The Impact of Health Intervention Programs on Education: Evidence from the Malaria Eradication Program in Tanzania.

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Abstract

Improving educational outcomes, particularly test scores, has become increasingly important in light of the persistent learning crisis that has been observed among students in low-income countries. Given the strong link that exists between health and education, public health interventions may offer an avenue to enhance academic performance by improving cognitive development and school participation through disease eradication. This study utilizes exogenous variation in malaria prevalence and the 2004 national malaria eradication intervention in Tanzania to assess the impact reduced malaria exposure has on academic achievement and educational attainment. It relies on administrative data on lower secondary school performance from the National Examinations Council of Tanzania, Demographic and Health Survey results, and a difference-in-differences strategy, and finds that reduced exposure to malaria increased test scores by 0.14 standard deviations, which is equivalent to 5.8% of the mean score. Effects varied by subject: test scores increased by approximately 5.8% in STEM subjects and 7.4% in arts and business subjects. We also find that the malaria eradication intervention led to an increase of 2.4 years of education for individuals born after the policy was implemented and 0.58 years for individuals who were preschoolers or school-aged when it was implemented in 2004. These findings suggest that integrated health interventions can yield substantial returns in terms of educational outcomes in Tanzania and across Sub-Saharan Africa.

Keywords: Impact of health interventions; Malaria eradication; Integrated health intervention; Tanzania; longitudinal data; Health and education

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I. Introduction

The strong relationship that exists between good health and educational outcomes is increasingly recognized as fundamental to human capital development (UNESCO, 2016; WHO, 2021). While numerous efforts have focused on the chronic underfunding of education (Klees, 2024; Hares et al., 2023; OECD, 2023), the fragmented prioritization of Sustainable Development Goal 4 (Hares et al., 2022), and weak accountability systems (Montoya and Crouch, 2023), less emphasis has been placed on integrating health as a structural constraint to learning, particularly in high-burden contexts such as Sub-Saharan Africa. A growing body of research has established that improving child health can lead to measurable gains in educational outcomes, including school attendance, cognitive performance, and learning achievement (Miguel and Kremer, 2004; Baird et al., 2016). Yet, in many contexts, particularly in Sub-Saharan Africa, persistently high disease burdens continue to undermine investments in education (Yao et al., 2021; Christie et al., 2017, 2011). At the global level, around 60% of 10-year-old children are unable to read and understand a simple text, and the learning poverty rate is even higher in Sub-Saharan Africa, at 86% (Angrist et al., 2023; World Bank, 2019). These figures underscore the need to more explicitly consider health as a binding constraint to more equitable, quality education.

Malaria is a typical endemic disease that warrants consideration when assessing various educational outcomes in Sub-Saharan Africa. Beyond health, malaria impacts children's cognitive abilities and potentially disrupts the human capital development process (Burlando, 2012; Fernando et al., 2003). Malaria exposure in utero and in early childhood may have a far more severe impact than exposure later in life due to brain damage and long-term cognitive impairment (McClure et al., 2013; Spreen et al., 1995). Contracting severe malaria, such as cerebral malaria (CM), during the period of maximum cellular growth in the brain (up to 12 months of age) may result in mental retardation, or language or memory impairments, and beyond that, may affect higher-order brain functions such as planning, decision-making, self-awareness, and social sensitivity until age 7 (Holding and

Snow, 2001; Ngoungou et al., 2007; Mung'ala-Odera et al., 2004). In Uganda, children aged 5–12 who contracted CM were found to have lower spelling and reading scores than children from the same household or neighbourhood who did not experience severe malaria, while those who contracted severe malarial anaemia showed poorer spelling scores 2–9 years after their episode of severe malaria (Nakitende et al., 2023). A parallel study by Boivin et al. (2007) involving children in the same age group (5–12 years) in Uganda revealed that a greater proportion of those who were admitted to the hospital for CM exhibited poor working memory and lacked attention 6 months after discharge than healthy children and those with uncomplicated malaria from the same community (11.9% vs. 2.3% for memory, and 16.7% vs. 2.3% for attention, respectively). On the other hand, uncomplicated malaria may indirectly impact education by increasing the rate of absenteeism (Gboeloh and Elele, 2016; King et al., 2015; Simwaka et al., 2009) since the number of days a child misses school increases with each reoccurrence.

Despite the fact that the link between malaria and negative educational outcomes is well-established, the literature is inconsistent—but generally positive—about malaria reduction leading to improved educational outcomes. For example, Lucas (2010) found that the malaria eradication program implemented in Paraguay and Sri Lanka in the mid-twentieth century increased lifetime female educational attainment and literacy. Similarly, Shih and Lin (2018) found that malaria eradication in Taiwan in the 1950s increased the educational attainment of men and married men's spouses. In the Sub-Saharan African context, Barofsky et al. (2015) showed that a reduction in malaria incidence in southwestern Uganda increased overall educational attainment by about half a year for both males and females and boosted primary school completion among females. In addition to educational attainment, there is evidence students' school attendance and cognitive skills improved following malaria eradication in Mozambique and Mexico (Venkataramani, 2012; Cirera et al., 2022).

In Ghana, a school-based participatory health education program significantly reduced parasite prevalence among schoolchildren but had no measurable effect on educational outcomes (Ayi et al., 2010). Similarly, malaria screening and treatment as part of a school-based malaria prevention intervention in Kenya were found to have no significant impact on sustained classroom attention (Brooker et al., 2010). While Halliday et al. (2014) found an intermittent preventive treatment intervention had no effects on the educational outcomes of schoolchildren along the southern coast of Kenya, Clarke et al. (2008) reported it had positive and significant effects in western Kenya. In Costa Rica, the positive effects a malaria eradication program had on educational attainment were found to be moderated by school system characteristics and child labour market conditions (Mora-Garcia, 2018). Cutler et al. (2010), for their part, evaluated a nationwide eradication program in India in the 1950s and found no evidence of increased educational attainment for men, and mixed evidence for women. Similar findings were also documented by Venkataramani (2012) in Mexico.

Apart from malaria eradication efforts, evidence other health-related interventions, such as deworming, have cognitive and educational benefits is also mixed. For instance, a randomized controlled trial found a deworming intervention in rural Guatemala yielded no significant improvements in school performance, including reading, vocabulary, or attendance, despite measurable health gains (Watkins et al., 1996). Similarly, a large randomized trial reported a deworming intervention in Peru had no significant effects on cognitive, language, or motor development after one year of deworming (Joseph et al., 2015). In contrast, long-term follow-up data from a mass school-based deworming intervention in Kenya indicated the intervention reduced absenteeism by 25% and improved educational outcomes. Notably, girls who received deworming treatment during childhood were 9.6 percentage points more likely to pass the secondary school entrance exam (Miguel and Kremer, 2004; Baird et al., 2016).

Evidence nutritional interventions have cognitive and educational effects is also mixed. A systematic review of 12 randomized controlled trials conducted in Germany, Ethiopia, and Norway found there were no significant cognitive improvements associated with various nutritional interventions (Widen et al., 2022). However, more targeted interventions that address micronutrient deficiencies show stronger effects. In China, iron-deficient students who received supplementation improved their standardized math scores by 5–25% (Lopez-Pena et al., 2017). Similarly, studies have reported anaemic children in Indonesia who received iron supplementation exhibited substantially improved visual attention, concept acquisition, and overall learning achievement (Soemantri et al., 1985; Soemantri, 1985).

In this study, we contribute to the literature by exploring the impact reduced exposure to malaria has on children's learning outcomes and educational attainment. We look at the plausibly exogenous variation resulting from nationwide policy interventions that were implemented by the Tanzanian government in the mid-2000s to eradicate malaria and the spatial variation in malaria prevalence across Tanzania. A difference-in-differences (DiD) approach is used to determine the differential intensity of malaria exposure before the intervention by focusing on areas with high and low malaria incidence, as determined by elevation, for identification. More specifically, we compare the educational outcomes of children in areas located less than 1700 meters above sea level (high endemic areas) with those of children in areas situated more than 1700 meters above sea level (low endemic areas), similar to a previous study by Gansey (2020). To assess whether the policy benefited students differently by subject area, we categorized students into two groups: (i) science, technology, engineering, and mathematics (STEM) subjects, including physics, chemistry, biology, and mathematics; and (ii) arts and business subjects, including history, civics, geography, English language, English literature, Kiswahili, bookkeeping, and commerce.

This study contributes to the literature in several important ways. First, it focuses on both educational attainment and achievement. Previous studies have predominantly examined educational attainment, with the exception of Venkataramani (2012), as well as Cirera et al. (2022), who assessed only the impact on test scores. Analyzing student test scores alongside years of schooling enables us to determine which of the two aspects of educational outcomes is more likely to benefit from malaria eradication, given that evidence from other contexts suggests that effects may be limited to one outcome rather than affect both simultaneously.

Second, to the best of our knowledge, this is the first study in Sub-Saharan Africa to use nationwide administrative records from the Tanzania Secondary School National Examination Assessment Results (NEAR) to assess the impact malaria eradication has on education. This dataset offers a key advantage over other quasi-experimental studies as it covers all students who take national exams and thereby provides high statistical power and improves the generalizability of findings. The data used capture individual students' overall and subject-specific final grades for lower secondary education (Form IV) between 2003 and 2010 and were obtained from the National Examinations Council of Tanzania (NECTA). The NECTA data were complemented with data from the 2004 and 2022 editions of the Tanzanian Demographic and Health Survey (DHS) to measure educational achievement and cognitive skill level based on students' final exam scores, and educational attainment based on their number of years of schooling. Our study differs from the study conducted by Cirera et al. (2022) as that study used terminal exam results obtained from Mozambique students' school records that were based on non-standardized assessment tools, and captured only a few schools within a single region, whereas this study utilizes test scores from nationally standardized exams. Consequently, the results obtained by Cirera et al. (2022) may reflect differences in the strength of the assessments rather than the true effect of the intervention.

We find that the malaria eradication intervention significantly increased educational attainment among individuals with reduced exposure to malaria. The magnitude of the effect varies by cohort, which reflects differences in timing and intensity of exposure. Individuals born after the 2004 intervention experienced the largest gains, with an average increase of 2.4 years of schooling, while those who were school-aged or preschoolers in 2004 gained 0.58 years of schooling. In terms of academic performance, reduced malaria exposure led to an average increase of 0.14 standard deviations (SDs), which is equivalent to 5.8% of the mean test score. We also document heterogeneous effects by subject specialization, with students taking arts and business subjects exhibiting larger improvements than those taking STEM subjects—approximately 7.4% of the mean score vs. 5.8%.

The remainder of this paper is organized as follows: Section 2 presents the context; Section 3 discusses the methodology used; Section 4 presents and discusses the results; and Section 5 concludes the study.

II. Context

2.1 Education System and Policy Reforms in Tanzania

2.1.1 Education System

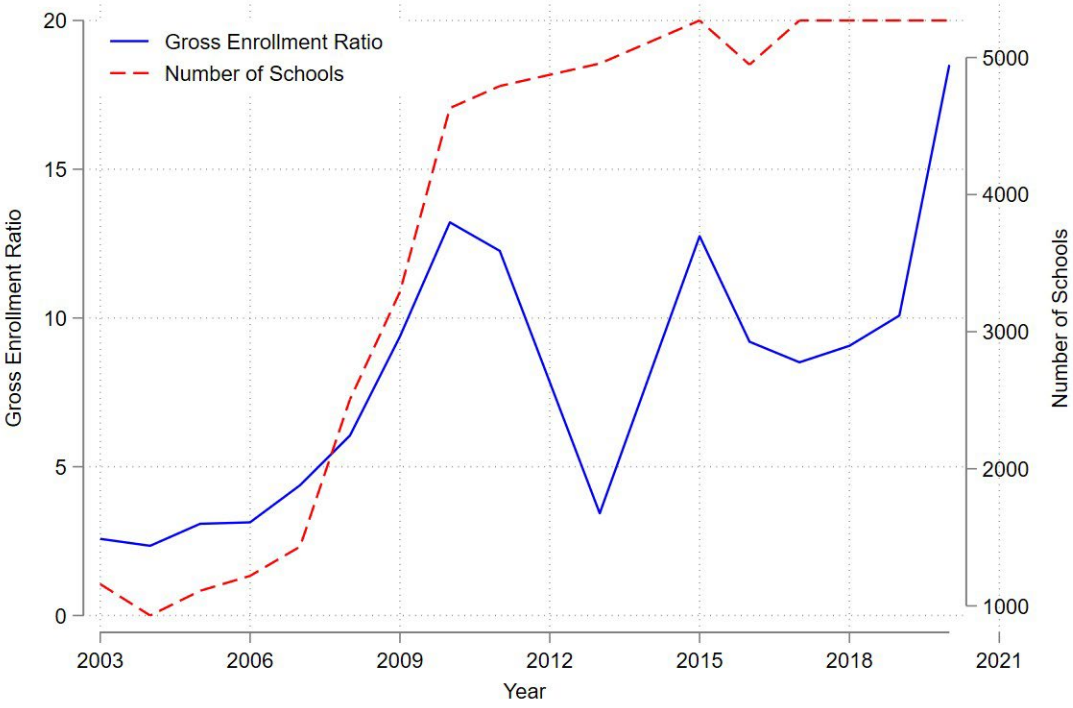
The education system in Tanzania comprises pre-primary, primary, secondary, and tertiary education. Since 2014, following the adoption of the Education and Training Policy (ETP), the one-year pre-primary education program has been compulsory and free for all children aged 5–6 years. Primary education traditionally spans seven years (Standard I to Standard VII) for children aged 7–13. It is structured to build competence in reading, writing, and numeracy at the lower primary level (Standards I to III) and to develop skills in subjects such as Kiswahili, English, mathematics, civics and ethics, the science of work, and other optional languages at the upper primary level. Students take a national exam in Standard IV. Until 2024, they also took another national exam entitled the Primary School Leaving Examination (PSLE) at the end of primary school to qualify for secondary education. However, the revised ETP (2023) that came into effect in 2024 reduced the duration of primary education to six years (Standard I to Standard VI) and effectively eliminated the PSLE.

Secondary education consists of four years of lower secondary (Forms I to IV) and two years of upper secondary (Forms V and VI). Prior to the implementation of the ETP (2014), secondary education was not compulsory. However, following structural adjustments under that policy, secondary education became compulsory and free as part of the basic (public) education program starting in 2016. Form IV marks the end of lower secondary education in Tanzania and is when all eligible students nationwide take the National Examination Assessment (NEA). Students may be examined on different subjects depending on factors such as their stream of study (STEM or arts and business) and school type (technical or non-technical). The core subjects that are assessed by the NEA include mathematics, physics, chemistry, biology, geography, history, civics, English language, Kiswahili, bookkeeping, and commerce. Additionally, students may opt for additional non-core subjects such as additional/advanced mathematics, English literature, nutrition, and agriculture. Students from all streams are required to take a minimum of seven subjects including basic mathematics, which is compulsory. Upper secondary often includes specialized tracks (academic or technical/vocational) and prepares students for higher education or the workforce. However, the system has faced challenges, such as rapid expansion, teacher shortages, and quality concerns, that have prompted various reforms in the last two decades.

2.1.2 Policy Reforms in Education

Since the mid-2000s, Tanzania has implemented a series of policies and reforms to improve the quality and accessibility of secondary education in response to increasing demand due to rising enrollment rates following the introduction of universal primary education. One such policy was the Secondary Education Development Programme (SEDP-I 2004–2009), which aimed to enhance education quality and performance in secondary schools by providing in-service teacher training and improving the availability of teaching and learning facilities, among other goals. Despite the efforts made, SEDP-I achieved only limited success and led to the launch of SEDP-II. This second phase introduced new strategies such as invigorating science teaching methods at all levels and incorporating information and communication technology as a tool for teaching and learning in contemporary Tanzanian secondary schools to address its predecessor's limitations (URT, 2010). In addition to these programs, the government launched an initiative in 2005 to fast-track the process of increasing access to secondary school by ensuring that each ward in Tanzania had at least one secondary school. The modality chosen to achieve the goals set was community contributions and the requirement that households contribute cash, time, or materials for school construction. This resulted in an enormous increase in the number of schools and enrollment within a few years (Habyarimana et al., 2020). Figure 1 plots the gross enrollment ratio (GER) and the number of schools from 2003 to 2020 and suggests there is a correlation between enrollment and infrastructure expansion. The number of schools increased steadily starting in 2003, with a notable upswing starting in 2007—two years after the one-school-per-ward initiative was introduced in 2005. The GER trends upward over the same period and increases sharply starting in 2006, which signals improved access to education.

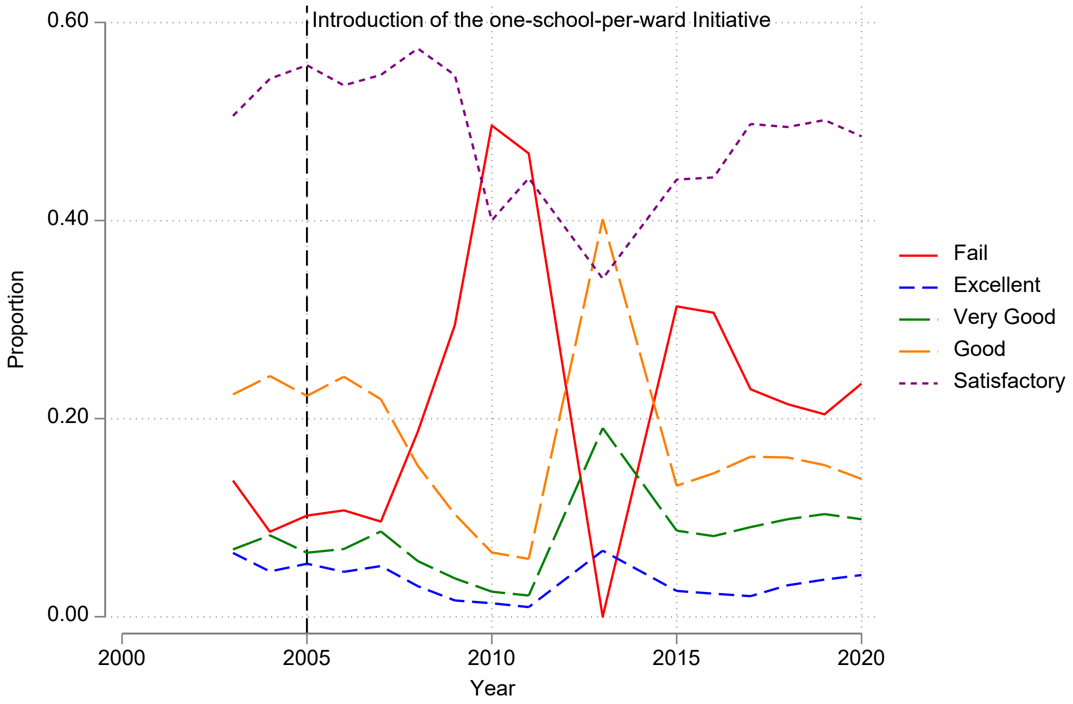
Figure 1. Student Enrollment and Number of Schools (2003–2020)



Note: The figure illustrates the gross student enrollment ratio in lower secondary schools and the total number of schools for the period 2003–2020. Gross enrollment values are based on the number of students who completed lower secondary school (Form IV) according to the Tanzanian NEAR and may be slightly lower than actual Form I enrollment levels. School-aged population data were obtained from the United Nations data portal.

However, despite these initiatives, educational performance did not improve. Rather, it deteriorated by more than 40% between 2007 and 2012 (Habyarimana et al., 2020). This trend is also evident in Figure 2, which summarizes secondary students' performance across five achievement bands for the period 2003–2020. The graph shows that the proportion of students failing the final exam was relatively low and stable prior to 2007 but rose sharply between 2008 and 2010 before declining again around 2012. The proportion of students achieving "Good" and "Very Good" grades also declined significantly between 2005 and 2010, which is consistent with an increase in failure rates. The share of students attaining "Excellent" grades—which was a small minority to begin with—also exhibited a modest downward trend.

Figure 2. Student Performance on Form IV Final Exam (2003–2020)



Note: The figure plots the performance trends of students in lower secondary schools across five performance levels (Excellent, Very Good, Good, Satisfactory, Fail) for the period 2003–2020.

The sharp performance decline between 2008 and 2010 coincides with a rapid increase in access to secondary education following the introduction of the one-school-per-ward initiative in 2005. While the policy succeeded in increasing enrollment, it appears to have strained the system's capacity to deliver quality education. This was due in part to a severe shortage of qualified teachers, as the teacher count failed to keep pace with the surge in student numbers across more than 3,000 newly established schools (Habyarimana et al., 2020). The problem was further exacerbated by the 2008 policy decision to address teacher shortages by deploying high school graduates with only a few months of pedagogical training (Habyarimana et al., 2020). The slight rebound that can be observed in most of the performance levels shown in Figure 2 after 2013 aligns with the adoption and implementation of the Big Results Now in Education (BRNED) initiative that the Government of Tanzania adapted from a Malaysian initiative and introduced in 2013. While BRNED was found to improve performance, its impact was largely concentrated in schools in the bottom two deciles (Cilliers et al., 2021).[1]

2.2 Malaria Prevalence and Interventions in Tanzania

2.2.1 Malaria Prevalence

Tanzania ranks among the top ten nations grappling with a high incidence of both malaria cases and fatalities and accounted for 3% of global cases and 13.4% of cases in eastern and southern Africa in 2020 (Severe Malaria Observatory, 2021; Avis, 2022). A comparison of average malaria prevalence between 2000 and 2019 across five eastern African countries—Uganda, Burundi, Tanzania, Rwanda, and Kenya—is provided in Figure 3 and shows that Uganda bears the highest burden, followed by Burundi and Tanzania. In contrast, Rwanda and Kenya report the two lowest prevalence rates. This places Tanzania in the middle position within the region, with a significantly lower malaria burden than Uganda and Burundi, but a higher burden than Rwanda and Kenya.

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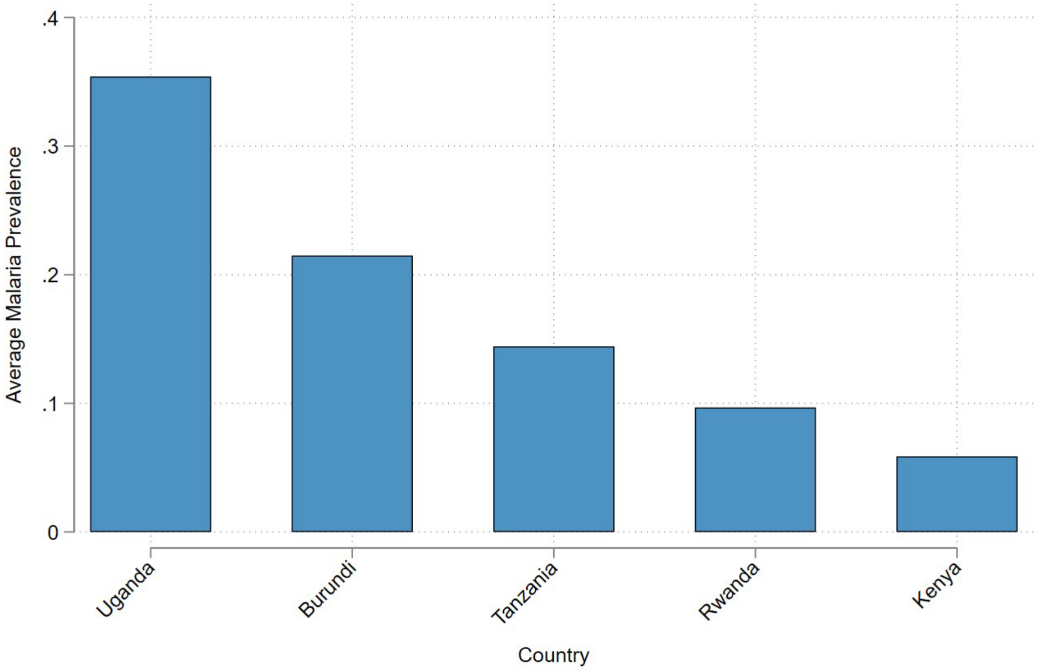
[1] BRNED was a package of reforms aimed at improving the quality of education and increasing exam scores in both primary and secondary schools (World Bank, 2014). It introduced a series of top-down accountability measures designed to increase pressure on education system bureaucrats (Rodriguez-Segura and Mbiti, 2022). The initiative's key components included: (i) official school rankings, (ii) capitation grants, (iii) the School Improvement Toolkit, (iv) a school incentive scheme, (v) the construction of basic facilities, (vi) teacher motivation initiatives, (vii) the Student-Teacher Enrichment Programme, (viii) the 3Rs teacher training, and (ix) national reading, writing, and arithmetic assessments (World Bank, 2014).

The rate of malaria transmission varies from place to place depending on the climate suitability of an area and the season (Figure 4). Tanzania's climate pattern is classified as either unimodal or bimodal depending on whether a region receives substantial rainfall once or twice a year. This climatic variation influences the dynamics of malaria transmission across the country's different ecological zones. Although Tanzania generally experiences a tropical climate, the weather varies significantly by region and zone and is contingent on the elevation level and rainfall patterns of a particular area. The country's topography is a blend of mountainous terrain, notably in the northern and southern highlands, and plateaus, which are predominantly in the central part. In many parts of the country, the climate is often warm enough to be conducive to the survival and breeding of the malaria vector (Lindblade et al., 2000; Rogers and Randolph, 2000). However, Tanzania's highland areas are less favorable environments for the vector due to lower temperatures (Hagenlocher and Castro, 2015; Rogers and Randolph, 2000). The highland regions typically experience temperatures that range from 10 to 20 degrees Celsius in both the cold and hot seasons and occasionally drop below zero during the cold season. Approximately 93% of mainland Tanzania's population lives in malaria-endemic areas, with the Lake (northwestern), Western (far western), and Southern (southeastern) zones considered regions of heightened transmission risk (URT, 2016).

Figure 3. Average Malaria Prevalence by Country (2000–2019)

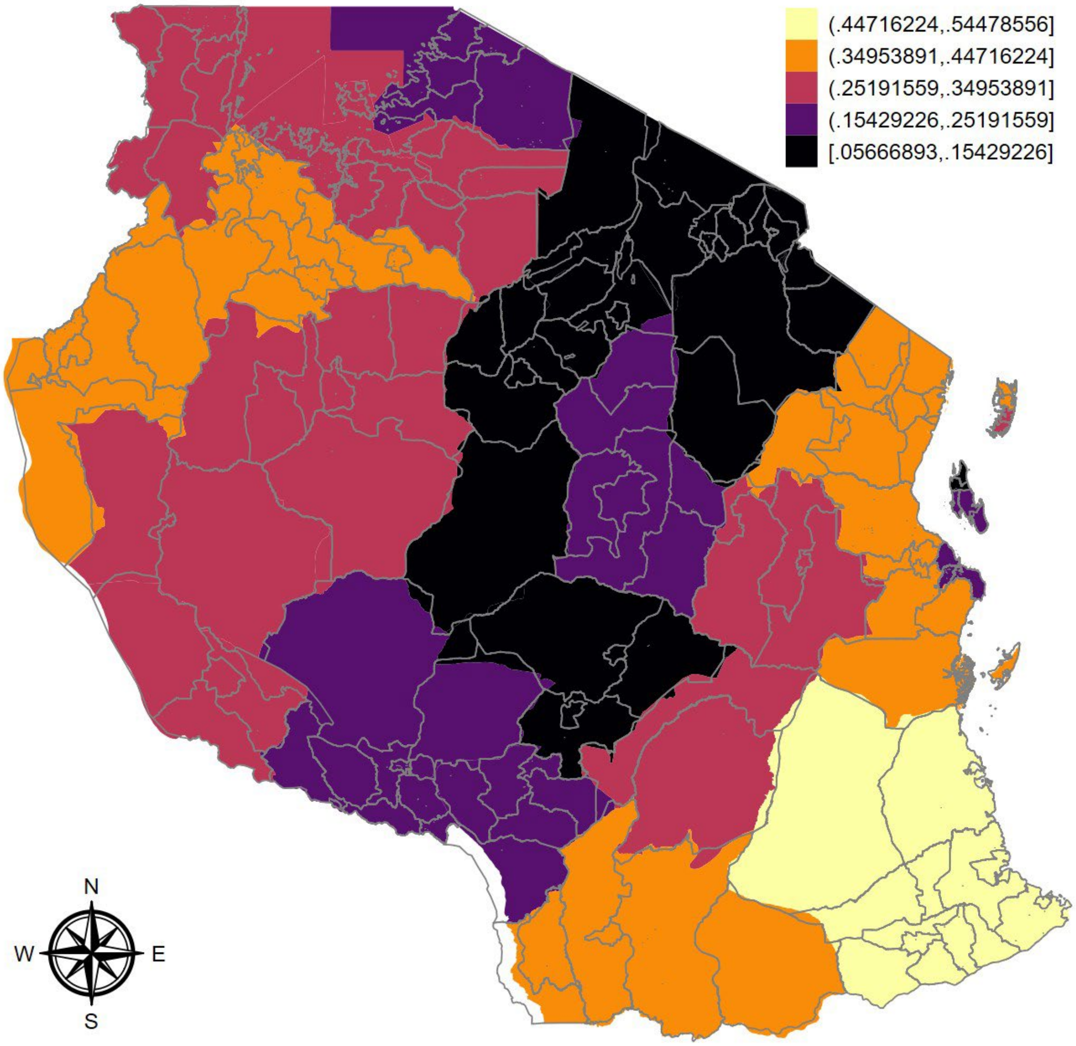


Note: The figure compares the average malaria prevalence of five eastern African countries for the period 2000–2019. Data source: Institute for Health Metrics and Evaluation (IHME).

2.2.2 Malaria Eradication Program in Tanzania

Tanzania's National Malaria Control Programme (NMCP) was rolled out in 2004 as a nationwide response to the country's high malaria burden. It built on district-level pilots from the 1990s (Premji et al., 1995; Fraser-Hurt and Lyimo, 1998; Hanson et al., 2009) and employed an integrated strategy that included: (i) increased use of insecticide-treated bed nets (ITNs), (ii) intermittent preventive treatment for pregnant women, (iii) indoor residual spraying, and (iv) the use of artemisinin-based combination therapy as the first line of treatment (Bonner et al., 2011).

Figure 4. Spatial Distribution of Malaria in Tanzania in 2004



Note: The figure presents the spatial distribution of malaria incidence across regions in Tanzania. The malaria data used were sourced from the Global Malaria Incidence Estimates provided by IHME.

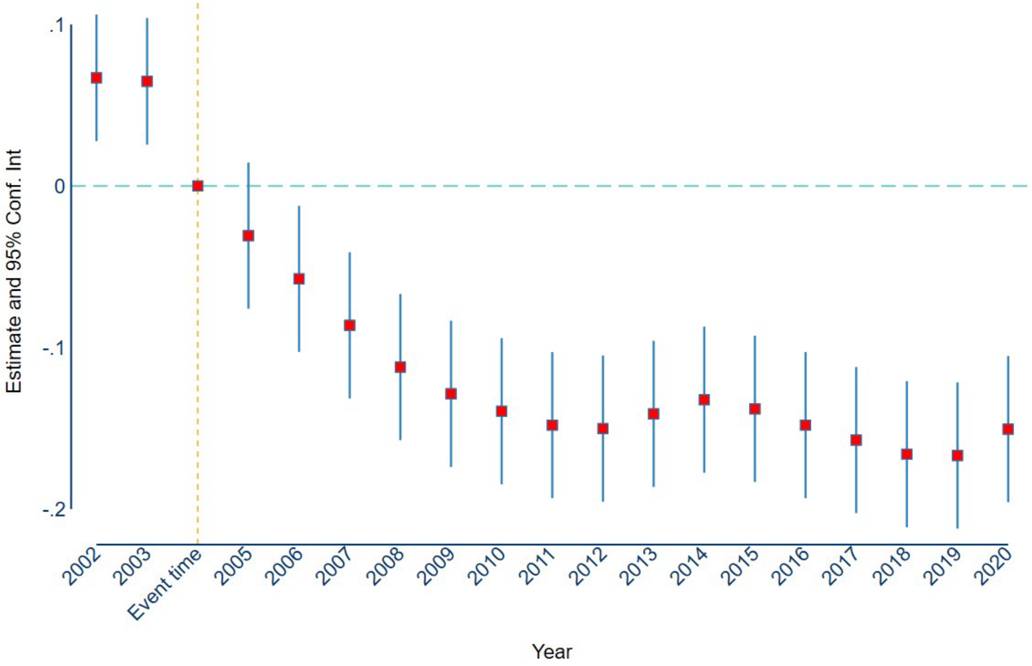
The first intervention introduced under the NMCP was the National Insecticide-Treated Nets Programme, which aimed to scale up ITN use. To operationalize it, the Tanzania National Voucher Scheme (TNVS) was launched in October 2004. The TNVS provided subsidized ITNs through a voucher system ("Hati Punguzo"). Eligibility was initially limited to pregnant women and later expanded to children under five in 2007 (Bonner et al., 2011; Hanson et al., 2009). Vouchers were valued at 2,750 Tanzanian shillings (TZS) at the time of the program's launch, and their value was increased to 3,250 TZS in January 2007. Eligible pregnant women could use the voucher, which they had to present along with their antenatal care card, to purchase any size ITN, while distribution for children under five was typically coordinated during measles vaccination clinic days.

Despite these efforts, coverage remained low. By 2008, only 26% of children under five slept under an ITN—well below the 60% target (Bonner et al., 2011). This led to the launch of the Under-5 Catch-Up Campaign in October 2008, which distributed 8.7 million free ITNs across the country, with rollout targeting children under five and prioritizing malaria-endemic areas. This was followed by the Universal Coverage Campaign (UCC) in 2010–2011, which expanded free ITN provision to all households in the hopes of covering every sleeping space (Croke, 2017; Renggli et al., 2013).

To sustain the gains achieved after the UCC, in 2013, the government introduced the School Net Programme (SNP) in three southern Tanzanian regions (Lindi, Mtwara, and Ruvuma) (Scates et al., 2020; Stuck et al., 2017; Lalji et al., 2016). This initiative provided free long-lasting insecticidal nets to all primary school children in Standards I, III, V, and VII as well as secondary school students in Forms II and IV (Stuck et al., 2017). This initiative introduced heterogeneities among students in different regions, which may complicate the evaluation of the program. In light of this, our analysis is limited to the 2004–2011 period—until one year before the SNP was introduced—to avoid identification threats from the SNP.

Figure 5 represents an event study plot showing how malaria prevalence evolved over the years before and after the 2004 malaria eradication intervention program. The x-axis plots time by year, and the y-axis plots the estimated coefficients from the event study specifications. The figure indicates there was a substantial and progressive reduction in malaria incidence starting in 2005, i.e., following the implementation of the malaria eradication campaign in 2004. This suggests that the intervention significantly reduced exposure to malaria and the risks associated with malaria illness. The 2023 School Malaria Parasitological Survey also reported malaria prevalence among primary school children dropped, from 21.6% in 2015 to 11.3% in 2023 (Chacky et al., 2025). Similarly, national statistics from Tanzania's health facilities reveal malaria cases decreased 55% between 2015 and 2023, and malaria-related hospital admissions and deaths dropped by 61% and 69%, respectively, over the same period (Ifakara Health Institute, 2023). Broader national health indicators also align with this trend: under-five mortality declined by 45% between 1999 and 2010, and the prevalence of severe anaemia among children aged 6–59 months halved, going from 11.1% in 2005 to 5.5% in 2010 (Smithson et al., 2015).

Figure 5. Malaria Incidence Dynamics in Tanzania (2002–2020)



Note: The event study plot provides point estimates and 95% confidence intervals illustrating the dynamics of the malaria incidence rate among individuals 15+ years old before and after the introduction of Tanzania's malaria eradication intervention program. The graph was obtained by regressing the malaria incidence rate on year dummies, treating 2004 as the reference period, and controlling for regional fixed effects.

III. Methodology

3.1 Data

3.1.1 Exam Data

The first set of data used in this study comes from the Tanzania Secondary School National Examination Results (TSSNER) administrative records that are maintained by NECTA. The data contain results for the standardized lower secondary (Form IV) exam that were digitally collected over multiple years beginning in 2003. In this study, we focus on the period 2003–2011. The TSSNER contains records for a nationally representative sample of school-aged children from both public and private schools who take the final exam at the end of Form IV. The data include a unique identifier for each student and each school, which may make it possible to link students and schools to their respective geographic locations at the district or regional level. However, since the district-level information is incomplete (provided for 80% of the schools) and therefore less reliable, in this study, we use the school name in place of the region and students' location identifier rather than the district for the second administrative level. The TSSNER also contains information about whether a student is a school candidate (registered in mainstream education) or a private candidate (registered outside mainstream education to take the national exam). Information about the school type—whether each school is public or private—was externally obtained from the President's Office and merged with the TSSNER data on the basis of school names.

3.1.2 Demographic Health Survey

The second set of data used is repeated cross-sectional data that were compiled from the 2004 and 2010 editions of the Tanzanian DHS. The DHS follows a two-stage clustered sampling process. In the first stage, clusters consisting of enumeration areas are selected. In the second stage, households are systematically selected from each cluster. The total number of households sampled for the 2004 and 2022 editions of the DHS were 9,735 and 16,354, respectively. All women and men aged 15–49 found in the households at the time of the interview were eligible to participate. The DHS contains a wealth of individual, household, and community-level information, including age, gender, and educational attainment. We focus on a subset of variables for our analysis, specifically education-related variables and other relevant characteristics.

3.1.3 Malaria Data and Other Data

The malaria data used in the analysis for the main results were sourced from the Global Malaria Incidence, Prevalence, and Mortality Geospatial Estimates 2000–2011 provided by IHME. The data were estimated from the geolocation data of household surveys including the DHS, the Malaria Indicator Survey, and other country-specific surveys, as well as routine surveillance data. The dataset contains estimates of malaria prevalence and incidence for age groups 0–4 years, 5–14 years, and 15 years and over. In the study, we used the malaria prevalence rates for the 5–14 years and 15+ years age groups, to which most secondary school-aged children belong.

We merged these datasets with the DHS data on the basis of district names, which serve as clusters in the DHS, and the NECTA administrative data on the basis of regions. During the merging process, households in the DHS that migrated to new locations were assigned the values of the original location where children were born or lived for the longest duration. The NECTA data were merged based only on the location of the school that a student attended due to a lack of individual student migration information. We also extracted sub-national gross domestic product (GDP) data from the DOSE, which we use as a proxy for socio-economic status (Wenz et al., 2023). Additionally, yearly temperature and precipitation data from Climate Research Unit Version 4.05 were obtained from the AidData research lab at William and Mary university. We constructed a health index from DHS data and then used it to derive poverty quintiles in order to categorize households into five groups based on their socio-economic status. We then merged this information with the NECTA data to generate additional control variables for our regressions.

3.1.4 Measuring Outcome Variables

The outcome variables considered in this study are educational achievement and attainment. To measure educational attainment, we use an individual's level of education in years of schooling collected from the DHS data. To measure educational achievement, we rely on the exam results in the TSSNER to construct an aggregate score performance indicator.

In the TSSNER, exam results are recorded for each subject in the form of grades that are based on raw percentages. The scale is as follows: 75–100% = an A (the best grade), 65–74% = a B, 45–64% = a C, 30–44% = a D, and 0–29% = an F. In addition, the grades are weighted, with the best grade receiving a weight of 1 and the worst grade, a weight of 5. A student's overall final aggregate score is obtained by summing up the weights of their top seven subjects. The highest achievable score is 7 (indicating straight A's with a weight of 1 each), and the lowest is 35 (indicating straight F's with a weight of 5 each). These scores are further classified into five divisions: I (Excellent), II (Very Good), III (Good), IV (Satisfactory), and 0 (Fail) (see Table A1 in Appendix A for detailed information on the total point grading system and divisions).

For the purpose of this study, we standardized performance scores by reversing the grade weights and assigning a weight of 5 to the best grade (A) and a weight of 1 to the worst grade (F). As a result, the highest score possible, indicating the best performance, became 35, and the lowest became 7.

Table 1 presents summary statistics for the variables used in this study. The top panel in the table presents summary statistics derived from the NECTA dataset, and the bottom panel, ones derived from the DHS dataset. The average performance score is approximately 13, which is equivalent to satisfactory performance in terms of NECTA's division classifications. About 54% of the students in the sample are male, and 74% and 93% of students completed secondary school over the eight-year period they were enrolled in public schools as school candidates.

Table 1. Summary Statistics

	Mean	**SD**	**Min**	**Max**	**N**
NECTA Sample					
Performance Score	12.64	5.23	7	35	1236029
Student = Male	0.54	0.50	0	1	1236029
Public School	0.71	0.45	0	1	1236029
Socio-economic Status	13.93	0.32	13.35	14.81	1236029
School Candidate	0.92	0.27	0	1	1236029
Temperature	3.16	0.07	3.03	3.31	1236029
Precipitation	6.85	0.33	5.85	7.59	1236029
Location					
Coastal Zone	0.15	0.35	0	1	1236029
Northern Zone	0.22	0.41	0	1	1236029
Lake Zone	0.24	0.43	0	1	1236029
Central Zone	0.11	0.32	0	1	1236029
Southern Zone	0.10	0.30	0	1	1236029
Southern Highland Zone	0.15	0.35	0	1	1236029
Western Zone	0.04	0.19	0	1	1236029
Observations	1,236,029				
DHS Sample					
Years of Schooling	4.42	5.44	0.00	29.00	83459
Malaria Incidence Rate (15+ Years)	0.17	0.11	0.05	0.54	83459
Malaria Incidence Rate (5–14 Years)	0.18	0.12	0.04	0.58	83459
Gender (1 = Male)	0.47	0.50	0.00	1.00	83431
Location (1 = Urban)	0.30	0.46	0.00	1.00	77643
Individual Age	32.68	18.62	19	95.00	83306
Wealth Quintiles					
Poorest	0.18	0.39	0.00	1.00	77643
Poorer	0.19	0.39	0.00	1.00	77643
Middle	0.19	0.39	0.00	1.00	77643
Richer	0.22	0.41	0.00	1.00	77643
Richest	0.22	0.42	0.00	1.00	77643
Observations	77,643				

Note: This table provides summary statistics for the variables used in this study. The top panel displays descriptive statistics for the administrative test score data obtained from NECTA, while the bottom panel presents descriptive statistics for the sample pooled from the 2004 and 2022 editions of the DHS.

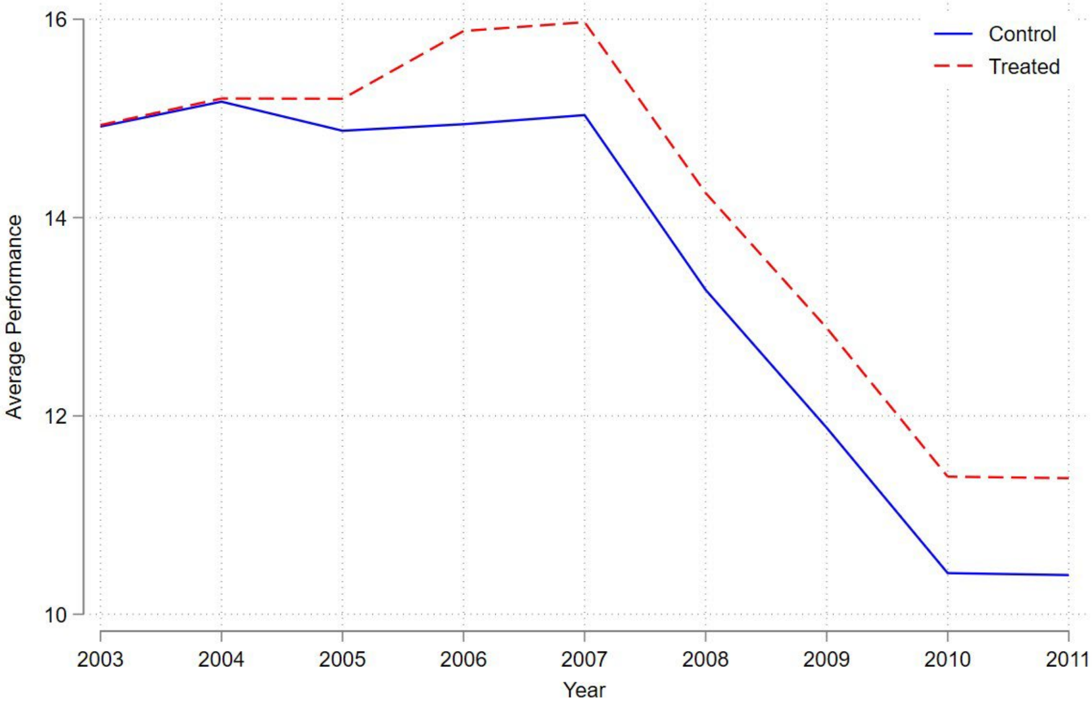
As can be seen in the bottom panel of Table 1, the average level of educational attainment is approximately four years of schooling. Males constitute 47% of the sample, and the average age of the sample is 32 years. Approximately 30% of respondents reside in rural areas. Regarding wealth distribution, 18% of the sample falls into the lowest quintile, 19%, the middle quintile, and 22%, the highest quintile. The average malaria prevalence across locations is 17% for individuals aged 15+ years and 18% for those aged 5–14 years.

3.2 Defining Treatment

Similar to Gansey (2020), we define treatment based on the altitude of the district and region in which a student's school is located to classify areas with high malaria prevalence and those with low malaria prevalence. The literature broadly shows that areas located more than 1700 meters above sea level have low malaria prevalence compared to areas located below that altitude due to climatic conditions being unfavorable for mosquito survival (Bødker et al., 2003; Maxwell et al., 2003; Chandler et al., 2006). Thus, we assign districts with pre-intervention low malaria prevalence (> 1700 meters above sea level) to the control group and those with high malaria prevalence (< 1700 meters above sea level) to the treatment group. Our identification strategy assumes that students in high malaria prevalence zones are more likely to benefit from the national malaria eradication program—primarily through improvements in general health and reductions in malaria-induced absenteeism—than students in low prevalence zones, for whom the program is expected to have minimal marginal health or schooling effects.

Figure 6 supports the validity of this assumption. Prior to the intervention in 2004, academic performance in areas at high risk and those at low risk of malaria (the treated and control groups, respectively) followed similar trends, which suggests comparability between the two groups. Following the introduction of the malaria eradication program, we observe a marked divergence: average student performance improves significantly more in high-risk areas than in low-risk areas. This divergence persists even in the face of a subsequent general decline in performance due to other policy shocks after 2007, which indicates that the treatment group maintains relatively better performance levels. The divergence in outcomes observed after 2004 thus supports the assumption that low-risk areas provide a valid counterfactual for high-risk areas in the absence of the intervention.[2]

Figure 6. Average Performance of Students in the Treatment and Control Groups (2003–2011)



Note: The figure shows the performance trends of students in lower secondary school and compares high malaria-endemic areas (treatment group) with low malaria-endemic areas (control group) before and after the 2004 intervention. Student performance is measured using the aggregate score performance indicator from the NECTA data.

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[2] This approach assumes that trends in educational outcomes in areas with low malaria prevalence represent a suitable counterfactual for those in areas with high malaria prevalence had the latter areas not been exposed to a substantial reduction in malaria.

3.3 Estimation Strategy

To estimate the causal effect the malaria intervention program had on student academic performance, we use a canonical two-period, two-group DiD design. This method compares changes in the outcomes of the treated and control groups over time under the identifying assumption that both groups would have followed similar trends in the absence of the intervention (Gruber and Mullainathan, 2005; Kling et al., 2007).

In this study, schools located in regions that are less than 1700 meters above sea level—areas with historically high malaria prevalence—constitute the treated group, while those located more than 1700 meters above sea level—in areas with low malaria prevalence—serve as the control group. Although the malaria intervention program was implemented nationwide in 2004, its intensity varied systematically based on pre-existing malaria risk, which is exogenously determined by altitude and climate (Bødker et al., 2003). This exogenous geographic variation enables us to apply a DiD approach to compare differential impacts across regions with differing malaria burdens. The DiD approach is more suitable than alternative quasi-experimental methods, such as propensity score matching and instrumental variables, due to the absence of rich pre-treatment covariates and the difficulty of identifying valid instruments.

While a staggered DiD approach may appear suitable given the phased rollout of the malaria eradication program, it is inappropriate in our context due to the absence of clearly defined treatment timing at the unit level. First, the program's phased implementation overlapped considerably across districts and cohorts, with eligibility criteria—such as being a pregnant woman or a child under five—applied repeatedly and expanded over time. This resulted in multiple indistinct waves of exposure, which make it difficult to assign precise treatment timing at the individual or school level. Second, the program generated positive spillovers beyond the directly targeted groups. For instance, school-aged children residing in households or districts reached during the early phases of the intervention likely benefited from both direct access to IBNs and community-wide reductions in malaria transmission. These spillovers violate the stable unit treatment value assumption that is required for identification in staggered DiD models, particularly the no-interference condition (Xu, 2025).

Given these limitations, we adopt a 2x2 DiD design that uses baseline malaria exposure risk (proxied by altitude) and the 2004 national policy shock as our sources of variation. The 2*x*2 DiD regression equation to identify the eradication program's treatment effects for student *i* in region *r* is as follows:

$$Y_{irt} = \alpha + \beta 1 \mathrm{Malaria}_r + \beta_2 \mathrm{Post}_{2004} + \beta 3 (\mathrm{Malaria}_r \times \mathrm{Post}_{2004}) + Xirt' \gamma + \lambda_t + \delta_r + \epsilon_{it} \quad (1)$$

where Y_{irt} is the aggregate performance score of student *i* in region *r* and year *t*. $Malaria_r$ is a binary indicator of regional high malaria prevalence; $Post_{2004}$ is a dummy for post-intervention years; and the interaction term identifies the DiD estimate β_3. The model includes year fixed effects (λ_t), regional fixed effects (δ_r), and student and school covariates (X'_{irt}), including school type (public/private) and candidate status (school/private). Equation 1 is also estimated separately for STEM subjects—physics, chemistry, biology, and mathematics—and arts and business subjects, including history, civics, geography, English language, English literature, Kiswahili, bookkeeping, and commerce.

To assess the impact the malaria eradication intervention had on educational attainment, cohort-based comparisons were constructed from the DHS data. The analysis focuses on individuals aged 7–45 years—a range that reflects the historical pattern of delayed school entry in Tanzania. In 2004, the average age of a Standard I student was 10 years, with some students as old as 24 years, and approximately 6% of students were 18 years or older (see Figure B1 in Appendix B).

For estimation purposes, individuals were classified into three cohorts based on their likely exposure to the intervention: (i) those born after 2004, (ii) those who were preschoolers or school-aged in 2004, and (iii) the full sample of individuals aged 7–45 years. Grouping individuals in this way captures variation in exposure intensity and expected benefits. Individuals born after 2004 were likely exposed to the intervention from the prenatal stage and throughout early childhood and are therefore expected to benefit most from the reduction in malaria burden. In contrast, individuals who were already of school age in 2004 may have experienced early-life malaria exposure, which could have resulted in irreversible developmental or cognitive effects despite reduced exposure in later years.[3]

Consistent with the earlier analysis, we classified individuals living in areas with high malaria risk—which are defined as regions located less than 1,700 meters above sea level—as the treatment group, and those living in low-risk areas (regions located more than 1,700 meters above sea level) as the control group. To mitigate bias introduced by internal migration and to more accurately capture early-life exposure, individuals were assigned malaria risk status based on their location of residence during childhood rather than their current location.

The validity of the DiD approach relies on the parallel trends assumption, which requires that the outcome trajectories of the treated and control groups would have followed similar paths in the absence of treatment. While this assumption is inherently untestable, its plausibility can be assessed empirically. In our case, the availability of only a single pre-intervention period precludes formal testing (e.g., through leads in an event-study specification). We therefore rely on a graphical comparison of mean test scores before and after the intervention, as shown in Figure 6. The similarity that is observed in the groups' pre-intervention outcomes offers some support for the plausibility of the parallel trends assumption.

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[3] This cohort-based analysis could not be replicated using the NECTA data due to the absence of individual-level age information, which prevents grouping students into comparable cohorts.

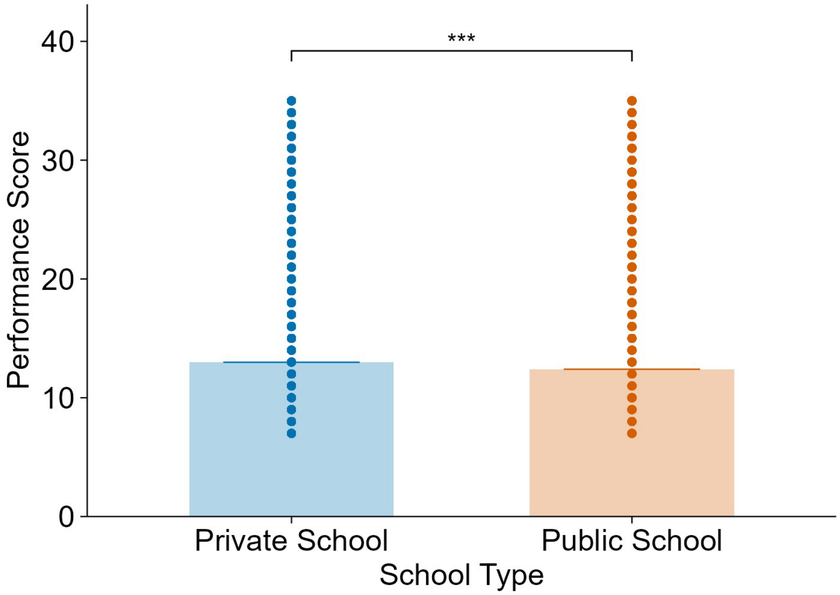
IV. Results

4.1 Descriptive Results

Figures 7 and 8 show the average performance of students in public and private schools and male and female students, respectively. Figure 7 indicates that although the performance difference between students in public and private schools is statistically significant, the gap is not substantially large—approximately one score unit. Students in private schools appear to perform better than those in public schools, which aligns with findings documented in the literature (Delprato and Chudgar, 2018; Parvez and Laxminarayana, 2022; Colaço et al., 2025).

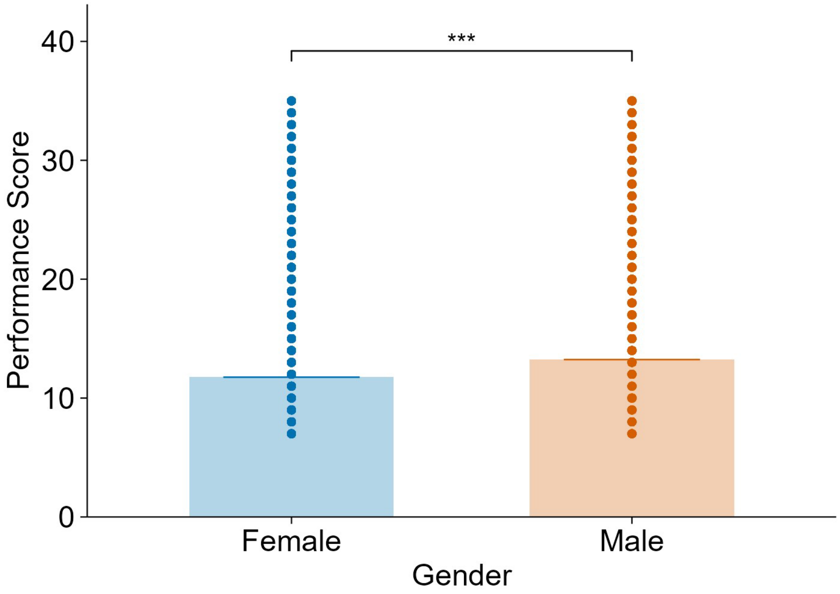
Figure 8 indicates there is a smaller yet significant gender gap in test scores between male and female students that favors male students. Unlike countries in Latin America and the Caribbean, East Asia, and the Pacific, which have achieved gender parity in educational outcomes between boys and girls (Wils and Goujon, 1998; Bruns and Rakotomalala, 2003; Hewett and Lloyd, 2005; Bloom, 2006), a gap persists in Tanzania, which mirrors the situation in many Sub-Saharan African countries (UNESCO, 2015).

Figure 7. Distribution of Aggregate Performance Scores by School Type



Note: The figure plots average performance scores by type of school for the period 2003–2010. The t-test (in asterisks) evaluates whether the difference between the means of the two groups is statistically significant.

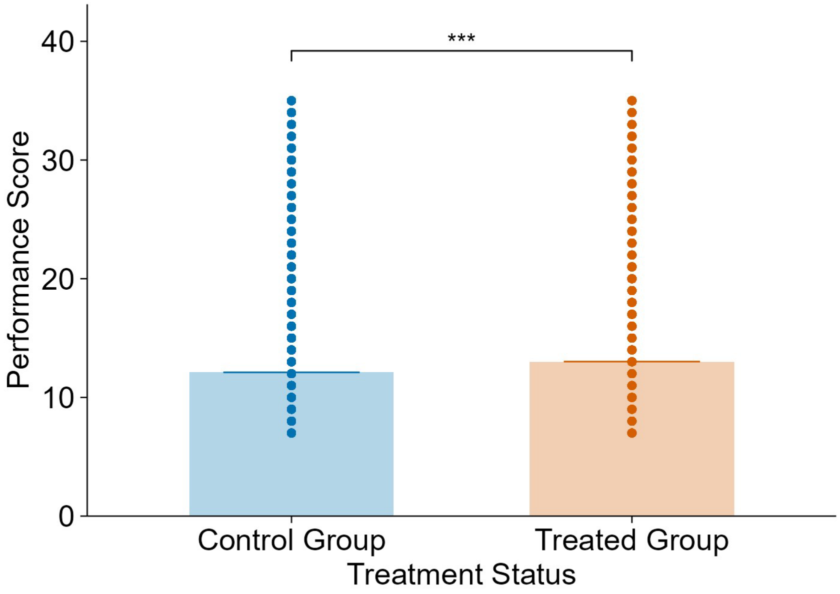
Figure 8. Distribution of Aggregate Performance Scores by Gender



Note: The figure plots students' average performance scores by gender for the period 2003–2010. The t-test (in asterisks) evaluates whether the difference between the means of the two groups is statistically significant.

Figure 9 presents students' average performance scores by treatment group (Treated vs. Control). The results indicate that students in the Treated group performed better on average than those in the Control group, as evidenced by the statistically significant difference in their test scores. The difference in aggregate performance scores that is observed in Figure 9 is suggestive, however, and does not convey any causal inference regarding the impact of the malaria eradication program.

Figure 9. Distribution of Aggregate Performance Scores by Treatment Status

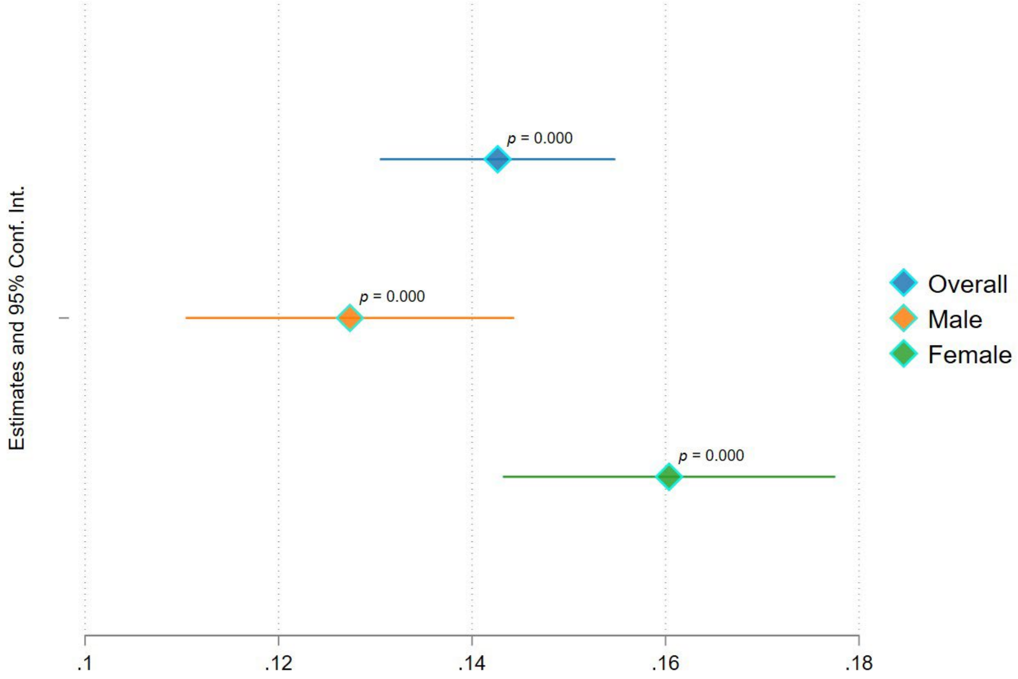


Note: The figure plots students' average performance scores by treatment status (Treated vs. Control) for the period 2003–2010. The t-test (in asterisks) evaluates whether the difference between the means of the two groups is statistically significant.

4.2 Impact Malaria Reduction has on Academic Performance

In this section, we discuss the DiD results regarding the impact reduced malaria exposure has on educational outcomes. Figure 10 presents the impact the Tanzanian malaria eradication program had on lower secondary academic performance. The results were estimated both for the full sample and by gender to assess whether male and female students benefited differently from the program. The results in Figure 10 show the malaria eradication program had a positive effect on student academic performance, which is consistent with reduced exposure to malaria. The program increased performance by 0.14 SDs—which is equivalent to a gain of approximately 0.73 points or 5.8% of the average score (mean score = 12.64)—for the full sample, 0.13 SDs (≈ 0.68 points or 5.4%) for male students, and 0.16 SDs (≈ 0.84 points or 6.6%) for female students. These findings align with evidence from Kenya and Mozambique (Brooker et al., 2013; Cirera et al., 2022).

Figure 10. DiD Coefficients: Impact of Malaria Eradication Program on Academic Performance by Gender

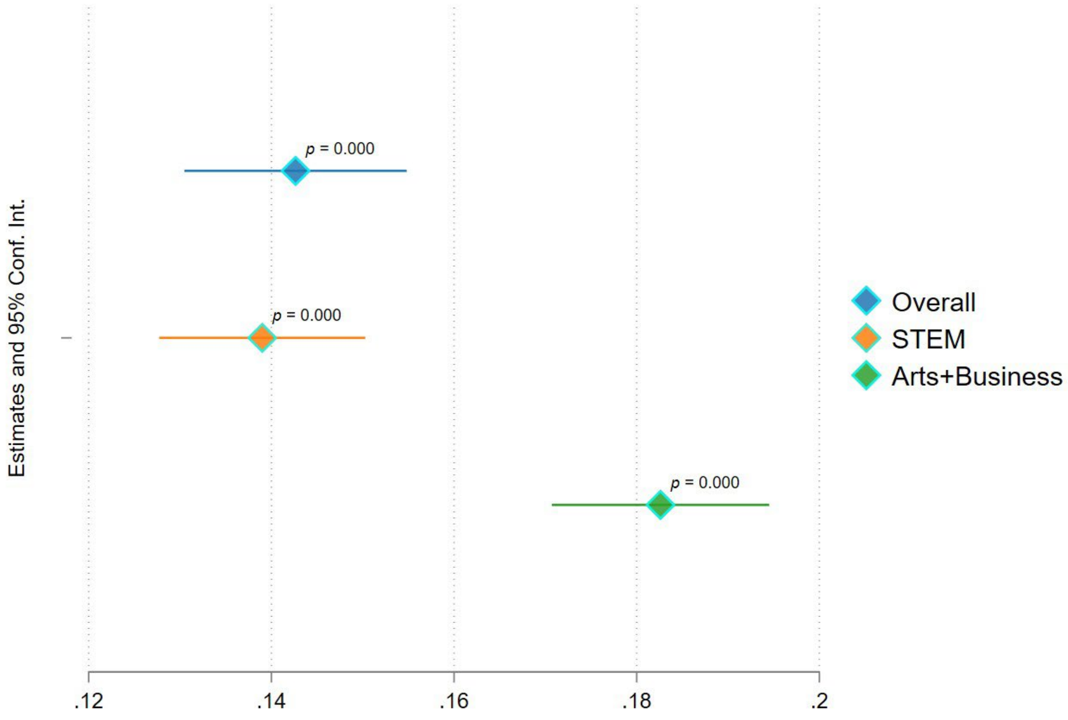


Note: The figure plots the 2x2 DiD regression coefficients estimating the impact the malaria eradication program had on students' performance scores in SDs while controlling for student, school, and community characteristics. The graph was plotted for the full sample of students and disaggregated by gender. Standard errors are robustly corrected for the bias in the variance of the residual that arises under homoskedasticity using a jackknife estimator. The results of the correspondence analysis are presented in Table A2 in Appendix A.

4.2.1 Heterogeneous Effects by Specialization

Due to increased interest in STEM, we explore whether the malaria intervention program had heterogeneous impacts on students' academic performance for STEM subjects and arts and business subjects. The DiD results presented in Figure 11 show that performance scores for arts and business subjects increased more than those for STEM subjects. Student performance in STEM subjects rose by 0.14 SDs (≈ 0.73 points or 5.8% of the mean score), while performance in arts and business subjects increased by 0.18 SDs (≈ 0.94 points or 7.4% of the mean). These differences suggest that reduced malaria exposure may have a stronger effect on performance in subjects that rely more heavily on language and memory skills (see also Table A6 in Appendix A).

Figure 11. DiD Coefficients: Impact of Malaria Eradication Program on Academic Performance by Specialization



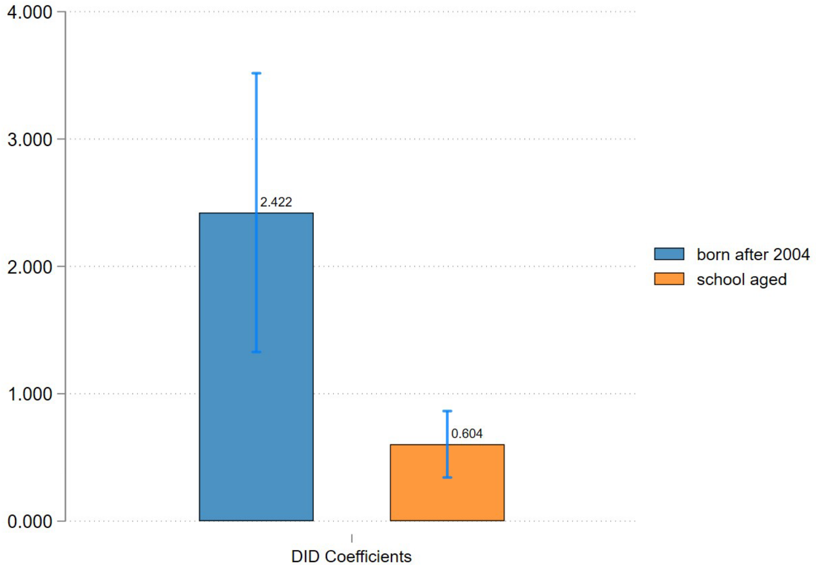
Note: The figure plots the 2x2 DiD regression coefficients showing the impact the malaria eradication program had on STEM and arts and business subject test scores. Standard errors are robustly corrected for the bias in the variance of the residual that arises under homoskedasticity using a jackknife estimator. The results of the correspondence analysis are presented in Table A3 in Appendix A.

4.3 Impact Malaria Reduction has on Educational Attainment

The DiD estimates of the policy intervention's impact are presented in Figure 12. The results are estimated for different cohorts that benefited from the malaria eradication intervention program depending on their intensity of exposure to malaria on the basis of age. The first cohort represents individuals who were born after the 2004 implementation of the policy intervention, and the second cohort includes individuals who were preschoolers or school-aged in 2004.

The results in Figure 12 show the coefficients are positive and significant for both cohorts, which indicates an increase in the number of years of education of individuals with low malaria exposure due to the policy intervention. The point estimate is larger in size for the cohort born after the intervention period, as expected. There is a gain of about 2.4 years of education for this cohort, compared to 0.58 years for preschoolers and school-aged individuals, who benefited from the policy intervention but were exposed to high malaria incidence in utero and in early childhood. The theoretical and empirical literature predicts that children exposed to high malaria incidence during critical growth and development windows, such as while in utero and until the age of five, may be disproportionately more affected than their counterparts who are unexposed or exposed later in life (Milner et al., 2020; De Beaudrap et al., 2016). In utero malaria exposure shapes the infant immune system and increases the risk of getting malaria during childhood (Park et al., 2020; Bauserman et al., 2019; Jagannathan, 2018). Children infected with malaria multiple times during their growth stages due to poor immunity to infectious diseases stand to lose in terms of learning and years of education.

Figure 12. DiD Coefficients: Impact of Malaria Eradication Program on Educational Attainment



Note: The figure displays the 2x2 DiD regression coefficients estimating the impact the malaria eradication program had on students' number of years of schooling. The estimation was conducted for two cohorts: (i) intervention beneficiaries born after 2004 (aged < 19 years) and (ii) intervention beneficiaries who were preschoolers or school-aged in 2004 (aged 19–44 years). The official age for joining Standard I in Tanzania is 7 years old. The comparison uses the 2004 and 2022 editions of the DHS as the baseline and endline databases, respectively. Standard errors are clustered at the regional level.

4.4 Model Identification Threat and Robustness Checks

In this section, we further discuss and provide robustness assessments for the identification of the model specified in Section 3.3. Whereas the DHS results provide detailed information about individual migration status to estimate the impact reduced malaria exposure has on educational attainment, the NECTA administrative records do not. Up to this point, estimation approaches have assumed results are valid even in the presence of migration, which is a strong but uncontrolled assumption. Apart from household migration, which may lead to a student moving from one area to another and is beyond our control due to insufficient information, students may also migrate from one location to another when changing schools. We expect household migration to have limited impact compared to school-change migration, however, given the low rate of household migration and relocation of school-aged children to other regions in Tanzania for non-academic reasons. The majority of migration appears to be at the individual level and among older household members seeking job opportunities or marriage, and other factors.[4]

Most child migration occurs during the transition from primary school to secondary school, as students may be admitted to secondary schools located in different districts and regions. While controlling for the migration of students admitted to private secondary schools is challenging, we can conduct somewhat of a robustness test of our results by restricting the sample to public schools. Admission to public secondary schools is merit-based, and the government allocates students to schools with priority given to students who reside in the district or region where a school is located. Only in exceptional cases, particularly for outstanding performance, are students assigned to schools located in another region, and these students are assigned mainly to special schools. The introduction of the one-school-per-ward initiative in the mid-2000s, which aimed to establish at least one lower secondary school in each ward across the country, reinforced retaining students who passed the PSLE within the district or region by giving them priority access to spots in secondary schools in the same ward or in nearby wards in the same district or region.

Figure 13 presents the DiD point estimates of the impact the malaria eradication program had on students' academic performance by gender with the sample restricted to public schools for robustness. Excluding private schools from the sample does not significantly alter the findings, which remain largely consistent with the main results. The interaction coefficients are positive and significant, similar to those in Figure 10, and range from 0.13 SDs for male students to 0.14 SDs for the full sample and 0.16 SDs for female students. Disaggregating by subject stream (STEM vs. arts and business) reveals similar patterns (see Figure 14). The program increased academic performance 0.14 SD for

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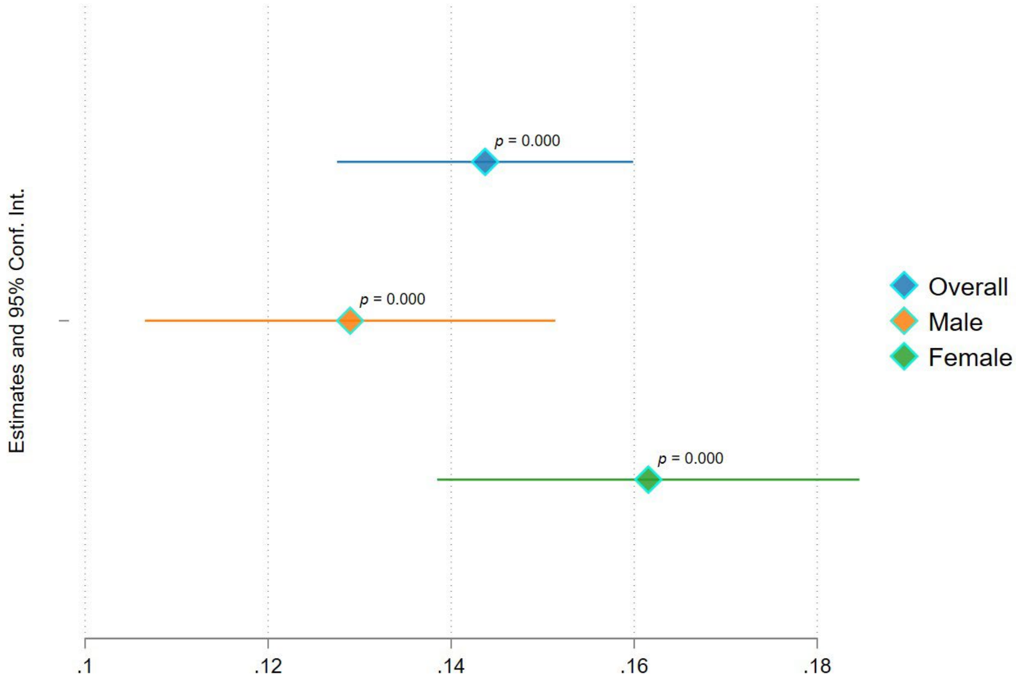
[4] School-aged child migration is rare for the most part.

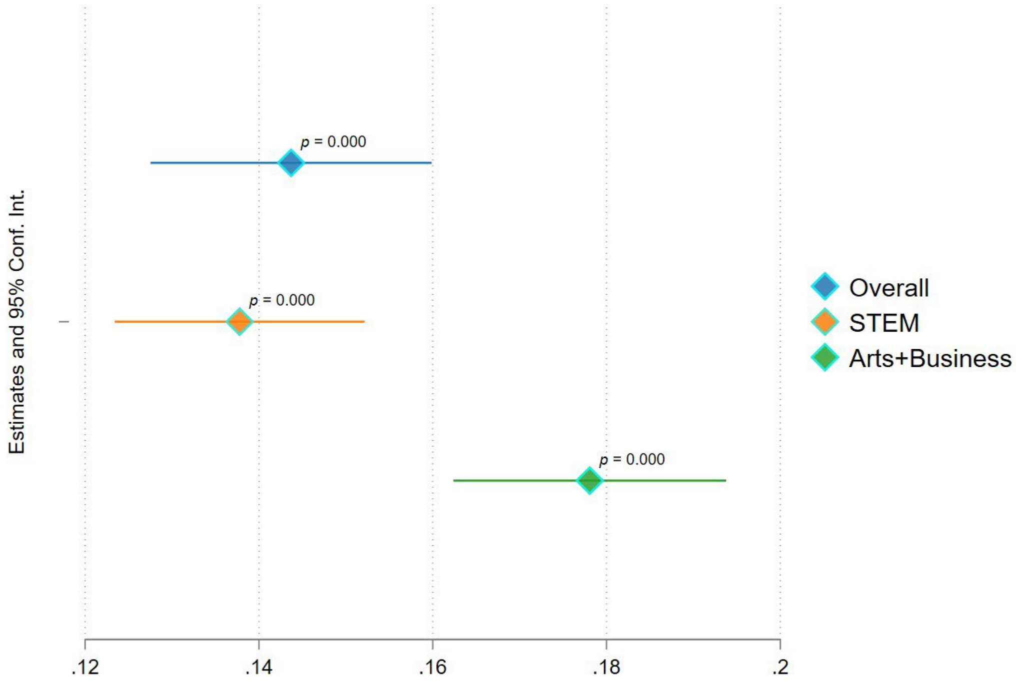
STEM subjects and 0.18 SD for arts and business subjects. These results also remain robust when special schools are excluded from the list of government schools.

Figure 13. DiD Coefficients: Impact of Malaria Eradication Program on Academic Performance by Gender in Public Schools



Note: The figure displays the 2x2 DiD regression coefficients with the sample restricted to public schools for the robustness checks. Standard errors are robustly corrected for the bias in the variance of the residual that arises under homoskedasticity using a jackknife estimator. The results of the correspondence analysis are presented in Table A5 in Appendix A.

Figure 14. DiD Coefficients: Impact of Malaria Eradication Program on Academic Performance by Specialization in Public Schools



Note: The figure displays the 2x2 DiD regression coefficients with the sample restricted to public schools for the robustness checks. Standard errors are robustly corrected for the bias in the variance of the residual that arises under homoskedasticity using a jackknife estimator. The results of the correspondence analysis are presented in Table A6 in Appendix A.

V. Conclusion

This study evaluates the unintended educational impacts of Tanzania's 2004 national malaria eradication program. Using nationally representative administrative data from NECTA and household survey data from the DHS as well as a DiD framework, we find that reduced malaria exposure significantly improved educational outcomes. More specifically, academic performance increased by 0.14 SDs overall (≈ 5.8% of the mean score), with stronger effects for students studying arts and business subjects. Years of schooling also increased, with the cohort born after the intervention was introduced gaining up to 2.4 additional years of education.

Despite the robustness of our identification strategy, several limitations must be acknowledged. First, the NECTA administrative data lack individual migration histories, which may introduce measurement error if students migrated between the treatment and control regions. Second, having only one pre-intervention period (rather than multiple ones) limits our ability to test the parallel trends assumption beyond a graphical analysis. Finally, while basing treatment assignment on altitude is plausibly exogenous, unobserved region-specific shocks correlated with elevation cannot be completely ruled out.

The findings carry important policy implications as they underscore the educational returns of integrated health interventions. The results suggest that cross-sectoral investments—in this case, in malaria control—can yield sizable gains in educational attainment and performance, and highlight the need for education policies to incorporate health as a core component of human capital development. Further evaluations using individual-level panel data or staggered program rollouts across sub-national units represent important areas for future research to strengthen causal attribution.

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VI. Appendix A: Tables

Table A1. Lower Secondary Education Grading System in Tanzania

Grading + Weight			(Total Point Grading System)		
Grade	**Marks (%)**	**Grade Weight**	**Division**	**Score (Cutoff Values)**	**Remarks**
A	75–100	1	I	7–17	Excellent
B	65–74	2	II	18–21	Very Good
C	45–64	3	III	22–25	Good
D	30–44	4	IV	26–33	Satisfactory
F	0–29	5	0	34–35	Fail

Note: The left panel displays the grades for each subject in the Form IV national exam along with their corresponding weights. The sum of the weights for the top seven subjects provides the total score. The best possible score is 7, and the worst, 35. The right panel shows the division classifications that are based on the aggregate score, and their accompanying remarks.

Table A2. Impact of Malaria Eradication Program on Academic Performance by Gender

	(1)	(2)	(3)
	Performance Score		
	Full Sample	**Male**	**Female**
Treatment x Post-Intervention	0.143***	0.127***	0.160***
	(0.006)	(0.009)	(0.009)
Treatment	0.008	0.011	0.004
	(0.006)	(0.008)	(0.008)
Post-Intervention	-0.833***	-0.930***	-0.718***
	(0.006)	(0.008)	(0.008)
School Ownership	-0.083***	-0.071***	-0.097***
	(0.002)	(0.003)	(0.003)
Economic Status (Log GDP)	-0.005	-0.013**	0.003
	(0.004)	(0.006)	(0.005)
Candidate Type	0.489***	0.594***	0.404***
	(0.002)	(0.003)	(0.003)
Gender = Male	0.286***		
	(0.002)		
Location Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
Observations	1236029	667875	568154

Note: The table displays the regression results from the DiD estimation of the impact the Tanzanian malaria eradication program had on academic performance by gender. Column (1) presents the results for the full sample, and Columns (2) and (3) show the results for male and female students, respectively. Robust standard errors are in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table A3. Impact of Malaria Eradication Program on Academic Performance by Specialization

	(1)	(2)	(3)
	Performance Score		
	Full Sample	**STEM**	**Arts + Business**
Treatment x Post-Intervention	0.143***	0.139***	0.183***
	(0.006)	(0.006)	(0.006)
Treatment	0.008	0.008	0.005
	(0.006)	(0.005)	(0.006)
Post-Intervention	-0.833***	-0.375***	-0.747***
	(0.006)	(0.005)	(0.006)
Gender = Male	0.286***	0.285***	0.192***
	(0.002)	(0.002)	(0.002)
School Ownership	-0.083***	-0.056***	-0.055***
	(0.002)	(0.002)	(0.002)
Economic Status (Log GDP)	-0.005	-0.013***	0.017***
	(0.004)	(0.004)	(0.004)
Candidate Type	0.489***	0.414***	0.387***
	(0.002)	(0.003)	(0.003)
Observations	1236029	1203048	1206900
Location Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes

Note: The table displays the regression results from the DiD estimation of the impact the Tanzanian malaria eradication program had on academic performance by specialization. Column (1) presents the results for the full sample, and Columns (2) and (3) show the results for STEM subjects and arts and business subjects, respectively. Robust standard errors are in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table A4. Impact of Malaria Eradication Program on Educational Attainment

	(1)	(2)
	Years of Schooling	
	Born After 2004	School-Aged
Treatment x Post-Intervention	2.422***	0.604***
	(0.558)	(0.133)
Treatment	-0.299***	-0.381***
	(0.034)	(0.095)
Post-Intervention	-1.360***	0.579***
	(0.430)	(0.116)
Gender = Male	0.093**	-0.681***
	(0.045)	(0.072)
Residence = Urban	-0.106	-2.197***
	(0.100)	(0.079)
Household Head Age	0.314***	-0.032***
	(0.003)	(0.003)
Wealth Quintiles		
Poorer	-0.075	0.938***
	(0.062)	(0.084)
Middle	0.010	1.550***
	(0.052)	(0.086)
Richer	0.224***	2.460***
	(0.053)	(0.096)
Richest	0.453***	4.224***
	(0.120)	(0.113)

Location Fixed Effects	Yes	Yes
Observations	21810	55767

Note: The table displays the regression results from the DiD estimation of the impact the Tanzanian malaria eradication program had on educational attainment. Column (1) presents the results for students who were born after the policy was implemented, and Column (2) shows the results for students who were of school age when it was implemented in 2004. Robust standard errors are in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table A5. Robustness Test: Impact of Malaria Eradication Program on Academic Performance by Gender

	(1)	(2)	(3)
	Performance Score		
	Full Sample	Male	Female
Treatment x Post-Intervention	0.144***	0.129***	0.162***
	(0.008)	(0.011)	(0.012)
Treatment	0.015*	0.018*	0.010
	(0.008)	(0.011)	(0.011)
Post-Intervention	-0.145***	-0.213***	-0.138***
	(0.009)	(0.012)	(0.012)
Economic Status (Log GDP)	0.011**	-0.009	0.033***
	(0.005)	(0.008)	(0.007)
Candidate Type	0.460***	0.571***	0.371***
	(0.003)	(0.004)	(0.003)
Gender = Male	0.306***		
	(0.002)		
Location Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
Observations	875747	476588	399159

Note: The table displays the regression results for the robustness check accounting for the effect migration had on the estimates. Column (1) presents the results for the full sample, and Columns (2) and (3) show the results for male and female students, respectively. Robust standard errors are in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

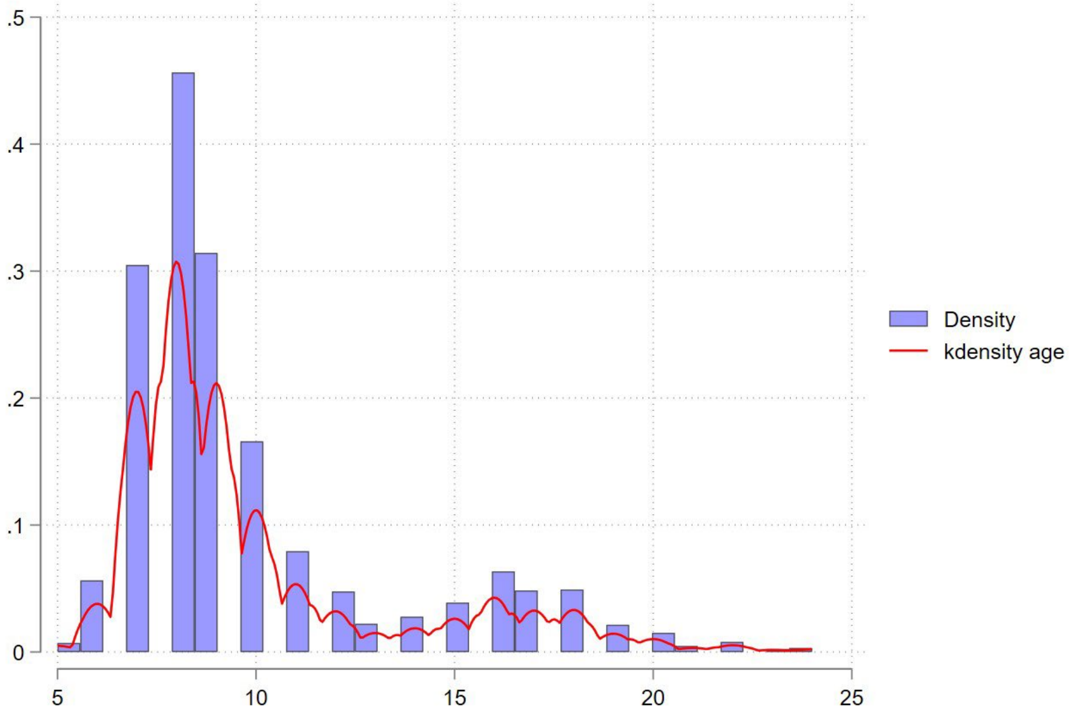
Table A6. Robustness Test: Impact of Malaria Eradication Program on Academic Performance by Specialization

	(1)	(2)	(3)
	Performance Score		
	Full Sample	STEM	Arts + Business
Treatment x Post-Intervention	0.144***	0.138***	0.178***
	(0.008)	(0.007)	(0.008)
Treatment	0.015*	0.015**	0.008
	(0.008)	(0.007)	(0.008)
Post-Intervention	-0.145***	-0.187***	-0.017**
	(0.009)	(0.008)	(0.008)
Gender = Male	0.306***	0.295***	0.212***
	(0.002)	(0.002)	(0.002)
Economic Status (Log GDP)	0.011**	0.001	0.010*
	(0.005)	(0.005)	(0.005)
Candidate Type	0.460***	0.423***	0.356***
	(0.003)	(0.004)	(0.003)
Location Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
Observations	875747	850848	852673

Note: The table displays the regression results for the robustness check accounting for the effect migration had on the estimates. Column (1) presents the results for the full sample, and Columns (2) and (3) show the results for STEM subjects and arts and business subjects, respectively. Robust standard errors are in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

VII.Appendix B: Figures

Figure B1. Age Distribution of Students in Standard I in 2004



Note: The figure depicts the age distribution of students in Standard I in 2004 based on the 2004 Demographic Health Survey. The official age for joining Standard I in Tanzania is 7 years old.