Endline Report 2023

Effectiveness and Scalability of Multifaceted Programs for School Dropout Reduction and Academic Attainment in Bangladesh

SAIST FOUNDATION

IDRC · CRDI

Canada

GPE KIX
KNOWLEDGE INNOVATION EXCHANGE

Published By

Research and Innovation Division
South Asian Institute for Social Transformation (SAIST)
29 West Panthapath, Bir Uttam Kazi Nuruzzaman Road
Dhaka 1205, Bangladesh

Research Team

Dr. U S Rokeya Akhter, Project Leader
Juwel Rana, Country Research Leader
Dr. Imdadul Haque Talukder, Senior Research Fellow
Dr. Mohammad Sazzad Hasan, Senior Research Fellow
Toufica Sultana, Director, Knowledge Dissemination
Helal Uddin, Research Fellow
Ridwana Nahrin, Coordinator, Research & Innovation
Patricia Luna, Research Fellow

Senior Consultant

Prof. Dr. Mohammad Bellal Hossain, University of Dhaka, Bangladesh
Dr. Rakibul Islam, Senior Research Fellow, Monash University, Australia
Prof. Dr. Amm Quamruzzaman, University of California, Berkeley, USA

Design and Layout

Juwel Rana

ACKNOWLEDGEMENT

This endline report is an output from the Bangladesh Team for the consortium project *Effectiveness and Scalability of Programs for Children who are Out of School and At Risk of Dropping Out in Bangladesh, Bhutan, and Nepal* prepared by the South Asian Institute for Social Transformation (SAIST). The project is funded by the Global Partnership for Education (GPE) Knowledge and Innovation Exchange (KIX), and International Development Research Centre (IDRC) to improve inclusive access and learning outcomes for Out-of-School Children (OOSC) and children who are at risk of dropping out. The Bangladesh team is profoundly grateful to GPE KIX and IDRC for their generous financial support of this project. We would like to express our appreciation to all the board members of the SAIST Foundation, as well as to the research team members and data enumerators, for their significant contributions and active participation in the fieldwork. Moreover, we extend our heartfelt gratitude to the Bangladesh Ministry of Primary and Mass Education, and Directorate of Secondary and Higher Education, education officers, as well as school principals, esteemed teachers, school managing committee members, students, and their parents for providing invaluable cooperation and sharing their experiences throughout the study. This project would not have been possible without their generous contribution of time and information.

EXECUTIVE SUMMARY

School dropout remains a significant problem in Bangladesh, despite high enrollment rates in primary education. The country faces a notably poor school completion rate, leading to a substantial number of OOSC. In response to the limitations of existing policies, and programs for OOSC and children at risk of dropping out, the SAIST Foundation has embarked on an ambitious project titled, *Effectiveness and Scalability of Programs for Children Who Are Out of School and at Risk of Dropping Out in Bangladesh*. This project aimed to identify risk factors and develop scalable policies and programs. It involved designing and implementing multifaceted programs to mitigate dropout risks, address learning losses in math and science, and provide access to quality education. The study employed a quasi-experimental design and a target trial framework, utilizing appropriate analytic methods to evaluate the effectiveness of these multifaceted programs. It focused on risk of school dropout, science and math performance, and the cost-effectiveness and benefits of the interventions. Moreover, the study assessed the generalizability, transportability, and potential for national scale-up of these interventions. The multifaceted interventions were implemented at multiple levels, targeting students, teachers, schools, parents and community.

Effectiveness of Interventions on School Dropout

- Our multifaceted programs averted 11 to 13 percent risk of school dropout among treated school students compared to controlled school students.

- Dropout risk escalates among students from poor households and higher grades, with boys being more vulnerable than girls. Consequently, interventions proved more effective in high school students than in primary school students.

- Student-level Average Treatment Effect among Treated (ATT) also showed similar but slightly lower (11%) impact of interventions in reducing risk of school dropout.

Effectiveness of Interventions on STEM Educational Attainment

- Overall, the multifaceted programs successfully enhanced students' performance in Science, Technology, Engineering and Mathematics (STEM) education, leading to a notable increase of 6.80 points in math scores and 7.48 points in science scores (out of 100).

Gender Equality and Social Inclusion (GESI)

- We have observed disparities in school dropout risk reduction in terms of GESI indicators including household wealth index, sex of child, nutritional status, functional difficulties, bullying in school, access to internet and smartphone usage for study. The heterogeneous impact of programs was statistically significant only by household wealth index.

- For STEM educational attainment, we did not observe any statistical evidence of heterogeneity of programs impact by GESI indicators except for extra tuition support.

- It is evident that students with both SAIST supplementary tutoring support and extra tuition by parents performed substantially better in STEM subjects than the students who did not get support from our programs and had no extra tuition support.

Cost-Effectiveness and Cost Benefit Analysis

- The overall out-of-pocket (OOP) educational expenses per student during the intervention period was Bangladeshi Taka (BDT) 26,217.67, which is lower than the control group students (BDT 30854.33) and higher than the government annual expenditure.

- The Incremental Cost Effectiveness Ratios (ICERs) were BDT 565.33 per percentage point reduction in school dropout risk, BDT 939 for each additional point increase in mathematics scores, and BDT 854 for each point improvement in science scores.

- The Cost-Benefit Ratio (CBR) indicates that for every 1 BDT invested, the return in terms of increased future earnings is about 6.41 to 9.78 BDT for school dropout reduction and approximately 7.19 to 14.89 BDT for STEM education.

Generalizability, Transportability, and Scalability

- We generalized and transported the effects of the multifaceted programs to the target and transportable populations, taking into account differences in sex, grades, and the interaction between sex and grades.

- Effect estimates for school dropout, and STEM educational attainment were generalizable to target population (25,291,450 students, Grades 1 to 9 in 2022) after accounting for differences in Sex, Grades and Sex-Grades.

- Effect estimates for school dropout and STEM educational attainment were also transportable to a sub-population with differing settings and characteristics in Dinajpur (involving 540 students from Grades 1 to 9 in 2023). Additionally, the ATT demonstrated higher precision when adjusted for differences by sex, grades, and the interaction between sex and grades.

- The impact of the short-term multifaceted programs was scalable on a broader scale. When we extrapolated these results for hypothetical long-term interventions at the national level, there was a significant reduction in school dropout rates (approximately 75%).

Our study suggests that well-designed and properly implemented multifaceted programs have successfully reduced the risk of school dropout and improved STEM educational attainment among students from marginalized communities. Furthermore, these effects were not only cost-effective and beneficial in the long term, but also generalizable, transportable, and scalable at the national level. The study's impacts can be interpreted causally due to its high internal and external validity.

TABLE OF CONTENTS

Introduction **12**

1.0 Background . . . 12

1.1 Theory of Change . . . 15

1.2 Objectives . . . 16

Study Design and Multifaceted Programs **17**

2.0 Quasi-Experimental Design . . . 17

2.1 Household, Parents and Student Recruitment . . . 18

2.2 Multifaceted Programs . . . 18

2.2.1 Tracking OOSC and at Risk of School Dropout Students . . . 20

2.2.2 Parents-Teachers Meetings and Motivational Campaigns at Community . . . 20

2.2.3 Capacity Building of Teachers and Campaigns on STEM Education . . . 20

2.2.4 Remedial Learning Support and Blended Teaching Approach 21

2.2.5 Supplementary Programs . . . 22

2.3 Endline Survey . . . 22

2.4 Data Analysis and Reporting . . . 23

2.5 Ethical Consideration . . . 26

2.6 Attrition, Compliance, and Spillover Effect . . . 27

Effectiveness of Interventions on School Dropout **28**

3.0 Rationale . . . 28

3.1 Program Activities . . . 29

3.1.1 Experiential and Blended Teaching Capacity Building . . . 29

3.1.2 School-Based Programs for Students . . . 30

3.1.3 Community Engagement . . . 30

3.2 Predictors of Intervention Impact on School Dropout . . . 31

3.3 School-level Effectiveness of Intervention on Dropout . . . 32

3.4 Student-level Effectiveness of Interventions on School Dropout . . . 34
3.5 Discussion and Conclusion . . . 34

Effectiveness of Intervention on STEM Education 37
4.0 Rationale . . . 37
4.1 Program Activities . . . 38
4.2 Predictors of Intervention Impact on STEM . . . 39
4.3 Student-level Effectiveness of Intervention on STEM Education . . . 40
4.4 Discussion and Conclusion . . . 41

Gender Equality and Social Inclusion 42
5.0 Rationale . . . 42
5.1 Programs and Methods . . . 45
5.2 Disparities in Risk of School Dropout Reduction . . . 45
5.3 Disparities in STEM Educational Attainment . . . 47
5.4 Discussion and Conclusion . . . 47

Cost-Effectiveness and Benefit Analysis 51
6.0 Rationale . . . 51
6.1 Data Source and Cost Calculation . . . 52
6.2 Cost-Effectiveness Analysis . . . 52
6.3 Out-Of-Pocket Educational Expenses . . . 53
6.4 Cost-Effectiveness Analysis . . . 54
6.5 Cost-Benefit Ratio . . . 55
6.6 Discussion and Conclusion . . . 57

Generalizability, Transportability, and Scalability 59
7.0 Rationale . . . 59
7.1 Methods . . . 59
7.2 Comparison of Study and Target Population . . . 62
7.3 Impact of Multifaceted Programs and Generalizability . . . 62

7.4 Impact of Multifaceted Programs and Transportability 63
7.5 Generalizability and Transportability 65
7.6 Impact of Multifaceted Programs and Scalability 66

Conclusion and Policy Implication **69**
8.0 Strengths and Limitations 69
8.1 Conclusion 69
8.2 Policy Implications 70

LIST OF TABLES

Table	Page
Table 1: Components of the Multifaceted Programs	19
Table 2: Study Sample and Instruments	23
Table 3: Analytic Strategies and Objectives	24
Table 4: Program Trial Emulation Framework	25
Table 5: Out-Of-Pocket Educational Expenses	53
Table 6: ICER of Multifaceted Programs On School Dropout and STEM Education	54
Table 7: Cost-Benefit Analysis of Educational Outcomes	56
Table 8: Characteristics of SAIST Cohort Participants and Students in Bangladesh in 2022	60
Table 9: Generalizability of Impact on National Student Population in Bangladesh in 2022	61
Table 10: Characteristics of Transportable Population in Dinajpur in 2023	63
Table 11: Transportability of Impact on Students in Dinajpur in 2023	64

LIST OF FIGURES

Figure	Page
Figure 1: Conceptual Framework	14
Figure 2: Theory of Change	16
Figure 3: Map of the Treatment and Control Area	17
Figure 4: Timeline of the Project Implementation	18
Figure 5: Relative Importance of Factors Associated with Intervention Impact	31
Figure 6: School-level Effectiveness of Interventions on Risk of Dropout (Raw Data)	32
Figure 7: School-level Effectiveness of Interventions on Risk of Dropout	33
Figure 8: Student-level Effectiveness of Interventions on Risk of Dropout	34
Figure 9: Relative Importance of Factors Associated with Intervention Impact on STEM	39
Figure 10: Student-level Effectiveness of Interventions on STEM Education	40
Figure 11: Disparities in Risk of School Dropout Reduction	44
Figure 12: Disparities in Math Score	46
Figure 13: Disparities in Science Score	48
Figure 14: Simple Schematic of the Multistage Markov Model of Progression between Risk of Dropout States	66
Figure 15A: Long-Term Impact and Scalability of Intervention among Treated	67
Figure 15B: Long-Term Impact and Scalability of Intervention among Treated	68

LIST OF ABBREVIATIONS

Abbreviation	Elaboration
ATT	Average Treatment Effect among Treated
BANBEIS	Bangladesh Bureau of Education Information and Statistics
BIDS	Bangladesh Institute of Development Studies
CBR	Cost-Benefit Ratio
CEA	Cost-Effectiveness Analysis
CLR	Confidence Limit Ratio
CSA	Chronic School Absenteeism
cSTM	Cohort State Transition Model
DNCC	Dhaka North City Corporation
DSCC	Dhaka South City Corporation
ECA	Extra-Curricular Activities
FGD	Focused Group Discussion
FW	Future Wages
GDP	Gross Domestic Product
GEE	Generalized Estimating Equations
GESI	Gender Equality and Social Inclusion
GSHS	Global School-based Student Health Survey
GPE	Global Partnership for Education
GSC	Generalized Synthetic Controls
ICERs	Incremental Cost Effectiveness Ratios
ICT	Information and Communication Technology
IDI	In-depth Interviews
IDRC	International Development Research Centre
IPTW	Inverse Probability Treatment Weighting
IPW	Inverse Probability Weighting
IOTW	Inverse Odds of Transportability Weights
IOW	Inverse Odds of Weighting
KIX	Knowledge and Innovation Exchange
LMICs	Low- and Middle-Income Countries
MPO	Monthly Payment Order
NEP	National Education Policy
OOSC	Out-Of-School Children
OOP	Out-Of-Pocket
PTM	Parents-Teachers Meeting
PEDP	Primary Education Development Programme
RCT	Randomized Control Trial
SAIST	South Asian Institute for Social Transformation
SDG	Sustainable Development Goals
SHAP	SHapley Additive exPlanations
STEM	Science Technology Engineering and Mathematics
SCM	Synthetic Control Method
TIMSS	Trends in International Mathematics and Science Study
UNICEF	United Nations Children's Fund

CHAPTER ONE

Introduction

1.0 Background

Education has always been a critical tool for the development of any country's generation to reach its maximum potential. Additionally, education serves as the primary catalyst in social growth and development from personal life to national, regional, and global scales. The education system is also linked to the national health and health system, health behavior, life expectancy, gender equality, and gross national wealth. Similarly, with the growth of the national economy, education has an imperative consequence for admitting young adults into the national and global workforce with different benefits in terms of social, health, and productive careers. However, these all-developmental aspects and opportunities may be hampered due to the negative consequence of student's dropout.

Hence, school dropout has become a serious concern for policymakers, educators, and the general population, as the school dropout rates are higher globally, rendering a large proportion of the population unable to enter the global and national labor markets. Although the school dropout rate varies broadly even across developed countries, the situation is more shocking in Low- and Middle-Income Countries (LMICs) particularly countries in South Asia. For example, 430 million students in South Asia face educational disadvantages at all levels due to school closures during COVID-19 (UNICEF 2021b). Consequently, an additional ten million girls are at higher risk of child marriage. Before the COVID-19 pandemic, more than 35 million children did not attend pre-primary education (UNICEF 2019), while after the pandemic, only 69% had access to early childhood education (UNICEF 2021a). As many South Asian countries have similar socioeconomic characteristics, the school dropout rate is higher due to identical causes (Haseeb 2021).

However, school dropout is a serious concern in Bangladesh despite high enrollment rate. For example, according to the Bangladesh Bureau of Education Information and Statistics (BANBEIS), the dropout rate for primary schools in Bangladesh was 18.5% in 2017, while the dropout rate for secondary schools was even higher (27.5%). Nearly seven out of ten children (e.g., 4.6 million) between the ages of lower secondary and upper secondary—are not enrolled in school (UNICEF Bangladesh 2020). These rates have remained relatively consistent over the past few years. The proportion of children who finish a level of schooling is influenced by regional and socioeconomic differences. Nearly half of the students who do not finish each level of education are children who live in Dhaka and Chattogram (UNICEF Bangladesh 2020).

Bangladesh is one of the most populated countries in the world, with 160 million population, and covers a large number of urban populations. As per the 2022 census, a total of 52,009,072 people live in urban areas (Dhaka Tribune 2019). Approximately 40% of them are children. The dropout rate among slum children in Dhaka has become a significant concern. For example, according to a study conducted by the Bangladesh Institute of Development Studies (BIDS), the dropout rate among slum children in Dhaka city is significantly higher than the national average, with a 35% dropout rate in primary school and 45% among secondary school children (BIDS 2014).

There are several factors why the dropout rate among slum children in Dhaka is so high, including a higher level of poverty. Many families living in Dhaka slums are unable to afford the cost of education for their children, which forces children to drop out of school and engage in income-generating activities to provide family support (Quattri and Watkins 2019). Additionally, the poor living conditions in slum areas are another prime factor contributing to higher dropout rates which makes children more susceptible to illnesses and resulting in absenteeism (Smita, Rabbi, and Mohammad 2020). Another factor that contributes to high dropout rates among slum children is the lack of access to quality education. Most of the schools in slum areas are overcrowded and under-resourced, which creates more challenges and difficulties for children to learn and stay engaged in their studies (Farah, Karim, and Afrin 2019). Furthermore, slum children lack educational support compared to children from affluent families, which can also be a significant factor for higher dropout.

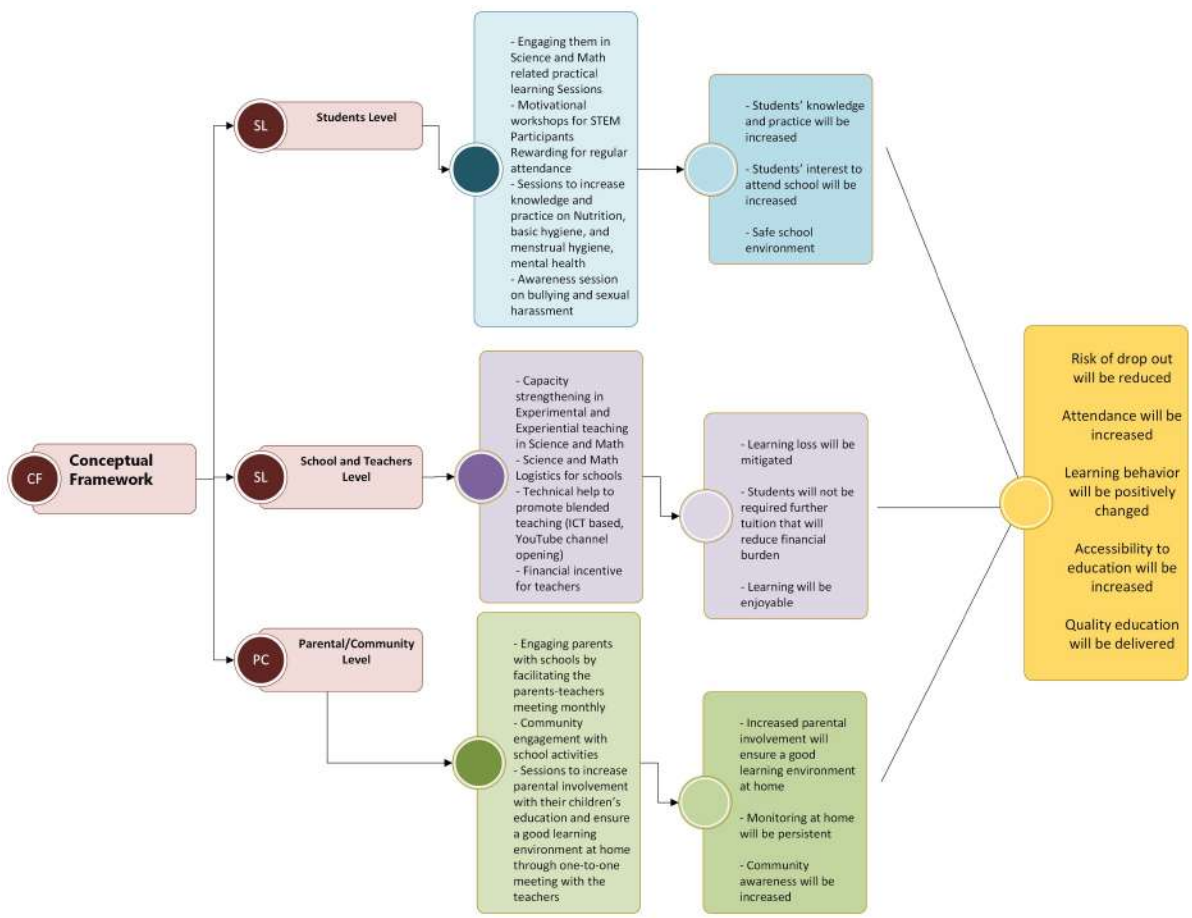
Despite these challenges, there have been efforts to address the problem of high dropout rates among slum children in Dhaka. The government has implemented different programs to provide financial assistance to poor families to meet the cost of education for their children. Additionally, there have been efforts to improve the quality of education in slums by building new schools and hiring additional teachers. However, many of these efforts have not been as sustainable and effective as presumed.

Regarding these initiatives (activities, practices, and approaches) and considering the limitation of existing interventions targeted at OOSC and children at risk of dropping out, the SAIST Foundation, an emerging nonprofit organization in Bangladesh, has been actively working to implement the project of *Effectiveness and Scalability of Programs for Children Who Are Out of School and at Risk of Dropping Out in Bangladesh, Bhutan, and Nepal* in Bangladesh. The IDRC, the GPE KIX have funded the project intending to help LMICs improve their educational system and obtain sustainable developmental goal (SDG) 4.

SAIST foundation, therefore, aimed to identify the factors working behind the risk of dropout and STEM educational attainment among the slum children studying at 8 schools of Dhaka South and North City Corporations. Identifying the factors, efficient and effective multifaceted programs were planned and implemented that were expected to potentially provide the children access to quality education in treated students through the IDRC-funded

2021-2023 project. The nature of the study was evaluative action research that examined the schemes for the OOSC and at risk of dropout in the country, assessed its potentiality for scalability, and contributed to capacity building of stakeholders who directly engage in adopting, implementing, continuing, and scaling these initiatives for the future. Following the conceptual framework **(Figure 1)**, SAIST targeted to reduce the risk of dropout in the primary and secondary schools of these two slum areas by intervening both at the school and community levels.

Figure 1: Conceptual Framework



The 10-month interventions contributed to preventing the risk of dropout by reducing absenteeism caused by multiple factors at the student, school/teacher, parental and community levels. Furthermore, this study also enhanced inclusive access to learning opportunities for all children in the selected slum areas, as well as improved access to quality education through strengthening the experimental and experiential teaching capacity of the teachers. SAIST's study also facilitated blended learning that offered students to access learning materials from anywhere. Besides focusing on strengthening teachers' capacity, parental involvement was also emphasized. The intention is to not only enhance enrollment and retention rates but also empower stakeholders to drive positive changes in education. Hence, through these interventions, the project envisioned a significant and positive impact on the educational landscape for OOSC children in Bangladesh.

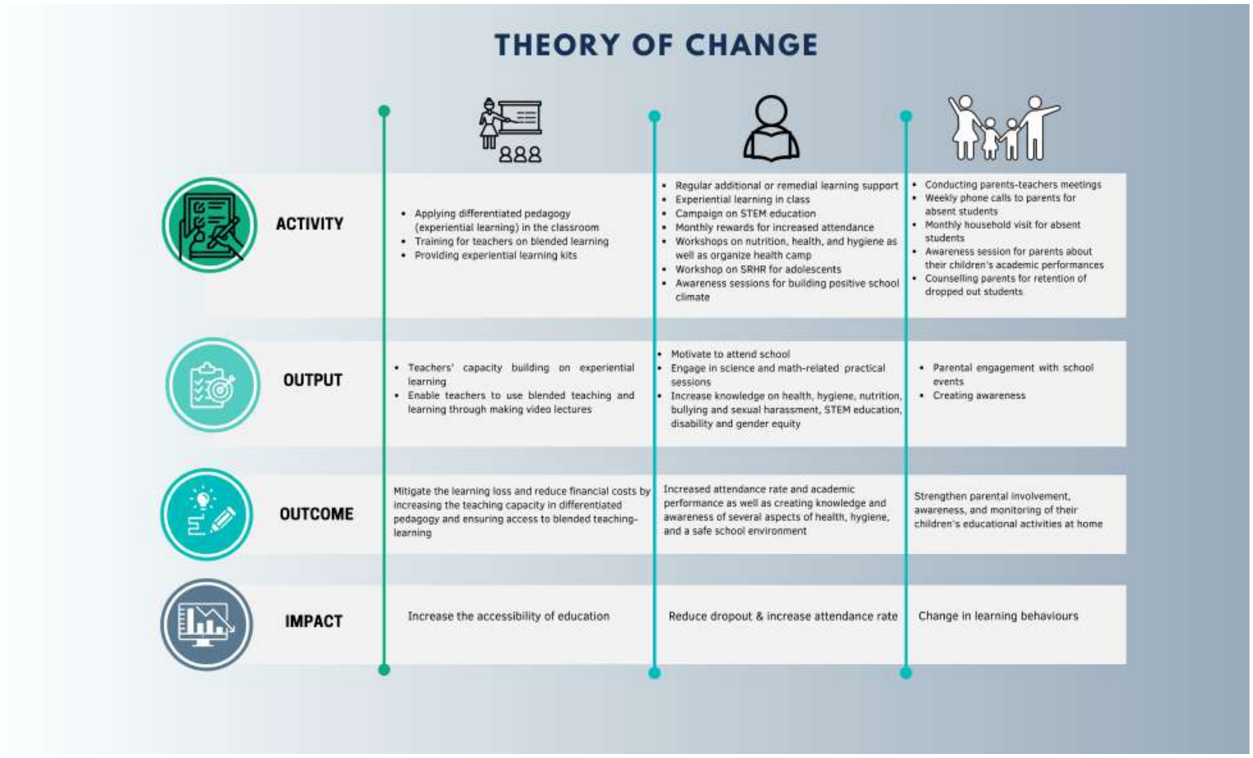
1.1 Theory of Change

The interventions were designed to promote gender-sensitive, equitable, and inclusive education for Out-Of-School Children (OOSC) and those at risk of dropping out in targeted schools. Given their multifaceted nature, the projected outcomes align with each level of intervention. For instance, at the parental and community level, the goal was to strengthen parental involvement, awareness, and monitoring of their children's educational activities at home. At the school and teacher level, the aim was to mitigate learning loss and reduce financial costs by enhancing experimental and experiential teaching capacities and ensuring access to Information and Communication Technology (ICT)-based blended teaching. Lastly, at the student level, the interventions sought to increase attendance rates and academic performance, and to foster knowledge and awareness about various health, hygiene, and positive school environment aspects.

To achieve the expected outcomes, the SAIST team implemented several activities at the student, school and teacher, and parents and community levels. These activities included providing award and educational materials, science and math kits, arranging workshops and awareness sessions, monitoring attendance, parent-teacher meetings, parental involvement in school activities, and helping to implement experiential teaching in science and math along with blending teaching-learning.

Moreover, within the framework of project objectives, this report seeks to answer the following research questions: do the interventions designed for school and teacher level, student level, parent, and community levels have an effective impact on reducing school dropout? Are these interventions cost-effective for increasing attendance rate and grade and feasible to scale up? How the study ensured the GESI component through the interventions. Considering these questions, this report included a total of nine sections. These are the following: Section One provided the background, rationale, and objectives of the study; Section Two described the study design and multifaceted programs; Section Three discussed the impact of interventions on school dropout; Section Four talked about the effectiveness of interventions on math and science performance, Section Five dealt with GESI component; Section Six provided cost-effective and cost-benefit analysis; Section Seven was about generalizability, transportability and scalability to test the affordability and potential to scale-up of the interventions; and finally Section Eight offered overall concluding remarks and policy implications.

Figure 2: Theory of Change



1.2 Objectives

The main aim of this research project was to strengthen educational opportunities for children who are currently out of school or at risk of dropping out. Additionally, the study's focus was also mapping effective multifaceted strategies and practices that can overcome barriers to gender-sensitive, inclusive and quality education. Considering the broad objective, the study had significant specific objectives. These are the following:

i. To identify the factors associated with risk of school dropout

ii. To design and implement multifaceted programs to reduce OOSC and children at risk of dropping out from school

iii. To design and implement multifaceted programs to minimize learning loss and improve STEM educational attainment

iv. To measure the scalability of the multifaceted programs by evaluating cost-effectiveness, generalizability and transportability of the interventions for scaling up at the national level

v. To ensure inclusive access to learning opportunities for school children from the marginalized communities as well as improved access to quality education

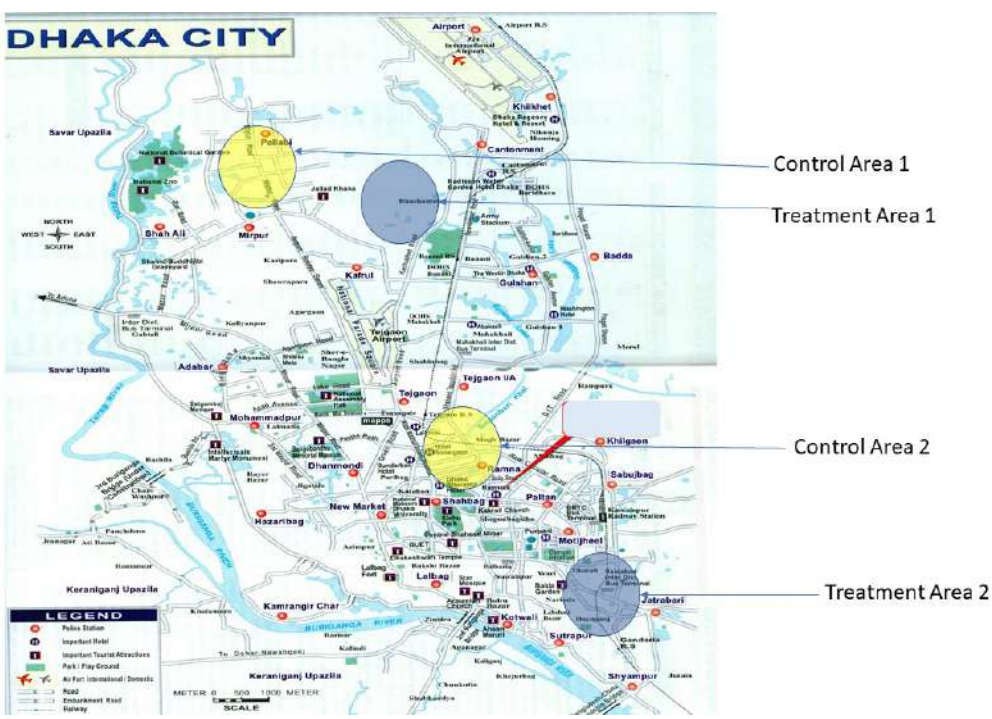
CHAPTER TWO

Study Design and Multifaceted Programs

2.0 Quasi-Experimental Design

The study employed a quasi-experimental design with mixed methods, integrating quantitative and qualitative techniques. Initially, a scoping review of existing policies and programs (2000-2021) aimed at reducing school dropout in Bangladesh was conducted. This review helped identify modifiable and scalable programs suitable for the local context. Four large slum areas in Dhaka City were then selected as marginalized communities for this study. The selection was based on specific inclusion criteria and similarities among the areas, such as their size, population, and the proximity of public primary and secondary schools within a 2-kilometer radius. The selected areas were the Kajlarpar and Boro Moghbazar slum areas from Dhaka South City Corporation (DSCC), and the Bhasantek and Rupnagar Slum areas from Dhaka North City Corporation (DNCC). In each of these four areas, one public primary school (preprimary to grade 5) and one secondary school (grades 6 to 10) operating under the Monthly Payment Order (MPO) system were identified as eligible, totaling four primary and four secondary schools across all areas **(Figure 3)**.

Figure 3: Map of the Treatment and Control Area

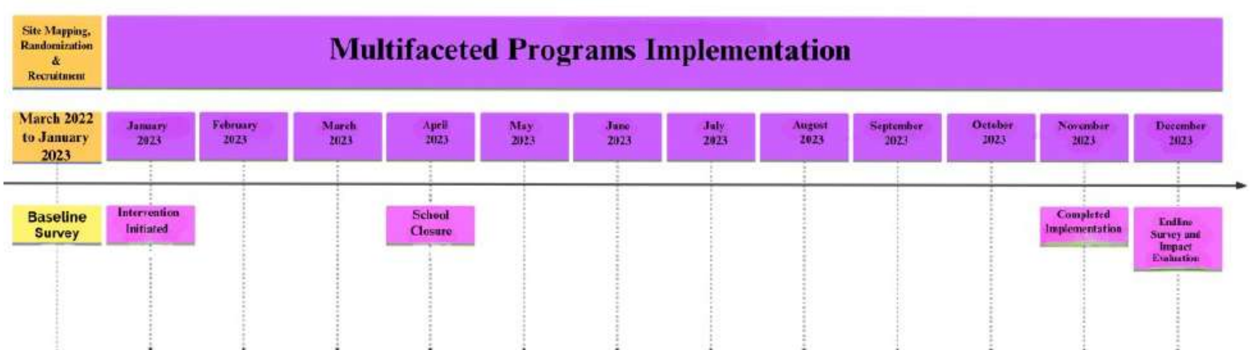


Using a cluster randomization technique, one primary and one secondary school from each of these areas (from both DNCC and DSCC) were randomly assigned to either receive multifaceted intervention developed by SAIST or no intervention. After the random assignment of school-level treatment strategies, we identified two categories of students in both the treatment and control schools: those who were out of school children (OOSC) and those at risk of dropout. Eligible OOSC were defined as those who were enrolled in January 2022 but then absent from March 2022 to next six consecutive months. Separately, eligible students at risk of dropout were identified as those having a monthly absence rate of 10% or more, starting from March 2022. School year in 2022 was started from March because classes were resumed after school closure due to COVID-19 pandemic. These criteria were applied to students ranging from preprimary to grade 8 in the year 2022 and a total of 1040 students across the schools (~130 from each school) were identified for this study.

2.1 Household, Parents and Student Recruitment

Between September 10 and October 20, 2022, the SAIST team gathered contact information from schools and verified the addresses of selected students over the phone, explaining the study objectives. From October 21 to November 30, 2022, the team visited each household, engaged with parents and community members to discuss the study objectives, and build rapport for future steps. Finally, SAIST team was able to recruit 1026 parents and students while 14 parents were non-reachable/declined to join the study **(Figure 4).**

Figure 4: Timeline of the Project Implementation



2.2 Multifaceted Programs

Multifaceted programs were implemented over 10 months on 19 math and science teachers and 619 students studying in grade 1 to grade 9 in 2023 in four treatment schools who were OOSC and at risk of dropout as well as on parents/communities of the treated students **(Figure 4)**. The programs were implemented in three tiers (teacher level, student level, and parental and community level), which were planned to reduce risk of school dropout, improve educational attainment in STEM related subjects, and perception and behavior of the teachers, students, and parents.

Table 1: Components of the Multifaceted Programs

Outcomes	Components of Multifaceted Interventions
Risk of School Dropout	• Weekly absenteeism tracking through school registers • Weekly phone calls to parents for absent students • Monthly household visit for absent students • Awareness sessions with parents about their children's absenteeism • Monitoring attendance at student level through attendance tracker cards monthly • Monthly rewards for increased attendance
STEM Education Performance	• Training on differentiated pedagogy and individualized learning in the classroom through experiential learning • Regular weekly supplementary/remedial learning support for STEM subjects in the school and community • Quarterly catch-up classes, and extra tutoring support around examinations • Campaign on STEM education (math and science) • Providing experiential learning kits for STEM subjects • Training for teachers on blended learning • Preparing video lectures as part of blended learning • Awareness session for parents about their children's academic performances
Behaviour and Perception	• Parents-teacher meeting • Creating student friendly classroom environment through positive relationships between teachers and students • Creating positive school climate through awareness sessions and workshop on, bullying, sexual harassment, disability, and gender equity • Counselling parents for retention of dropped out students • Sexual and reproductive health activities, such as menstrual hygiene management sessions for adolescent girls • Awareness sessions on health, hygiene, and nutrition for all the students • Awareness session for parents about their children's health and hygiene, and child marriage • Counselling and financial support for out-of-school students to bring them back

2.2.1 Tracking OOSC and at Risk of School Dropout Students

Tracking OOSC and students at risk of dropout by monitoring school registers, attendance tracker cards, phone calls, and household visits aims to address and reduce school absenteeism. The overarching goal of this program is to enhance regular attendance and, consequently, improve overall student engagement and learning loss reduction. By implementing a comprehensive tracking system, the initiative seeks to create a proactive and personalized approach to monitor and tackle risk of dropout. The students were provided an attendance card to track their monthly attendance. It was required to collect parents and teachers' signatures on the cards, which were checked every month by two teaching fellows. Weekly phone calls were made to parents regarding absenteeism of their child that allowed quick identification and resolution of issues related to absenteeism. Moreover, SAIST has implemented home visits to gain a deeper insight into the environments where students reside. This allows us to work closely with parents or guardians to overcome any obstacles that might hinder regular attendance. Consequently, the initiative is focused on developing a proactive and tailored strategy to effectively reduce absenteeism.

2.2.2 Parents-Teachers Meetings and Motivational Campaigns at Community

Organizing the Parents-Teachers Meeting (PTM) once every year is mandatory for schools, according to the National Education Policy 2010 (NEP). SAIST initiative scaled up the frequency by conducting four PTMs every year in each school. The primary aim of this program was to create a supportive and interactive platform where parents and teachers can engage in meaningful discussions about the progress, development, and well-being of the students. The overarching goal was to foster motivation among parents through targeted community visits, establishing connections, and bridging the information gap with schools to enhance awareness of their children's educational status. Parents gained insights about their child's academic performance, behavior, and overall growth, while teachers receive valuable input from parents regarding the child's home environment and individual needs. This two-way communication fostered a holistic understanding of the students.

2.2.3 Capacity Building of Teachers and Campaigns on STEM Education

These programs aimed to foster experiential and experimental learning and discover real-world applications for the students by conducting months-long capacity building training on differentiated pedagogy by master trainers and assistance for the math and science teachers. Additionally, we provided STEM Kits to demonstrate grade-specific science and math lessons in classroom and our teaching fellows helped teachers in demonstrating science and math concepts in classroom using those Kits. SAIST also organized campaigns on STEM education and science fairs in treated schools. Experiential and experimental learning pedagogy enhances the quality of education by encouraging critical thinking, problem-solving, and the practical application of theoretical knowledge, minimizing fear of math and science as well as reducing learning loss. By bridging the gap between classroom instruction and real-world scenarios, the program aspires to support students in classroom learning, so that they don't need additional private tuition. Another reason was to prepare them for the challenges and opportunities of a rapidly evolving global landscape.

The initiatives emphasized gender inclusive STEM education, offered professional development for teachers, and integrated technology into the learning process. The program empowered students to minimize fear and aspire about science and math lessons and enabled teachers to demonstrate experiential teaching pedagogy. SAIST thus met project objectives of building knowledge about innovative practices and strategies addressing barriers to inclusive access to education and better learning outcomes for children at risk of dropping. Furthermore, we built capacity of key stakeholders to generate, use and exchange knowledge and practices that promote inclusive access. National Education Board revised the curriculum and came up with National Curriculum Framework 2021 where experiential learning was appreciated. A gradual application of the curriculum is expected by 2024. The National Education Policy 2010 focuses on inclusive and equitable quality education and lifelong learning opportunities for all, which aligns with the Government's Delta plan. Since this initiative aligns with the government's plan, we received support in different phases of the implementation.

2.2.4 Remedial Learning Support and Blended Teaching Approach

The remedial learning support and blended teaching approach was implemented to reduce the learning loss of students. In crowded classrooms with traditional teaching method, student may find it challenging to understand STEM subjects and be afraid of participating in class, which leads of learning loss and risk of dropout. The remedial learning support component seeks to bridge these gaps by offering personalized assistance directly within the classroom setting or in the community, ensuring that students receive tailored guidance to comprehend and master academic concepts. The intervention was introduced through the appointment of two learning influencers in the treatment areas who provided 10 months-long supplementary learning support to the students. They even supported the students incurring learning loss by helping them with their studies around their exam times.

To establish blended learning in full swing, science and math teachers from each school were trained and requested in providing video lectures and preparing online materials. 5 science lecture videos for grade 5 to grade 9 were produced. This initiative required more time to train the teachers, prepare the videos, open the YouTube channels for each school, upload them in the channels, and make students habituated to follow them. Due to the short intervention time, it remained partially implemented. However, this initiative minimized the learning disparities among students who fall behind due to fear of math and science, lose interest in their studies, and eventually discontinue their education. To attain this objective, efforts were made to enhance teachers' capacity in implementing experiential and experimental pedagogies in classroom and online learning materials to provide additional assistance to students during school time and in the community.

2.2.5 Supplementary Programs

From July to August 2023, four distinct sessions – Menstrual Hygiene, Basic Health and Hygiene, Awareness against Sexual Harassment, and Anti-Bullying – were conducted over two months in four treatment schools, totaling 14 sessions. These sessions, led by public health professionals, were tailored to provide age-appropriate information for each class. The Menstrual Hygiene sessions aimed to foster a supportive environment for female students, enabling them to manage menstrual needs without stigma, thereby reducing absenteeism. Basic Health and Hygiene sessions were designed for all students to promote a conducive learning environment. The Sexual Harassment Awareness sessions played a crucial role in protecting students, especially girls, from circumstances that might interrupt their education. Similarly, the Anti-Bullying sessions aimed to create a safe, inclusive school climate, diminishing dropout risks for vulnerable students. The overarching goal was to advance gender equity, social inclusiveness, and a safe school environment, thereby addressing factors contributing to school dropout risks.

2.3 Endline Survey

In December 2023, an endline survey was conducted on 945 students using a structured questionnaire to assess the risk of school dropout, collecting household and academic information. The survey was carried out by data enumerators under the supervision of SAIST staff, with one supervisor in each of the four study areas. Prior to data collection, the field team, including enumerators, underwent training on survey and interview techniques and familiarization with the questionnaire. This training included field piloting to prepare for actual fieldwork. Supervisors managed questionnaire administration and monitored data collection, assisting enumerators with field challenges and contributing to data gathering. Data was uploaded to the Kobo server after each interview, with the supervising team reviewing and correcting any discrepancies daily. Following fieldwork completion, field supervisors and the Research Coordinator conducted a final data cleaning and prepared the dataset for analysis. Details of study sample and instruments used in the endline are in **Table 2**.

Table 2: Study Sample and Instruments

Quantitative Instruments and Sample		
Participants	**Baseline 2022**	**Endline 2023**
Treatment	629 (Grades 0-8)	575 (Grades 1-9)
Control	411 (Grades 0-8)	370 (Grades 1-9)
Households and Students Surveyed	1026 (14 non-response/non-reachable)	945 (81 migrated/dropout)
Students Out of School & at Risk of Dropout in Study Schools	1026	945
Math Score	1026	945
Science Score	929	837
Migrated to Different Area/Schools	-	67 of 1026
Dropout/Out of School	56 of total 1040	14 of 1026
Qualitative Instruments and Sample		
Participants	**Focused Group Discussion at Endline**	**In-depth Interview at Endline**
Teachers	4 FGDs (24 teachers)	14 teachers
Students	2 FGDs (10 students)	16 students
Parents	2 FGDs (9 parents)	4 parents
STEM Teaching Fellow	-----	2 fellows
Innovators	-----	2 innovators

We utilized qualitative methods such as focused group discussions (FGD) and in-depth interviews (IDI) alongside quantitative data to uncover the underlying mechanisms of school dropout in marginalized communities. These methods gathered insights into the perspectives of teachers, students, and parents/caregivers on schooling, new teaching techniques, the impact of COVID-19, and efforts to bridge educational gaps. Additionally, interviewers encouraged participants to elaborate on pertinent and intriguing responses where relevant (**Table 2**).

2.4 Data Analysis and Reporting

Analytic strategies by objectives and outcomes are summarized in **Table 3.** To identify the relative importance of school, student and community level predictors of risk of dropout and STEM education, we have applied interpretable machine learning (ML) approaches including the random forest, extreme gradient boosting, support vector machine and neural network including SHAP (SHapley Additive exPlanations) values. We have also identified and presented the relative importance of factors for predicting the causal impact of programs on outcomes using causal forest method, rather than the outcome itself. Variables that significantly alter the accuracy of intervention effect estimation when permuted are considered important.

Table 3: Analytic Strategies and Objectives

Items	Method	Goal	Outcome	Study Population
Risk of School Dropout	Generalized Synthetic Controls (GSC)	School level average treatment effect among treated (ATT) for school dropout	Risk of school dropout in schools: monthly proportions of absenteeism	4 government primary and 4 MPO secondary schools randomized at baseline (n=8)
	Generalized Estimating Equations (GEE) with Inverse Probability Weighting (IPW)	Student level ATT for school dropout	Risk of school dropout among individual: monthly proportions of absenteeism	Students (Grades 1-9) living in Dhaka Slums at endline (n=945)
STEM Educational Attainment	GEE with IPW	Student level ATT for math score before and after intervention	Individual mean difference of math score (100 points) after intervention	Students (Grades 1-9) living in Dhaka Slums at endline (n=945)
	GEE with IPW	Student level ATT for science score before and after intervention	Individual mean difference of science score (100 points) after intervention	Students (Grades 3-9 with science subject) living in Dhaka Slums at endline (n=837)
GESI	GEE with IPW	Disparities in treatment impact	Risk of school dropout and STEM education attainment	Students living in Dhaka Slums at endline (n=945 & n=837)
Affordability	Incremental Cost-Effectiveness Ratio (ICER)	Cost-effectiveness of the interventions	Cost 1% prevention of dropout; 1 point increase in math and science scores	Students living in Dhaka Slums at endline (n=945 & n=837)
	Cost-Benefit Ratio (CBR)	Benefit of schooling and STEM education in future wages (FW) against intervention costs	FW by additional year of schooling & STEM education against cost	Students living in Dhaka Slums at endline (n=945 & n=837)
Generalizability	GEE with Inverse Odds of Weighting (IOW)	Relevance of study results at national level; reduce sampling bias; ensure reliability and internal validity of results	ATT for school dropout, and STEM education attainment	Students enrolled at grades 1-9 in public schools in Bangladesh in 2022 (n=25291450) [Source: BANBEIS 2023]
Transportability	GEE with Inverse Odds of Weighting (IOW)	Relevance of study results in external population & settings; external validity of study findings	ATT for school dropout, and STEM education attainment	Students enrolled in 2 MPO secondary & 1 govt. primary school in grades 1 to 9 in Dinajpur in 2023
Scaling Intervention	Markov Cohort State Transition Model (CSTM)	Project long-term impact and feasibility of scaling intervention impact	5 states of risk of dropout in treated vs control and completion of grade 9	10000 simulated population with similar baseline characteristics

To estimate school-level effectiveness of the multifaceted programs on risk of dropout, we used the Generalized Synthetic Control (GSC) method and schools were unit of analysis in GSC. We checked the random assignment of treatment strategies and evaluate imbalance between treatment and control school students using standardized mean difference by 63 baseline covariates. It suggests that treatment and control school students were slightly imbalanced for 6 baseline covariates that could be by chance. However, we applied the Generalized Estimating Equation (GEE) with Inverse Probability Weighting (IPW) method for estimating impact of multifaceted programs at student-level. Hence, the study employed a target trial framework at analytic stage to emulate a hypothetical Randomized Control Trial (RCT) using the quasi-experimental data.

Table 4: Program Trial Emulation Framework

Target Trial Emulation	Description
Eligibility Criteria	**Inclusion:** Students from urban slums enrolled in the randomly assigned treatment and control schools (Grade 0-8) in Dhaka city who are at high risk of dropout (=>10% monthly absent days). **Exclusion:** Students from non-formal schools or above grade 8 during the recruitment period.
Treatment Strategies	**i)** Enrolled in the treatment or control schools in January 2022 and remained in the same school in the school year during the implementation of multifaced programs over the 10 months. **ii)** Did not migrate to another school or drop out of school during the follow-up.
Assignment Procedures	**Design Level:** Schools were randomly assigned to either strategy at baseline; both schools and students were aware of their assigned strategy. **Analytical Level:** To avoid imbalance between treatment and control groups and residual confounding, we further assumed randomization conditional on the imbalanced baseline covariates
Time Zero and Follow-up	For each eligible school and student, follow-up begins at assignment (baseline or time zero) and continues until migrated to another school/region or drop out from school or administrative end of follow-up (10 months after baseline), whichever occurs first
Outcomes	**i)** 10-month risk of school dropout related to absenteeism (Difference-in-Differences of 10-month proportion of absenteeism). **ii)** STEM educational attainment (Difference-in-Differences of pre-post intervention science and math score).
Causal Contrasts	Observational analogue of the per-protocol effect.
Data and Unit of Analysis	**Per-protocol Analysis** **School Level:** Generalized synthetic control (GSC) method for school-level intervention impact. **Student Level:** Inverse probability weighting (IPW) method to adjust for baseline or residual confounding.

To address imbalance between treatment and control group students as well as reducing baseline or residual confounding, we further assumed randomization of treatment assignment conditional on the baseline covariates **(Table 4)**. We have estimated ATT at student-level for risk of dropout, math and science scores as well as for the GESI analysis. Furthermore, the Incremental Cost-Effectiveness Ratio (ICER) and Cost-Benefit Ratio (CBR) were calculated to analyse the cost-effectiveness of these interventions and future benefits. Additionally, to test the generalizability, we conducted Cardinality Matching, a computational method, to find the largest possible number of matched students from grade 1 to 9 at the national level including the GEE with IPW method. Similarly, we evaluated transportability of our programs impact in a different geographic area and population including 3 schools from Dinajpur with 540 students using GEE with inverse odds of transportability weights (IOTW). Finally, we used the Markov cohort state-transition model (cSTM) to measure the scalability of our program impact. cSTM is a commonly used decision model that calculates the average number of individuals in each state using a transition probability matrix and project long-term program impact. The qualitative approach used Thematic Analysis technique that required the Bengali to English transcription of IDI and FGD. Then the transcriptions were translated into English, and coding stages were followed. The second level of analysis involved preparing themes and putting the codes under specific themes.

2.5 Ethical Consideration

Before commencing the study, SAIST secured ethical clearance from the North South University Ethical Review Board (NSU IRB ID: 2023/OR-NSU/IRB/0307). Additional authorization for the school-level intervention was granted by the Bangladesh Ministry of Primary and Mass Education and the Directorate of Secondary & Higher Education. The data collection team received thorough training on ethical practices, including proper introductions, explaining the study's purpose, informing about the use of collected data, ensuring voluntary participation, and the right to withdraw at any stage without repercussions, to get informed consent from each participant. Throughout the intervention period and field data collection phase, the survey team, led by their supervisors, engaged with key stakeholders like the Ministry of Education, Thana education officers, and school headteachers for introductions and to obtain their consent for the endline survey. In all interactions with stakeholders and participants, the team adhered to cultural norms and practices. When using household questionnaires, the interview location was chosen by the household member to maintain comfort and respect for family norms. After the interviews, data collectors expressed gratitude to respondents for their contribution to the endline survey.

2.6 Attrition, Compliance, and Spillover Effect

We were able to reach 92% of the baseline participants at the endline survey. We have measured same outcome and covariates during baseline and endline survey. Only 1.3 percent household declined to participate or were non-reachable. However, 67 students migrated to another region or schools while 14 were dropout at the end of implementation. There is lower chance of spillover effect because locations of the study schools are distant from each other. Moreover, we have conducted several sensitivity analyses to check robustness of randomization and study results.

CHAPTER THREE

Effectiveness of Interventions on School Dropout

3.0 Rationale

School dropout has emerged as a global problem for education researchers, policymakers, educators, and guardians due to its significance as an indicator of educational outcomes and its implications for present and future challenges. Recent research has highlighted the harmful impacts of school dropout across various life stages (Attwood & Croll, 2006; Ramberg et al., 2019). For instance, absenteeism negatively influences academic achievement, school completion, post-school success, learning, social adjustment, and other socioeconomic factors (Gubbels, Van Der Put, & Assink, 2019; Klein, Sosu, & Dare, 2022; Santibanez & Guarino, 2020; Santibañez & Guarino, 2021). Studies also show that dropping out is associated with numerous life-course issues, such as early marriage (Murphy-Graham, Cohen, & Pacheco-Montoya, 2020), economic hardship (Pong & Ju, 2000; Sarker, Min, & Hossin, 2019), health problems (Beller, Geyer, & Epping, 2022), and socioemotional difficulties (Hijdra et al., 2023), in addition to health risk behaviors like smoking, drug use, and alcohol consumption (Chou et al., 2006; White et al., 2007). A study spanning 71 countries across different income levels found Chronic School Absenteeism (CSA) linked to peer victimization, lack of peer support, loneliness, heightened anxiety, obesity, sedentary lifestyles, and severe food insecurity (Rahman et al., 2023). Given these wide-ranging implications, school dropout is a pressing global and national problem that demands vigilant monitoring and the implementation of effective interventions at global and national settings.

While the global school dropout rate is high, it is higher and its negative impact is more pronounced in developing countries such as Bangladesh. In 2022, despite high enrollment rates of 97% in primary schools and 59% in secondary schools, Bangladesh faced dropout rates of 14% and 37%, respectively (BANBEIS, 2022). It also suggest that the transition from primary school to secondary was relatively low (only 59% compared to 97% in primary). Recent studies, including those using data from the Global School-based Student Health Survey (GSHS), revealed that school absenteeism is more prevalent in Bangladesh compared to neighboring South Asian and Southeast Asian countries like Pakistan, Afghanistan, Vietnam, and Thailand (Hasan et al., 2023; Pengpid & Peltzer, 2017). Moreover, the school dropout rate among students from marginalized communities in Bangladesh exceeds the national average (Piscitello et al., 2022), which has been increased in the post-pandemic period (BANBEIS, 2022). Despite this, there is a lack of empirical research focused on identifying and developing effective interventions to reduce dropout rates among underprivileged and marginalized students in formal primary and secondary education settings in Bangladesh.

Couple of initiatives are taken by NGOs to address this issue by providing informal education facilities to OOSC, which is not the sustainable solution to retain these OOSC into the mainstream education system.

Given the severe personal, national, and global repercussions of school dropout, there is an urgent need for scalable interventions aimed at reducing dropout rates and learning losses, especially in the most vulnerable communities. Despite this need, there is a scarcity of research documenting the success of comprehensive interventions in resource-limited environments, such as for students residing in urban slums. Therefore, this study focuses on evaluating the effectiveness of short-term, multifaceted programs based in schools and communities. These interventions are designed to mitigate the risk of school dropout and combat learning loss among students from marginalized communities who are enrolled in formal primary and secondary educational institutions.

3.1 Program Activities

The baseline survey conducted for this study identified several risk factors contributing to the likelihood of dropout in primary and secondary schools, classified at the individual, family, and school levels. At the individual level, determinants such as students' health status, their motivation, and engagement in school activities were noted. Family-level determinants encompassed factors like socioeconomic status, the structure of the family unit, and the extent of parental involvement in their children's education. Meanwhile, at the school level, key determinants included the overall quality of teaching, the school environment, and the teachers' approaches to addressing absenteeism. These findings highlight the multifaceted nature of the dropout problem, necessitating a comprehensive approach to address these varied determinants.

3.1.1 Experiential and Blended Teaching Capacity Building

Addressing the identified needs, we organized regular training sessions led by government-certified master trainers of Math and Science to enhance the capabilities of teachers in experiential and experimental teaching methods. Additionally, we supplied grade-specific educational materials for science and math lessons, aligning with textbook content. To further support this initiative, two teaching fellows were appointed for each treatment school – one with a background in Education Science and the other in STEM – to assist science and math teachers in applying experiential teaching techniques and conducting classroom demonstrations. These fellows played a crucial role in helping teachers prepare and conduct experiments and develop class lectures.

Beyond hands-on teaching, our approach also encompassed blended learning. Teachers were trained to create YouTube channels, produce video content, and upload educational videos. This digital resource was designed to provide students with remedial education on challenging topics. As part of this intervention, students received in-class and community-based remedial STEM education support for 10 months. Evidence from previous studies indicates that providing in-class learning support, fostering a conducive learning environment, and offering after-school classes are effective strategies in bridging learning gaps (Kearney & Graczyk, 2014; Swansea, 2010).

3.1.2 School-Based Programs for Students

The implementation of a comprehensive and proactive system to monitor and address student absenteeism involved tracking OOSC and those at risk of dropping out. This system included several key components: the use of attendance cards for systematic recording and tracking of student attendance, initiating phone calls for direct communication between schools and parents, and conducting household visits to understand the underlying reasons for absenteeism. This strategy emphasized real-time tracking, prompt communication, and tailored interventions to foster a supportive environment that promotes regular attendance, which is crucial for academic success. In addition to these measures, we provided educational materials and rewards to incentivize students who regularly attended classes.

Moreover, we organized events and sessions addressing critical topics such as nutrition, health and hygiene, bullying, participation in STEM fields, creating a disability-friendly environment, gender equity, and menstrual hygiene. These activities were designed to equip students with essential knowledge and skills, helping them to overcome challenges that often contribute to school dropout and absenteeism. By addressing these issues comprehensively, the program aimed to reduce absenteeism and support students in their educational journey.

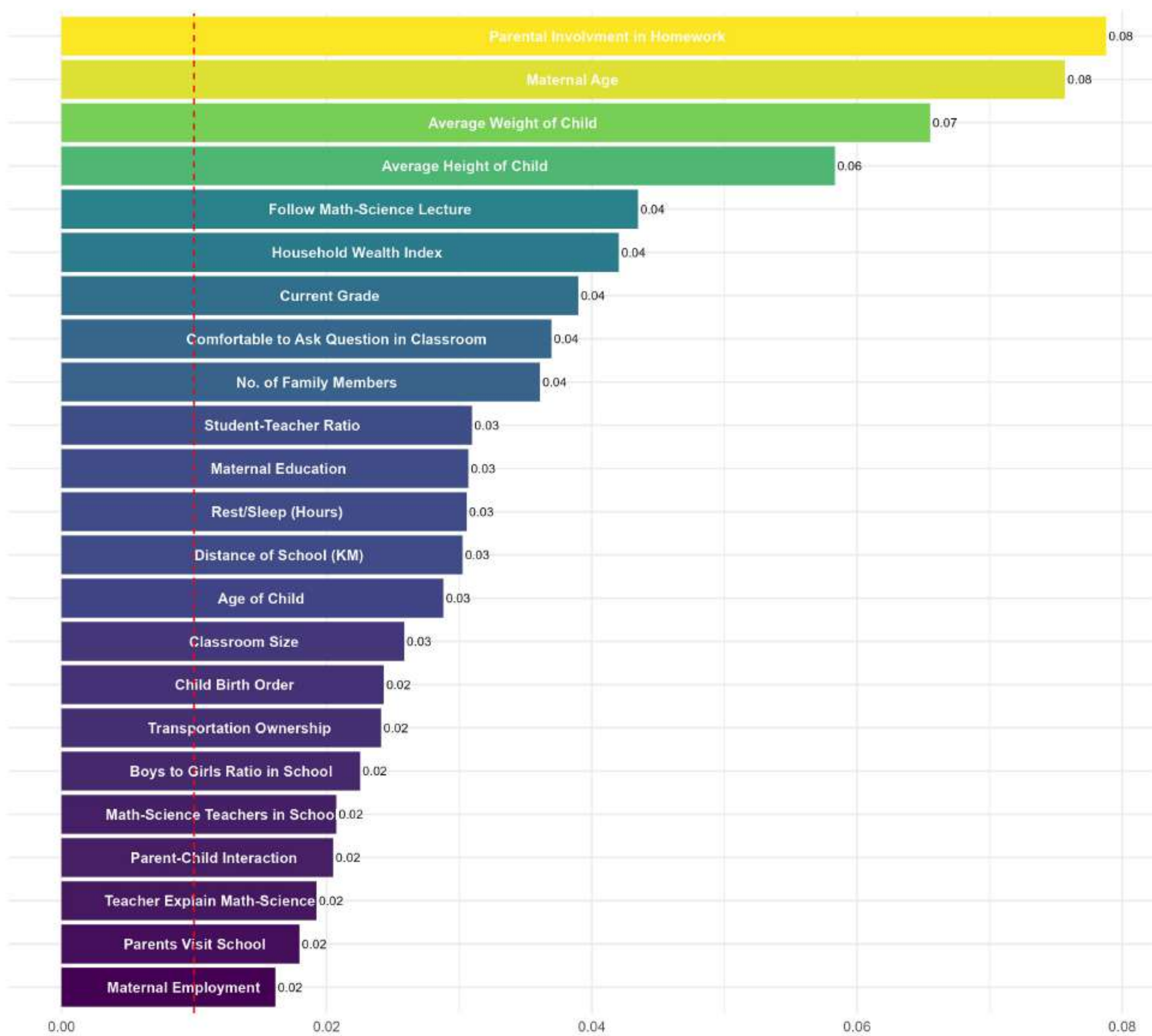
3.1.3 Community Engagement

Parental involvement is crucial in promoting the importance of education, positive home environment, good nutrition, sound health, proper hygiene practices, prevention of child marriage, and the reduction of child labor, all of which are directly linked to school dropout and absenteeism rates. To tackle these challenges, initiatives such as PTMs, home visits, and motivational campaigns at the community level have been implemented. These initiatives focus on fostering open communication and collaboration between parents and teachers. This intervention acknowledges the vital role of the partnership between parents and teachers in creating a positive and supportive educational environment in school and home, which is essential for the overall well-being and educational attainment of children.

3.2 Predictors of Intervention Impact on School Dropout

To assess the significance of various predictors in determining the variability or heterogeneity of intervention effects across individuals. Using a permutation-based machine learning approach, we evaluated 63 risk factors across student, family, community, and school levels to identify the most significant predictors of intervention effect variability, as depicted in **Figure 5**. The bar lengths in the figure indicate each predictor's importance, with longer bars denoting higher significance. Parental involvement, nutritional status, quality education and household wealth index were couple of the top factors.

Figure 5: Relative Importance of Factors Associated with Intervention Impact

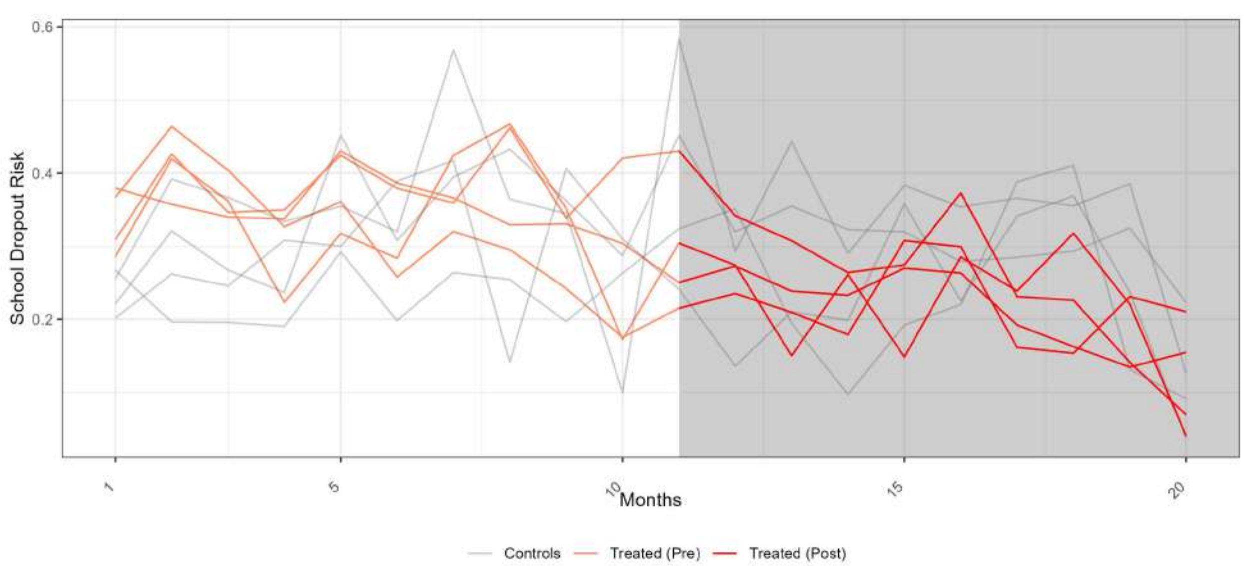


3.3 School-level Effectiveness of Intervention on Dropout

We have estimated school-level average treatment effect on the treated (ATT) of the multifaceted programs using the Generalized Synthetic Control (GSC) Method **(Figure 6-7)**. It is an advanced statistical technique based on the Synthetic Control Method (SCM) and provides greater flexibility in modeling time-series data with the incorporation of multiple control units. Hence, this method put together a synthetic or counterfactual control group by linking weighted averages of similar control units to assess what would have occurred to the treated unit in the absence of the intervention (Costa et al. 2023; Xu 2017).The GSC method "imputes counterfactuals for each treated unit using control group information based on a linear interactive fixed effects model that incorporates unit-specific intercepts interacted with time-varying coefficients" (Xu 2017).

Analysis of raw data shows the change in school dropout risk over a period of 20 months in treated schools at pre-treatment and post-treatment period comparing with control schools **(Figure 6)**. The treated group (post-intervention) shows a marked decrease in dropout risk after the intervention, which suggests that the treatment was effective in reducing the risk of dropping out. The multiple red lines seem to converge, indicating consistency in the treatment's impact.

Figure 6: School-level Effectiveness of Interventions on Risk of Dropout (Raw Data)



Results derived from the final GSC method represents the comparison between the actual risk of dropout in the treated schools and the counterfactual dropout risk predicted by the synthetic control **(Figure 7A)**. It shows the ATT over time, from 10 months before to 10 months after the multifaceted programs began. There was a noticeable downward trend in the risk of school dropout starting at month 0, which corresponds to the initiation of the intervention. By month 10, the risk has decreased significantly, suggesting that the multifaceted programs had a positive effect in reducing school dropout risk. The overall ATT for 10-month multifaceted programs was -0.13 (95% CI: -0.07 to -0.19), which suggests that the intervention reduced the school dropout risk by an average of 13 percent in those schools where programs were implemented **(Figure 7A)**.

Figure 7: School-level Effectiveness of Interventions on Risk of Dropout

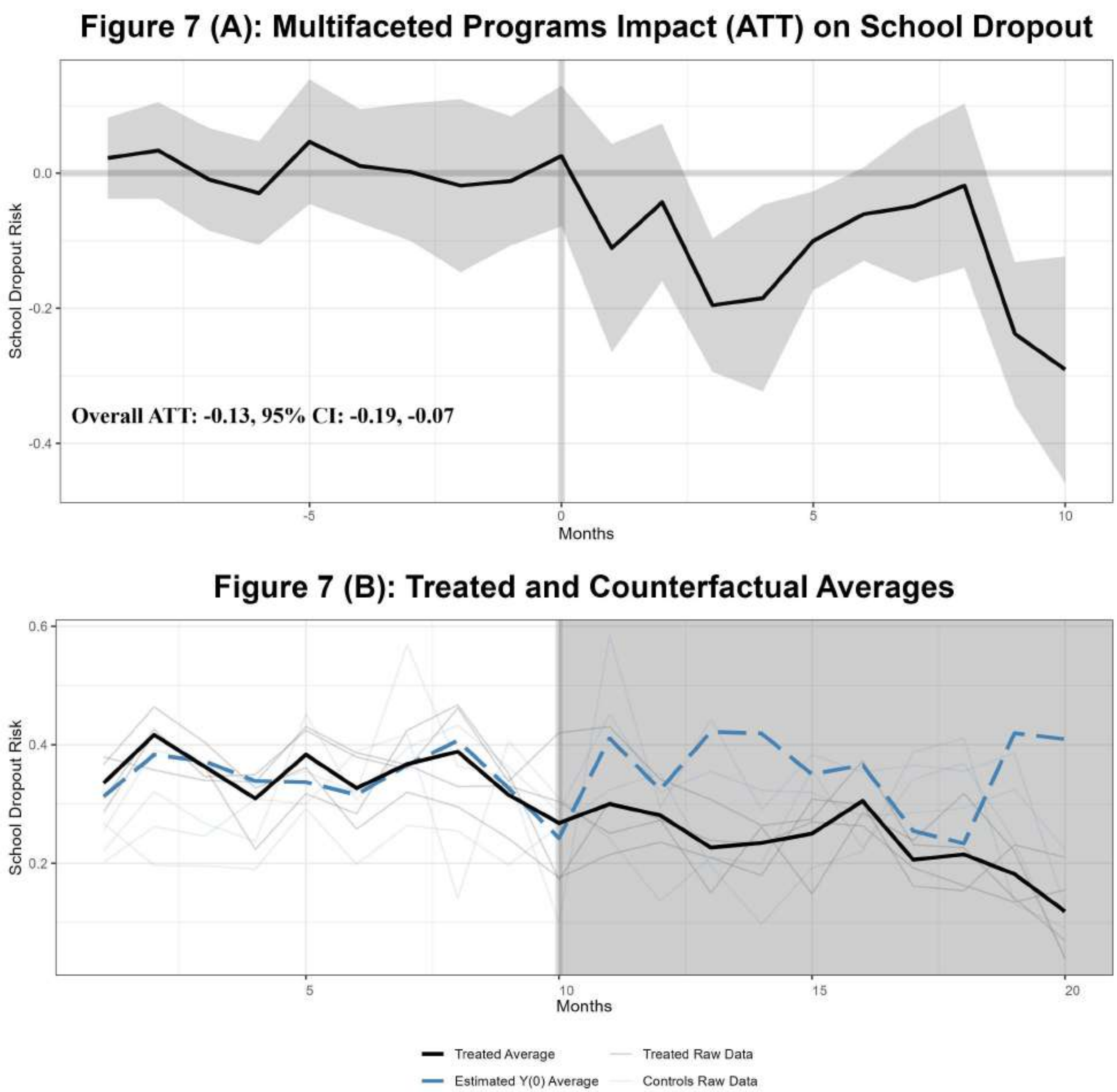
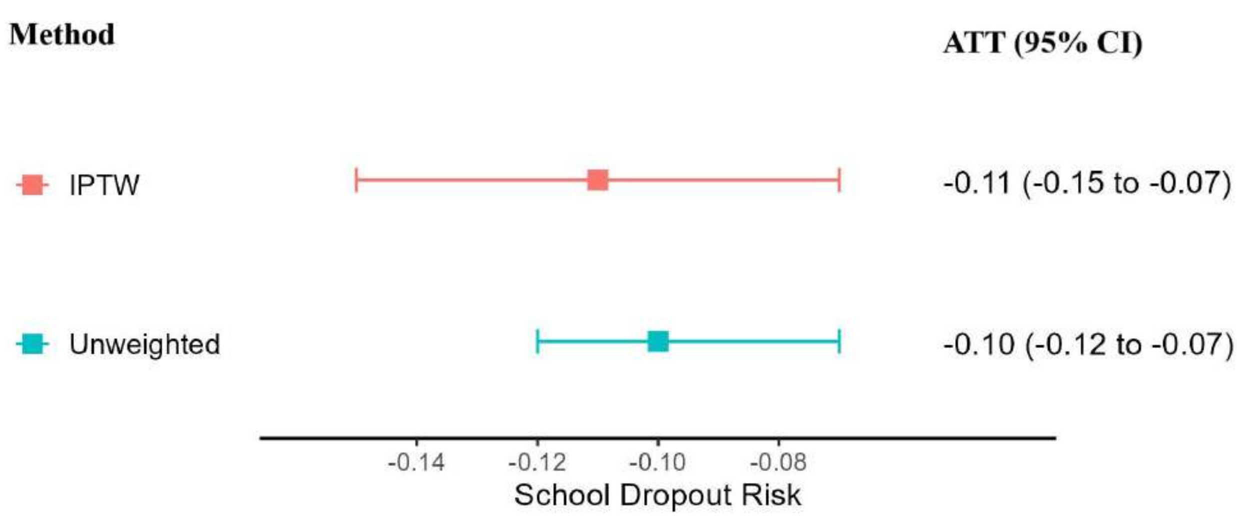


Figure 7B compares the treated group's average school dropout risk (solid black line) and the estimated counterfactual (what would have been expected without the intervention, shown as a dashed blue line) over a period extending to 20 months. The raw data points for both the treated group (dashed blue lines) and the controls (light gray lines) are also plotted, which show school-wise variability around the averages. The treated group's risk of school dropout appears to be consistently lower than the estimated counterfactual average beyond the months after program initiation, indicating the effectiveness of the treatment. The figure indicates that initially, the risk of dropping out was greater for the group receiving the treatment. However, following the start of the intervention (beginning from month 0), there was a notable change. The dropout risk for this treated group closely matched the projected counterfactual average, which implies that the program effectively reduced their risk of dropping out. Without intervention, the risk of dropout would been more than 40% in the treated schools. Overall, both figures suggest that the multifaceted programs were effective in reducing the risk of school dropout among the treated students, with the effects becoming more pronounced over time.

3.4 Student-level Effectiveness of Interventions on School Dropout

We have also estimated student-level effectiveness of our multifaceted programs applying Target Trial Framework and the per-protocol effect was estimated using GEE with IPTW **(Figure 8)**. Our programs reduced 11% risk of school dropout among treated students. This result confirms school-level estimates though ATT was slightly attenuated.

Figure 8: Student-level Effectiveness of Interventions on Risk of Dropout



3.5 Discussion and Conclusion

Overall, our programs averted 11 to 13 percent risk of school dropout among treated students compared to controlled students. Additionally, the risk of dropout increases with higher grades, and boys had a higher risk of dropout compared to girls (Details in Chapter 5). Interestingly, interventions were slightly more effective in high schools compared to primary schools . Remedial tutoring support and experiential teaching-learning had a significant positive impact on engaging students in class and reducing fear of STEM education and learning loss. For example, a science teacher of grade 8 stated about experiential learning...

"*The teaching fellows from SAIST used to help us prepare the materials for experiential learning in science classes. They always would keep the experiments aligned with the topic to be taught the next day. It has been a great deal of support to us, as well as to the students. They used to wait eagerly for the next classes, which was a noteworthy difference.*"

Furthermore, program activities like rewards for attendance and attendance tracking have effectively reduced the risk of school absenteeism. A math teacher of grade 6 also said the impact of these two interventions to motivate students to attend class regularly.

"*Students received monthly attendance tracker cards and showed great enthusiasm in coloring the days they attended school, often comparing cards with one another. The anticipation of rewards further motivated them, and their excitement served as an inspiration for their peers to attend school regularly.*"

Education, an essential element for human capital, is broadly seen as the catalyst of development in LMICs (Behrman 2022). It is evident that increased access to quality education positively impacts cognitive functioning as an important human capital outcome (Mazumder, Rosales-Rueda, and Triyana 2019). Hence, interventions such as experiential teaching can increase student engagement and motivation, which can lead to better attendance, reduced learning loss as well as school dropout. For example, a study conducted by the National Survey of Student Engagement documented that students who participated in experiential learning activities were more likely to attend class regularly and be more engaged in their coursework (Kuh et al., 2008). Similarly, another study conducted by the University of California found that students who joined in experiential learning activities reported feeling more connected to study topics, and their peers, resulting in better attendance (Jacobson et al. 2016). In addition, students who participated in experiential learning activities reported increased interest and motivation in their coursework, which may contribute to better attendance and reduced absenteeism (Association for Experiential Education 2015).

Furthermore, a lack of parental involvement in children's education can also lead to school absenteeism and dropout. For example, in Bangladesh, many low-income families place a low priority on education and may not fully understand the potentials of their children's education. As a result, children may not receive the support they need to succeed in school and may be more at risk of dropout. Therefore, parental engagement has a significant impact on reducing school dropout (Muula et al. 2012; Pengpid and Peltzer 2020).

Commending the program's effort in engaging parents in their children education and bridging between schools and parents, one of the class teachers stated...

You (SAIST) were involved not only with the students but also with the parents which is highly appreciating. Due to the parents-teachers meetings, counselling sessions, and, home visits, the attendance of students has increased to an extent. As a class teacher, I'm really happy about that.

Moreover, previous studies also supported the findings that male students had a greater risk of school dropout than females (Hasan et al., 2023; Pengpid and Peltzer, 2017; Seidu, 2019). This pattern is evident in South Asian and South East Asian countries, Ghana, Mozambik due to cultural expectations towards males and females (Pengpid and Peltzer 2017; Seidu 2019; Seidu et al. 2019; Siziya, Muula, and Rudatsikira 2007). Hence, our findings suggest that well-designed and properly implemented multifaceted, long-term interventions can reduce the burden of school dropout in Bangladesh.

Quality data along with proper monitoring system, we have observed significant impact of our multifaceted programs in reducing risk of school dropout, which may not be possible to replicate without considering both demand and supply sides. Moreover, a dedicated team for programs implementation is required to achieve optimum output. We have employed a sophisticated study design, proper implementation and monitoring systems. To minimize any design-level challenges, we have employed the target trial approach, a design principle for observational studies that seeks to emulate the key features of an RCT. By doing so, researchers can strengthen causal inferences from observational data. By emulating an RCT, we have reduced potential biases and improved the validity of the study findings. By combining GEE and IPTW along with target trial framework, addressing both the inter-cluster correlation of the data (with GEE) and the treatment selection bias (with IPTW). This combination is intended to provide a more accurate estimate of the per-protocol effect, which is the effect of treatment among those who adhered to the intervention protocol. Student-level findings confirm the effectiveness indicated by school-level estimates. The slight attenuation of ATT may be due to accounting for residual confounding and biases that could overlook in school-level estimates. Therefore, we can interpret our programs impact causally because of its high internal and external validity, including appropriate analytic framework.

CHAPTER FOUR

Effectiveness of Intervention on STEM Education

4.0 Rationale

Scientific literacy empowers individuals to apply their understanding of science in daily life, thereby contributing positively to society, as noted by Bybee (2014), Deehan, MacDonald, and Morris (2022), and Roberts and Bybee (2014). The U.S. National Academies of Sciences, Engineering, and Mathematics recently emphasized the critical role of effective science education in fostering students' inherent curiosity (National Academies of Sciences, Engineering, and Mathematics 2022). Despite this, the quality of science education remains substandard, particularly in low- and middle-income countries (LMICs). Data spanning the last quarter-century from the Trends in International Mathematics and Science Study (TIMSS) reveal that the level of foundational science proficiency in primary education is still insufficient for students to fully realize their potential (Thomson et al. 2020). Ahmed and Uddin (2022) found that nearly 40% of students who successfully completed Grade 5 lack the essential skills that should have been developed in Grade 1 in Bangladesh. They also observed a pronounced learning skills gap between students from the poorest and richest families that widens throughout primary school, further exacerbated by factors such as parental education, awareness, and students' being over the typical age for their grade, a divide that remains consistent over the primary school period.

The National Student Assessment 2022 conducted by the government of Bangladesh revealed that over 60% of third graders and 70% of fifth graders do not meet the expected math proficiency levels for their grades. Mathematics is integral across various fields including science, technology, business, medicine, and environmental and management sectors (Reilly, Edel Mary, 2007). Furthermore, proficiency in school mathematics acts as a critical "gateway," opening up opportunities in future life. Early school math proficiency is a key determinant in whether students pursue secondary education or opt for alternative paths post-high school (Lee, 2012), with these choices significantly affecting future earnings (Baum, Ma, and Payea, 2010; Deming et al., 2013). Given the pivotal role of school mathematics performance in shaping adult outcomes, it is imperative to provide high-quality mathematics education at both primary and secondary levels. Currently, a significant number of students are inadequately prepared for advanced mathematics in post-secondary education or to make informed decisions about their educational paths due to insufficient math scores.

There is a significant link between performance in math and science and the likelihood of dropping out of school. Students who struggle with these subjects often face greater academic difficulties, which can undermine their confidence and engagement with school.

For instance, students intimidated by math and science tend to experience a decline in learning and become increasingly averse to attending school, leading to a heightened risk of dropping out. Proficiency in mathematics and science is crucial across numerous career paths, and poor performance in these areas can foster frustration, disinterest, and feelings of inadequacy, further increasing dropout rates. Additionally, the need for extra private tuition to overcome challenges in these subjects may not be feasible for students from low-income families, exacerbating learning losses and aversions to math and science, and thus elevating dropout risks.

Despite various efforts in recent years to enhance science and math skills, there remains a substantial need for improvement. A significant number of students continue to underperform in math and science; even those who pass often lack an understanding of their practical applications beyond the classroom. This underscores an urgent need for targeted interventions to boost STEM education through science and math achievements. Therefore, this study investigates the impact of comprehensive intervention strategies on improving STEM education attainment and quality among students residing in urban slums and attending formal primary and secondary schools in Dhaka city.

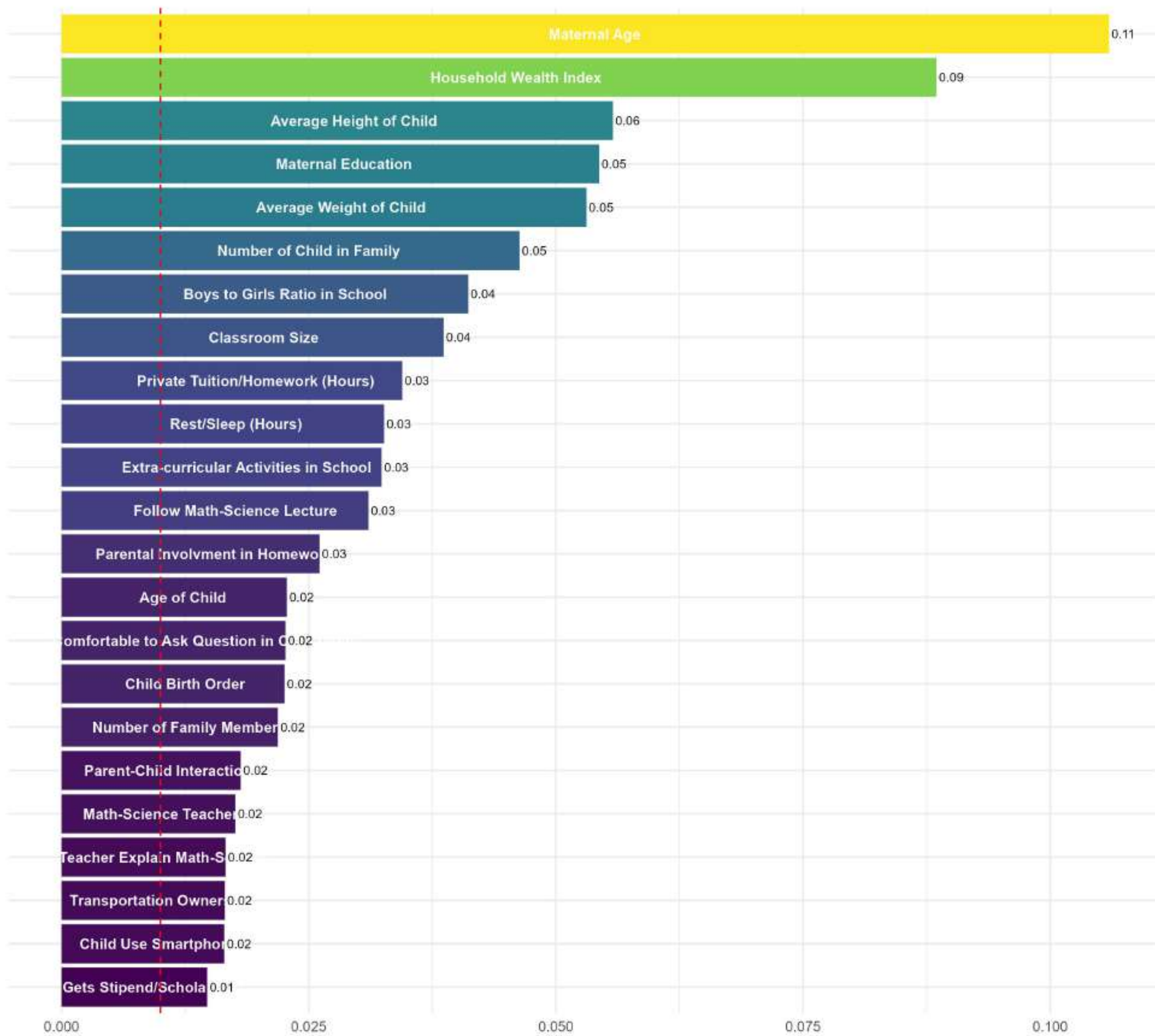
4.1 Program Activities

Our baseline survey revealed that poor performance in math and science, fear of STEM subjects, and a lack of quality STEM education and adequately trained teachers were key reasons for learning gap and student absenteeism. Additionally, the absence of proper equipment for science and math demonstrations significantly impacted student engagement in these classes. To tackle these issues, we implemented comprehensive interventions aimed at mitigating learning losses and reducing fear associated with STEM subjects, which subsequently led to enhanced academic outcomes, especially in math and science scores.

The intervention strategies included distributing STEM kits to schools involved in the program and organizing science fairs and sessions to raise awareness about the importance of STEM education, thereby motivating students towards these subjects. During full-day workshops held in schools, students, under the guidance of their teachers and a group of volunteer young scientists from Bangladesh, engaged in creating innovative tools and conducting experiments. Science and math teachers received training to deliver more hands-on, experimental lessons utilizing the STEM kits. Additionally, our trained teaching fellows supported classroom teachers in demonstrating practical applications of math and science concepts through these kits. We also offered supplementary tutoring and blended learning opportunities, allowing students to catch up on their studies at their convenience.

To address broader aspects of student health and well-being, the program included workshops on menstrual hygiene and basic health practices. These efforts aimed to create a more inclusive and supportive school environment, reducing absenteeism. PTMs facilitated by SAIST helped bridge the communication gap between parents and educators. The effectiveness of these meetings was assessed through attendance records, parent feedback, and measures of academic progress, providing insights into the relationship between parental engagement and student achievement.

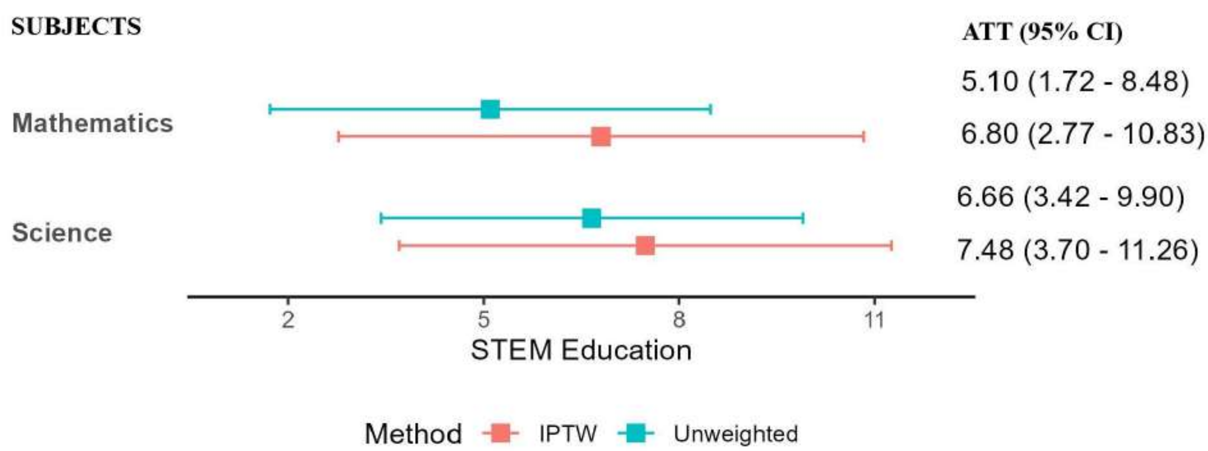
Figure 9: Relative Importance of Factors Associated with Intervention Impact on STEM



4.2 Predictors of Intervention Impact on STEM

Figure 9 is showcasing the importance of various predictors on STEM education derived by ML model that has used a permutation-based approach to evaluate the significance of different factors in predicting the variability of intervention effects on STEM education. The length of each bar represents the importance score of each predictor, with longer bars indicating greater importance. The figure highlights the most influential factors, as determined by their permutation scores that exceed its median distribution. Maternal education, household wealth index, nutritional status and number of child in family were the top predictors of variability in STEM education.

Figure 10: Student-level Effectiveness of Interventions on STEM Education



4.3 Student-level Effectiveness of Intervention on STEM Education

We observed that performance in STEM related subjects depends more on individual, family and community level factors. Moreover, we have math and science score out of 100 (based on their yearly final exam) only for two time points-baseline and endline period. In this regard, GSC will not be a suitable analytic approach. Therefore, we have estimated student-level effectiveness of intervention on STEM education employing target trial framework with GEE and IPTW. The target trial framework reduces potential design level biases such as selection bias while GEE with IPTW minimizes inter-cluster correlation and residual confounding effect at analytic stage. The effect estimates is the per-protocol effect because we did not include students who did not adhere to treatment at the end of the program implementation.

The ATT represents the average effect of a STEM education intervention on the treated group compared to a control group **(Figure 10)**. For mathematics, the unweighted ATT was 5.10 with a 95% CI 1.72 to 8.48. Similarly, the IPTW estimated an ATT of 6.80 with a 95% CI 2.77 to 10.83. The unweighted ATT for science was 6.66 with a 95% CI 3.42 to 9.90 while the IPTW method estimated an ATT of 7.48 with a 95% CI 3.70 to 11.26. Overall, the multifaceted programs successfully enhanced students' performance in STEM education, leading to an average increase of 6.80 points in math scores and 7.48 points in science scores (out of 100) in the yearly final tests. IPTW method yields a higher impact of the interventions compared to only GEE method for both subjects. However, both methods indicate a positive effect on the STEM education, with all intervals being above zero and not crossing the zero line, suggesting the increases are statistically significant.

4.4 Discussion and Conclusion

The multifaceted programs successfully improved students' performance in STEM education, leading to a notable increase of 6.80 points in math scores and 7.48 points in science scores from baseline to endline. It suggests that experiential and experimental teaching along with in-class demonstration worked well in improving learning gap and reducing fear about STEM education. A variety of approaches including cross-curricular integration (DeLuca, Ogden, and Pero 2015), first-hand science teaching experience (Khan and VanWynsberghe 2020), problem-solved-based learning education (Ford et al. 2013) have confirmed to be useful to science teaching and learning. Moreover, supplementary tutoring support alleviated the financial burden on parents typically associated with coaching or extra tuition, addressing economic barriers that can impede academic achievement and contribute to school dropout. Our FGD findings indicated that- *a student dropped out of school because the family could not pay six months' fees.*

Students who receive personalized tutoring show significant academic gains compared to their peers (Rahman et al. 2020; Ruthbah et al. 2016). Early engagement and good performance in STEM related subjects are important to confirm positive science trajectories, as a large body of previous studies argued that student's science disengagement has a higher likelihood to worsen after the primary level and tends to pose more challenges to remediate (Ali et al. 2013; Denessen et al. 2015; DeWitt and Archer 2015; DeWitt, Archer, and Osborne 2014; Said et al. 2016). Additionally, school-based activities such as experiential learning, awareness sessions, and science fairs have a significant positive impact on student's academic engagement and performance. Mother of a student in our FGD reported- "*My son loves to attend school STEM programs and the joy of school activities brings more interest to attending classes and makes him serious about studies. His academic results are also quite impressive in this regard.*"

Our programs, thus, leveraged the power of in-class tutoring and community engagement to provide targeted support and we evaluated effectiveness of intervention, with empirical data evidencing academic gains in STEM education among participating students. Results are robust because both unweighted and IPTW findings showed consistency. Furthermore, quasi-experimental design, objective measures of math and science scores and comprehensive target trial approach maximized internal and external validity of our results.

CHAPTER FIVE

Gender Equality and Social Inclusion

5.0 Rationale

The GESI framework confronts the imbalances in power dynamics that individuals encounter based on factors such as gender, socioeconomic background, geographic location, caste, ethnicity, language, and personal agency, as well as intersections among these factors. Emphasizing proactive measures, GESI aims to rectify these imbalances, lessen disparities, and guarantee equal rights, opportunities, and dignity for everyone, irrespective of their social identity (UNDP 2017).

Building on the crucial need for comprehensive primary and secondary education as a cornerstone for sustainable development, as outlined by Chisamya et al. (2012) and the United Nations (2015), it's clear that gender plays a pivotal role in educational attainment in Bangladesh. Despite notable strides in primary education access, gender disparities persist, particularly impeding secondary education in areas with limited resources (Sarker, Karim, and Suffiun 2017). The societal and cultural norms around gender significantly influence the educational journey of students. Girls, for instance, often encounter societal barriers that curtail their educational opportunities and propel them towards early marriage, leading to a high dropout rate among teenage students (Nahid 2014; Sarkar, Reza, and Hossain 2014). In contrast, boys are more likely to leave school in certain regions, driven by the need to contribute economically through income-generating activities (Sabates, Hossain, and Lewin 2013). Furthermore, when resources within a household are scarce, the allocation often favors boys, exacerbating the challenge for girls to continue their education, especially when faced with escalating educational expenses. This gendered aspect of resource distribution within households underscores the need for targeted strategies to address these imbalances and promote equitable access to education for all genders.

In addition to the impact of gender norms and socioeconomic factors on school dropout risks, as previously discussed, students' personal characteristics also play a significant role. Existing research highlights the correlation between children's health and nutritional conditions and their educational outcomes, including school enrollment and dropout rates (Alderman et al. 2001; Ghuman et al. 2006; Pridmore 2007). This connection underscores how health-nutrition related issues can act as barriers to consistent educational participation.

Furthermore, students with functional difficulties and disabilities face unique challenges, particularly in LMICs. As Peters (2003) notes, a critical obstacle for these students is the lack of access to quality education, often exacerbated by physical or psychological impairments.

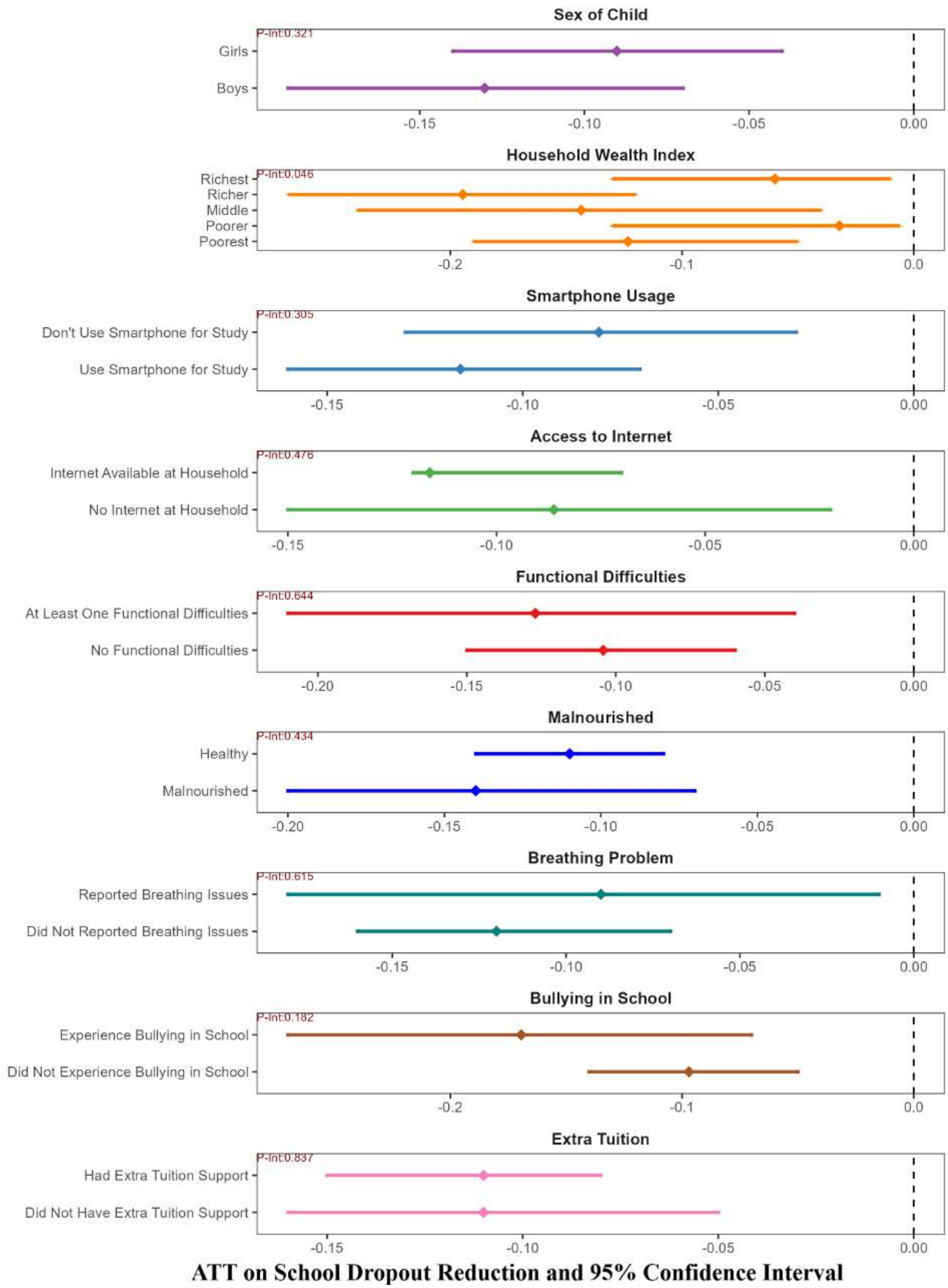
Even when educational opportunities are available, students with disabilities frequently encounter barriers to completing their education. These include a scarcity of resources such as trained teachers who can cater to their specific needs, a school environment that is not conducive to learning for all, and the absence of inclusive school policies and guidelines that address the needs of children with physical and mental challenges. This situation creates an additional layer of complexity in ensuring equitable education for all students, demanding targeted interventions and inclusive policies to bridge these gaps. As noted by Filmer (2008), children with disabilities in Bangladesh face significant barriers even at the initial stage of their education. Their likelihood of starting school is markedly lower compared to their peers without disabilities. Moreover, for those who do manage to enroll, the prospects of progressing through the educational system and advancing to higher grades remain dismally low.

The household wealth index emerges as another critical determinant, particularly in shaping school attainment. This index, a comprehensive measure of a family's assets, both durable and non-durable, plays a significant role in determining access to educational resources, such as quality schooling, educational materials, and private tutoring. Families with a higher wealth index usually have greater access to enhanced educational opportunities, including well-equipped schools and robust support systems. Conversely, children from lower wealth index households often struggle to access nutritional foods, better health facilities and quality education due to financial limitations. This disparity leads to unequal school attainment rates, with students from poorer households facing difficulties in procuring necessary study materials, which can result in lower attendance and higher dropout rates. The lack of financial resources in these households also means that extra tutoring or educational support, crucial for academic success, is often out of reach, hindering their educational advancement. Previous study also observed disparities in learning outcomes based on household wealth index in Bangladesh (Ahmmed and Uddin 2022).

In the context of our study, the selected eight schools primarily serve the marginalized segments of society. Ensuring the inclusion of underprivileged children, those with functional difficulties, minority groups, and learning gaps requires collaborative efforts from various stakeholders, including teachers, school management committees, and educational authorities. While the majority of these schools have a sufficient number of female teachers, they still lack gender-sensitive infrastructure and facilities accessible to students with disabilities. Crowded and inadequate infrastructure further exacerbates these challenges.

However, there is a gap in research exploring how the effectiveness of interventions aimed at reducing school dropout rates and STEM education may vary according to students' gender, health, nutritional and disability status, family income, school environment and access to educational resources.

Figure 11: Disparities in Risk of School Dropout Reduction



Therefore, this section aims to assess the impact of multifaceted programs across these individual, family and school-level factors, to provide a comprehensive understanding of their efficacy in diverse contexts.

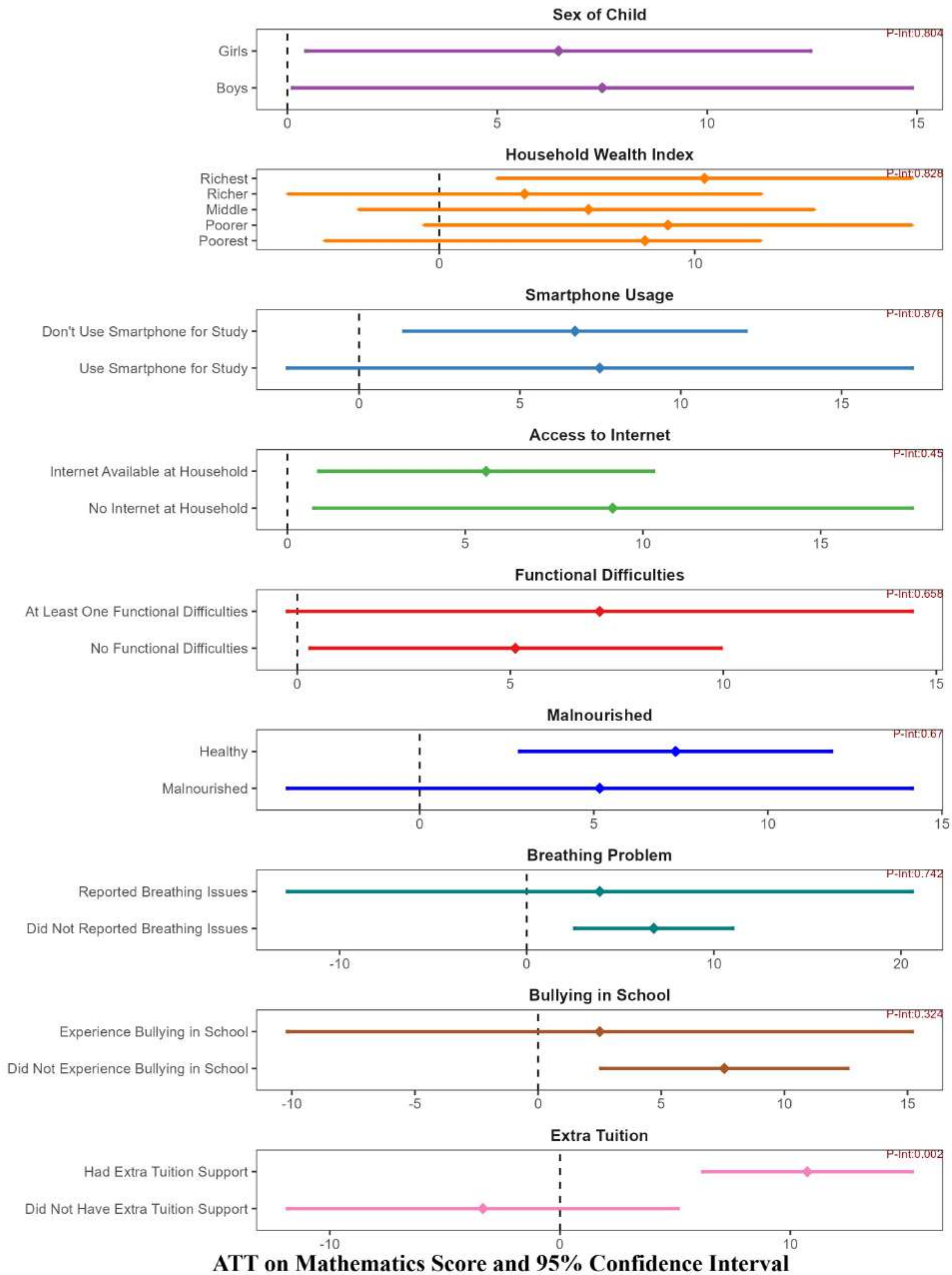
5.1 Programs and Methods

To address the challenges of school dropout, we implemented short-term multifaceted interventions, including tracking of OOSC and students at risk of dropping out via attendance card, phone calls, and household visits; PTMs and awareness campaign for parents; campaign on STEM education and experiential learning to motivate students towards STEM education; additional tutoring support and blended learning to reduce learning loss and supplementary activities such as menstrual hygiene management, basic health camp; hygiene session, awareness against sexual harassment, and anti-bullying sessions. We outlined our GESI analysis for our three outcomes (school dropout, math score, and science score) considering child biological sex, household wealth index, access to smartphone and internet, functional difficulties, health and nutritional status, bullying in school and extra private tuition support to examine whether the effect of multifaceted interventions varies through these factors. Student-level effectiveness were estimated applying GEE with IPTW for GESI outcomes and p-interaction (p-int <0.15) was estimated to test statistical evidence of heterogeneous programs impact.

5.2 Disparities in Risk of School Dropout Reduction

Figure 11 presents ATT of multifaceted programs on school dropout risk reduction by GESI indicators. P-int <0.15 suggests the statistically significant presence of disparities in risk of school dropout reduction. In terms of statistical cutoff, we have only observed disparities by household wealth index. Despite the statistical insignificance, we have observed noticeable disparities in school dropout risk reduction in terms of GESI indicators including sex of child, nutritional status, functional difficulties, bullying in school, access to internet and smartphone usage for study. Lack of statistically significant disparities by GESI indicators suggest that our study design, multifaceted programs implementation and analytic approach with target trial framework addressed heterogeneity of treatment efficacy by minimizing chances of biases such as selection bias by effect modifier, and violation of exchangeability, positivity and consistency assumptions. For example, we did not see any difference for extra private tuition because remedial teaching support was one of the main components of our multifaceted programs to reduce learning gap and fear of science and math.

Figure 12: Disparities in Math Score



5.3 Disparities in STEM Educational Attainment

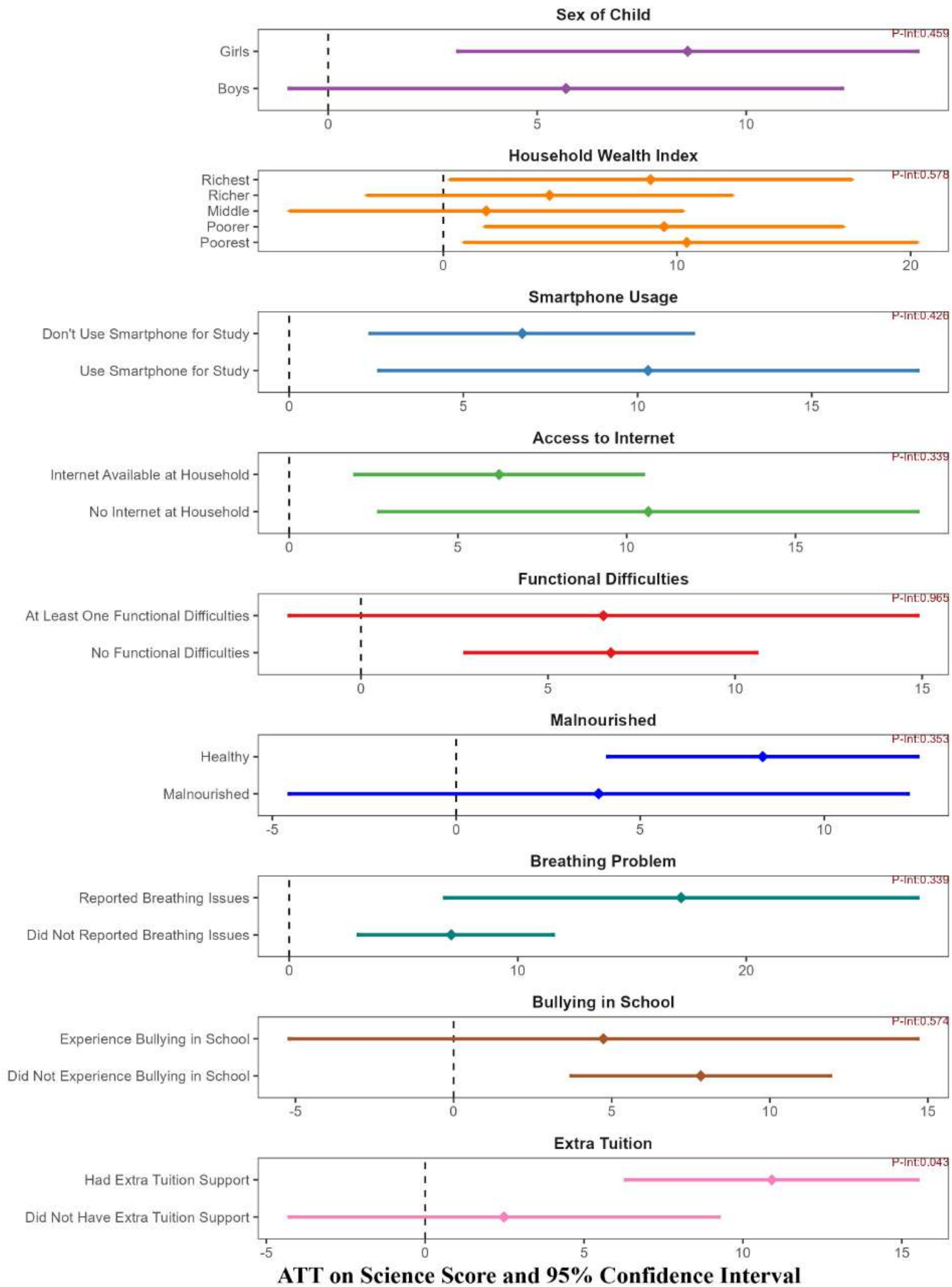
Figure 12-13 show disparities of multifaceted programs impact on STEM education achievement by GESI indicators. We did not observe any statistical evidence of heterogeneity of program impact by GESI indicators except for extra tuition support. It is evident that students with our supplementary tutoring support and extra tuition performed substantially better in math and science than the students who did not get support from our programs and had no extra tuition support by parents. It suggests joint effect of our program and extra tuition by parents. Moreover, we observed statistically insignificant differences of programs impact by GESI indicators including bullying in school, nutritional and health status, sex of children and household wealth index. Lack of Statistically significant disparities by GESI indicators suggest that we minimized potential biases and heterogeneity in most of the context.

5.4 Discussion and Conclusion

Overall, results showed that there was no significant differences in the ATT by GESI indicators. These results are slightly different by GESI indicators, which are due to random variability rather than heterogeneity of programs impact. It means our study design and programs implementation was able to dilute any residual confounding and selection bias by these moderators/modifiers. We have observed evidence of disparities in school dropout only by household wealth index. The explanation could be that we did not provide any kinds of financial incentives to the families and it was not component of our multifaceted programs. Moreover, household wealth index is a consistent and long-term financial strength of the families that is not easily modifiable.

In Bangladesh, where economic disparities are evident, households with higher wealth can better support their children's education, leading to greater access to quality schools and resources. Conversely, less affluent families face challenges in meeting educational costs, creating gaps in educational quality and inclusiveness. Our findings indicate that education can consume about 10% of a family's monthly income, a significant strain on household finances. Notably, families involved in our educational interventions reported lower additional educational spending than those in control group. To ensure equitable education for all, it's crucial to bridge this income-education divide through policies that level the educational playing field and alleviate the financial pressures on families, enabling them to focus more on their children's nutrition and overall well-being.

Figure 13: Disparities in Science Score



Our multifaceted programs were able to address disparities by household wealth index offering equitable access to quality remedial and supplementary tutoring support. Thus, the heterogeneity by household wealth index was diluted in the context of math and science scores because we have directly intervened on science and math education. Furthermore, the joint effect of our STEM education support and extra private tuition by parents substantially increased students performance.

The National Education Policy (NEP) 2010 emphasizes integrating students with disabilities into mainstream schools by improving accessibility and training teachers in inclusive education techniques. It also advocates for specialized support for children with severe disabilities. Additionally, substantial state funding has been allocated to enhance school infrastructure nationwide under initiatives like the Primary Education Development Programme (PEDP) 2 and 3 and the Secondary Education Quality and Access Enhancement Project, focusing on creating gender and disability-friendly educational facilities.

Despite the introduction of government-led initiatives aimed at supporting students with disabilities, their impact remains largely unseen in the schools selected for our study. According to our baseline report, out of the eight schools examined, only five had enrolled students with physical and mental disabilities. Attendance patterns for these students were notably irregular, with some only appearing for mandatory public examinations. The schools in question are grappling with significant infrastructural deficiencies that hinder the creation of a disability-friendly environment. This includes a lack of specialized training for teachers in adaptive teaching methods and insufficient logistical support for students with disabilities.

Observations revealed that none of the schools are equipped with essential amenities for disabled students, such as toilets accessible to the disabled, facilities for sign language interpretation, or provision of simplified information. Furthermore, even among the schools that do accommodate disabled students, the facilities remain woefully inadequate. For instance, only one primary school provides braille materials, and while one high school has a disabled-friendly entrance, another has both a ramp and a disabled-friendly lift.

Additionally, there is a pressing need to address the issue of bullying within these educational institutions. Creating a safe and nurturing school environment is paramount, not only in enhancing academic performance but also in ensuring the well-being of all students, particularly those with disabilities. Reducing bullying is not merely a matter of discipline but also a necessary step towards inclusivity, allowing every student the opportunity to learn and thrive without fear of harassment or discrimination.

Raising parental awareness about the value of education is crucial. In one of the communities we studied, there was a belief that education was costly and futile. Our research shows that dropout rates rise with each grade level, with boys at greater risk than girls. The lack of viable job prospects post-education often leads parents to direct their sons towards technical apprenticeships. Conversely, economic pressures drive the early marriage of girls, often leading them to low-wage labor post-marriage, curtailing their education.

Globally, school-based interventions have proven effective in fostering gender equity and inclusive environments, addressing issues from menstrual hygiene to bullying. Despite the non-significant disparities by GESI indicators in our quantitative findings, our qualitative efforts, including awareness programs and parental engagement, have shown promise in enhancing understanding of GESI principles and reducing disparities in school dropout reduction and STEM educational attainment.

CHAPTER SIX

Cost-Effectiveness and Benefit Analysis

6.0 Rationale

Education, as a crucial aspect of human capital, is widely considered to be the heart of development in LMICs (Behrman 2022). The effect of increased access to education has been evident in producing increased cognitive development as an important human capital outcome (Mazumder, Rosales-Rueda, and Triyana 2019). A global review of 139 countries from 1950 to 2014 found both private and social returns to be high and on a rising trend globally (Psacharopoulos and Patrinos 2018). As mentioned earlier, school dropout hinders the progressive perspectives of education in many ways, and different interventions have been provided to prevent dropout and enhance academic excellence in different settings. The Economic Cost of OOSC as % of gross domestic product (GDP) ranged 0.3% to 7.2% in Southeast Asian countries (UNESCO 2015). A similar type of estimation showed that the economic cost of OOSC as of GDP was about 1.45% for Bangladesh (Thomas and Burnett 2013), which could be higher after accounting multisectoral costs of exclusion from schooling.

To reduce school dropout and minimize the associated economic loss, several programs are regularly implemented in LMICs, which showed beneficial to recover substantial economic loss. For example, a study in 14 LMICs funded by IDRC showed that school feeding programs benefited 190 million children, costing USD 11 billion annually and yielding USD 180 billion in human capital returns, USD 7 billion in social protection benefits, and USD 23 billion in local agricultural gains (Verguet et al. 2020). Moreover, one additional year of schooling increased at least 9% increase in future wages (Psacharopoulos et al. 2018). Similarly, a recent study on the private returns of education in Bangladesh also estimated that the average earnings increase from each additional year of education was 13% to 18%, with higher gains for individuals with STEM educations, women (20%) than men (13%) (Mamumn et al. 2021).

Cost-effectiveness Analysis (CEA) and Cost-Benefit Ratio (CBR) has been a widely acceptable tool to the policy stakeholders for choosing the best alternatives in terms of the value of money (Levin 1988). CEA compares two or more educational interventions based on their effectiveness and costs in attaining a particular objective (e.g., increasing mathematics achievement, reducing school dropout). Costs and benefits of programs are usually estimated across multiple sectors including education, future wage premium, health and nutrition, social protection and agricultural economy. Understanding the CBR of an intervention can aid in determining its scalability. If an intervention is highly effective but also cost-efficient, it may be more easily adapted and scaled to different contexts or larger populations. However, there is limited documentation in the literature regarding the affordability and benefits of these interventions in LMICs particularly in Bangladesh. Additionally, policy stakeholders have scant evidence to choose the most productive interventions relative to their costs, particularly in settings with scarce resources. Hence, the purpose of using CEA and CBR was to assess the affordability of the SAIST multifaceted programs to reduce school dropout and STEM educational attainment (mathematics and science scores).

6.1 Data Source and Cost Calculation

The CEA utilized both primary and secondary data sources. The "ingredients method" (Hummel-Rossi and Ashdown 2002; Levin and Belfield 2015) was applied, necessitating the use of detailed user-level data from various sources such as schools, parents, education administration, and government documents, instead of solely relying on national education budget figures. Cost data were categorized into three domains: fees paid by parents to schools (including admission, exams, and other school-imposed fees), out-of-school expenses borne by parents (such as coaching, private tuition, transportation, school uniforms, meals, and educational materials), and the cost of the intervention itself. Since the intervention cost was calculable only for schools directly received the intervention, equivalent costs were estimated for non-intervention schools with similar programs. All costs were measured in the current Bangladeshi currency (BDT), without adjusting for inflation, given that the intervention period spanned only 10 months.

6.2 Cost-Effectiveness Analysis

All costs were reported by parents of the students of intervention and non-intervention schools. Effectiveness of the multifaceted programs in treatment schools were estimated in chapter 3 and 4. We considered two outcomes- risk of dropout and STEM education achievement (in mathematics and science). Risk of dropout was calculated in proportion to values of percentage of school absent days monthly, and STEM education achievements (in science and mathematics scores) were calculated on a point of 0 to 100 scale. Finally, the incremental cost-effectiveness ratio (ICER) was calculated using the following formula-

$$\text{ICER} = \frac{\text{Per Student Cost (treatment school)} - \text{Per Student Cost (control school)}}{\text{Outcome (treatment school)} - \text{Outcome (control school)}}$$

For calculating the ICER value of school dropout risk reduction, we used the aforementioned formula, and then the ICER value was multiplied by 0.01 to get per the additional cost spent for decreasing 1% of school dropout risk as the values of dropout risk reduction were calculated in the form of a proportion of 0 to 1 scale. Three ICER values were calculated-school dropout, science, and mathematics scores. These values provide information on how much additional money (in BDT) was spent for decreasing per percent of school dropout risk, and per unit increase of mathematics and science score.

6.3 Out-Of-Pocket Educational Expenses

The overall out-of-pocket (OOP) educational expenses, as detailed in Table 4, reveal differences between the treatment and control groups. The aggregate OOP costs per student were BDT 27,964.97 for the intervention period, BDT 33,557.96 annually, and BDT 2,796.50 monthly. Within the treatment group, the per-student OOP expenditure during the intervention period was BDT 26,217.67. When extrapolated, this results in annual expenses of BDT 31,461.20 and a monthly cost of BDT 2,621.77. Conversely, for the control group, the per-student OOP expenditure was BDT 30,854.33 for the intervention period, translating to BDT 37,025.20 annually and BDT 3,085.43 monthly. Additionally, the treatment group parents spent BDT 21,515.14 (intervention period), BDT 25,818.17 (annually), and BDT 2,151.51 (monthly) on other educational purposes like private tuition, materials, and transportation. In contrast, parents in the control group spent BDT 27,070.41 during the intervention period, BDT 32,484.49 annually, and BDT 2,707.04 monthly on similar expenses. We found that the average household income ranged from 20 to 25 thousand in study population and around 10% of their monthly income are spent for a single child educational expenses **(Table 5)**. In summary, students in the treatment group incurred lower OOP educational expenses than those in the control group for all measured periods, indicating that the intervention might have effectively reduced education-related costs for the treatment group.

Table 5: Out-Of-Pocket Educational Expenses

	Total Out-of-Pocket Cost (Paid to School and Paid for Other Educational Purposes)		
Per Student Cost	**10-month Intervention**	**Yearly**	**Monthly**
Treatment Group	26217.67	31461.20	2621.77
Control Group	30854.33	37025.20	3085.43
Overall	27964.97	33557.96	2796.50
	Per Student Cost Paid for Other Educational Purpose		
Per student cost	**10-month Intervention**	**Yearly**	**Monthly**
Treatment Group	21515.14	25818.17	2151.51
Control Group	27070.41	32484.49	2707.04
Overall	23637.52	28365.03	2363.75

Note: All costs were reported by parents and calculated in the current value of BDT.

6.4 Cost-Effectiveness Analysis

The treatment group saw a decrease in the risk of school dropout by 11% after the intervention, while the control group had an increase by 0.3%. The incremental cost (additional cost for reducing school dropout risk) was BDT 6,388.21. The incremental effect (change in the probability of school dropout) was -0.11 for the treatment group, which indicates an 11% reduction in dropout risk. The ICER, which represents the cost per percentage point reduction in dropout risk, was BDT 565.33.

For STEM education, the treatment group experienced an average increase of 3.80 points in mathematics scores at post-intervention, whereas the control group had an average decrease of 3.0 points. The incremental cost to achieve this increase in math scores was the same as the dropout risk, BDT 6,388.21. The incremental effect, or improvement in mathematics scores, was 6.8 points when comparing the treatment group's improvement over the control group's decrease. The ICER for mathematics scores was BDT 939, indicating the cost for each additional point increase in math scores **(Table 6)**.

Table 6: ICER of Multifaceted Programs On School Dropout and STEM Education

Item	Treatment Group	Control Group
Risk of School Dropout		
Per Student Cost	6388.21	0.00
Difference between Post-Pre-Treatment Period	-0.11	0.003
Incremental Cost	6388.21	
Incremental Effect	-0.113	
ICER	565.33	
Mathematics Score		
Per Student Cost	6388.21	0.00
Difference between Post-Pre-Treatment Period	3.80	-3.0
Incremental Cost	6388.21	
Incremental Effect	6.8	
ICER	939	
Science Score		
Per Student Cost	6388.21	0.00
Difference between Post-Pre-Treatment Period	10.14	2.66
Incremental Cost	6388.21	
Incremental Effect	7.48	
ICER	854	

For science scores, the treatment group's average score increased by 10.14 points, while the control group's average score increased by 2.66 points. The incremental cost for science score improvements was also BDT 6,388.21. The incremental effect was 7.48 points, suggesting that the treatment group's scores increased by 7.48 points more than the control group's scores. The ICER for science scores was BDT 854, reflecting the cost for each additional point of improvement in science scores.

The costs associated with reducing dropout risk and enhancing STEM educational achievement have been effectively quantified through the ICER, demonstrating cost-effectiveness both nationally and globally. The ICER values indicate that the intervention was more cost-effective in reducing the risk of school dropout than in boosting STEM education, as the cost per unit of effect was lower for dropout reduction. Notably, the intervention appears to have mitigated dropout risk by primarily improving academic performance. This suggests that the pathway of academic attainment was a significant factor in the program's effectiveness in reducing school dropout rates, although it was relatively expensive than addressing school dropout directly **(Table 6)**.

6.5 Cost-Benefit Ratio

Cost-benefit analysis is an essential tool for optimizing educational interventions, ensuring that limited educational resources are used effectively to produce the greatest possible benefit. Evaluating CBR for programs thoroughly requires a complete accounting of all benefits and costs across various sectors. However, we developed our CBR analysis framework to estimate potential costs and benefits of multifaceted programs by accounting for effect on wage premium or future earnings because of lack reliable estimates and input data for other sectors. We have used FW formula suggested by previous studies (Verguet 2020; Psacharopoulos et al. 2018). The current average annual wage in Bangladesh was derived from the latest Labor Force Survey 2022. The return of educational investment in terms of income per capita due to additional schooling years was extracted from Mamun and colleagues (2021). The intervention cost data was available from our own project expenditure sheet. In our study addressing school dropout reduction, we applied a 13.2% increase in per capita income (95% CI: 10.46% to 15.94%), while for achievements in STEM education, we utilized an 18% increase (95% CI: 11.73% to 24.27%). These figures were based on the estimates of a previous study conducted in Bangladesh (Mamun et al. 2021). To accurately represent the uncertainty inherent in these estimates, we calculated the CBR using the ranges provided by the confidence intervals.

First, we calculated the future wage gains per child resulting from educational advancements, considering a working span of 45 years (from age 15 to 60), with a 3% annual discount rate.

The formula for FW calculation was:

$$FW = W * A * \sum_{i=5}^{49} (1+r)^i$$

Where FW represents future wages, W denotes the base wage, A is the % wage increase due to completion of one year of schooling, and r is the 3% annual discount rate.

W = Mean annual income [Average annual wage was 164028 BDT (13669*12)]

A = Income per capita increase [School Dropout: 10.46% to 15.94%; STEM Education: 11.73% to 24.27%]

r = Annual discount rate of 3%

T = Working lifetime [Total 45 years time periods]

i = For i in range (5, 5 + T)

Second, **we used calculated FW in CBR calculation as follows:**

$$\text{CBR} = \frac{FW}{\text{Total Cost Over Lifetime}}$$

where,

FW represents the Future Wages

Annual cost per student was 6,388.21

Total Cost Over Lifetime is the annual cost per student*T

The calculated FW school dropout reduction were 1,844,202 to 2,810,381 BDT that represents the present value of the additional future earnings a student is expected to gain due to the intervention and completion of an additional school year, discounted over a 45-year working lifetime, starting 5 years into the future, with 10.46% to 15.94% increase in future earnings. The total cost incurred over the 45-year working lifetime, based on an annual cost of 6,388.21 BDT per student, was 287,469.5 BDT. This is the aggregate investment made in the student over their educational period, discounted at a 3% rate. The The CBR was approximately 6.41 to 9.78. This means that for every 1 BDT invested in school dropout reduction, the return in terms of the present value of increased future earnings is about 6.41 to 9.78 BDT per student.

Table 7: Cost-Benefit Analysis of Educational Outcomes

Item	School Year Completion	STEM Education
Future Wage Increase	1,844,202 to 2,810,381 BDT	2,068,116 to 4,279,043 BDT
Cost-Benefit Ratio	6.41 to 9.78	7.19 to 14.89

Similarly, a projected increase of 2.07 to 4.28 million BDT in future earnings suggests a substantial economic benefit from investment in STEM education. The CBR suggests that for every 1 BDT spent on STEM education, the return, in terms of increased future earnings, ranges from approximately 7.19 BDT to 14.89 BDT **(Table 7)**.

6.6 Discussion and Conclusion

In our study, the monthly OOP education expenses for all students was found to be BDT 2796.50 (in the intervention period), which was more than the government education budget per student of BDT 2477.013. Our study found that around 10% of the household income is spent on a single child education. Our findings are coherent with previous national studies. The monthly household income of people of Bangladesh in 2022 was BDT 32,422, while monthly expenditure was found to be BDT 31,500, according to the Household Income and Expenditure Survey 2022. Global Education Monitoring Report-2022 reported that families bear 71% of the total education expenditure in Bangladesh. The income Gini coefficient was 0.499 in 2022, and the national poverty rate in the urban population of Bangladesh was 14.7% (Bangladesh Bureau of Statistics-BBS 2022). In our study, the participants were from the slums of Dhaka city, and their OOP for child education in seems very high from the perspectives of household income, poverty rate, and inequality of income of the country that leads to huge financial burden for the low-income families particularly in marginalized communities.

For 1% school dropout risk reduction, the incremental intervention cost was BDT 565. On the other hand, to increase 1% of Science and Mathematics scores, BDT 854 and BDT 939 were spent consecutively. All ICER values were far below the willingness to pay threshold, which clearly indicates that our intervention was cost-effective in terms of the value of money and utility gain in education. The study by Lakshminarayana et al., 2013 in India with almost similar type of interventions found the cost per 0.1 SD increase in composite academic test score £5.58, which was BDT 776 of the exchanged value at current rate (Lakshminarayana et al. 2013). Studies with multifaceted programs were expensive than single intervention (Asim et al. 2016) and we can, therefore, argue that our interventions were cost-effective compared to other South Asian studies .

Our CBR estimates show that for every BDT invested in multifaceted programs, there is a return of 6 to 15 fold in terms of their increased future earnings capacity. Our estimates are consistent and somewhat lower than the previous studies because of considering only future income component. Multisectoral benefits will increase the CBR (Verguet 2020; Psacharopoulos et al. 2018, Banerjee et al. 2015). It demonstrates that the economic benefits, in terms of enhanced future earnings potential, significantly outweigh the costs of the educational program. The intervention's impact is not immediate but spans over the working lifetime of the individual, emphasizing the enduring value of educational improvements. Beyond individual financial gains, such educational outcomes can have broader socioeconomic benefits, contributing to workforce development, economic growth, and societal well-being.

The findings hinge significantly on the assumptions used, especially the percentage increase in future earnings and the discount rate. Although the results appear favorable, it's important to interpret them in light of these assumptions. Nonetheless, adopting a long-term perspective is essential in education policy and planning. This approach acknowledges that the advantages of investing in programs aimed at reducing school dropout rates and enhancing STEM education typically unfold over a prolonged duration.

CHAPTER SEVEN

Generalizability, Transportability, and Scalability

7.0 Rationale

In the educational landscape of Bangladesh, implementing effective interventions is crucial in addressing the multifaceted challenges faced by its diverse student population. Bangladesh's education system grapples with distinct challenges, including access, quality, and equity, compounded by the persistent problem of student dropout rates. The dropout phenomenon poses a significant hurdle to sustained educational progress, reflecting complex interactions between socioeconomic factors, cultural dynamics, and the quality of educational infrastructure. The dropout rates presented by the Bangladesh Bureau of Education Information and Statistics (BANBEIS 2022) underscore the significant academic challenges the country faces. In 2022, the dropout rate for primary schools was reported at 14%, with an even higher rate of 39% for secondary schools. Notably, almost half of the students who fail to complete each academic level are concentrated in the urban centers of Dhaka and Chattogram (UNICEF Bangladesh 2020). This underscores the urgency for targeted interventions, especially within the framework of quasi-experimental designs, to address the complex factors contributing to dropout rates and enhance educational continuity for the children of Bangladesh.

Against the backdrop of the pronounced dropout rates and academic challenges highlighted, we implemented a quasi-experimental study to address these pressing issues as a strategic response. Our study, characterized as evaluative action research, examined schemes designed for OOSC within the country. This comprehensive assessment aimed not only to scrutinize the effectiveness of the existing initiatives but also to evaluate their potential for scalability. However, the evaluation of scalability within our study is intricately linked to the external validity of the effect estimates of our interventions beyond the immediate study context. Therefore, this present study aims to investigate the generalizability and transportability of our study findings to specific target populations to assess that the interventions examined possess relevance and effectiveness in diverse educational settings, thereby informing evidence-based practices on a broader scale.

7.1 Methods

The effect estimates of our intervention in the trial population were extrapolated to the national and local target populations to evaluate the external validity in terms of generalizability and transportability, respectively. To evaluate the generalizability of our interventions, we set the target population as the number of students enrolled in primary (Grade 1 to Grade

5) and secondary (Grade 6 to Grade 9) levels of education in Bangladesh in 2022, provided by the Bangladesh Bureau of Educational Information and Statistics (BANBEIS 2022). As the individual-level data were unavailable, we used the marginal and joint distribution of Sex and Grades.

Table 8: Characteristics of SAIST Cohort Participants and Students in Bangladesh in 2022

Characteristics	Study Population (n=824)		National Population (n= 25,291,450)	
	N	%	N	%
Age, years (Mean, SD)	11.5 (2.4)		NA	
Boys	352	42.7	12349405	48.8
Grades				
Grade 1	26	3.2	3250251	12.9
Grade 2	59	7.2	3598319	14.2
Grade 3	73	8.9	3357052	13.3
Grade 4	95	11.5	3154918	12.5
Grade 5	82	10.0	3604427	14.3
Grade 6	112	13.6	2162623	8.6
Grade 7	124	15.0	2099856	8.3
Grade 8	159	19.3	2120446	8.4
Grade 9	94	11.4	1943558	7.7
Grades x Boys				
Grade 1	14	1.7	1644849	6.5
Grade 2	27	3.3	1824116	7.2
Grade 3	35	4.2	1708300	6.8
Grade 4	39	4.7	1605670	6.3
Grade 5	29	3.5	1800388	7.1
Grade 6	54	6.6	983720	3.9
Grade 7	46	5.6	943090	3.7
Grade 8	79	9.6	965512	3.8
Grade 9	29	3.5	873760	3.5

NA, Not Available; SD, Standard deviation

Baseline characteristics of the study and target populations were described using proportions, medians, and interquartile ranges. Comparisons of the selected covariates were made between participants in the treatment and control groups among matched and unmatched study populations using Student's t-test for continuous variables or a chi-squared test for categorical variables. Changes in outcome variables over time were compared by GEE method (Zeger, Liang, and Albert 1988). GEE analysis included the main effect of group (treatment vs. control), time, and their interactions.

Table 9: Generalizability of ATT on National Student Population in Bangladesh in 2022

Outcomes	ATT	95 % CI	CL Ratio
Risk of School Dropout			
Cohort Results			
Unweighted	-0.10	(-0.12, -0.07)	1.71
Weighted[1]	-0.11	(-0.15, -0.07)	2.14
Population Results			
Sex weighted	-0.11	(-0.15, -0.07)	2.14
Grade weighted	-0.12	(-0.17, -0.06)	2.83
Grade-Sex weighted	-0.13	(-0.18, -0.09)	2.00
Math Score			
Cohort Results			
Unweighted	5.10	(1.72, 8.48)	0.20
Weighted[1]	6.80	(2.77, 10.83)	0.26
Population Results			
Sex weighted	6.87	(2.82, 10.92)	0.26
Grade weighted	4.23	(-0.30, 8.75)	-0.03
Grade-Sex weighted	9.80	(3.48, 16.11)	0.22
Science Score			
Cohort Results			
Unweighted	6.66	(3.42, 9.90)	0.34
Weighted[1]	7.48	(3.70, 11.26)	0.33
Population Results			
Sex weighted	7.26	(3.43, 11.09)	0.31
Grade weighted	4.04	(-0.62, 8.70)	-0.07
Grade-Sex weighted	6.78	(1.41, 12.16)	0.12

[1] Weighted with IPTW; CL: Confidence Limit Ratio

We aimed to obtain effect estimates that are valid both internally and externally. For an internally valid effect estimate, we used cardinality matching (Visconti and Zubizarreta 2018) and inverse probability of treatment weighting (Stuart, Bradshaw, and Leaf 2015) to achieve the exchangeability of treatment. Age, Sex, Grade, and BMI of the child, mother's education, and household wealth index were used as matching covariates.

In addition, the following variables were selected for adjustment in the GEE model: disability status, mother's age, number of children in the family, parental involvement in the child's homework, spending time with the indexed child, providing private tuition to the child, having adequate sleep and rest by the child, attending parent-teacher meetings, facilitating study on YouTube, child receiving any stipend, classroom size (in square feet), student-teacher ratio, boys-girls ratio, ECA, whether the indexed child is comfortable asking questions to the teachers, follow mathematics lectures and encountered any bullying incidence. This was to minimize the potential confounding effects of these variables on the effect estimate. We used IPTW to apply the adjustment. This involved calculating each subject's propensity score (Stuart et al. 2015) for being in the treatment group using logistic regression that included all the independent variables mentioned earlier.

The inverse of these propensity scores was then calculated for each subject. Inverse odds weights for transportability (Westreich et al. 2017) were calculated to extrapolate our effect estimates to national and local target populations (exchangeability of selection into the sample). This involved calculating the propensity of being in the study sample compared to the target population based on the distribution of Sex and Grade in the target population. The corresponding weights were obtained by using the inverse of the propensity scores. These weights were then multiplied with the treatment weights and used as weights in the GEE models. The precision of the effect estimates was evaluated using the confidence limit ratio (CLR) (Cole and Stuart 2010).

7.2 Comparison of Study and Target Population

Table 8 presents a comprehensive overview of the characteristics of study participants comprised of 812 cardinality-matched individuals, against the national population enrolled students in grades 1 to 9 in Bangladesh in 2022, totaling 25,291,450 students. The study population demonstrates a mean age of 11.5 years with a male prevalence of 42.7%, contrasting the national male student percentage of 48.8%. We found that the proportion of enrolled students in primary education (Grades 1-5) in the study population is lower than that of the national population. However, the proportion of enrolled students in secondary education (Grades 6-9) is higher in the study population than in the national population. We also observed a similar pattern in the distribution of Grade levels and Sex (boys).

7.3 Impact of Multifaceted Programs and Generalizability

The per-protocol analysis of the unadjusted study population found a 10% (CI: 7, 13%) reduction in risk of school dropout among the students in treatment schools compared to those in control schools **(Table 9)**. The adjusted estimate of such a reduction was 11% (CI: 7, 15). **Table 9** displays the effect estimates after standardizing the cohort results to the target population by adjusting for Sex and Grades. After accounting for the difference in Sex between the cohort and target population, the ATT was almost similar. Similarly, the ATT was slightly higher (12%) when accounting for the difference in Grades. When we accounted for both Sex and Grades, the ATT was increased to 13%. All the weighted estimates have a similar level of precision, as demonstrated by the CLR in **Table 9**. However, precision was lower when we generalized the effect estimates to the target population for Grades, as indicated by the CLR (2.77). **Table 9** also shows that ATT were higher for math and science scores after accounting for Sex and both Sex and Grades. However, ATT for both math and science score were attenuated when accounting for the difference in Grades. Precision was higher for Sex and Sex-Grades except for only Grades when generalized our estimates to target population.

Table 10: Characteristics of Transportable Population in Dinajpur in 2023

Characteristics	n=540	%
Age, years (Mean, SD)	540	12.8 (2.8)
Boys	303	56.1
Grade 1	17	3.1
Grade 2	22	4.1
Grade 3	16	3.0
Grade 4	21	3.9
Grade 5	15	2.8
Grade 6	107	19.8
Grade 7	123	22.8
Grade 8	105	19.4
Grade 9	88	16.3

7.4 Impact of Multifaceted Programs and Transportability

We recruited 3 schools in Dinajpur, about 400 KM away from the main study area and the transportable population consists of 540 students enrolled in primary and secondary schools in these schools in 2023, with an average age of 12.8 years, indicating a predominantly adolescent demographic. The gender distribution shows a majority of boys, constituting 56.1% of the population. The grade distribution reveals that the majority of the population is in the upper grades (6 through 9), with these grades accounting for over 78% of the individuals **(Table 10)**. These discrepancies could be informative for understanding patterns of school dropout and STEM educational attainment. For example, if the study population has a more balanced gender distribution or a different grade composition, it may indicate that the transportable population is facing specific challenges or conditions that are not as prevalent in the general student body.

Table 11: Transportability of Impact on Students in Dinajpur in 2023

Outcomes	ATT	95 % CI	CL Ratio
Cohort Results			
Unweighted	-0.10	(-0.12, -0.07)	1.71
Weighted[1]	-0.11	(-0.15, -0.07)	2.14
Transportability Results			
Sex weighted	-0.12	(-0.15, -0.09)	1.67
Grade weighted	-0.12	(-0.15, -0.10)	1.50
Grade-Sex weighted	-0.13	(-0.16, -0.10)	1.60
Math Score			
Cohort Results			
Unweighted	5.10	(1.72, 8.48)	0.20
Weighted[1]	6.80	(2.77, 10.83)	0.26
Transportability Results			
Sex weighted	6.94	(2.79, 11.10)	0.25
Grade weighted	8.45	(3.81, 13.10)	0.29
Grade-Sex weighted	9.73	(5.21, 14.24)	0.37
Science Score			
Cohort Results			
Unweighted	6.66	(3.42, 9.90)	0.34
Weighted[1]	7.48	(3.70, 11.26)	0.33
Transportability Results			
Sex weighted	7.01	(3.05, 10.97)	0.28
Grade weighted	10.28	(6.95, 13.61)	0.51
Grade-Sex weighted	10.68	(7.08, 14.28)	0.50

[1]Weighted with IPTW; CL: Confidence Limit Ratio

Our analysis reported that three-level multifaceted short-term interventions were effective in reducing the risk of school dropout and increasing the STEM educational attainment among treated. We further transported our estimates to Grades 1-9 students in another area (Dinajpur) accounting same characteristics. **Table 11** displays the effect estimates after standardizing the cohort results to the transportable population by adjusting for Sex and Grades. After accounting for the difference in Sex and Grades between the cohort and transportable population, the ATT was was slightly higher (12%). When we accounted for both Sex and Grades, the ATT was increased to 13%. In congruence to school dropout reduction, ATT for both math and science score were higher when accounting for the difference in Sex, Grades as well as both Sex-Grades. All the weighted estimates have a similar level of precision when transported our estimates transportable students in Dinajpur, as demonstrated by the CLR in **Table 11**. It indicated the transportability of the impact of our multifaceted interventions.

7.5 Generalizability and Transportability

Recognizing the need for targeted interventions within the unique educational context of Bangladesh, our study has been meticulously designed and implemented to evaluate the efficacy of specific interventions aimed at curbing dropout rates and improving STEM educational achievement. This study sought to discern the impact of educational interventions in national settings and navigate the intricate socioeconomic, cultural, and infrastructural factors contributing to student attrition in Bangladesh.

Our results demonstrated a 11 % reduction of school dropout risk among the students at treated schools. Moreover, our interventions increased math and science score by 6.8 and 7.5 points, respectively. Our generalized effect estimates were comparable to the study populations when single-factor-weights were adjusted. When the differences in Sex between study participants and the target population were accounted for, the ATT was similar and somewhat higher for three outcomes. Even though the study selected for girls (high proportion against boys) as compared to the national distribution of Sex, the effect appeared weaker in them. The standardized impact, therefore, was stronger due to the strong effect among the male counterparts. Similarly, when we accounted only for the difference in Grades between the study participants and the target population, the school dropout reduction was slightly higher in because the study selected against the primary students, and there were mixed effects among them. For the Grade-Sex-weighted estimate, the effect was more substantial (higher reduction of school dropout and increase of STEM education achievement). This could manifest the difference between the study participants and the target population. However, ATT accounting difference of Grades was lower for math and science score which may be due to the interaction by Sex and Grades and only Grades could not capture it.

Our transportability results demonstrated that the transported effect estimates were more substantial (higher reduction of school dropout and increase of STEM education achievement) after accounting differences between cohort population and target population in terms of Sex, Grades and Sex-Grades. It confirms the significant difference between the study participants and the transportable population and study settings, which is the important condition of being transportable population.

One of the crucial first steps to generalize and transport the impact of the study intervention on a target and transportable population is to identify the potential factors that could influence the intervention's effectiveness (Tipton and Olsen 2022; Weiss, Bloom, and Brock 2014). Using subject matter knowledge coupled with novel ML approaches, we selected student and school-level characteristics. Our method of meeting identification conditions regarding exchangeability was robust at both the design and analytic steps.

Regarding extrapolating our study findings, we selected Sex and Grades for adjustments. Our choice of moderators is evident in the reversed distribution of Sex and Grades among the study participants, the national student population and transportable student population in Dinajpur. We used statistical adjustments using IOTW (Westreich et al. 2017) to address those differences. Our adjustments were used to up-weighted the participants who were boys and in primary classes (Grade 1-5, underrepresented as compared to the national distribution, Table 8) and down-weighted those who were boys and in secondary classes (Grade 6-9, overrepresented as compared to the national distribution, Table 8). These adjustments reduced bias due to differences in the sample to the population at the expense of the precision of the estimates (wider confidence interval) (Tipton and Olsen 2022).

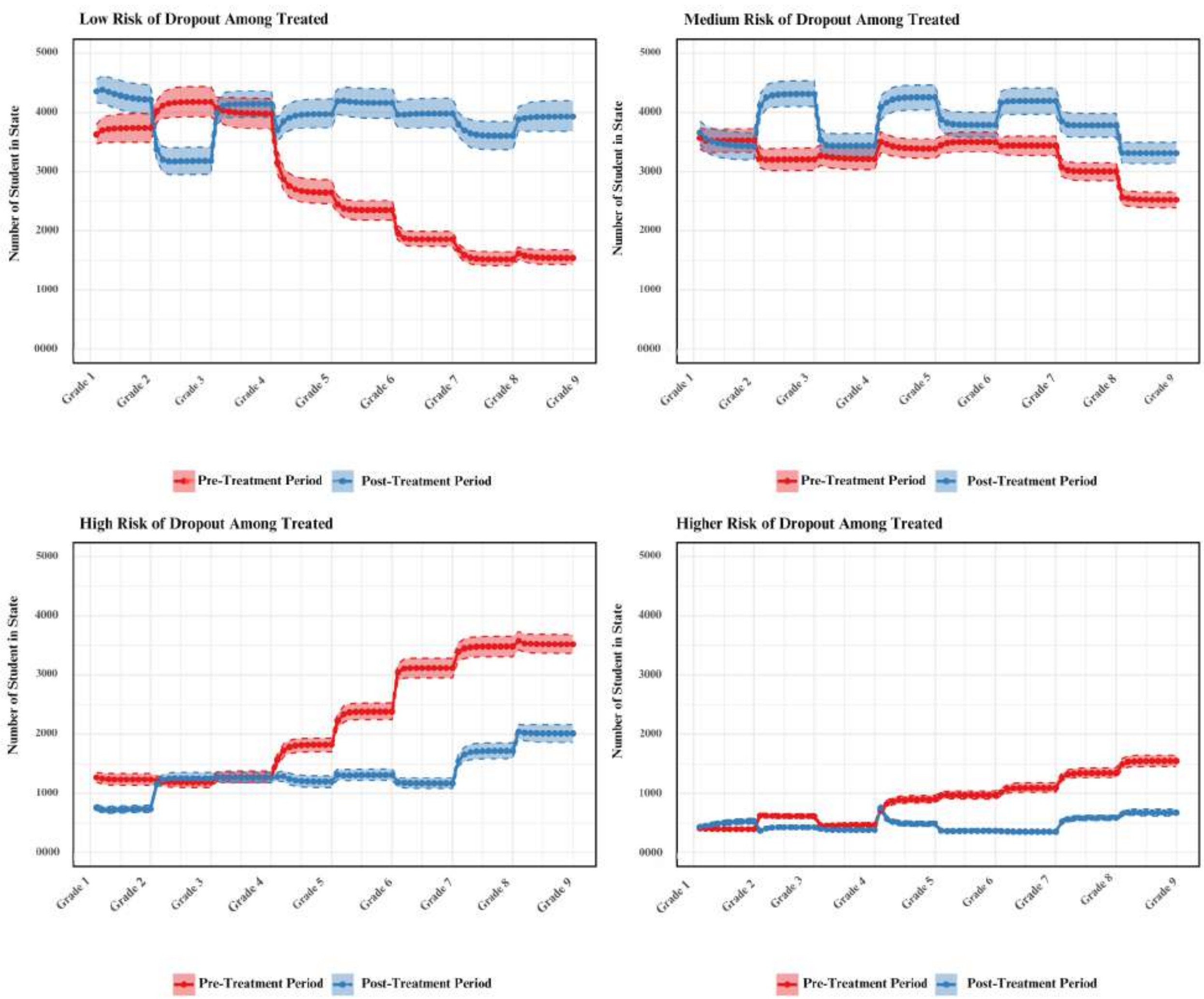
However, generalizability and transportability in terms of other measures (but unavailable at the national level) and unmeasured moderators was not possible and remained a limitation. Extrapolating the study findings to the national setting and in Dinajpur is crucial. It could be the case that some interventions and their effects vary significantly among students and schools (Weiss et al. 2017). Furthermore, educational impact studies have indicated disparities in outcomes across student subgroups and schools that exhibit diversity in their student compositions. As a result, the assumption that an intervention's success in specific study-participating schools guarantees similar effectiveness in other non-participating schools is dubious (Bell et al. 2016; Orr et al. 2019). From a policy perspective, it is essential to conduct a rigorous evaluation of the potential benefits of adopting the intervention more broadly in the population of policy interest. As far as we can establish, this is the first study in Bangladesh to evaluate the effectiveness of targeted interventions for OOSC and at risk of dropping out, and the generalizability and transportability of the impacts of such interventions in large settings.

Figure 14: Simple Schematic of the Multistage Markov Model of Progression between Risk of Dropout States

7.6 Impact of Multifaceted Programs and Scalability

The cohort state transition model (cSTM), simulating the educational journey of 10,000 students, tracks their monthly transition through five dropout risk categories based on absenteeism rates. These categories are defined as low risk (<=10% absenteeism), medium risk (11% to 35%), high risk (36% to 59%), higher risk (61% to 90%), and dropout (>90%) [**Figure 14**]. Unlike models with absorbing states, students in the cSTM can shift between adjacent risk states, reflecting changes in their risk of dropping out.

Figure 15A: Long-Term Impact and Scalability of Intervention among Treated



The model, designed to extrapolate over 8-academic cycles (Grade I-VIII), each lasting 10 months, to predict long-term impact of intervention in reducing risk of dropouts.The model operates in cycles, with each cycle representing 1 month. The 80th cycle is particularly crucial, marking a significant milestone in the model's projection and completion of junior school in Bangladesh. All students are assumed to start at Grade I and potentially advance to Grade IX. Transition probabilities are state-dependent, meaning a student's future risk state relies solely on their current one, without influence from their historical pattern of absenteeism. For this study, we introduced a 10% adjustment to these probabilities, applying a perturbation rate of 0.10, to account for variability. The resulting uncertainty in both the treatment and control groups is quantified by median values and a 95% CI, derived from percentile methods, to capture the potential range of outcomes.

Figure 15B: Long-Term Impact and Scalability of Intervention among Treated

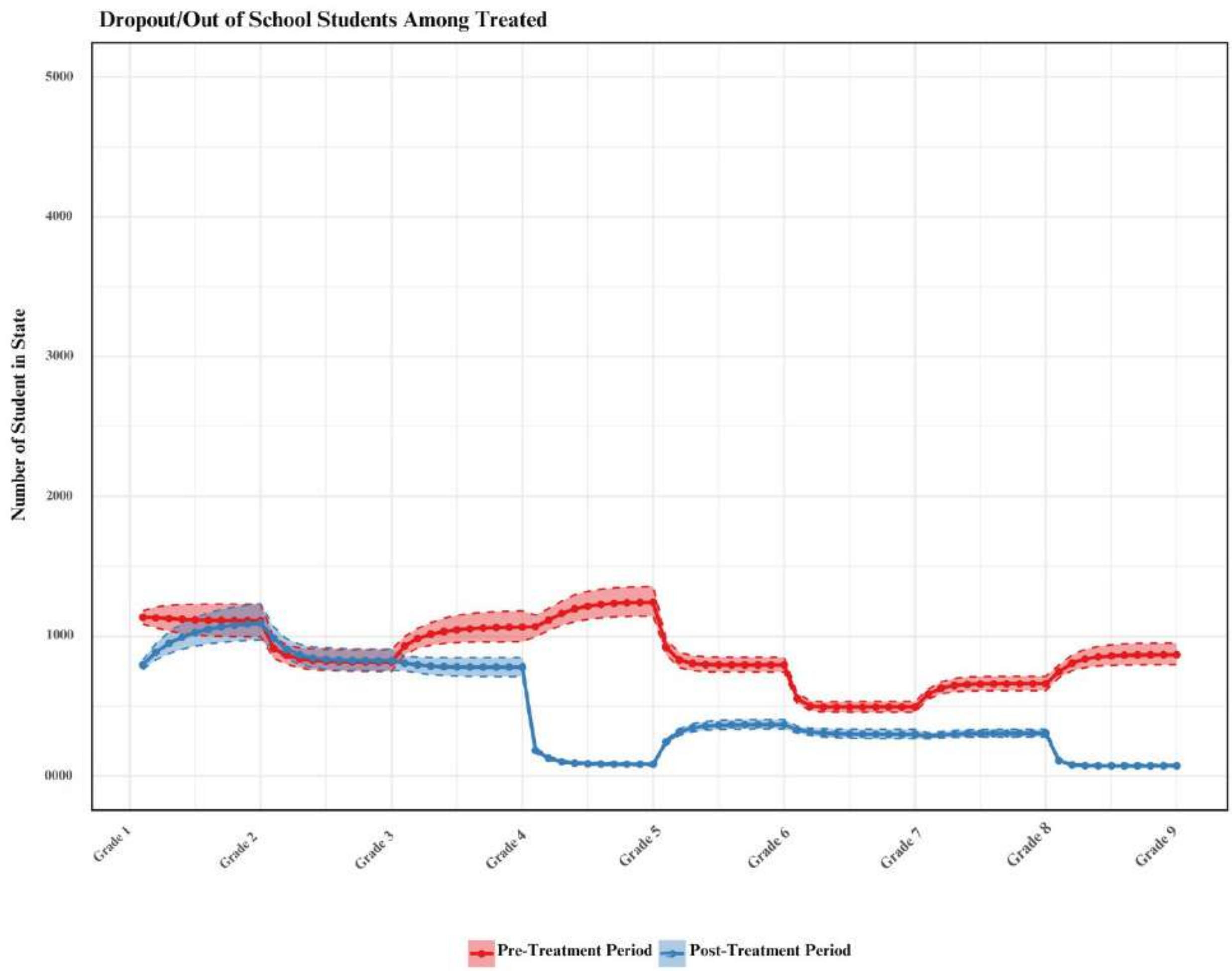


Figure 15A-B presented the long-term impact and scalability of intervention among treated. The result indicated that in the post-treatment period, the risk of dropout was significantly lower compared to the pre-treatment period among treated students at the national level, which is supported by the findings. It means that based on the findings from the short-term impact of multifaceted programs if we design long-term interventions at the national level, it significantly lowered the risk of dropout [**Figure 15A**] as well as significantly reduced school dropout (about 75%) [**Figure 15B**]**.** The parameter were robust to 10% changes in the initial transition probabilities and to the modeled uncertainties. Most of the students thus will complete their junior school that is attributable to the interventions.

CHAPTER EIGHT

Conclusion and Policy Implication

8.0 Strengths and Limitations

One of the main strengths of this study lies in the design and implementation of the programs, as they were carefully tailored to the sociocultural context of the study areas and population. Furthermore, the study employed a robust analytic framework and appropriate statistical methods to estimate the program's impact at both the school and student levels. Tests for generalizability, transportability, and scalability suggest high internal and external validity of our findings.

However, the study had some limitations. One potential issue was the possibility of a spillover effect, particularly since the schools were concurrently implemented government's new curriculum for grade 1, 6 and 7. This introduction to new curriculum involved a week-long training primarily on new curriculum implementation and assessment techniques. In contrast, our interventions, spanning 10 months, were specifically designed for reducing school dropout rates and improving STEM educational attainment at teacher, student, and parental/community levels. Teachers received training in effective implementation of experiential and experimental learning techniques. Consequently, any spillover effect is likely to be positive, as the school-level programs and activities were accessible to all students. This inclusivity means that even those who did not directly participate in the study could benefit, especially through the enhanced skills of their trained math and science teachers. Another limitation relates to the duration of the program implementation. The 10-month period, while allowing for meticulous activity planning, may not have been sufficient to observe the full spectrum of potential long-term effects.

8.1 Conclusion

The short-term multifaceted interventions we implemented have shown a significant impact in promoting inclusive and quality education, as evidenced by positive changes in school dropout rates and learning outcomes in STEM subjects. Based on our baseline report, we implemented effective interventions at various levels – student, school, teacher, parental, and community – to address factors contributing to the risk of dropout and poor performance in STEM subjects in primary and secondary schools. Our results revealed noteworthy improvements post-intervention in reducing dropout risk and closing learning gaps in STEM education. The meaningful impacts we observed are directly attributable to the specific activities carried out during our interventions. These included enhancing teachers' capacity for experiential teaching, fostering community engagement through parental awareness sessions and PTMs and boosting students' motivation, and raising awareness and practices regarding key issues such as nutrition, health, menstrual hygiene, bullying, and sexual harassment.

In summary, the findings from this study offer a persuasive blueprint for LMICs, including Bangladesh, to design and implement effective, affordable, and scalable educational programs. When executed well, these programs can substantially reduce school dropout rates, enhance STEM education, and foster inclusivity and equality in the educational landscape.

8.2 Policy Implications

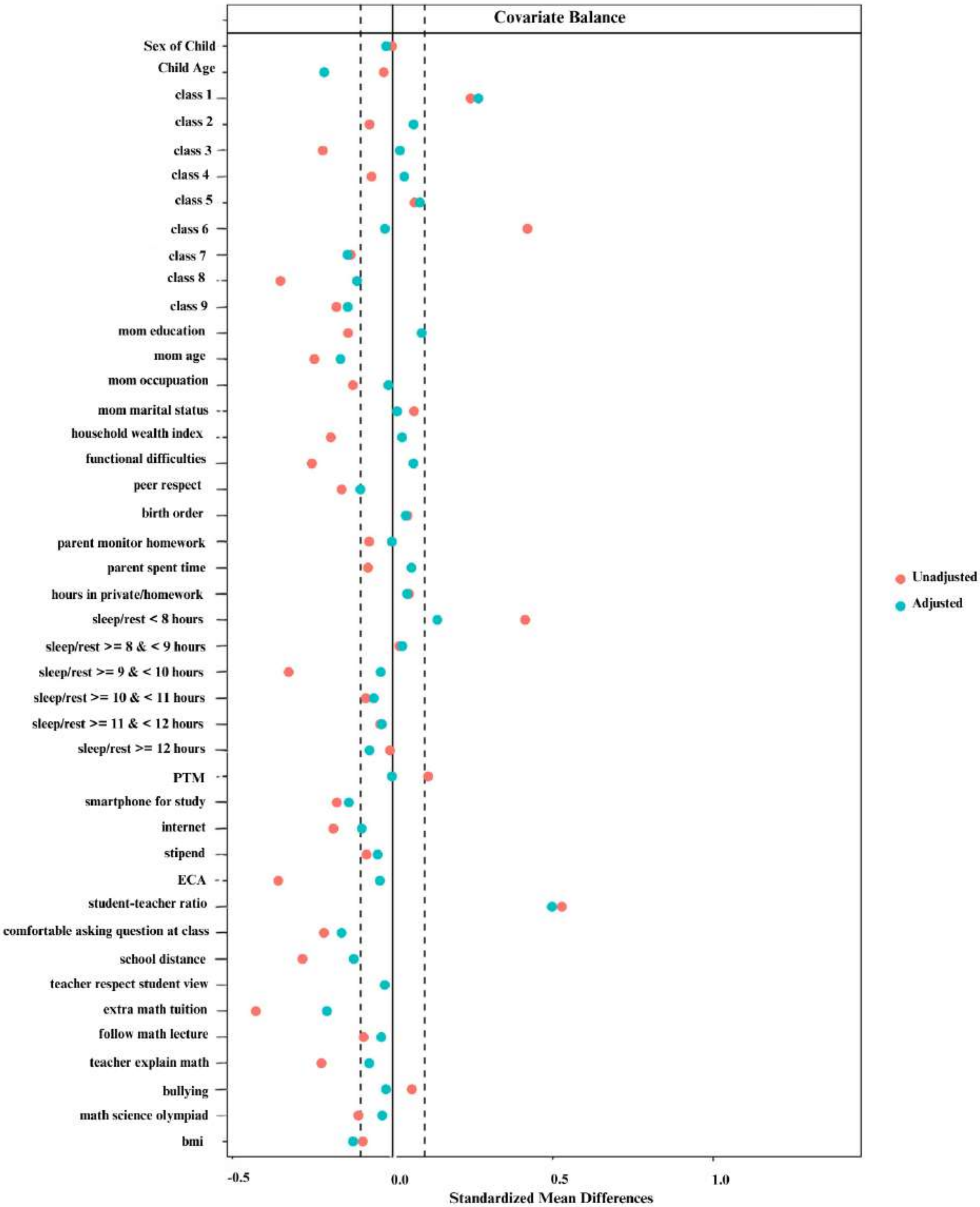
The SAIST Foundation's programs in Bangladesh have significantly reduced school dropout risk and improved STEM education attainment, especially among high-risk groups such as students from low-income households and boys in higher grades. These multifaceted programs have successfully reduced school dropout rates by 11 to 13% and markedly improved STEM performance, showcasing their effectiveness in targeted educational strategies. A key aspect of the program's success lies in its ability to address disparities in educational outcomes influenced by factors such as household wealth, gender, and nutritional status. This was achieved by integrating GESI indicators and providing supplementary tutoring, especially in STEM subjects to bridge learning gaps.

Additionally, the affordability of these interventions makes them not only effective but also cost-efficient, suggesting long-term benefits in terms of increased earnings. This efficiency, coupled with their scalability, suggests that similar programs could significantly reduce dropout rates at a national level if widely implemented. The study further highlights the importance of enhanced infrastructure to support disabled students and emphasizes the critical role of community engagement, like promoting parental awareness and involvement, in improving quality education.

By adopting a data-driven approach and addressing learning disparities, the study reinforces the need for evidence-based policies and support systems for low-income families. These initiatives are crucial for ensuring equitable access to quality education for all, in alignment with SDG-4, regardless of disadvantaged background.

APPENDICES

Appendix 1. Covariate Balance at Design and Analytic Level



দৈনিক উপস্থিতির তালিকা

Appendix 2: Students Attendance Card

আইডি নংঃ

শিক্ষার্থীর নামঃ **শ্রেণীঃ**

বিদ্যালয়ের নামঃ **শাখাঃ**

তুমি কি এই মাসে নিয়মিত স্কুলে উপস্থিত থাকতে পারবে? পারলে তোমার জন্য রয়েছে পুরস্কার!

মার্চ ২০২৩

রবি	সোম	মঙ্গল	বুধ	বৃহস্পতি	শুক্র	শনি
			১	২	৩	৪
৫	৬	৭	৮	৯	১০	১১
১২	১৩	১৪	১৫	১৬	১৭	১৮
১৯	২০	২১	২২	২৩	২৪	২৫
২৬	২৭	২৮	২৯	৩০	৩১	

- **উপস্থিত থাকলে ঘরগুলো সবুজ রঙ কর**
- **অনুপস্থিত থাকলে ঘরগুলো ফাঁকা রাখ**

মোট কার্যদিবসঃ .... দিন

মোট উপস্থিতিঃ .... দিন

মোট অনুপস্থিতিঃ .... দিন

অভিভাবকের স্বাক্ষরঃ **শিক্ষকের স্বাক্ষরঃ**

....

SAIST FOUNDATION IDRC · CRDI Canada GPE KIX

Appendix 3: STEM Education Campaign in School [Photo@SAIST]

Appendix 4: Teachers Training on STEM Education and Kits Distribution

STEM Kits Distribution Photo@SAIST 2022

Appendix 5: Menstrual Hygiene Awareness Leaflet

Appendix 6: Nutrition Campaign Leaflet

দৈনিক স্বাস্থ্যবিধি ও পুষ্টিকর খাদ্যাভ্যাস

সুস্থ দেহ সুন্দর মন
সুষম খাদ্য প্রয়োজন

SAIST FOUNDATION

IDRC · CRDI

Canada

GPE KIX

ইভ টিজিং প্রতিরোধে সামাজিক সচেতনতামূলক কর্মশালা

Appendix 7: Eve Teasing Awareness Leaflet

জরুরি হটলাইন 1098 | নারী ও শিশু নির্যাতন প্রতিরোধে ১০৯ | জরুরি সেবা ৯৯৯ | সরকারি তথ্য ও সেবা ৩৩৩

"উত্ত্যক্তকারীদের বিরুদ্ধে রুখে দাঁড়ান নিরাপদ শিক্ষাঙ্গন নিশ্চিত করুন"

SAIST FOUNDATION

REFERENCES

Ahmmed, Sakil, and Mahtab Uddin. 2022. "Exploring the Disparities in Learning Outcomes among the Primary School Students of Bangladesh." *International Journal of Educational Development* 93:102644. doi: 10.1016/j.ijedudev.2022.102644.

Alderman, Harold, Jere R. Behrman, Victor Lavy, and Rekha Menon. 2001. "Child Health and School Enrollment: A Longitudinal Analysis." *Journal of Human Resources* 185–205.

Ali, Mohamed Moustafa, Robert Yager, Esme Hacieminoglu, and Ilke Caliskan. 2013. "Changes in Student Attitudes Regarding Science When Taught by Teachers Without Experiences With a Model Professional Development Program." *School Science and Mathematics* 113(3):109–19. doi: 10.1111/ssm.12008.

Asim, Salman, Robert S. Chase, Amit Dar, and Achim Schmillen. 2016. "Improving Learning Outcomes in South Asia: Findings from a Decade of Impact Evaluations." *The World Bank Research Observer* lkw006. doi: 10.1093/wbro/lkw006.

Attwood, Gaynor, and Paul Croll. 2006. "Truancy in Secondary School Pupils: Prevalence, Trajectories and Pupil Perspectives." *Research Papers in Education* 21(4):467–84. doi: 10.1080/02671520600942446.

BANBEIS. 2022. *Bangladesh Education Statistics 2022*.

Banerjee, A., E. Duflo, N. Goldberg, D. Karlan, R. Osei, W. Pariente, J. Shapiro, B. Thuysbaert, and C. Udry. 2015. "A Multifaceted Program Causes Lasting Progress for the Very Poor: Evidence from Six Countries." *Science* 348(6236):1260799–1260799. doi: 10.1126/science.1260799.

Bangladesh Bureau of Statistics (BBS). 2022. *Household Income and Expenditure Survey (HIES) 2022*.

Bangladesh Bureau of Statistics (BBS). 2023. *Labour Force Survey 2022 Bangladesh*. Dhaka: Ministry of Planning.

Baum, Sandy, Jennifer Ma, and Kathleen Payea. 2010. *Education Pays, 2010: The Benefits of Higher Education for Individuals and Society. Trends in Higher Education Series*. College Board Advocacy & Policy Center.

Behrman, Jere R. 2022. *Parental Investments and Children's Human Capital in Low-to-Middle-Income Countries*. 1st ed. Cambridge University Press.

Bell, Stephen H., Robert B. Olsen, Larry L. Orr, and Elizabeth A. Stuart. 2016. "Estimates of External Validity Bias When Impact Evaluations Select Sites Nonrandomly." *Educational Evaluation and Policy Analysis* 38(2):318–35.

Beller, Johannes, Siegfried Geyer, and Jelena Epping. 2022. "Health and Study Dropout: Health Aspects Differentially Predict Attrition." *BMC Medical Research Methodology* 22(1):31. doi: 10.1186/s12874-022-01508-w.

BIDS. 2014. *Impact Evaluation Study Of Reaching Out of School Children (ROSC) Project of the Ministry of Primary and Mass Education.* Dhaka: Bangladesh Institute of Development Studies.

Bybee, Rodger W. 2014. "NGSS and the Next Generation of Science Teachers." *Journal of Science Teacher Education* 25(2):211–21. doi: 10.1007/s10972-014-9381-4.

Chisamya, Grace, Joan DeJaeghere, Nancy Kendall, and Marufa Aziz Khan. 2012. "Gender and Education for All: Progress and Problems in Achieving Gender Equity." *International Journal of Educational Development* 32(6):743–55. doi: 10.1016/j.ijedudev.2011.10.004.

Chou, Ling-Chih, Chi-Yin Ho, Chuan-Yu Chen, and Wei J. Chen. 2006. "Truancy and Illicit Drug Use among Adolescents Surveyed via Street Outreach." *Addictive Behaviors* 31(1):149–54. doi: 10.1016/j.addbeh.2005.04.011.

Cole, Stephen R., and Elizabeth A. Stuart. 2010. "Generalizing Evidence from Randomized Clinical Trials to Target Populations: The ACTG 320 Trial." *American Journal of Epidemiology* 172(1):107–15.

Costa, Luis, Vivek F. Farias, Patricio Foncea, Jingyuan (Donna) Gan, Ayush Garg, Ivo Rosa Montenegro, Kumarjit Pathak, Tianyi Peng, and Dusan Popovic. 2023. "Generalized Synthetic Control for TestOps at ABI: Models, Algorithms, and Infrastructure." *INFORMS Journal on Applied Analytics* 53(5):336–49. doi: 10.1287/inte.2023.0028.

Deehan, James, Amy MacDonald, and Christopher Morris. 2022. "A Scoping Review of Interventions in Primary Science Education." *Studies in Science Education* 1–43. doi: 10.1080/03057267.2022.2154997.

DeLuca, Christopher, Holly Ogden, and Elizabeth Pero. 2015. "Reconceptualizing Elementary Preservice Teacher Education: Examining an Integrated-Curriculum Approach." *The New Educator* 11(3):227–50. doi: 10.1080/1547688X.2014.960986.

Deming, David, Sarah Cohodes, David James Deming, Jennifer Jennings, and Christopher Jencks. 2013. "School Accountability, Postsecondary Attainment and Earnings."

Denessen, Eddie, Nienke Vos, Fred Hasselman, and Monika Louws. 2015. "The Relationship between Primary School Teacher and Student Attitudes towards Science and Technology." *Education Research International* 2015:e534690. doi: 10.1155/2015/534690.

DeWitt, Jennifer, and Louise Archer. 2015. "Who Aspires to a Science Career? A Comparison of Survey Responses from Primary and Secondary School Students." *International Journal of Science Education* 37(13):2170–92. doi: 10.1080/09500693.2015.1071899.

DeWitt, Jennifer, Louise Archer, and Jonathan Osborne. 2014. "Science-Related Aspirations Across the Primary–Secondary Divide: Evidence from Two Surveys in England." *International Journal of Science Education* 36(10):1609–29. doi: 10.1080/09500693.2013.871659.

Dhaka Tribune. 2019. "Govt Plans to Feed All Primary School Goers by 2023." *Dhaka Tribune*. Retrieved January 4, 2024 (https://www.dhakatribune.com/bangladesh/government-affairs/185099/govt-plans-to-feed-all-primary-school-goers-by).

Directorate of Primary Education. 2023. *The National Student Assessment (NSA) 2022: Grades 3 and 5*. Dhaka: Ministry of Primary and Mass Education.

Farah, Shayela, Mohoshina Karim, and Sharmina Afrin. 2019. "Situation of Working Slum Children in Dhaka City." *Delta Medical College Journal* 7(1):26–30.

Filmer, Deon. 2008. "Disability, Poverty, and Schooling in Developing Countries: Results from 14 Household Surveys." *The World Bank Economic Review* 22(1):141–63.

Ford, Danielle J., Steve Fifield, John Madsen, and Xiaoyu Qian. 2013. "The Science Semester: Cross-Disciplinary Inquiry for Prospective Elementary Teachers." *Journal of Science Teacher Education* 24(6):1049–72. doi: 10.1007/s10972-012-9326-8.

Ghuman, Sharon, Jere Behrman, Socorro Gultiano, and Elizabeth King. 2006. "Children's Nutrition, School Quality and Primary School Enrollment in the Philippines." Citeseer.

Gubbels, Jeanne, Claudia E. Van Der Put, and Mark Assink. 2019. "Risk Factors for School Absenteeism and Dropout: A Meta-Analytic Review." *Journal of Youth and Adolescence* 48(9):1637–67. doi: 10.1007/s10964-019-01072-5.

Hasan, Md. Khalid, Helal Uddin, Tahmina Bintay Younos, Nur A. Habiba Mukta, and Dilara Zahid. 2023. "Prevalence of Truancy among School-Going Adolescents in Three South Asian Countries: Association with Potential Risk and Protective Factors." *International Journal of Adolescence and Youth* 28(1):2242480. doi: 10.1080/02673843.2023.2242480.

Haseeb, Faiza. 2021. "Dynamics of Primary School Dropouts in South Asia and Its Repercussions for SDGs." *Current Issues in Development Studies* 1(1):34–45.

Hijdra, R., J. Oude Groeniger, A. Burdorf, and M. Schuring. 2023. "The Effect of Mental Disorders in Youth on NEET and the Mediating Role of High School Dropout." *European Journal of Public Health* 33(Supplement_2):ckad160.1329. doi: 10.1093/eurpub/ckad160.1329.

Hummel-Rossi, Barbara, and Jane Ashdown. 2002. "The State of Cost-Benefit and Cost-Effectiveness Analyses in Education." *Review of Educational Research* 72(1):1–30. doi: 10.3102/00346543072001001.

Jacobson, Michael J., Kapur, Manu, and Reimann, Peter. 2016. "Conceptualizing Debates in Learning and Educational Research: Toward a Complex Systems Conceptual Framework of

Learning." *Educational Psychologist.* 51 (2): 210-218. doi: 10.1080/00461520.2016.1166963

Kearney, Christopher A., and Patricia Graczyk. 2014. "A Response to Intervention Model to Promote School Attendance and Decrease School Absenteeism." *Child & Youth Care Forum* 43(1):1–25. doi: 10.1007/s10566-013-9222-1.

Khan, Samia A., and Rob VanWynsberghe. 2020. "A Synthesis of the Research on Community Service Learning in Preservice Science Teacher Education." *Frontiers in Education* 5.

Klein, Markus, Edward M. Sosu, and Shadrach Dare. 2022. "School Absenteeism and Academic Achievement: Does the Reason for Absence Matter?" *AERA Open* 8:233285842110711. doi: 10.1177/23328584211071115.

Kuh, George D., Cruce, Ty M., Shoup, Rick, and Kinzie, Jillian.2008. "Unmasking the Effects of Student Engagement on First-Year College Grades and Persistence." *The Journal of Higher Education* 79(5): 540–63.doi: 10.1353/jhe.0.0019

Lakshminarayana, Rashmi, Alex Eble, Preetha Bhakta, Chris Frost, Peter Boone, Diana Elbourne, and Vera Mann. 2013. "The Support to Rural India's Public Education System (STRIPES) Trial: A Cluster Randomised Controlled Trial of Supplementary Teaching, Learning Material and Material Support" edited by R. L. Patterson. *PLoS ONE* 8(7):e65775. doi: 10.1371/journal.pone.0065775.

Lee, Jaekyung. 2012. "College for All: Gaps Between Desirable and Actual P–12 Math Achievement Trajectories for College Readiness." *Educational Researcher* 41(2):43–55. doi: 10.3102/0013189X11432746.

Levin, Henry M. 1988. "Cost-Effectiveness and Educational Policy." *Educational Evaluation and Policy Analysis* 10(1):51–69. doi: 10.3102/01623737010001051.

Levin, Henry M., and Clive Belfield. 2015. "Guiding the Development and Use of Cost-Effectiveness Analysis in Education." *Journal of Research on Educational Effectiveness* 8(3):400–418. doi: 10.1080/19345747.2014.915604.

Mamun, Shamsul Arifeen Khan, Brad R. Taylor, Son Nghiem, Mohammad Mafizur Rahman, and Rasheda Khanam. 2021. "The Private Returns to Education in Rural Bangladesh." *International Journal of Educational Development* 84:102424. doi: 10.1016/j.ijedudev.2021.102424.

Mazumder, Bhashkar, Maria Rosales-Rueda, and Margaret Triyana. 2019. "Intergenerational Human Capital Spillovers: Indonesia's School Construction and Its Effects on the Next Generation." *AEA Papers and Proceedings* 109:243–49. doi: 10.1257/pandp.20191059.

Murphy-Graham, Erin, Alison K. Cohen, and Diana Pacheco-Montoya. 2020. "School Dropout, Child Marriage, and Early Pregnancy among Adolescent Girls in Rural Honduras."

Comparative Education Review 64(4):703–24. doi: 10.1086/710766.

Muula, Adamson S., Emmanuel Rudatsikira, Olusegun Babaniyi, Peter Songolo, and Seter Siziya. 2012. "Prevalence and Correlates for School Truancy among Pupils in Grades 7-10: Results from the 2004 Zambia Global School-Based Health Survey." *BMC Research Notes* 5(1):48. doi: 10.1186/1756-0500-5-48.

Nahid, Ferdousi. 2014. "Child Marriage in Bangladesh: Socio-Legal Analysis." *International Journal of Sociology and Anthropology* 6(1):1–7.

National Academies of Sciences, Engineering, and Mathematics. 2022. *Science and Engineering in Preschool Through Elementary Grades: The Brilliance of Children and the Strengths of Educators.* The National Academies Press.

Orr, Larry L., Robert B. Olsen, Stephen H. Bell, Ian Schmid, Azim Shivji, and Elizabeth A. Stuart. 2019. "Using the Results from Rigorous Multisite Evaluations to Inform Local Policy Decisions." *Journal of Policy Analysis and Management* 38(4):978–1003.

Pengpid, Supa, and Karl Peltzer. 2017. "Prevalence, Demographic and Psychosocial Correlates for School Truancy among Students Aged 13–15 in the Association of Southeast Asian Nations (ASEAN) Member States." *Journal of Child & Adolescent Mental Health* 29(3):197–203. doi: 10.2989/17280583.2017.1377716.

Pengpid, Supa, and Karl Peltzer. 2020. "High Prevalence of School Truancy in a National Sample of In-School Adolescents in Kuwait: Internalizing, Externalizing and Social Risk Factors." *Journal of Human Behavior in the Social Environment* 30(6):687–94. doi: 10.1080/10911359.2020.1736229.

Peters, Susan J. 2003. "Inclusive Education: Achieving Education for All by Including Those with Disabilities and Special Education Needs." *Washington DC: World Bank* 1–133.

Piscitello, Jennifer, Youn Kyoung Kim, Marmar Orooji, and Samuel Robison. 2022. "Sociodemographic Risk, School Engagement, and Community Characteristics: A Mediated Approach to Understanding High School Dropout." *Children and Youth Services Review* 133:106347. doi: 10.1016/j.childyouth.2021.106347.

Pong, Suet-Ling, and Dong-Beom Ju. 2000. "The Effects of Change in Family Structure and Income on Dropping Out of Middle and High School." *Journal of Family Issues* 21(2):147–69. doi: 10.1177/019251300021002001.

Pridmore, Pat. 2007. *Impact of Health on Education Access and Achievement: A Cross-National Review of the Research Evidence. Create Pathways to Access. Research Monograph No. 2.* ERIC.

Psacharopoulos, George, and Harry Anthony Patrinos. 2018. "Returns to Investment in Education: A Decennial Review of the Global Literature." *Education Economics* 26(5):445–

58. doi: 10.1080/09645292.2018.1484426.

Quattri, Maria, and Kevin Watkins. 2019. “Child Labour and Education – A Survey of Slum Settlements in Dhaka (Bangladesh).” *World Development Perspectives* 13:50–66. doi: 10.1016/j.wdp.2019.02.005.

Rahman, Md. Ashfikur, Andre M. N. Renzaho, Satyajit Kundu, Md. Abdul Awal, Md. Ashikuzzaman, Lijun Fan, Bright Opoku Ahinkorah, Joshua Okyere, Joseph Kihika Kamara, and Rashidul Alam Mahumud. 2023. “Prevalence and Factors Associated with Chronic School Absenteeism among 207,107 in-School Adolescents: Findings from Cross-Sectional Studies in 71 Low-Middle and High-Income Countries” edited by M. I. Islam. *PLOS ONE* 18(5):e0283046. doi: 10.1371/journal.pone.0283046.

Rahman, Twyeafur M., Franssen, Loe, and Khan, Hafiz T.A. 2020. “The Impact of After-School Programme on Student Achievement: Empirical Evidence from the ASA Education Programme in Bangladesh.” *The European Journal of Developmental Research,* 32: (612–626). doi: 10.1057/s41287-019-00231-5

Ramberg, Joacim, Sara Brolin Låftman, Ylva B. Almquist, and Bitte Modin. 2019. “School Effectiveness and Students’ Perceptions of Teacher Caring: A Multilevel Study.” *Improving Schools* 22(1):55–71. doi: 10.1177/1365480218764693.

Reilly, Edel Mary. 2007. “Writing to Learn Mathematics: A Mixed Method Study.” Indiana University of Pennsylvania.

Roberts, Douglas A., and Rodger W. Bybee. 2014. *Scientific Literacy, Science Literacy, and Science Education.* Routledge Handbooks Online.

Ruthbah, Ummul, Rabbani, Atonu, Hossain, Salim, and Sarwar, Golam. 2016. “Do extra hours of tutoring payoff? Evaluation of a community education programme in Bangladesh.” *Journal of Development Effectiveness*, 8(2): 196-215. doi: 10.1080/19439342.2015.1111922

Sabates, Ricardo, Altaf Hossain, and Keith M. Lewin. 2013. “School Drop out in Bangladesh: Insights Using Panel Data.” *International Journal of Educational Development* 33(3):225–32. doi: 10.1016/j.ijedudev.2012.09.007.

Said, Ziad, Ryan Summers, Fouad Abd-El-Khalick, and Shuai Wang. 2016. “Attitudes toward Science among Grades 3 through 12 Arab Students in Qatar: Findings from a Cross-Sectional National Study.” *International Journal of Science Education* 38(4):621–43. doi: 10.1080/09500693.2016.1156184.

Santibanez, Lucrecia, and Cassandra Guarino. 2020. “The Effects of Absenteeism on Cognitive and Social-Emotional Outcomes: Lessons for COVID-19.” doi: 10.26300/YJ9M-X430.

Santibañez, Lucrecia, and Cassandra M. Guarino. 2021. “The Effects of Absenteeism on Academic and Social-Emotional Outcomes: Lessons for COVID-19.” *Educational Researcher*

50(6):392–400. doi: 10.3102/0013189X21994488.

Sarkar, Ripon Kumar, Md Mohoshin Reza, and Md Elias Hossain. 2014. "Socio Cultural Barriers of Girls' Educational Attainment Experiences from Rural Bangladesh." *Cultural Anthropology* 349:358.

Sarker, Md Nazirul Islam, Wu Min, and Md Altab Hossin. 2019. "Economic Effect of School Dropout in Bangladesh." *International Journal of Information and Education Technology* 9(2):136–42. doi: 10.18178/ijiet.2019.9.2.1188.

Sarker, Shahidul, A. H. M. Zehadul Karim, and Samrat Mohammad Abu Suffiun. 2017. "Parental Educational Aspiration and Gender Inequality of Rural Children in Bangladesh: The Role of Parental Attitudes of Traditional Gender Role, Gender Biased Capability, and Gender." *Journal of International Women's Studies* 18(2):134–42.

Seidu, Abdul-Aziz. 2019. "Prevalence and Correlates of Truancy among School-Going Adolescents in Mozambique: Evidence from the 2015 Global School-Based Health Survey." *The Scientific World Journal* 2019:e9863890. doi: 10.1155/2019/9863890.

Seidu, Abdul-Aziz, Bright Opoku Ahinkorah, Eugene Kofuor Maafo Darteh, Louis Kobina Dadzie, Kwamena Sekyi Dickson, and Hubert Amu. 2019. "Prevalence and Correlates of Truancy among In-School Adolescents in Ghana: Evidence from the 2012 Global School-Based Student Health Survey." *Journal of Child & Adolescent Mental Health* 31(1):51–61. doi: 10.2989/17280583.2019.1585359.

Siziya, Seter, Adamson S. Muula, and Emmanuel Rudatsikira. 2007. "Prevalence and Correlates of Truancy among Adolescents in Swaziland: Findings from the Global School-Based Health Survey." *Child and Adolescent Psychiatry and Mental Health* 1(1):15. doi: 10.1186/1753-2000-1-15.

Smita, Marzia Khatan, Md Fajlay Rabbi, and Shoeab Mohammad. 2020. "Reasons behind Dropping out of Slum Children from Non-Formal School in Dhaka." *Jurnal Iqra': Kajian Ilmu Pendidikan* 5(2):14–29.

Stuart, Elizabeth A., Catherine P. Bradshaw, and Philip J. Leaf. 2015. "Assessing the Generalizability of Randomized Trial Results to Target Populations." *Prevention Science* 16:475–85.

Swansea, Ken Reid. 2010. "Finding Strategic Solutions to Reduce Truancy." *Research in Education* 84(1):1–18. doi: 10.7227/RIE.84.1.

Thomas, Millan, and Burnett, Nicholas. 2013. "Exclusion from Education: The Economic Cost of Out of School Children in 20 Countries." *Result for Development.* Retrieved January 23, (https://r4d.org/resources/exclusion-education-economic-cost-school-children-20-countries/)

Thomas, Milan, and Burnett, Nicholas. 2015. "The Economic Cost of Out-of-School Children in Southeast Asia." *UNESCO Digital Library.* Retrieved January 23, (https://unesdoc.unesco.org/ark:/48223/pf0000233993)

Thomson, Sue, Wernert, Nicole, Rodrigues, Sima, and O'Grady, Elizabeth. 2020. "TIMSS 2019 Australia. Volume I: Student performance." *Australian Council for Educational Research.* doi: 10.37517/978-1-74286-614-7

Tipton, Elizabeth, and Robert B. Olsen. 2022. *Enhancing the Generalizability of Impact Studies in Education.* Mathematica Policy Research.

UNDP. 2017. "A Common Framework for Gender Equality and Social Inclusion." *International Development Partners Group, Nepal.* Retrieved January 23, (https://www.undp.org/sites/g/files/zskgke326/files/migration/np/GESI-framework-Report_Final_2017.pdf)

UNICEF. 2019. "35 Million Children in South Asia Are Not Attending Age Appropriate Pre-Primary Education – UNICEF." Retrieved January 4, 2024 (https://www.unicef.org/rosa/press-releases/35-million-children-south-asia-are-not-attending-age-appropriate-pre-primary).

UNICEF. 2021a. "Every Child Learns | UNICEF." Retrieved January 4, 2024 (https://www.unicef.org/reports/UNICEF-education-strategy-2019-2030).

UNICEF. 2021b. "Repeated School Closures Due to COVID-19 Leading to Learning Loss and Widening Inequities in South Asia, UNICEF Research Shows." Retrieved January 4, 2024 (https://www.unicef.org/rosa/press-releases/repeated-school-closures-due-covid-19-leading-learning-loss-and-widening-inequities).

UNICEF Bangladesh. 2020. "Bangladesh Education Fact Sheets 2020: Analysis for Learning and Equity Using Bangladesh MICS." *Dhaka: UNICEF.*

United Nations. 2015. *Transforming Our World: The 2030 Agenda for Sustainable Development | Department of Economic and Social Affairs.*

Verguet, Stéphane, Paulina Limasalle, Averi Chakrabarti, Arif Husain, Carmen Burbano, Lesley Drake, and Donald AP Bundy. 2020. "The Broader Economic Value of School Feeding Programs in Low-and Middle-Income Countries: Estimating the Multi-Sectoral Returns to Public Health, Human Capital, Social Protection, and the Local Economy." *Frontiers in Public Health* 8:587046.

Visconti, Giancarlo, and José R. Zubizarreta. 2018. "Handling Limited Overlap in Observational Studies with Cardinality Matching." *Observational Studies* 4(1):217–49.

Weiss, Michael J., Howard S. Bloom, and Thomas Brock. 2014. "A Conceptual Framework for Studying the Sources of Variation in Program Effects." *Journal of Policy Analysis and Management* 33(3):778–808.

Weiss, Michael J., Howard S. Bloom, Natalya Verbitsky-Savitz, Himani Gupta, Alma E. Vigil, and Daniel N. Cullinan. 2017. "How Much Do the Effects of Education and Training Programs Vary across Sites? Evidence from Past Multisite Randomized Trials." *Journal of Research on Educational Effectiveness* 10(4):843–76.

Westreich, Daniel, Jessie K. Edwards, Catherine R. Lesko, Elizabeth Stuart, and Stephen R. Cole. 2017. "Transportability of Trial Results Using Inverse Odds of Sampling Weights." *American Journal of Epidemiology* 186(8):1010–14.

White, Helene Raskin, Nancy M. Violette, Lisa Metzger, and Magda Stouthamer-Loeber. 2007. "Adolescent Risk Factors for Late-Onset Smoking Among African American Young Men." *Nicotine & Tobacco Research* 9(1):153–61. doi: 10.1080/14622200601078350.

Xu, Yiqing. 2017. "Generalized Synthetic Control Method: Causal Inference with Interactive Fixed Effects Models." *Political Analysis* 25(1):57–76. doi: 10.1017/pan.2016.2.

Zeger, Scott L., Kung-Yee Liang, and Paul S. Albert. 1988. "Models for Longitudinal Data: A Generalized Estimating Equation Approach." *Biometrics* 1049–60.