could potentially reveal even larger disparities in reading proficiency.

Another limitation of the reading test is the potential for floor effects in countries with particularly low reading proficiency. The test may fail to capture important variations in the skill levels of children who do not pass it. For instance, in some countries, specific linguistic challenges—such as difficulties distinguishing between the sounds of "r" and "l"—could influence performance on the reading test, and it remains uncertain how these factors might affect the results.

Second, it is crucial to recognise that this study exclusively focuses on children currently enrolled in school. Many children not attending school and therefore not taking the reading test are disproportionately among disabled children or those from disadvantaged backgrounds. As a result, the disparities estimated in this group may have been underestimated.

Moreover, there is substantial variation in school attendance rates across the countries studied. Careful consideration is needed when analysing countries with low school enrolment. It is important to emphasise that the conclusions drawn in this paper are applicable exclusively to children enrolled in school and cannot be generalised to encompass all children in these countries.

Third, the selection of countries in this study was not guided by strict predefined criteria but was rather constrained by data availability. It is essential to interpret the estimated disparities cautiously due to the inherent arbitrariness associated with the selection of countries in this paper.

6. Conclusion

Our study provides new evidence on the reading proficiency of school children aged 10-14 across 11 African countries, drawing from unique nationally representative data. Through a standardized reading test, the paper uncovers notably low overall reading skills and significant disparities among school children across 11 African countries. By examining the correlations between diverse regional, familial, and individual factors, we aimed to uncover important factors that may influence school children's acquired reading skills.

A comparative analysis across 11 African countries suggests that disparities in reading skills among children from disadvantaged backgrounds are non-existent or minimal in countries with low overall reading proficiency. In contrast, these disparities are more pronounced in some countries with mid-level reading proficiency. Notably, despite having the highest overall reading proficiency, Tunisia shows no significant differences in reading skills across the social groups examined. On the other hand, given the basic nature of the reading test in this study, we can only conclude that there are no significant disparities in basic reading skills among disadvantaged children in Tunisia. However, larger disparities may emerge if more extensive reading skills are assessed.

One unique contribution of our study lies in its findings related to children with disabilities (CWD), a topic that has received relatively little attention in recent literature, likely due to data limitations. Benefiting from the large sample size from country-pooled data in the MICS standardised data, this study emphasises disparities in reading skills among children with different types of disabilities – a critical dimension often overlooked by many studies due to sample size limits.

Our study highlights a persistent gap in reading skills between CWD and CWOD across countries and various social groups, underscoring the unique challenges CWD faces. Interestingly, the differences in reading skills between CWD in poorer conditions and those in better socioeconomic conditions mirror the disparities observed among CWOD.

This paper underscores the critical role of micro-level socioeconomic factors in addressing challenges faced by vulnerable populations and enhancing reading skills for all. However, certain vulnerable groups, such as CWD, encounter unique challenges in acquiring reading skills. Although better school quality and socioeconomic conditions enhance reading skills among CWD, a significant gap between CWD and CWOD persists. Further targeted and in-depth research is essential to understand the underlying dynamics and identify tailored interventions, which extend beyond the scope of this paper.

7. References

1. UN. Sustainable Development Goals: Department of Economic and Social Affairs; 2015. [Cited 2024 Oct 4]. Available from: https://sdgs.un.org
2. UNDP. Human development for everyone. Human Development Report 2016. New York: UNDP. [Cited 2024 Oct 4]. Available from: https://hdr.undp.org/content/human-development-report-2016
3. Evans DK, Mendez Acosta A. Education in Africa: What are we learning? Journal of African Economies. 2021;30(1):13-54.
4. Bashir S, Lockheed M, Ninan E, Tan JP. Facing forward: Schooling for learning in Africa. The World Bank; 2018 Sep 17.
5. Musau Z. Africa grapples with huge disparities in education. Africa Renewal. 2018;31(3):10-1.
6. World Bank. World development report 2018: Learning to realize education's promise2018. [Cited 2024 Oct 4]. Available from: https://www.worldbank.org/en/publication/wdr2018
7. UNESCO. Teaching and Learning: Achieving quality for all. 2014. [Cited 2024 Oct 4]. Available from: https://www.unesco.org/gem-report/en/teaching-and-learning-achieving-quality-all
8. Hernandez D. How third-grade reading skills and poverty influence high school graduation, Annie E. 2011. [Cited 2024 Oct 4]. Available from: https://files.eric.ed.gov/fulltext/ED518818.pdf
9. Heckman J, Pinto R, Savelyev P. Understanding the mechanisms through which an influential early childhood program boosted adult outcomes. American Economic Review. 2013;103(6):2052-86.
10. Dolean D, Melby-Lervåg M, Tincas I, Damsa C, Lervåg A. Achievement gap: Socioeconomic status affects reading development beyond language and cognition in children facing poverty. Learning and Instruction. 2019 Oct 1;63:101218.
11. Zhang Y. Urban-rural literacy gaps in Sub-Saharan Africa: The roles of socioeconomic status and school quality. Comparative education review. 2006;50(4):581-602.
12. Clercq Fd. The persistence of South African educational inequalities: The need for understanding and relying on analytical frameworks. Education as Change. 2020;24(1):1-22.
13. Chmielewski AK. The global increase in the socioeconomic achievement gap, 1964 to 2015. American sociological review. 2019 Jun;84(3):517-44.
14. León J, Álvarez-Álvarez C, Martínez-Abad F. Contextual effect of school SES on reading performance: A comparison between countries in the European Union. Compare: A Journal of Comparative and International Education. 2022 May 19;52(4):674-88.
15. Kim YS, Lee H, Zuilkowski SS. Impact of literacy interventions on reading skills in low-and middle-income countries: A meta-analysis. Child development. 2020 Mar;91(2):638-60.
16. Park H. Home literacy environments and children's reading performance: A comparative study of 25 countries. Educational Research and Evaluation. 2008 Dec 1;14(6):489-505.
17. Chiu MM, McBride-Chang C. Gender, context, and reading: A comparison of students in 43 countries. Scientific studies of reading. 2006 Oct 1;10(4):331-62.
18. Chiu MM, McBride-Chang C. Family and reading in 41 countries: Differences across cultures and students. Scientific Studies of Reading. 2010 Nov 4;14(6):514-43.
19. Shiel G, Eivers E. International comparisons of reading literacy: What can they tell us?. Cambridge journal of education. 2009 Sep 1;39(3):345-60.
20. Lilenstein, A. (2018). Integrating indicators of education quantity and quality in six francophone African countries (No. 09/2018).
21. Kouamo, R. N. (2024). School work performance in sub-Saharan Africa: A bivariate multilevel analysis. International Journal of Educational Research, 126, 102388.
22. Kadio, K. E. (2023). Academic achievements in Sub-Saharan Africa: contexts, peers and inequalities. Education Economics, 31(2), 166-188.

23. UN. Convention on the Rights of Persons with Disabilities (CRPD) 2006 [Cited 2024 Oct 4]. Available from: https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html
24. Filmer D. Disability, Poverty, and Schooling in Developing Countries: Results from 14 Household Surveys. The World Bank Economic Review. 2008;22(1):141-63.
25. Mizunoya S, Mitra S, Yamasaki I. Disability and School Attendance in 15 Low-and Middle-Income Countries. World Development. 2018;104:388-403.
26. UNICEF (2022) . Seen, counted, included: using data to shed light on the well-being of children with disabilities. New York: United Nations Children's Fund. Available online at: https://data.unicef.org/resources/children-with-disabilities-report-2021/
27. Singal N, Sabates R, Aslam M, Saeed S. School enrolment and learning outcomes for children with disabilities: findings from a household survey in Pakistan. International Journal of Inclusive Education. 2020;24(13):1410-30.
28. Wodon Q, Male C, Montenegro C, Nayihouba A. The Challenge of Inclusive Education in Sub-Saharan Africa. The Price of Exclusion: Disability and Education. World Bank. 2018. [Cited 2024 Oct 4]. Available from: https://documents1.worldbank.org/curated/ru/171921543522923182/pdf/132586-WP-P168381-PUBLIC-WorldBank-SSAInclusive-Disability-v6-Web.pdf
29. UNESCO. Education and Disability: Analysis of Data from 49 Countries. United Nations Educational, Scientific and Cultural Organization. 2018. [Cited 2024 Oct 4]. Available from: https://uis.unesco.org/sites/default/files/documents/ip49-education-disability-2018-en.pdf
30. Zhang H, Holden ST. Numeracy skills learning of children in Africa:—Are disabled children lagging behind? Plos one. 2023;18(4):e0284821.
31. Reschly AL. Reading and school completion: Critical connections and Matthew effects. Reading & Writing Quarterly. 2010;26(1):67-90.
32. Pace A, Luo R, Hirsh-Pasek K, Golinkoff RM. Identifying pathways between socioeconomic status and language development. Annual Review of Linguistics. 2017;3:285-308.
33. Lee VE, Burkam DT. Inequality at the starting gate: Social background differences in achievement as children begin school: ERIC; 2002.
34. Anderson KG, Case A, Lam D. Causes and consequences of schooling outcomes in South Africa: Evidence from survey data. Social dynamics. 2001;27(1):37-59.
35. Leventhal T, Brooks-Gunn J. The neighborhoods they live in: the effects of neighborhood residence on child and adolescent outcomes. Psychological bulletin. 2000;126(2):309.
36. Premeaux SF. Impact of applicant disability on selection: The role of disability type, physical attractiveness, and proximity. Journal of Business and Psychology. 2001;16:291-8.
37. Anastasiou D, Kauffman JM. A Social Constructionist Approach to Disability: Implications for Special Education. Exceptional Children. 2011;77(3):367-84.
38. Le Fanu G, Schmidt E, Virendrakumar B. Inclusive education for children with visual impairments in sub-Saharan Africa: Realising the promise of the Convention on the Rights of Persons with Disabilities. International Journal of Educational Development. 2022;91:102574.
39. Corn AL, Koenig AJ. Literacy for students with low vision: A framework for delivering instruction. Journal of Visual Impairment & Blindness. 2002;96(5):305-21.
40. Kushalnagar P, Mathur G, Moreland CJ, Napoli DJ, Osterling W, Padden C, et al. Infants and children with hearing loss need early language access. The Journal of clinical ethics. 2010;21(2):140-2.
41. Mayberry R. The importance of childhood to language acquisition: Evidence from American Sign Language. The development of speech perception. 1994:57-90.
42. Tanya Lereya S, Cattan S, Yoon Y, Gilbert R, Deighton J. How does the association between special education need and absence vary overtime and across special education need types? European Journal of Special Needs Education. 2023;38(2):245-59.

43. Tolar TD, Fuchs L, Fletcher JM, Fuchs D, Hamlett CL. Cognitive Profiles of Mathematical Problem Solving Learning Disability for Different Definitions of Disability. J Learn Disabil. 2016;49(3):240-56.
44. Chan LKS, Dally K. Learning disabilities and literacy & numeracy development. Australian Journal of Learning Disabilities. 2001;6(1):12-9.
45. Lewis E, Mitra S, Yap J. Do Disability Inequalities Grow with Development? Evidence from 40 Countries. Sustainability. 2022;14(9):5110.
46. Groce NE, Mont D. Counting Disability: Emerging Consensus on the Washington Group Questionnaire. The Lancet Global Health. 2017;5(7):e649-e50.
47. WG. An Introduction to Washington Group on Disability Statistics Question Sets. 2020. [Cited 2024 Oct 4]. Available from: https://www.washingtongroup-disability.com/fileadmin/uploads/wg/The_Washington_Group_Primer_-_English.pdf
48. Five functional domains for behavioural and psychological disabilities: accepting change, controlling behaviour, making friends, anxiety, and depression, are not included since their prevalence rates across the countries vary greatly. It might indicate a large disparity in interpreting these functional domains in the local context. We classify vision disability as severe difficulty (cannot at all or a lot of difficulty) in vision even with glasses or contact lenses, hearing disability as severe difficulty in hearing even with a hearing aid, physical disability as severe difficulty in self-care or walking 500 meters on level ground without equipment or assistance, and intellectual disability as severe difficulties in communication, learning, remembering, or concentrating on activities that the child enjoys doing. Finally, those who reported more than one co-occurring severe functional difficulty are categorized as having multiple disabilities.
49. MICS survey reading tests mainly use same text with primary official teaching languages in these countries, which are English in The Gambia, Ghana, Lesotho, Malawi, and Zimbabwe; French in Central African Republic, Chad, DRCongo, Madagascar, Togo, and Tunisia. The story is same across all countries, but total number of words vary depending on the language used.
50. In Malawi and Zimbabwe, some children whose main teaching language is local language only did a reading test for local language.
51. Dolean, D., Melby-Lervåg, M., Tincas, I., Damsa, C., & Lervåg, A. (2019). Achievement gap: Socioeconomic status affects reading development beyond language and cognition in children facing poverty. Learning and Instruction, 63, 101218.
52. Reilly, D., Neumann, D. L., & Andrews, G. (2019). Gender differences in reading and writing achievement: Evidence from the National Assessment of Educational Progress (NAEP). American Psychologist, 74(4), 445.
53. Webbink, E., Smits, J., & Jong, E. D. (2015). Child labor in Africa and Asia: Household and context determinants of hours worked in paid labor by young children in 16 low-income countries. The European Journal of Development Research, 27, 84-98.
54. Edmonds, E. V. (2015). Economic growth and child labor in low income economies. A Systhesis Paper Prepared for IZA/DFID. Bonn: Institute for the Study of Labor.
55. Naveed TA, Gordon D, Ullah S, Zhang M. The construction of an asset index at household level and measurement of economic disparities in Punjab (Pakistan) by using MICS-micro data. Social indicators research. 2021 May;155:73-95.
56. Note that IPW cannot adjust the bias if the bias is related with other characteristics that we do not have information on.
57. The coefficient for children with multiple disabilities become insignificant when more control variables included. The sample size is quite limited due to the very low school attendance in this group of children, which may lead to high standard error.

Figures

Fig 1 Estimated proportion of 14-year-old children with satisfactory reading skills across social groups by country, with 95% Confidence Interval

Note: The predictions are calculated at the means of covariates, with separate predictions for each country.

“Poor” refers to children from families in the lowest quintile of the asset index, while “Non-poor” includes all children not in this quintile.

“No school” refers to children from families without any schooling, while “Other” includes all children from families with some level of formal education.

CA: Cenral Africa Republic; CH: Chad; DRC:DRCongo; GH: Ghana; LE: Lesotho; MD: Madagascar; ML: Malawi; TGA: The Gambia; TO: Togo; TN: Tunisia; ZI: Zimbabwe

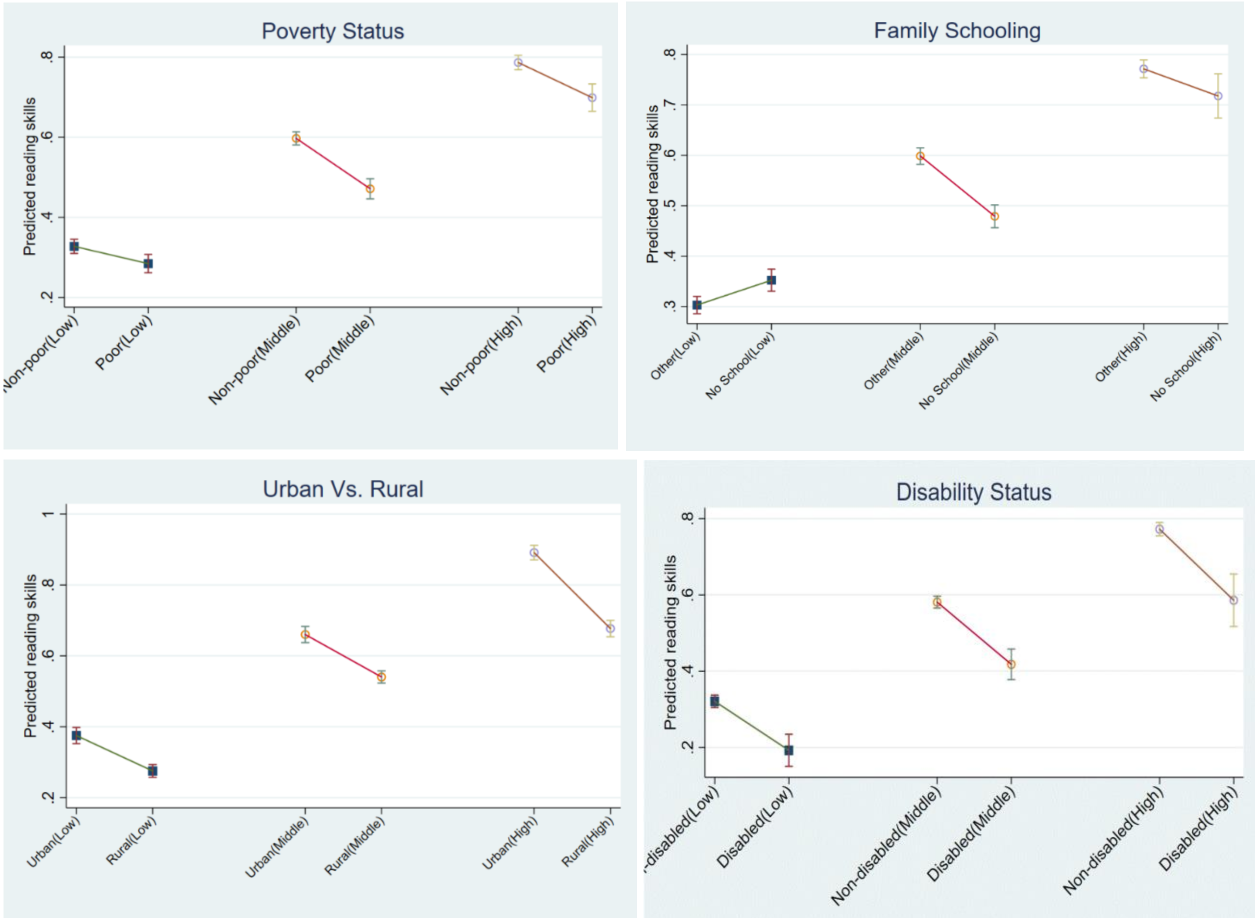

Fig 2 Estimated proportion of 14-year-old children with satisfactory reading skills by country groups, with 95% Confidence Interval
Note: The predictions are calculated at the means of covariates, with separate predictions for each country group with low, middle or high proficiency.
"Poor" refers to children from families in the lowest quintile of the asset index, while "Non-poor" includes all children not in this quintile.
"No school" refers to children from families without any schooling, while "Other" includes all children from families with some level of formal education.
Low: Cenral Africa Republic, Chad, DRCongo, and The Gambia; Middle: Ghana, Madagascar, Malawi, and Togo; High: Lesotho, Tunisia, and Zimbabwe

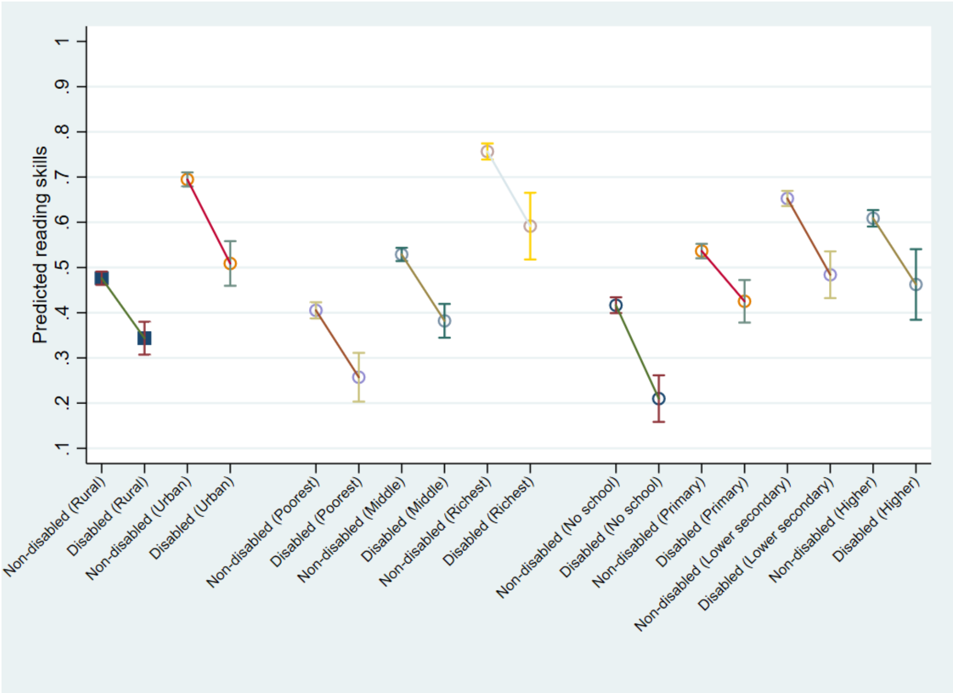

Fig 3 Estimated proportion of 14-year-old children with satisfactory reading skills for CWD and CWOD across various social groups (Country FE), with 95% confidence intervals.

Note: The predictions are calculated at the means of covariates across all countries, with separate predictions for various social groups related to rural and urban residences, family wealth index, and the highest educational level among household members.

Supporting information

S1 Table. Regression results from first stage of selection model for each country

Variable	Central Africa R.	Chad	DRCongo	Ghana	Lesotho	Madagascar	Malawi	The Gambia	Togo	Tunisia	Zimbabwe
Disabled	-0.292*	-0.07	-0.592***	-0.440***	-0.389*	-0.16	-0.309***	-0.714**	0.045	-0.305	0.078
Location (base category: urban)											
	-0.280**	-0.253**	-0.197**	-0.290***	-0.169	0.038	-0.130*	-0.212	-0.24	0.189	0.378
Wealth index (base category=Poorest)											
Second quintile	0.12	0.239*	0.033	0.014	0.251*	0.268**	0.156**	-0.184	0.09	-0.166	0.155
Middle	0.102	0.354**	0.253***	0.208	0.353**	0.367***	0.272***	-0.231	0.068	0.169	0.167
Fourth quintile	0.300*	0.323**	0.490***	0.304*	0.282*	0.455***	0.383***	-0.28	0.117	0.288	0.747**
Richest	0.343*	0.507***	0.811***	0.256	0.573***	0.334**	0.539***	0.096	0.14	0.233	0.664*
Highest Educational level in the household (base category=No school)											
Primary	-0.08	0.007	-0.055	-0.104	0.227*	0.105	0.155**	0.148	0.061	-0.109	0.244
Junior High	0.066	0.138	0.066	0.023	0.074	0.11	0.366***	0.159	-0.094	-0.128	0.28
Senior High+	0.047	0.085	0.066	0.185	-0.148	0.047	0.568***	-0.038	-0.001	-0.119	0.795
Age (Base category=10)											
11	-0.018	0.021	0.053	0.098	0.202	0.12	0.196***	0.172	0.137	-0.175	0.111
e12	-0.057	0.094	0.166*	0.273**	0.134	0.125	0.303***	0.254	-0.086	-0.045	0.085
age13	0.056	0.077	0.323***	0.349***	0.157	0.261**	0.430***	0.492**	0.034	-0.167	0.117
age14	0.116	0.203	0.495***	0.631***	0.176	0.336***	0.571***	0.512***	0.241	-0.223	0.222
Gender (Base category: Boys)	-0.167*	0.063	-0.091	-0.099	0.290***	0.058	0.258***	0.222*	-0.066	-0.019	0.371***
Constant	1.133***	0.790***	0.889***	1.704***	0.458	0.29	-0.131	1.068**	1.934***	1.681***	-0.08
Sample size	1458	1910	3468	3159	1823	2972	6332	1355	1663	1669	2144

S2 Table. Sensitivity test

Sensitivity test to the selection of different cutoff thresholds for the outcome variable of reading proficiency. Regression results for the first hypothesis with cutoff points at 80% and 90% are presented in S2.1 Table and S2.2 Table. Regression results for the second hypothesis with cutoff points at 80%, 85%, and 90% are presented in S2.3 Table. Regression results for the third hypothesis with cutoff points at 80%, 85%, and 90% are presented in S2.3 Table. No large sensitivity to the selection of different cutoff thresholds is detected.

S2.1 IPW least squares regressions by micro-level factors (outcome variable cutoff at 80%)

	Model1	Model2	Model3	Model4	Model5
Wealth index (base category=Poorest)					
Second quintile	0.057***				0.042***
	(0.010)				(0.010)
Middle	0.112***				0.080***
	(0.009)				(0.010)
Fourth quintile	0.208***				0.146***
	(0.010)				(0.011)
Richest	0.372***				0.265***
	(0.010)				(0.012)
Highest Educational level in the household (base category=No school)					
Primary		0.058***			0.031***
		(0.009)			(0.009)
Junior secondary		0.208***			0.094***
		(0.010)			(0.010)
Senior secondary or higher		0.211***			0.082***
		(0.011)			(0.011)
			-		-
Location (base category: urban)			0.225***		0.087***
			(0.008)		(0.009)
Disability status (base category: non-disabled)					
Vision disability				0.032	0.022
				(0.036)	(0.036)
Hearing disability				-0.137**	-0.096*
				(0.050)	(0.047)
Physical disability				0.028	0.064
				(0.035)	(0.035)
				-	-
Intellectual disability				0.165***	0.158***
				(0.016)	(0.016)
				-	
Multiple disabilities				0.167***	-0.119*
				(0.050)	(0.050)
Gender (Base category: Men)	0.037***	0.042***	0.040***	0.043***	0.035***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Age (Base category=10)					
age11	0.064***	0.067***	0.065***	0.073***	0.063***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
age12	0.117***	0.121***	0.116***	0.120***	0.115***

	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
age13	0.170***	0.176***	0.171***	0.175***	0.170***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
age14	0.216***	0.227***	0.222***	0.229***	0.215***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Country (Base category=Central Africa R.)					
Chad	0.039*	0.077***	0.082***	0.033	0.065***
	(0.016)	(0.018)	(0.018)	(0.018)	(0.017)
DRCongo	0.092***	-0.021	0.045**	0.002	0.064***
	(0.014)	(0.016)	(0.015)	(0.016)	(0.015)
Ghana	0.348***	0.292***	0.310***	0.300***	0.338***
	(0.015)	(0.017)	(0.016)	(0.019)	(0.015)
Lesotho	0.490***	0.439***	0.470***	0.409***	0.492***
	(0.017)	(0.017)	(0.018)	(0.018)	(0.017)
Madagascar	0.416***	0.400***	0.424***	0.373***	0.429***
	(0.016)	(0.017)	(0.017)	(0.018)	(0.016)
Malawi	0.378***	0.370***	0.426***	0.334***	0.407***
	(0.014)	(0.015)	(0.015)	(0.015)	(0.015)
The Gambia	0.239***	0.227***	0.173***	0.164***	0.238***
	(0.018)	(0.019)	(0.019)	(0.020)	(0.018)
Togo	0.276***	0.243***	0.259***	0.216***	0.284***
	(0.018)	(0.019)	(0.019)	(0.020)	(0.017)
Tunisia	0.772***	0.716***	0.686***	0.716***	0.736***
	(0.013)	(0.014)	(0.015)	(0.015)	(0.014)
Zimbabwe	0.440***	0.369***	0.440***	0.385***	0.431***
	(0.015)	(0.017)	(0.016)	(0.018)	(0.015)
Constant	-0.177***	-0.107***	0.123***	0.017	-0.116***
	(0.016)	(0.016)	(0.016)	(0.015)	(0.019)
Sample size	23591	23572	23591	23591	23572
R2	0.225	0.186	0.199	0.163	0.237

S2.2 IPW least squares regressions by micro-level factors (outcome variable cutoff at 90%)

	Model1	Model2	Model3	Model4	Model5
Wealth index (base category=Poorest)					
Second quintile	0.055***				0.042***
	(0.009)				(0.009)
Middle	0.101***				0.073***
	(0.009)				(0.009)
Fourth quintile	0.186***				0.131***
	(0.009)				(0.010)
Richest	0.337***				0.240***
	(0.010)				(0.012)
Highest Educational level in the household (base category=No school)					
Primary		0.046***			0.022**
		(0.008)			(0.008)
Junior secondary		0.185***			0.083***
		(0.009)			(0.009)
Senior secondary or higher		0.190***			0.075***
		(0.011)			(0.011)
Location (base category: urban)			-0.203***		-0.078***
			(0.008)		(0.009)

Disability status (base category: non-disabled)					
Vision disability				0.022	0.013
				(0.036)	(0.036)
Hearing disability				-0.127**	-0.090*
				(0.047)	(0.045)
Physical disability				0.038	0.071
				(0.036)	(0.036)
Intellectual disability				-0.148***	-0.141***
				(0.015)	(0.014)
Multiple disabilities				-0.142**	-0.099*
				(0.048)	(0.048)
Gender (Base category: Men)	0.034***	0.038***	0.037***	0.040***	0.032***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Age (Base category=10)					
age11	0.054***	0.057***	0.055***	0.063***	0.053***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
age12	0.093***	0.096***	0.092***	0.096***	0.091***
	(0.008)	(0.009)	(0.009)	(0.009)	(0.008)
age13	0.135***	0.139***	0.135***	0.140***	0.135***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
age14	0.173***	0.183***	0.178***	0.185***	0.172***
	(0.009)	(0.009)	(0.009)	(0.010)	(0.009)
Country (Base category=Central Africa R.)					
Chad	0.040**	0.074***	0.079***	0.035*	0.062***
	(0.015)	(0.016)	(0.016)	(0.016)	(0.015)
DRCongo	0.073***	-0.030*	0.031*	-0.008	0.046***
	(0.013)	(0.014)	(0.013)	(0.014)	(0.013)
Ghana	0.283***	0.232***	0.248***	0.239***	0.273***
	(0.014)	(0.016)	(0.015)	(0.017)	(0.014)
Lesotho	0.361***	0.316***	0.342***	0.288***	0.363***
	(0.017)	(0.018)	(0.018)	(0.019)	(0.017)
Madagascar	0.290***	0.277***	0.298***	0.252***	0.303***
	(0.015)	(0.016)	(0.016)	(0.017)	(0.015)
Malawi	0.258***	0.251***	0.301***	0.218***	0.284***
	(0.013)	(0.013)	(0.014)	(0.014)	(0.014)
The Gambia	0.196***	0.183***	0.137***	0.128***	0.193***
	(0.016)	(0.017)	(0.017)	(0.018)	(0.016)
Togo	0.204***	0.174***	0.189***	0.150***	0.211***
	(0.015)	(0.016)	(0.016)	(0.017)	(0.015)
Tunisia	0.680***	0.630***	0.602***	0.629***	0.647***
	(0.014)	(0.015)	(0.015)	(0.015)	(0.015)
Zimbabwe	0.428***	0.365***	0.428***	0.379***	0.420***
	(0.015)	(0.017)	(0.016)	(0.017)	(0.015)
Constant	-0.178***	-0.111***	0.092***	-0.003	-0.121***
	(0.015)	(0.015)	(0.015)	(0.014)	(0.019)
Sample size	23591	23572	23591	23591	23572
R2	0.182	0.148	0.16	0.128	0.193

S2.3 IPW least squares regressions by micro-level factors (continuous outcome variable)

	Model1	Model2	Model3	Model4	Model5
Wealth index (base category=Poorest)					
Second quintile	0.064***				0.051***
	(0.008)				(0.008)
Middle	0.117***				0.089***
	(0.008)				(0.008)
Fourth quintile	0.197***				0.143***
	(0.008)				(0.009)
Richest	0.330***				0.237***
	(0.008)				(0.010)
Highest Educational level in the household (base category=No school)					
Primary		0.054***			0.029***
		(0.008)			(0.007)
Junior secondary		0.185***			0.086***
		(0.008)			(0.008)
Senior secondary or higher		0.195***			0.083***
		(0.009)			(0.009)
Location (base category: urban)			-0.193***		-0.071***
			0.006		0.007
Disability status (base category: non-disabled)					
Vision disability				0.025	0.017
				(0.026)	(0.025)
Hearing disability				0.026	0.025
				(0.047)	(0.045)
Physical disability				0.000	0.031
				(0.028)	(0.028)
Intellectual disability				-0.170***	-0.164***
				(0.014)	(0.013)
Multiple disabilities				-0.164***	-0.123**
				(0.044)	(0.043)
Gender (Base category: Men)	0.037***	0.042***	0.040***	0.043***	0.036***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Age (Base category=10)					
age11	0.070***	0.073***	0.070***	0.078***	0.069***
	(0.007)	(0.008)	(0.008)	(0.008)	(0.007)
age12	0.120***	0.124***	0.120***	0.123***	0.119***
	(0.007)	(0.007)	(0.007)	(0.008)	(0.007)
age13	0.173***	0.178***	0.173***	0.177***	0.173***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
age14	0.218***	0.227***	0.223***	0.229***	0.217***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Country (Base category=Central Africa R.)					
Chad	0.062***	0.096***	0.098***	0.055**	0.083***
	(0.016)	(0.018)	(0.017)	(0.018)	(0.016)
DRCongo	0.109***	0.009	0.068***	0.03	0.080***
	(0.014)	(0.016)	(0.015)	(0.017)	(0.014)
Ghana	0.374***	0.325***	0.339***	0.331***	0.365***
	(0.014)	(0.016)	(0.015)	(0.018)	(0.013)
Lesotho	0.503***	0.458***	0.484***	0.430***	0.503***
	(0.015)	(0.016)	(0.016)	(0.017)	(0.015)
Madagascar	0.463***	0.450***	0.470***	0.426***	0.474***

	(0.014)	(0.015)	(0.015)	(0.016)	(0.013)
Malawi	0.409***	0.402***	0.449***	0.370***	0.431***
	(0.013)	(0.014)	(0.014)	(0.015)	(0.013)
The Gambia	0.278***	0.267***	0.219***	0.209***	0.277***
	(0.016)	(0.018)	(0.017)	(0.019)	(0.016)
Togo	0.276***	0.248***	0.260***	0.223***	0.283***
	(0.017)	(0.018)	(0.018)	(0.019)	(0.016)
Tunisia	0.687***	0.637***	0.612***	0.636***	0.654***
	(0.012)	(0.013)	(0.014)	(0.014)	(0.013)
Zimbabwe	0.491***	0.429***	0.490***	0.442***	0.481***
	(0.013)	(0.015)	(0.014)	(0.016)	(0.013)
Constant	-0.062***	0.005	0.208***	0.121***	-0.014
	(0.014)	(0.015)	(0.015)	(0.015)	(0.017)
Sample size	23591	23572	23591	23591	23572
R2	0.299	0.256	0.268	0.229	0.316

S2.4 IPW least squares regressions, interaction terms between various factors and country groups (outcome variable cutoff at 85%, 80%, and 90%)

	Family Schooling			Poverty Status			Urban Vs. Rural			Disability Status		
Cut point	0.85	0.8	0.9	0.85	0.8	0.9	0.85	0.8	0.9	0.85	0.8	0.9
Highest educational level in the household (base category=No school)												
Primary				0.034***	0.036***	0.018*	0.028***	0.029***	0.013	0.026**	0.028**	0.01
				(0.008)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Junior secondary				0.100***	0.095***	0.091***	0.069***	0.062***	0.062***	0.067***	0.060***	0.060***
				(0.010)	(0.010)	(0.009)	(0.010)	(0.010)	(0.009)	(0.010)	(0.010)	(0.009)
Senior secondary or higher				0.116***	0.118***	0.103***	0.080***	0.081***	0.069***	0.081***	0.082***	0.071***
				(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
No School	0.054***	0.056***	0.049***									
	(0.011)	(0.011)	(0.010)									
No School#Mid-reading country	-0.163***	-0.169***	-0.125***									
	(0.015)	(0.016)	(0.014)									
No School#High-reading country	-0.102***	-0.088***	-0.129***									
	(0.024)	(0.024)	(0.024)									
Wealth index (base category=Poorest)												
Second quintile	0.043***	0.042***	0.042***				0.040***	0.039***	0.037***	0.043***	0.042***	0.041***
	(0.010)	(0.010)	(0.009)				(0.010)	(0.010)	(0.009)	(0.010)	(0.010)	(0.009)
Middle	0.074***	0.079***	0.072***				0.070***	0.075***	0.065***	0.074***	0.079***	0.071***
	(0.010)	(0.010)	(0.009)				(0.010)	(0.010)	(0.009)	(0.010)	(0.010)	(0.009)
Fourth quintile	0.142***	0.144***	0.128***				0.137***	0.139***	0.120***	0.140***	0.143***	0.124***
	(0.011)	(0.011)	(0.010)				(0.011)	(0.011)	(0.010)	(0.011)	(0.011)	(0.010)
Richest	0.253***	0.261***	0.238***				0.245***	0.254***	0.225***	0.247***	0.256***	0.227***
	(0.012)	(0.012)	(0.012)				(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)

Poor				-0.043***	-0.046***	-0.037***						
				(0.012)	(0.012)	(0.010)						
Poor#Mid-reading country				-0.083***	-0.087***	-0.064***						
				(0.016)	(0.017)	(0.015)						
Poor#High-reading country				-0.045*	-0.037	-0.084***						
				(0.022)	(0.022)	(0.021)						
Location (base category: urban)	-0.124***	-0.120***	-0.114***	-0.185***	-0.185***	-0.168***	-0.075***	-0.081***	-0.045***	-0.115***	-0.112***	-0.106***
	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.013)	(0.013)	(0.012)	(0.009)	(0.009)	(0.009)
Rural#Mid-reading country							-0.029	-0.014	-0.047**			
							(0.017)	(0.017)	(0.016)			
Rural#High-reading country							-0.117***	-0.104***	-0.164***			
							(0.018)	(0.018)	(0.018)			
Disabled (base category: non-disabled)	-0.156***	-0.164***	-0.140***	-0.169***	-0.178***	-0.153***	-0.158***	-0.167***	-0.143***	-0.131***	-0.142***	-0.111***
	(0.015)	(0.015)	(0.014)	(0.015)	(0.015)	(0.014)	(0.015)	(0.015)	(0.014)	(0.021)	(0.021)	(0.019)
Disabled#Mid-reading country										-0.03	-0.029	-0.026
										(0.027)	(0.028)	(0.025)
Disabled#High-reading country										-0.053	-0.041	-0.092*
										(0.042)	(0.041)	(0.039)
Age (Base category=10)												
age11	0.063***	0.063***	0.053***	0.064***	0.063***	0.054***	0.063***	0.062***	0.053***	0.062***	0.061***	0.052***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
age12	0.112***	0.117***	0.092***	0.111***	0.116***	0.092***	0.112***	0.117***	0.092***	0.111***	0.117***	0.092***
	(0.009)	(0.009)	(0.008)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.008)	(0.009)	(0.009)	(0.008)
age13	0.163***	0.172***	0.135***	0.163***	0.173***	0.135***	0.162***	0.171***	0.134***	0.162***	0.171***	0.134***
	(0.009)	(0.009)	(0.008)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
age14	0.207***	0.218***	0.174***	0.210***	0.221***	0.177***	0.207***	0.218***	0.174***	0.206***	0.217***	0.173***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)

Gender (Base category: Men)	0.038***	0.038***	0.034***	0.040***	0.040***	0.035***	0.038***	0.038***	0.034***	0.038***	0.038***	0.034***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Country												
	0.314***	0.337***	0.238***	0.307***	0.330***	0.237***	0.293***	0.305***	0.238***	0.279***	0.301***	0.214***
	(0.008)	(0.009)	(0.008)	(0.009)	(0.009)	(0.008)	(0.014)	(0.014)	(0.013)	0.008	0.008	0.007
	0.478***	0.483***	0.430***	0.457***	0.460***	0.418***	0.522***	0.520***	0.502***	0.456***	0.461***	0.410***
	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)	(0.010)	(0.013)	(0.013)	(0.014)	0.009	0.009	0.009
Constant	0.009	0.017	-0.004	0.113***	0.126***	0.094***	-0.040*	-0.026	-0.058***	-0.019	-0.01	-0.025
	(0.016)	(0.016)	(0.016)	(0.014)	(0.015)	(0.014)	(0.017)	(0.017)	(0.016)	0.016	0.016	0.016
Sample size	23572	23572	23572	23572	23572	23572	23572	23572	23572	23572	23572	23572
R2	0.208	0.215	0.175	0.192	0.198	0.163	0.207	0.214	0.178	0.206	0.212	0.175

S2.5 IPW least squares regressions, interaction terms between various factors and country groups (continuous outcome variable)

	Family Schooling	Poverty Status	Urban Vs. Rural	Disability Status
Highest educational level in the household (base category=No school)				
Primary		0.032***	0.025***	0.026***
		(0.007)	(0.007)	(0.007)
Junior secondary		0.087***	0.059***	0.058***
		(0.008)	(0.008)	(0.008)
Senior secondary or higher		0.106***	0.076***	0.075***
		(0.008)	(0.008)	(0.008)
No School	0.056***			
	(0.010)			
No School#Mid-reading country	-0.163***			
	(0.013)			
No School#High-reading country	-0.093***			
	(0.018)			
Wealth index (base category=Poorest)				
Second quintile	0.051***		0.050***	0.050***
	(0.008)		(0.008)	(0.008)
Middle	0.089***		0.088***	0.089***
	(0.008)		(0.008)	(0.008)
Fourth quintile	0.144***		0.142***	0.144***
	(0.008)		(0.009)	(0.009)
Richest	0.241***		0.234***	0.236***
	(0.009)		(0.009)	(0.009)
Poor		-0.062***		
		(0.012)		
Poor#Mid-reading country		-0.076***		
		(0.015)		
Poor#High-reading country		-0.007		
		(0.019)		
Location (base category: urban)	-0.091***	-0.147***	-0.110***	-0.083***
	(0.006)	(0.006)	(0.012)	(0.007)
Rural#Mid-reading country			0.046***	
			(0.014)	
Rural#High-reading country			0.020	
			(0.015)	
Disabled (base category: non-disabled)	-0.170***	-0.182***	-0.173***	-0.175***
	(0.013)	(0.013)	(0.013)	(0.023)
Disabled#Mid-reading country				0.004
				(0.028)
Disabled#High-reading country				-0.004
				(0.035)
Age (Base category=10)				
age11	0.069***	0.069***	0.067***	0.067***
	(0.007)	(0.008)	(0.007)	(0.007)
age12	0.120***	0.119***	0.120***	0.120***
	(0.007)	(0.007)	(0.007)	(0.007)
age13	0.174***	0.175***	0.173***	0.173***
	(0.007)	(0.007)	(0.007)	(0.007)
age14	0.219***	0.221***	0.218***	0.218***
	(0.007)	(0.007)	(0.007)	(0.007)

Gender (Base category: Men)	0.039***	0.041***	0.039***	0.039***
	(0.005)	(0.005)	(0.005)	(0.005)
Country				
	0.341***	0.331***	0.275***	0.304***
	(0.008)	(0.008)	(0.011)	(0.007)
	0.462***	0.434***	0.427***	0.439***
	(0.008)	(0.008)	(0.011)	(0.008)
Constant	0.125***	0.238***	0.118***	0.102***
	(0.013)	(0.012)	(0.014)	(0.013)
Sample size	23572	23572	23572	23572
R2	0.29	0.27	0.286	0.286

S2.6 IPW least squares regressions, interaction terms between disability status and social factors (outcome variable cutoff at 85%, 80%, and 90%)

Cut point	0.85	0.8	0.9
Disabled (base category: non-disabled)	-0.249***	-0.268***	-0.249***
	(0.045)	(0.047)	(0.040)
Location (base category: urban)	-0.117***	-0.114***	-0.103***
	(0.009)	(0.009)	(0.009)
Disabled # Location			
Disabled # Rural	0.055	0.054	0.092**
	(0.035)	(0.035)	(0.032)
Wealth index (base category=Poorest)			
Middle	0.081***	0.081***	0.076***
	(0.008)	(0.009)	(0.008)
Richest	0.232***	0.238***	0.218***
	(0.012)	(0.012)	(0.012)
Disabled # Wealth Index			
Disabled#Middle	0.000	0.02	-0.003
	(0.034)	(0.035)	(0.031)
Disabled#Richest	0.01	0.039	0.013
	(0.057)	(0.056)	(0.053)
Primary	0.034***	0.032***	0.024**
	(0.009)	(0.009)	(0.008)
Junior secondary	0.109***	0.105***	0.092***
	(0.010)	(0.010)	(0.010)
Senior secondary or higher	0.096***	0.095***	0.084***
	(0.011)	(0.011)	(0.011)
Disabled # Highest Education level in the household			
Disabled#1	0.094**	0.086*	0.058
	(0.036)	(0.037)	(0.031)
Disabled#2	0.049	0.056	0.041
	(0.039)	(0.041)	(0.034)
Disabled#3	0.073	0.048	0.098*
	(0.050)	(0.051)	(0.046)
Age (Base category=10)			
age11	0.064***	0.063***	0.054***
	(0.009)	(0.009)	(0.009)
age12	0.111***	0.116***	0.092***
	(0.009)	(0.009)	(0.008)
age13	0.162***	0.172***	0.136***
	(0.009)	(0.009)	(0.008)
age14	0.206***	0.217***	0.174***

	(0.009)	(0.009)	(0.009)
Gender (Base category: Boys)	0.036***	0.036***	0.032***
	(0.006)	(0.006)	(0.006)
Country			
Chad	0.065***	0.070***	0.068***
	(0.017)	(0.017)	(0.015)
DRCongo	0.043**	0.053***	0.037**
	(0.014)	(0.014)	(0.013)
Ghana	0.315***	0.332***	0.268***
	(0.015)	(0.015)	(0.014)
Lesotho	0.466***	0.487***	0.360***
	(0.017)	(0.017)	(0.017)
Madagascar	0.388***	0.431***	0.304***
	(0.016)	(0.016)	(0.015)
Malawi	0.379***	0.413***	0.289***
	(0.014)	(0.015)	(0.014)
The Gambia	0.221***	0.231***	0.187***
	(0.018)	(0.018)	(0.016)
Togo	0.270***	0.280***	0.208***
	(0.017)	(0.017)	(0.015)
Tunisia	0.698***	0.723***	0.636***
	(0.014)	(0.014)	(0.015)
Zimbabwe	0.427***	0.424***	0.414***
	(0.015)	(0.015)	(0.015)
_cons	-0.097***	-0.093***	-0.100***
	(0.019)	(0.019)	(0.018)
Sample size	23572	23572	23572
R2	0.222	0.233	0.19

S2.7 IPW least squares regressions, interaction terms between disability status and social factors (continuous outcome variable)

	Cut point 0.85	Continuous
Disabled (base category: non-disabled)	-0.249***	-0.263***
	(0.045)	0.043
Location (base category: urban)	-0.117***	-0.093***
	(0.009)	0.007
Disabled # Location		
Disabled # Rural	0.055	0.008
	(0.035)	0.029
Wealth index (base category=Poorest)		
Middle	0.081***	0.085***
	(0.008)	0.007
Richest	0.232***	0.213***
	(0.012)	0.009
Disabled # Wealth Index		
Disabled#Middle	0.000	0.065*
	(0.034)	0.032
Disabled#Richest	0.01	0.048
	(0.057)	0.047
Highest educational level in the household (base category=No school)		
Primary	0.034***	0.031***
	(0.009)	0.008
Junior secondary	0.109***	0.096***
	(0.010)	0.008
Senior secondary or higher	0.096***	0.093***

	(0.011)	0.009
Disabled # Highest Education level in the household		
Disabled#1	0.094**	0.070*
	(0.036)	0.034
Disabled#2	0.049	0.037
	(0.039)	0.036
Disabled#3	0.073	0.062
	(0.050)	0.045
Age (Base category=10)		
age11	0.064***	0.070***
	(0.009)	0.007
age12	0.111***	0.120***
	(0.009)	0.007
age13	0.162***	0.175***
	(0.009)	0.007
age14	0.206***	0.219***
	(0.009)	0.007
Gender (Base category: Men)	0.036***	0.036***
	(0.006)	0.005
Country		
Chad	0.065***	0.088***
	(0.017)	0.016
DRCongo	0.043**	0.071***
	(0.014)	0.014
Ghana	0.315***	0.360***
	(0.015)	0.013
Lesotho	0.466***	0.499***
	(0.017)	0.015
Madagascar	0.388***	0.475***
	(0.016)	0.014
Malawi	0.379***	0.436***
	(0.014)	0.013
The Gambia	0.221***	0.271***
	(0.018)	0.016
Togo	0.270***	0.280***
	(0.017)	0.016
Tunisia	0.698***	0.643***
	(0.014)	0.013
Zimbabwe	0.427***	0.475***
	(0.015)	0.013
Constant	-0.097***	0.007
	(0.019)	0.016
Sample size	23572	23572
R2	0.222	0.311

IV Disability, Gender, and Sibling Impacts on Learning Outcomes in Ghana and Niger

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Disability, Gender, and Sibling Impacts on Learning Outcomes in Ghana and Niger

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Abstract

This study explores sibling influences on children's education in Ghana and Niger, focusing on disability and gender disparities. Data were collected in spring 2023 from 387 pupils in 27 primary schools in Ghana's Ashanti region and 573 pupils in 18 schools in Niger's Niamey. About 40% were identified as having disabilities using the Washington Group Child Functional Module. The analysis reveals a performance gap between children with and without disabilities. In Niger, girls outperform boys, while no significant gender differences are seen in Ghana. Sibling effects are insignificant in resource-poor Niger but substantial in Ghana, where older sisters benefit children with disabilities, and younger siblings negatively affect girls with disabilities. These findings highlight that gender biases affect sibling effects.

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 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 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 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 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 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 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 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[10], 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[11].

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

[10] 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.
[11]. 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.

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[12].

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[13].

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

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[12] 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.

[13] 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. 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.

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 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			0.02	5,687		
	(CWOD vs. CC)			0.15** (0.02,0.28)	0.032			-0.02 (-0.13,0.09)	0.605
	CWD	-0.16	145			-0.46	227		
	(CC vs. CWD)			0.16** (0.01,0.32)	0.046			0.49** (0.35,0.62)	0.000
Natural Science	CWOD	0.17	230			0.08	221		
	CC	0.00	2,803			0.01	3,139		
	(CWOD vs. CC)			0.18** (0.04,0.31)	0.014			0.08 (-0.06,0.21)	0.419
	CWD	-0.21	144			-0.26	137		
	(CC vs. CWD)			0.21** (0.04,0.38)	0.079			0.27** (0.10,0.44)	0.009
English (French reading[1])	CWOD	0.15	230			0.13	346		
	CC	0.00	2,844			0.01	5,688		
	(CWOD vs. CC)			0.15** (0.02,0.28)	0.017			0.12 (0.02,0.23)	0.034
	CWD	-0.21	143			-0.32	227		
	(CC vs. CWD)			0.21** (0.38,0.42)	0.012			0.33** (0.20,0.46)	0.000
Local Language (French writing[1])	CWOD	0.12	229			0.18	342		
	CC	0.00	2,920			0.00	5,317		
	(CWOD vs. CC)			0.12 (-0.01,0.25)	0.045			0.18 (0.07,0.29)	0.008
	CWD	-0.15	145			-0.26	218		
	(CC vs. CWD)			0.15 (-0.15,0.32)	0.114			0.26** (0.13,0.40)	0.000
Pooled school subjects	CWOD	0.15	919			0.10	1,255		
	CC	0.00	11,413			0.01	19,831		
	(CWOD vs. CC)			0.15 (0.08,0.22)	0.000			0.09 (0.03,0.15)	0.035
	CWD	-0.18	577			-0.33	809		
	(CC vs. CWD)			0.18** (0.10,0.27)	0.000			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			-0.03	222		
		(CWOS vs. CWS)			-0.06 (-0.32,0.20)	0.777			0.07 (-0.15,0.29)	0.365
	CWD	CWOS	-0.13	67			-0.45	77		
		CWS	-0.19	78			-0.47	150		
		(CWOS vs. CWS)			0.07 (-0.26,0.40)	0.358			0.01 (-0.26,0.29)	0.726
Natural Science	CWOD	CWOS	0.10	108			0.13	80		
		CWS	0.24	122			0.05	141		
		(CWOS vs. CWS)			-0.15 (-0.41,0.11)	0.586			0.07 (-0.20,0.29)	0.96
	CWD	CWOS	-0.07	67			-0.24	39		
		CWS	-0.34	77			-0.26	98		
		(CWOS vs. CWS)			0.26 (-0.07,0.59)	0.026			0.02 (-0.35,0.29)	0.884
English (French Reading[1])	CWOD	CWOS	0.10	108			0.24	124		
		CWS	0.18	122			0.06	222		
		(CWOS vs. CWS)			-0.08 (-0.34,0.18)	0.229			0.17 (-0.05,0.29)	0.17
	CWD	CWOS	-0.11	66			-0.37	77		
		CWS	-0.29	77			-0.29	150		
		(CWOS vs. CWS)			0.18 (-0.15,0.51)	0.354			-0.07 (-0.35,0.29)	0.816
Local language (French Writing[1])	CWOD	CWOS	0.09	107			0.20	123		
		CWS	0.15	122			0.17	219		
		(CWOS vs. CWS)			-0.06 (-0.32,0.20)	0.616			0.03 (-0.19,0.29)	0.209
	CWD	CWOS	-0.05	67			-0.24	73		
		CWS	-0.24	78			-0.27	145		
		(CWOS vs. CWS)			0.22 (-0.11,0.55)	0.336			0.03 (-0.25,0.29)	0.908
Pooled school subject	CWOD	CWOS	0.10	431			0.15	451		
		CWS	0.18	488			0.06	804		
		(CWOS vs. CWS)			-0.09 (-0.22,0.04)	0.148			0.09 (-0.03,0.29)	0.131
	CWD	CWOS	-0.09	267			-0.34	266		
		CWS	-0.27	310			-0.33	543		
		(CWOS vs. CWS)			0.18 (0.02,0.35)	0.003			-0.01 (-0.16,0.29)	0.958

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 favouring 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[14].

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.

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 explores the gender-related sibling effect within the context of socioeconomic development.

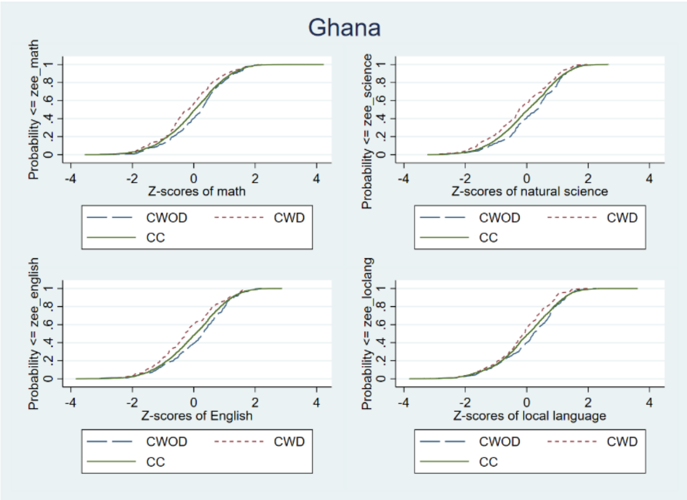
While evidence from developed contexts suggests that sibling status impacts children's development and education, this study ascertains that the overall sibling effects are comparatively meagre in impoverished African settings. However, a limitation of this study lies in its exclusive focus on academic outcomes as gauged by school records. Although no sibling effects on school learning performance were detected, there remains the potential for such effects on other educational aspects of children with disabilities, such as school attendance, involvement in school activities, socialization and children's well-being, which were beyond the scope of the educational outcome measurement in this study. Furthermore, as socioeconomic conditions enhance and educational opportunities are increasingly prized by parents, as exemplified in Ghana, the sibling effect tends to converge with findings from developed contexts.

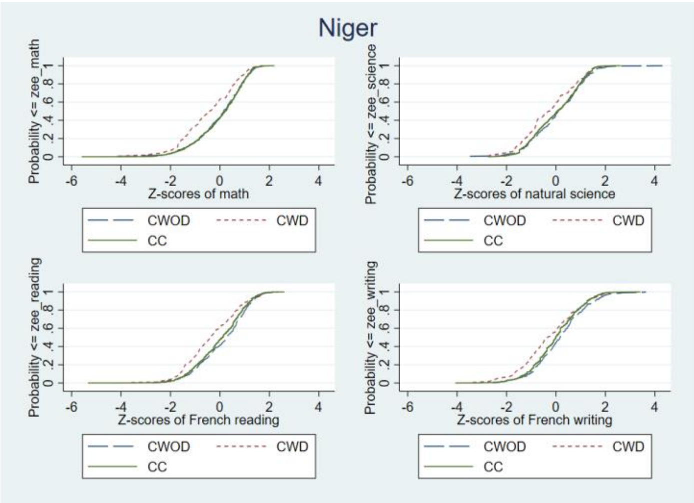
The study sheds light on the developmental risks faced by vulnerable groups, particularly from a gender perspective. While elder sisters exert a positive influence on the educational outcomes of their siblings with disabilities, girls with disabilities encounter unique challenges when younger siblings are present, even within matrilineal cultural systems such as those in Ghana. These findings underscore the importance of further research into the interplay between socioeconomic development, gender dynamics, and cultural norms in shaping the educational outcomes of children with disabilities. They also

[14] 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.

reinforce the need for targeted policies to promote girls’ education, particularly in regions undergoing socioeconomic advancement.

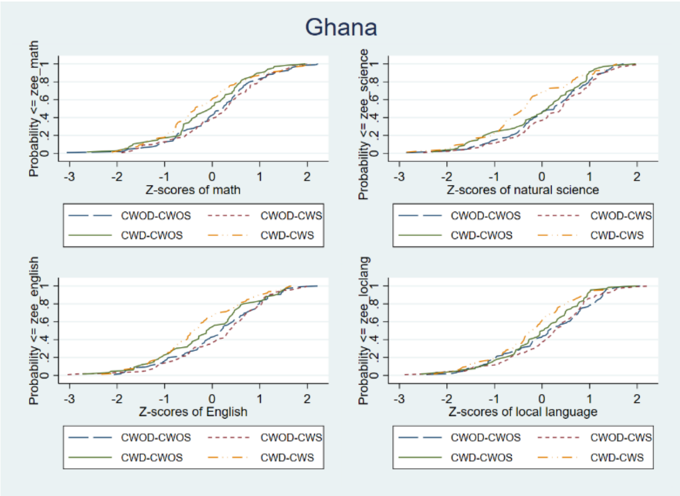
7. Appendices

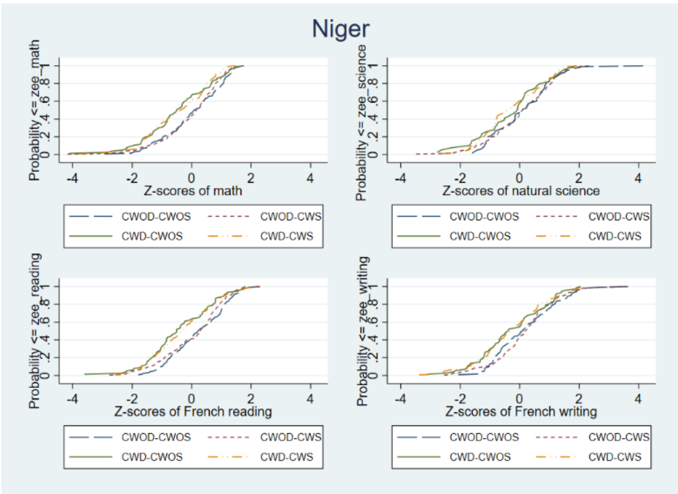




Appendix I. Cumulative distribution functions for normalized Z-scores of relative within-class school performance by disability status and sample type in Ghana and Niger

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

8. References

Anderson, E. (2015). The white space. Sociology of race and ethnicity, 1(1), 10-21.

Angrist, J. D., & Imbens, G. W. (1995). Two-stage least squares estimation of average causal effects in models with variable treatment intensity. Journal of the American statistical Association, 90(430), 431-442.

Asravor, R. K. (2021). Estimating the economic return to education in Ghana: a gender-based perspective. International Journal of Social Economics, 48(6), 843-861.

Ayalew, T. (2005). Parental preference, heterogeneity, and human capital inequality. Economic Development and Cultural Change, 53(2), 381-407.

Bank, S., & Kahn, M. D. (1975). Sisterhood-brotherhood is powerful: Sibling sub-systems and family therapy. Family process, 14(3), 311-337.

Berry, J., Dizon-Ross, R., & Jagnani, M. (2020). Not playing favorites: An experiment on parental fairness preferences. Retrieved from

Black, S. E., Breining, S., Figlio, D. N., Guryan, J., Karbownik, K., Nielsen, H. S., . . . Simonsen, M. (2021). Sibling spillovers. The Economic Journal, 131(633), 101-128.

Breinholt, A., & Conley, D. (2023). Child-driven parenting: Differential early childhood investment by offspring genotype. Social Forces, 102(1), 310-329.

Breining, S. N. (2014). The presence of ADHD: Spillovers between siblings. Economics Letters, 124(3), 469-473.

Brim, O. G. (1958). Family structure and sex role learning by children: A further analysis of Helen Koch's data. Sociometry, 21(1), 1-16.

Brody, G. H. (2004). Siblings' direct and indirect contributions to child development. Current directions in psychological science, 13(3), 124-126.

Brody, G. H., Stoneman, Z., & McCoy, J. K. (1992). Associations of maternal and paternal direct and differential behavior with sibling relationships: Contemporaneous and longitudinal analyses. Child Development, 63(1), 82-92.

Brody, G. H., Stoneman, Z., & McCoy, J. K. (2017). Contributions of family relationships and child temperaments to longitudinal variations in sibling relationship quality and sibling relationship styles. In Interpersonal Development (pp. 449-461): Routledge.

Card, D. (1999). The Causal Effect of Education on Earnings. In Handbook of Labor Economics (pp. 1801-1863): Elsevier.

Chi, Z., Malmberg, L. E., & Flouri, E. (2024). Sibling effects on problem and prosocial behavior in childhood: Patterns of intrafamilial “contagion” by birth order. Child Development, 95(3), 766-779.

Collins, M. (2022). Sibling Gender, Inheritance Customs and Educational Attainment: Evidence from Matrilineal and Patrilineal Societies. Retrieved from

Conley, D., & Lareau, A. (2008). Bringing sibling differences in: Enlarging our understanding of the transmission of advantage in families. Social class: How does it work, 179-200.

Dustan, A. (2018). Family networks and school choice. Journal of Development Economics, 134, 372-391.

Epple, D., & Romano, R. E. (2011). Peer effects in education: A survey of the theory and evidence. In Handbook of social economics (Vol. 1, pp. 1053-1163): Elsevier.

Feinberg, M., & Hetherington, E. M. (2001). Differential parenting as a within-family variable. Journal of Family Psychology, 15(1), 22.

Ferreira, J. (2023). Sibling Spillovers in Educational Achievement: Evidence from Tanzania. NOVA School of Business and Economics,

Fletcher, J., Hair, N. L., & Wolfe, B. L. (2012). Am I My brother's keeper? Sibling spillover effects: The case of developmental disabilities and externalizing behavior. Retrieved from

Glick, P., & Sahn, D. E. (2000). Schooling of girls and boys in a West African country: the effects of parental education, income, and household structure. Economics of Education Review, 19(1), 63-87.

Grätz, M., & Torche, F. (2016). Compensation or reinforcement? The stratification of parental responses to children’s early ability. Demography, 53(6), 1883-1904.

Hazan, M., & Zoabi, H. (2015). Sons or daughters? Sex preferences and the reversal of the gender educational gap. Journal of Demographic Economics, 81(2), 179-201.

Hedges, S., Mulder, M. B., James, S., & Lawson, D. W. (2016). Sending children to school: rural livelihoods and parental investment in education in northern Tanzania. Evolution and human behavior, 37(2), 142-151.

Joensen, J. S., & Nielsen, H. S. (2018). Spillovers in education choice. Journal of Public Economics, 157, 158-183.

Karbownik, K., & Özek, U. (2023). Setting a Good Example?: Examining Sibling Spillovers in Educational Achievement Using a Regression Discontinuity Design. Journal of Human Resources, 58(5), 1567-1607.
Kaul, T. (2018). Intra-household allocation of educational expenses: Gender discrimination and investing in the future. World Development, 104, 336-343.
Kravdal, Ø., Kodzi, I., & Sigle-Rushton, W. (2013). Effects of the number and age of Siblings on Educational Transitions in Sub-Saharan Africa. Studies in family planning, 44(3), 275-297.
La Ferrara, E., & Milazzo, A. (2017). Customary norms, inheritance, and human capital: evidence from a reform of the matrilineal system in Ghana. American Economic Journal: Applied Economics, 9(4), 166-185.
Landersø, R. K., Nielsen, H. S., & Simonsen, M. (2020). Effects of school starting age on the family. Journal of Human Resources, 55(4), 1258-1286.
Lareau, A. (2018). Unequal childhoods: Class, race, and family life. In Inequality in the 21st Century (pp. 444-451): Routledge.
Lee, J. (2008). Sibling size and investment in children's education: An Asian instrument. Journal of Population Economics, 21, 855-875.
Lindskog, A. (2013). The effect of siblings' education on school-entry in the Ethiopian highlands. Economics of Education Review, 34, 45-68.
Loury, L. D. (2004). Siblings and gender differences in African-American college attendance. Economics of Education Review, 23(3), 213-219.
Lowes, S. (2022). Kinship Structure and the Family: Evidence from the Matrilineal Belt. Retrieved from
Madans, J. H., Mont, D., & Loeb, M. (2015). Comments on Sabariego et al. Measuring Disability: Comparing the Impact of Two Data Collection Approaches on Disability Rates. Int. J. Environ. Res. Public Health, 2015, 12, 10329–10351.
Mattison, S. M., Mattison, P. M., Beheim, B. A., Liu, R., Blumenfield, T., Sum, C.-Y., . . . Alami, S. (2023). Gender disparities in material and educational resources differ by kinship system. Philosophical Transactions of the Royal Society B, 378(1883), 20220299.
McHale, S. M., Updegraff, K. A., & Whiteman, S. D. (2012). Sibling relationships and influences in childhood and adolescence. Journal of marriage and family, 74(5), 913-930.
McHale, S. M., Whiteman, S. D., Kim, J.-Y., & Crouter, A. C. (2007). Characteristics and correlates of sibling relationships in two-parent African American families. Journal of Family Psychology, 21(2), 227.
Nicoletti, C., & Rabe, B. (2019). Sibling spillover effects in school achievement. Journal of applied econometrics, 34(4), 482-501.
Oettinger, G. S. (2000). Sibling similarity in high school graduation outcomes: Causal interdependency or unobserved heterogeneity? Southern Economic Journal, 66(3), 631-648.
Parish, W. L., & Willis, R. J. (1993). Daughters, education, and family budgets Taiwan experiences. Journal of Human Resources, 863-898.
Parman, J. (2015). Childhood health and sibling outcomes: Nurture Reinforcing nature during the 1918 influenza pandemic. Explorations in Economic History, 58, 22-43.
Pasqua, S. (2005). Gender bias in parental investments in children's education: A theoretical analysis. Review of Economics of the Household, 3, 291-314.
Quisumbing, A. R., & Otsuka, K. (2001). Land inheritance and schooling in matrilineal societies: evidence from Sumatra. World Development, 29(12), 2093-2110.
Qureshi, J. A. (2018a). Siblings, teachers, and spillovers on academic achievement. Journal of Human Resources, 53(1), 272-297.
Qureshi, J. A. (2018b). Additional returns to investing in girls' education: Impact on younger sibling human capital. The Economic Journal, 128(616), 3285-3319.
Rose, P., & Al-Samarrai, S. (2001). Household constraints on schooling by gender: Empirical evidence from Ethiopia. Comparative Education Review, 45(1), 36-63.
Sacerdote, B. (2011). Peer effects in education: How might they work, how big are they and how much do we know thus far? In Handbook of the Economics of Education (Vol. 3, pp. 249-277): Elsevier.
Sanders, R. (2017). Sibling relationships: Theory and issues for practice: Bloomsbury Publishing.
UNDP. (2022). Human development Report 2021-2022. Retrieved from https://hdr.undp.org/content/human-development-report-2021-22
Whiteman, S. D., McHale, S. M., & Soli, A. (2011). Theoretical perspectives on sibling relationships. Journal of family theory & review, 3(2), 124-139.
Widmer, E. D., & Weiss, C. C. (2000). Do older siblings make a difference? The effects of older sibling support and older sibling adjustment on the adjustment of socially disadvantaged adolescents. Journal of Research on Adolescence, 10(1), 1-27.

World Bank. (2024). Fertility rate, total (birth per woman), Niger, Ghana. Retrieved from https://data.worldbank.org/indicator/SP.DYN.TFRT.IN?locations=NE-GH

Xiong, F., Zang, L., Zhou, L., & Liu, F. (2020). The effect of number of siblings and birth order on educational attainment: Empirical Evidence from Chinese General Social Survey. International Journal of Educational Development, 78, 102270.

Yi, J., Heckman, J. J., Zhang, J., & Conti, G. (2015). Early health shocks, intra-household resource allocation and child outcomes. The Economic Journal, 125(588), F347-F371.

Zajonc, R. B. (1976). Family Configuration and Intelligence: Variations in scholastic aptitude scores parallel trends in family size and the spacing of children. Science, 192(4236), 227-236.

Zajonc, R. B., & Markus, G. B. (1975). Birth order and intellectual development. Psychological review, 82(1), 74.

Zang, E., Tan, P. L., & Cook, P. J. (2023). Sibling spillovers: Having an academically successful older sibling may be more important for children in disadvantaged families. American Journal of Sociology, 128(5), 1529-1571.

Huafeng Zhang

Huafeng Zhang was born in Shanghai, China in 1977. She holds a BSc. Degree in Economics from Fudan University, China (2000), a MSc. Degree in Environmental and Development Economics from University of Oslo, Norway (2005). This thesis consists of an introduction and four independent papers. The thesis aims at exploring the school enrolment and learning outcomes for children with disabilities in selected African countries.

Paper I highlights substantial gaps in school enrolment between children with and without disabilities across eight African nations. It categorizes disabilities into functional domains to reveal diverse barriers. Young children with physical disabilities face significant difficulties enrolling in early childhood. Children with intellectual disabilities encounter persistent enrolment challenges and are at a heightened risk of dropping out. Those with multiple disabilities experience the most significant barriers to educational participation, underscoring the compounded impact of multiple impairments.

Paper II investigates numeracy skills among children aged 7-14 in eight African countries. Numeracy skills are generally low, with variations across countries and disability types. Children with vision and hearing disabilities perform similarly to their peers without disabilities, while those with physical, intellectual, or multiple disabilities lag behind. Using Instrumental Variable (IV) methods, the study identifies two effects of disability on numeracy skills. Children with physical and intellectual disabilities have lower numeracy due to fewer completed school years. Those with multiple disabilities face both reduced attendance and lower numeracy skills acquisition per completed school year.

Paper III analyses reading proficiency among children aged 10-14 across eleven African nations, revealing widespread low reading skills. The study identifies significant disparities in reading skills across countries and social groups, including children with disabilities, rural children, and those from poorer families. Countries with higher overall reading proficiency often show larger gaps between disadvantaged and non-disadvantaged groups. However, gaps between children with disabilities and their peers persist across all contexts. Despite these disadvantages, they benefit from overall improvements in reading proficiency and socioeconomic advancements.

Paper IV examines the role of disability and sibling effects on children's educational outcomes in Ghana and Niger, using primary survey data from selected areas. It identifies unique challenges faced by children with disabilities compared to those without disabilities. While sibling status influences children's development in the USA and Europe, this study finds overall sibling effects are small in impoverished African settings. However, negative sibling effects are reported for girls with disabilities in Ghana. The study highlights developmental risks faced by children with disabilities from a gender perspective.

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