Implementation Fidelity of Heat-Mitigation Infrastructure Interventions in Primary Schools in Selected Climate-Vulnerable Districts of Bangladesh: A Mixed-Method Study

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Declaration

I, Asmita Adhikari, hereby declare that this thesis, ―Implementation Fidelity of Heat-Mitigation Infrastructure Interventions in Primary Schools in Selected Climate-Vulnerable Districts of Bangladesh: A Mixed-Methods Study," is an original work submitted in partial fulfillment of the requirements for the degree of Master of Public Health (MPH) at the James P. Grant School of Public Health (JPGSPH), BRAC University, Dhaka, Bangladesh.

I further declare that this work has not been submitted previously, in whole or in part, for any other degree or examination at this or any other university or institution.

All sources used in this thesis have been duly acknowledged and cited. Any assistance received has been mentioned in the acknowledgements section.

I have also added a separate declaration on GenAI use at the end of this work.

Asmita Adhikari

02-06-2026

Approval

This thesis titled –Implementation Fidelity of Heat-Mitigation Infrastructure Interventions in Primary Schools in Selected Climate-Vulnerable Districts of Bangladesh: A Mixed-Methods Study" submitted by

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Of 2026 has been accepted as satisfactory in partial fulfillment of the requirements for the degree of Master of Public Health.

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Ethics Statement

Ethical approval for this study was obtained from the institutional review board of the BRAC James P. Grant School of Public Health at BRAC University (IRB protocol No. MPH-2025-016). Written informed consent was obtained from all participants prior to data collection. All procedures conducted in this study involving human participants were in accordance with the ethical standards of the Institutional Review Board and the 1975 Helsinki Deceleration.

Abstract

Background: Climate change is driving more frequent and intense heatwaves across South Asia, with children often experiencing the worst impacts. In low-income community settings of climate-vulnerable districts in Bangladesh, classrooms are often equipped with single-layer iron-tin roofs that frequently overheat, harming children's health, concentration, and learning. Passive cooling interventions such as solar-reflective paint (SRP) and bamboo ceilings with polyethylene foam (BCPF) are promising low-cost, electricity-free solutions. However, there is limited evidence regarding their effectiveness in reducing classroom temperatures and improving the health and well-being of children.

Objectives: The objective of this study was to assess the implementation fidelity of SRP and BCPF interventions in 69 BRAC primary schools in the Kurigram and Gaibandha districts of Bangladesh. Specific objectives were to (i) measure fidelity levels for each intervention and (ii) identify school, implementer, and context-level factors influencing fidelity.

Methods: A convergent parallel mixed-methods study was conducted nested within a pilot cluster randomised controlled trial. The pilot trial (parent study) assesses the impact of implementing the infrastructure interventions (SRP only, BCPF only, and combined) in 69 BRAC primary schools across eight sub-districts in Kurigram and Gaibandha districts of Bangladesh. The quantitative component of the study included 92 intervention-event observations (46 SRP + 46 BCPF) through structured observation checklists and a school-level questionnaire administered to monitoring officers (one per school) in 69 schools. The questionnaire and checklists were administered electronically via KoBoToolbox. Fidelity was operationalised across three dimensions, content adherence, coverage, and quality of delivery, using an adapted Carroll–Hasson fidelity framework. The qualitative component included conducting 15 key informant interviews with painters, carpenters, monitoring officers, and the project coordinator, who were purposively sampled across districts and intervention types. Quantitative analysis included descriptive statistics and hierarchical ordinary least squares (OLS) linear regression with Huber-White heteroscedasticity robust standard errors in which school readiness, implementer-level, and contextual determinants of composite fidelity were entered sequentially as nested blocks. Qualitative data were analysed thematically using a hybrid deductive–inductive approach guided by the Carroll–Hasson framework and the Theoretical

Domains Framework. Integration of quantitative (fidelity dimensions and determinants) and qualitative (themes) findings followed a side-by-side joint display approach for data triangulation.

Results: Mean composite fidelity was high for both interventions (SRP: 86.2%, SD = 6.4; BCPF: 88.8%, SD = 9.9). In both interventions, the fidelity dimensions ranked in the same order. Content adherence was the highest scoring dimension (SRP: 96.7%; BCPF: 92.2%); coverage was the second highest (SRP: 85.5%; BCPF: 91.3%); and quality of delivery was lowest in both interventions (SRP: 76.6%; BCPF: 82.9%). Qualitative findings showed that intensive supervision, structured training, community engagement, and adaptive responses to weather disruption helped maintain implementation fidelity for both interventions. However, inconsistent use of personal protective equipment (PPE) is identified as a major challenge affecting the quality-of-delivery dimension. This inconsistency accounted for a lower fidelity score on this dimension.

Conclusions: SRP and BCPF were implemented with high implementation fidelity in tin-shed primary schools in climate-vulnerable districts of Bangladesh, showing potential as low-cost, electricity-free heat-mitigation strategies. Enhancing the use of PPE among intervention implementation workers remains the main area for strengthening fidelity. Key elements that supported successful implementation in this pilot, such as strong supervision, flexibility in managing structural repairs, and weather-adaptive practices, should be maintained during scale-up. The findings provide practical evidence for BRAC, the government of Bangladesh, and other partners scaling climate-resilient infrastructure. Additionally, it contributes a replicable three-dimensional fidelity assessment framework applicable to other physical-construction interventions.

Keywords: implementation fidelity; heat mitigation; passive cooling; climate-resilient schools; mixed-methods; Bangladesh

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List of Acronyms

Acronyms	**Full Form**
BCPF	Bamboo Ceiling with Polyethylene Foam
BEP	BRAC Education Programme
CI	Confidence Interval
cRCT	Cluster Randomized Controlled Trial
IQR	Interquartile Range
IRB	Institutional Review Board
JPGSPH	James P. Grant School of Public Health
KII	Key Informant Interview
LMIC	Low- and Middle-Income Country
ND-GAIN	Notre Dame Global Adaptation Initiative
PPE	Personal Protective Equipment
SD	Standard Deviation
SRP	Solar-Reflective Paint
TDF	Theoretical Domains Framework
WHO	World Health Organization

Chapter 1: Introduction

1.1 Background and rationale

Climate change is causing more frequent heat waves around the world. This phenomenon directly impacts people's health and also affects ecosystems, food supply, and the spread of vector-borne diseases (IPCC, 2022). Between 2000 and 2019, an estimated 489,000 people died each year due to heat-related causes globally, with over half (51.1%) of these deaths occurring in Asia alone (Zhao et al., 2021). South Asia is facing a major challenge as temperatures rise and humidity increases (World Bank, 2023). Heat-related deaths in South Asia have increased by about 30% since 2000 (Zhao et al., 2021). It led to economic losses of about 1.5% to 5% of the region's GDP yearly. Urban heat, reliance on farming, and limited access to cooling are all contributing factors to this GDP loss (Im et al., 2017).

Children are more physiologically vulnerable to heat than adults due to a higher metabolic rate, lower thermoregulatory capacity, and larger surface-area-to-mass ratio that accelerates heat gain (Sahu et al., 2013). Increased classroom temperature impaired children's health, causing dehydration, heat illness, and respiratory symptoms. It also affects their cognitive performance, concentration, and academic attainment (Vasilakopoulou & Santamouris, 2025; Park et al., 2020). In 2024, a significant number of children worldwide, about 800 million, were affected by severe heatwaves (Save the Children, 2024). Apart from immediate threats of heatstroke and dehydration, increasing temperatures have been linked with respiratory diseases and negative mental health issues among children. The interrupted classroom activities due to scorching heat further deteriorate the continuity of learning (Save the Children, 2023). In South Asia, it is estimated that about 32,300 disability-adjusted life years (DALYS) among children are attributed to health issues and fatalities related to heat (UNICEF, 2024).

Studies suggest that extended exposure to high temperatures in educational facilities leads to a severe deterioration in cognition and educational performance. For every 1-degree Fahrenheit increase in average classroom temperatures, there is an associated 1% decrease in annual learning progression in the absence of cooling facilities (Park et al., 2020). Research studies suggest an integral connection between raised classroom temperatures, insufficient ventilation, and poor academic achievements. All these suggest the importance of comfortable learning environments within classrooms (Haverinen-Shaughnessy & Shaughnessy, 2015). Students from hotter climates often face problems related to concentration, general health, and academic outcomes (Romero et al., 2023).

Bangladesh is recognized as a country highly vulnerable to climate change, according to the ND-GAIN index. The country has experienced a sharp increase in both the intensity and frequency of heatwaves (ND-GAIN, n.d.; Rashid et al., 2024). In April 2024, schools were closed nationwide due to heatwaves, which affected the education of about 33 million children. In addition to government-run primary schools, Bangladesh is home to many NGO-run primary schools, including the BRAC Education Programme (BEP). The classrooms in these schools have single-layer iron roofs that absorb sunlight, leading to higher indoor temperatures during warmer periods. This can cause student fatigue, dehydration, heat-related skin conditions, and decreased concentration abilities (Bidassey-Manilal et al., 2016). These issues are mostly prominent in low socioeconomic groups, highlighting significant disparities (Vasilakopoulou & Santamouris, 2025).

A joint research initiative involving the BRAC James P. Grant School of Public Health (BRAC JPGSPH), the BEP, and the Department of Architecture at BRAC University is conducting a cluster randomized controlled trial in BRAC primary schools in Kurigram and Gaibandha districts of Bangladesh. This project primarily focuses on evaluating the impact of a set of interventions aimed at heat mitigation. The interventions include (a) applying solar-reflective paint (SRP) on iron-tin roofs and (b) constructing bamboo ceilings with polyethylene foam (BCPF) under the existing roofs for heat insulation. These designs are forms of passive cooling technologies that operate without electricity to enhance comfort, health, and educational outcomes. Detailed specifications of the interventions are presented in section 2.4.

Although the effectiveness of reflective coatings and insulation in cooling residential and institutional buildings is well-documented, there is a significant lack of evidence regarding the quality of implementation of such infrastructure enhancements in low-resource school environments and whether they reach the technical standards to achieve their planned results. Studies carried out in South Asia primarily focus on heat exposure, educational learning loss, and pre-warning systems, rather than assessing the adherence to technical specifications of structural adaptations like reflective roofing and insulated ceilings. Without the fidelity evaluation, a well-designed intervention may be wrongly attributed to its conceptual design when the real problem lies in how it was delivered. In implementation science, concluding that an intervention –does not work” when it was simply not implemented as intended is known as a type III error or "implementation failure." This misattribution represents a major threat to the internal validity of evaluations of complex interventions (Dobson & Cook, 1980; Carroll et al., 2007; Cross & West, 2011).

Implementation fidelity is –the degree to which an intervention is delivered as planned by its designers” (Carroll et al., 2007). It has two roles in implementation science. It is an important outcome in itself (Proctor et al., 2011). In addition, it gives an indication of whether trial outcomes exactly demonstrate true impact or are affected by incomplete implementations (Carroll et al., 2007; Hasson, 2010). In this study, fidelity acts as the dependent variable, measuring the extent to which SRP and BCPF were implemented as designed, along with providing insights into the parent cRCT's results.

To date, there have been limited scientific studies conducted in LMICs that assessed the adherence of heat-mitigation infrastructure interventions in tin-shed primary schools in Bangladesh. This evidence gap creates a real risk that the parent cRCT's results may be misinterpreted and that decisions to scale SRP and BCPF may be made without knowing the level of implementation quality required to produce health and learning benefits of primary school children.

This study employs a mixed-methods design to assess the fidelity of the SRP and BCPF interventions within the parent cRCT. It aims to assess how these interventions were implemented as planned and to identify factors related to schools, implementers, and the context that influence implementation. Additionally, the study will explore stakeholders' perspectives on barriers and facilitators encountered during this process. Furthermore, the study introduces a new concept by adapting the Carroll-Hasson fidelity framework specifically for construction-based interventions in resource-limited school settings. This adaptation serves as a useful model for examining implementation fidelity in similar climate-related infrastructure projects.

1.2 Problem statement

Bangladesh is highly vulnerable to the health and social effects of climate change. In recent years, the country has experienced recurrent heatwaves, which led to the closure of thousands of schools and deteriorated the learning environment of millions of children (Save the Children, 2024; UNICEF Bangladesh, 2024). During 2023 and 2024, a majority of the primary and secondary schools across the country were shut down for several days to weeks due to heat waves. It clearly shows the acute vulnerability of school infrastructures to uncontrolled rising temperatures (Save the Children, 2024). UNICEF's Children's Climate Risk Index (UNICEF, 2022) classifies Bangladesh among 15 countries where children face an “extremely high risk” from climate and environmental shocks. These shocks are heatwaves, flooding, vector-borne diseases, and air pollution, which threaten their survival, health, education, and well-being.

In response to rising temperatures, governments, development agencies, and technical institutions across the globe are increasingly promoting “heat-smart schools” as a climate-resilient solution for educational infrastructure. These schools are built in such a way that they keep the study areas cool. They use reflective roofs, modified ceilings, quality ventilation, and strategic shadings. All these help to protect students from scorching heat (Federation of American Scientists, 2024). Among these solutions, reflective roof coatings and roof-ceiling filling from retrofits are the best options in terms of practicality and cost. These methods decrease heat absorption and reduce indoor temperatures by increasing the roof's potential to reflect sunlight (Schneider et al., 2023; Krayenhoff et al., 2021). More recent studies on this matter state that these infrastructure upgrades should be aided by suitable financing and strong policy measures (Naidoo et al., 2025).

Children have a limited capacity to maintain body temperature, which makes them more prone to heat-related health issues such as heatstroke and dehydration (UNICEF Bangladesh, 2024). Long-term exposure to such conditions can hamper physical growth, cognitive development, and academic performance (Bakhtiar & Karim, 2025; Raza et al., 2025). To reduce the impact of heat waves in tin-shed schools in two climate-vulnerable districts of Bangladesh, the BRAC James P. Grant School of Public Health (BRAC JPGSPH), BRAC Education Programme, and Department of Architecture at BRAC University are jointly implementing two physical infrastructure interventions: Solar Reflective Paint (SRP) and Bamboo Ceiling with Polyethylene Foam

(BCPF). Implementing these solutions in school settings can be challenging. Limited resources, differences in school structure, and variations in local construction methods may affect how well these infrastructures are installed, maintained, and sustained over time (Pagrangan, 2026b).

From an implementation science perspective, how closely an intervention is delivered as originally intended" is known as "implementation fidelity," which is a key factor in determining whether a program achieves its expected outcomes (Carroll et al., 2007). However, most recent studies on thermal comfort and indoor environmental quality in schools have focused mainly on measurable outcomes such as temperature reduction, comfort, and air quality while giving less attention to whether the interventions were implemented as planned and to the organizational and human factors that influence their adoption (Naidoo et al., 2025). In the same way, research done on reflective roof coatings and high-albedo materials has focused on temperature cooling. Similar models or field studies can be performed in city areas (Krayenhoff et al., 2021; Schneider et al., 2023).

Implementation science provides proper outlines for analyzing how proficiently an intervention has been carried out. It also identifies the factors that are important for the successful implementation of an intervention (Carroll et al., 2007; Hasson, 2010). These frameworks are widely used in behavioral and educational interventions. However, they are rarely used to assess school infrastructure improvement interventions in LMIC settings. This study aims to fill this knowledge gap.

1.3 Study objectives

1.3.1 Overall objective

The main objective of this study is to evaluate how well the protocols were followed during the application of solar-reflective paint (SRP) and the installation of bamboo ceilings with polyethylene foam (BCPF) in primary schools in the Kurigram and Gaibandha districts of Bangladesh.

1.3.2 Specific objectives

1. To evaluate the implementation fidelity of SRP and BCPF interventions.

2. To determine school-level factors (school preparedness) and implementer-level factors (facilitation strategies, stakeholder engagement, and perceived difficulty) that affect implementation fidelity for each of these infrastructure interventions.

3. To provide practical recommendations for improving the implementation fidelity of these interventions.

1.4 Structure of the thesis

This thesis is divided into six chapters. Chapter 1 is an introduction, which includes the background, rationale, problem statement, and research objectives. Chapter 2 presents a summary of the relevant literature review, including national, regional, and worldwide data and literature related to the thesis title. Chapter 3 is the method, which includes the study design, setting, sampling methods, data collection tools, scoring methods, data analysis process, the mixed-methods integration plan, and ethical considerations. Chapter 4 presents the results, which include study findings, including bivariate and multivariable analyses of factors associated with implementation fidelity. It also deals with qualitative themes related to facilitators and barriers during implementation. Chapter 5 is the discussion section, which analyzes the findings in relation to the theoretical framework and existing reviews. In addition, it focuses on methodological strengths and study limitations. Chapter 6 contains the conclusion and recommendations sections, which address the main contributions of this study.

Chapter 2: Literature review

2.1 Heat, children, and school environment

2.1.1 Global evidence

Climate change is causing more frequent, prolonged, and severe heat waves. Increasing temperatures have severe impacts on health, including higher mortality and morbidity and lower productivity (Levin, 2022; IPCC, 2022). Extreme heat causes hundreds of deaths annually worldwide (Zhao et al., 2021). Children are more susceptible to these conditions because of their body physiology, high activity levels, and the time they spend in schools (WHO, 2024). Long-term exposure to heat can cause heatstroke and dehydration. In addition, it disrupts children's education by increasing school closures and reducing students' ability to learn effectively (Park et al., 2020).

Many studies have shown that increased classroom temperatures can affect students' thinking and academic performance negatively (Vasilakopoulou & Santamouris, 2025). A review of 14.5 million people across 61 countries found that learning ability is impaired in hot classrooms (Vasilakopoulou & Santamouris, 2025). Data suggest that higher temperatures and poor ventilation are directly associated with lower scores in the elementary schools in the Southwestern United States. Each 1°F rise in school temperature is associated with a 1% reduction in learning ability. Furthermore, a review study found that schools with many classrooms are associated with reduced concentration and academic performance among students (Romero et al., 2023).

Some studies have analyzed how to improve temperature comfort in schools and houses using reflective roof coatings and augmented roofing designs (Correia et al., 2024; Rawat & Singh, 2021). They suggest that passive cooling methods can decrease room temperatures without relying heavily on air conditioning systems. Likewise, data from Burkina Faso suggests cool roof techniques can be an optimal solution for mitigating heat-related problems (Bunker et al., 2024). Further, this study supports the use of cost-effective strategies. However, further studies are still necessary to assess how effectively these interventions can be implemented in resource-limited areas.

2.1.2 Evidence from Asia

Climate change is projected to increase extreme heat in South Asia, especially under high-emission scenarios (Kim et al., 2023; Im et al., 2017). Research shows that rising temperatures, combined with high humidity, crowded living conditions, and outdoor labor, are already contributing to significant health problems and economic losses linked to heat exposure (Saeed et al., 2021). Studies also indicate that many schools in South and Southeast Asia experience excessive heat, particularly where cooling systems are limited, and classrooms depend mainly on natural ventilation (Romero et al., 2023; Sheri, 2022). In addition, a qualitative study involving secondary school teachers in Singapore found that heat stress is a significant concern in schools, as it makes students tired, less attentive, and uncomfortable in hot weather, ultimately affecting their learning experience (Sheri, 2022).

Studies at the regional level show that numerous schools have roofs and walls that are insufficient to block heat. It results in excessively hot classrooms (Rawat & Singh, 2021). Observations in Asia indicate that passive cooling methods, such as reflective roofing, insulation, shading, and the use of natural materials like bamboo, can improve thermal regulation in schools and other public buildings (Correia et al., 2024; Rawat & Singh, 2021). Bamboo-based structures and shadings are superior to heat-absorbing materials in maintaining cooler indoor temperatures. It makes them more cost-effective and easier to adapt (Modiano et al., 2024). India has introduced heat-mitigating action plans in many cities. It includes pre-warning systems, public awareness projects, and targeted protection for high-risk populations. Ahmedabad has already shown that integrated strategies can reduce mortality rates from heat-related conditions. This model can be adopted in urban areas (Knowlton et al., 2014). However, most of this evidence is on building design or population-level heat planning rather than assessing the effectiveness of specific school-based approaches.

2.1.3 Evidence from Bangladesh

Bangladesh is highly vulnerable to climate change, with limited capacity to adapt to its impacts. Recent evidence suggests that extreme heat events in the country are becoming more frequent and more intense (Rashid et al., 2024). For example, in April 2024, a nationwide heatwave led to school closures across Bangladesh, disrupting education for an estimated 33 million children and highlighting the education system's vulnerability to extreme heat (Save the Children, 2024). Despite this, there remains limited research on effective strategies to reduce heat exposure in schools and on how well such interventions are implemented, underscoring the need for the present study.

Bangladesh is at high risk of climate change. It has limited capacity to counter the effects of climate-related challenges. Recent studies show heat events are becoming more frequent and severe (Rashid et al., 2024). In April 2024, a nationwide heat wave severely affected the whole nation. It affected the education of nearly 33 million children. This shows the education system's uncontrolled vulnerability to such extreme heat conditions (Save the Children, 2024).

2.2 Passive cooling interventions

This study focuses on two passive cooling strategies. a) cool roofs and adding an extra layer of polyethylene foam. b) A cool roof helps to reduce the heat absorbed by the building and reflect sunlight, whereas polyethylene foam underneath the ceiling, tin, or insulation helps in the reduction of transferred heat from the roof into the indoor spaces of the building.

Evidence shows that reflective cool roofs in hot-climate regions can significantly reduce roof temperatures by about 20°C and indoor air temperatures by around 1–4°C, improving occupant comfort (Rawat & Singh, 2021; Sasidhar & Ramgopal, 2022). Even in tropical heat, observations in schools and public buildings indicate comfortable conditions with reflective coatings and insulated roofing systems (Correia et al., 2024; Sasidhar & Ramgopal, 2022). Also, the studies suggest that well-designed bamboo-based ceilings and structural systems provide effective, low-cost thermal insulation, contributing to more ease in indoor environments (Modiano et al., 2024).

Although strong technical evidence supports these interventions, there is limited evidence on how effectively they are implemented in real-world settings. Many existing studies focus on simulations or short-term pilot demonstrations, with relatively few studies examining how these interventions are actually installed, used, and maintained in schools. This gap is crucial in LMICs, where resources and implementation capacity are often constrained.

2.3 Implementation fidelity: theory and determinants

2.3.1 Conceptual framework

A framework for implementation fidelity focuses on key components, such as adherence to the intervention, the dose delivered, and the quality of the delivery. Additionally, factors that influence fidelity include intervention complexity, support systems, participant engagement, and the broader context of implementation (Carroll et al., 2007). This fidelity framework is very much relevant to complex interventions that involve changes to physical environments and emphasizes that fidelity assessment should be adapted to the specific characteristics of each intervention (Hasson, 2010). Another study further positioned fidelity within a broader set of implementation outcomes (Proctor et al., 2011). Within this framework, fidelity plays an important role by linking the implementation of an intervention to its overall effectiveness.

This study uses an adapted framework to assess implementation fidelity by integrating key elements from Carroll et al. (2007) and Hasson (2010) with implementation outcomes from Proctor et al. (2011). In this study, fidelity plays a central role in determining whether the two interventions, SRP and BCPF, were delivered as intended and whether they are likely to achieve their expected effects on classroom temperature, children's health, and learning outcomes within the controlled trial setting in the parent cRCT.

In this research, implementation fidelity of SRP and BCPF has been assessed through evaluating how closely the construction and installation work followed the planned intervention protocols. Adherence is assessed across three key dimensions. Content adherence, Coverage, and Quality of delivery. Hasson et al. (2010) identified several factors that influence intervention effectiveness. In this study, factors such as facilitation (training quality, supervision, and feedback), intervention complexity (technical difficulty and school constraints), participant engagement among stakeholders, and contextual factors are included.

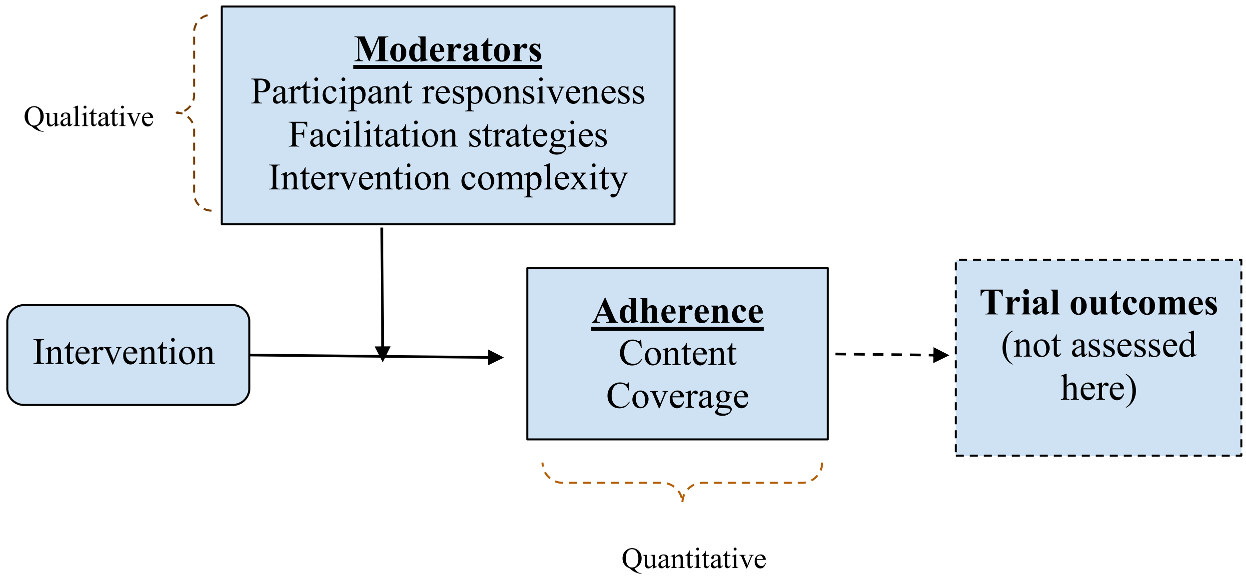

Figure 1: Adapted conceptual framework for implementation fidelity for SRP and BCPF (based on Carroll et al., 2007; Hasson, 2010; Proctor et al., 2011).

2.3.2 Determinants of fidelity

Systematic reviews mentioned that implementation fidelity is influenced by several consistent factors. At the implementer level, key determinants include the quality of training, clear instructions, prior experience, and confidence, as well as the frequency and quality of supervision and feedback (Hasson, 2010; Lebina et al., 2019). Fidelity is shaped by leadership support, resource availability, site readiness, and competing organizational priorities (Martin et al., 2023). Also, environmental conditions such as weather, logistical constraints, time pressures, and community involvement can further influence how closely interventions are delivered as intended, particularly in field-based projects and resource-limited settings.

2.3.3 Consequences of poor fidelity

Poor implementation fidelity in school and community programs results in weak or even no observable effects, even when the intervention itself is well designed. This failure of delivery, rather than the design, can lead to a Type III error or "implementation error" (Dusenbury et al., 2003; Little et al., 2013). Consequently, policymakers may discontinue effective programmes based on evaluation data that actually reflects weak implementation rather than the intervention.

Such issues reduce the accuracy of study findings and make it difficult to determine the true effectiveness of an intervention. For this reason, measuring and reporting fidelity is essential when evaluating program outcomes in both school and community settings (Trutschel et al., 2023).

2.4 The interventions

This fidelity study included all 69 intervention schools, categorized into three groups: 23 schools receiving SRP only, 23 receiving BCPF only, and 23 receiving both interventions. A total of 92 intervention events were observed, with 46 SRP-related and 46 BCPF-related implementation activities. As fidelity can only be assessed when an active intervention is being implemented, schools in the control group, which did not receive any intervention during the study period, were excluded from the fidelity analysis.

These two cooling methods do not require electricity, which makes them suitable for schools with limited power supplies. In 23 schools, both interventions were implemented together. Here, BCPF was installed first, followed by SRP on the roof. The SRP and BCPF work together to keep indoor spaces cooler. SRP reduces heat absorption at the roof level, while the BCPF helps limit the transfer of heat into the classroom. Table 1 and Table 2, respectively, elaborate intervention specifications for SRP and BCPF.

Table 1: Solar-Reflective Paint (SRP) intervention specifications.

Element	**Description**
Design objective	Reflect solar radiation from the iron-tin roof surface, reducing heat absorption and lowering indoor temperatures
Materials	Project-specified solar-reflective paint and primer (high solar reflectance and thermal emittance properties); no local paint substitutes permitted

Protocol summary	(1) Classroom emptied and roof access cleared; (2) structural and electrical safety check; (3) roof cleaned of dust, debris, and bird droppings; (4) rust and old paint treated/removed with sandpaper; (5) surface verified completely dry; (6) approved primer applied evenly across entire surface and dried 2–3 hours; (7) first coat of SRP applied horizontally (left to right) at specified coverage rate (1 litre per 72 sq. ft.); (8) dried 4–5 hours; (9) second coat applied vertically (cross-pattern) at same coverage rate
Full coverage definition	Two complete coats covering 100% of the targeted iron-tin roof area at the specified coverage rate
Target schools	SRP-only arm (n = 23 schools) and combined SRP + BCPF arm (n = 23 schools)

Table 2: Bamboo Ceiling with Polyethylene Foam (BCPF) intervention specifications.

Element	**Description**
Design objective	Create an insulated ceiling layer beneath the existing iron-tin roof using local bamboo and polyethylene (PE) foam to reduce heat transfer into the classroom.
Materials	Project-specified bamboo (correct type and size) and polyethylene P-foam (specified thickness); duct tape for sealing joints; no unapproved substitutes permitted.
Protocol summary	(1) Classroom emptied; (2) structural/load-bearing audit of roof and rafters; (3) electrical clearance; (4) cleaning of roof and rafters; (5) safety hazards addressed; (6) damaged tin or wood replaced; (7) tin sheets carefully opened; (8) P-foam inserted evenly without gaps, folds, or tears; (9) joints and overlaps sealed with tape; (10) bamboo panels anchored below the foam;

	(11) tin sheets reinstalled; (12) site cleared.
Full coverage definition	Complete P-foam coverage of 100% of the targeted ceiling area with all joints sealed and bamboo panels fully installed.
Target schools	BCPF-only arm (n = 23) and combined SRP+BCPF arm (n = 23); total n = 46.

Chapter 3: Methods

3.1 Study design

This study used a convergent parallel mixed-method design nested within a pilot cRCT implemented by BRAC JPGSPH in collaboration with BEP and the Architecture Department of BRAC University. The cRCT evaluates the impact of implementing SRP and BCPF to improve health and education outcomes of primary school children. This study examined whether these interventions were implemented as planned and explored the factors influencing implementation (Fetters et al., 2013).

A mixed-method design was chosen because implementation fidelity involves both measurable and contextual factors. Protocol adherence was assessed quantitatively using a structured checklist, and questionnaires were used to collect data from different implementer groups. Where stakeholders' experiences and perceived intervention complexity are better understood through a qualitative approach, through key informant interviews (KIIs). In this study, quantitative and qualitative data were collected simultaneously, analyzed separately, and integrated during interpretation.

3.2 Study area and settings

The study was conducted in BRAC primary schools in Kurigram and Gaibandha, two remote and climate-vulnerable districts in northwestern Bangladesh. These areas face frequent flooding, riverbank erosion, high poverty levels, and limited institutional support to adapt to extreme heat, floods, and droughts (Rana et al., 2023; RDRS-ICCCAD, 2024).

The BRAC Education Program (BEP) operates a non-formal education system using a one-classroom, one-teacher model for low-income communities (BRAC, n.d.). These classrooms typically have corrugated iron (tin) roofs and natural ventilation, with 4-5 windows and 1-2 doors. Tin roofs and walls make them prone to excessive indoor heat during heat waves. (Rawat & Singh, 2021).

An ongoing pilot cRCT includes 69 BRAC primary schools from these two districts. These schools were allocated into three intervention arms in the parent pilot cRCT. The infrastructure interventions are assigned to three arms: solar-reflective paint (SRP) only, bamboo ceilings with polyethylene foam (BCPF) only, and a combined arm with both interventions (SRP + BCPF). This study evaluates the fidelity of heat mitigation infrastructure interventions during implementation.

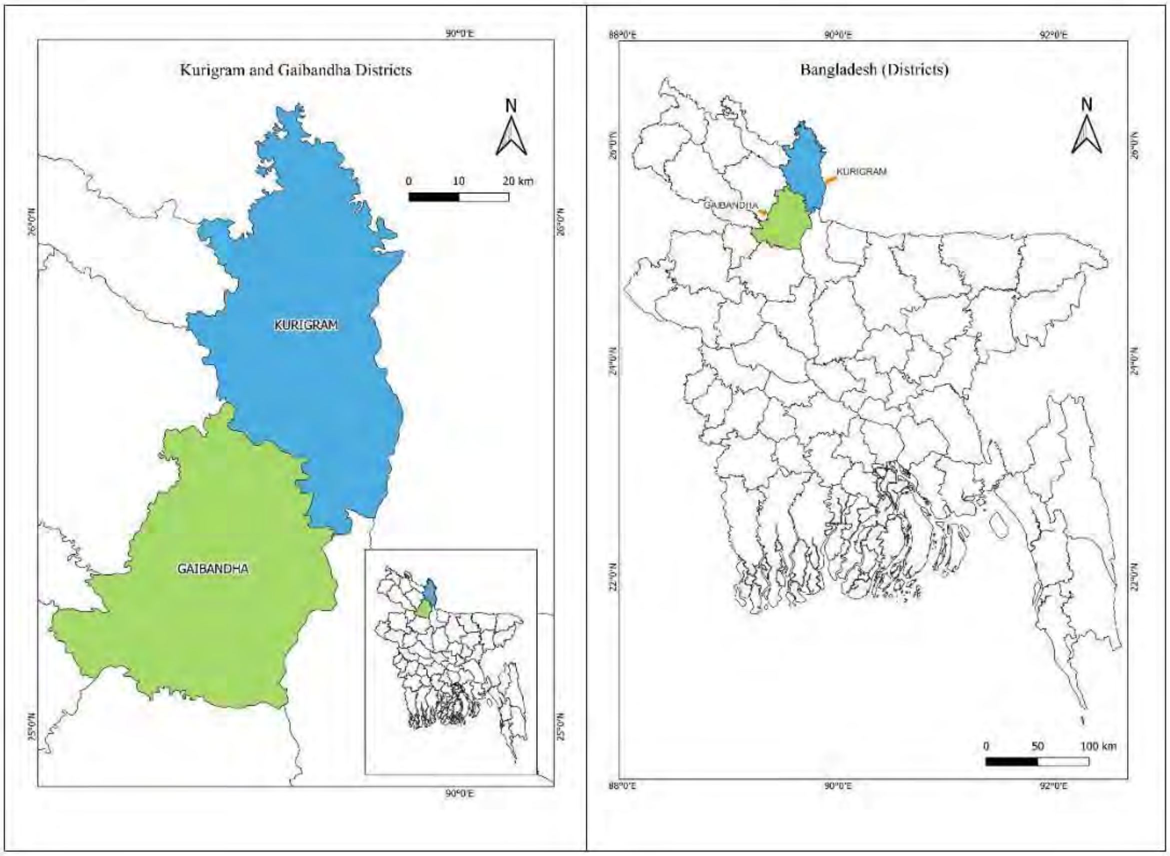

Figure 2: Location of study districts (Kurigram and Gaibandha, Bangladesh)

3.3 Study period

This study was conducted from January to June 2026, aligning with the timeline of the main cRCT. Quantitative and qualitative data were collected over approximately seven weeks, from early March to early April 2026, during the active implementation of the infrastructure interventions.

3.4 Study population

The study included key individuals involved in planning, implementing, and supervising the SRP and BCPF interventions in the parent trial. The school-level sample comprised BRAC Education Program primary schools in Kurigram and Gaibandha selected for the infrastructure improvement project. Eligible schools had classrooms with corrugated tin roofs designated to receive SRP, BCPF, or both interventions. Participants included workers directly involved in implementing the interventions, such as painters applying SRP and carpenters installing BCPF, as well as monitoring staff responsible for overseeing the implementation process.

3.4.1 Inclusion criteria

- BEP primary schools in Kurigram or Gaibandha that were part of an infrastructure intervention arm of the parent cRCT and had at least one tin-roof classroom targeted for SRP or BCPF.
- Within these schools, BEP focal persons, painters, carpenters, and monitoring officers who were involved in planning, supervision, or implementation of SRP and/or BCPF, and who provided informed consent.

3.4.2 Exclusion criteria

- Government and private primary schools in the same districts that were not operated by BRAC or were not included in the parent cRCT.
- BEP schools assigned to the parent cRCT's control arm or did not receive any infrastructure intervention during the study period.
- Schools with concrete or already well-insulated roofs, where SRP and BCPF were not required or planned.

3.5 Sample size

For the quantitative component, a census approach was used: all 69 intervention schools in the parent cRCT (23 SRP-only, 23 BCPF-only, and 23 combined) were included, yielding 92 intervention events (46 SRP and 46 BCPF, with the 23 combined-arm schools contributing observations for both SRP and BCPF). This approach follows recommendations for fidelity studies nested within trials, in which the goal is to describe implementation across all sites rather than to estimate population parameters from a probability sample. In each school, one monitoring officer who was present throughout the intervention process completed the school-level questionnaire, yielding 69 school-level respondents.

For the qualitative component, the sample size was guided by thematic saturation (Guest et al., 2006; Saunders et al., 2018). A total of 15 key informant interviews were completed: 8 intervention workers (4 painters and 4 carpenters), 6 monitoring officers, and 1 intervention coordinator. Saturation was defined as the point at which at least two consecutive interviews within a stakeholder group yielded no new codes relevant to the study objectives.

3.6 Sampling technique

In the quantitative component, 69 BRAC schools in the parent cRCT intervention were included as the allocation of SRP and BCPF had already been determined by the trial design. Within each school, a monitoring officer who was closely involved in monitoring the interventions was purposively selected to participate in the survey.

For the qualitative component, purposive sampling was used to select key informants who could provide in-depth insights into how the interventions were implemented at different levels. Participants were chosen to ensure coverage across both districts (Kurigram and Gaibandha) and across all intervention groups (SRP only, BCPF only, and combined). This approach was appropriate because the qualitative component aimed to understand processes, mechanisms, and contextual factors influencing implementation.

3.7 Variables

3.7.1 Dependent variables

The primary outcome was implementation fidelity for SRP and BCPF, measured per intervention event as a continuous composite score (0–100) scale, computed as the equally weighted mean of three percentage-score dimensions.

3.7.2 independent variables

Independent variables were grouped into three categories aligned with the theoretical framework.

- School-level variables (organisational readiness): three school-readiness variables. structural soundness of the school roof (binary; structurally ready vs. not ready), adequacy of material storage (binary; adequate vs. inadequate), and timely classroom vacating for installation (binary; adequate vs. inadequate).
- Implementer-level variables (facilitation and complexity): two implementer-level variables. supervisor presence during installation (binary; fully present vs. partially present), and perceived intervention difficulty (binary; difficult vs. not difficult).
- Contextual variables: two contextual variables. rain disruption to drying or installation (binary; disturbance vs. no disturbance), and heat/humidity affecting worker performance (binary; disturbance vs. no disturbance).

3.7.3 Operational definitions

- Implementation fidelity: the degree to which SRP and BCPF were delivered as planned. This includes using the correct materials, following the proper sequence of steps, ensuring full coverage of schoolroom areas, and maintaining workmanship.
- Content adherence: the use of approved materials and the completion of core technical steps in the correct order. For SRP, this involves surface cleaning, rust removal, leak repair, primer application, and the specified paint coats. BCPF required the insertion, alignment, sealing, and securing of foam and bamboo panels.
- Coverage (dose): the proportion of the targeted area that received full interventions. For SRP, this means the entire roof surface receives two coats of paint at the recommended rate of 1 liter per 72 square feet. For BCPF, it means the targeted ceiling area is completely covered with foam and bamboo sealing as intended.
- Quality of delivery: the observable workmanship and safety compliance. This includes the finished roof and ceiling, clean edges, secure fixtures, and the absence of major

defects such as bubbles and gaps. Also, safety measures such as PPE, ladders, and hazard controls should have been implemented during the process.

- Contextual factors: the extent to which external conditions can affect intervention implementation. This is measured in this study by rain-affected drying or installation and by the impact of extreme heat and humidity on worker performance.
- Intervention complexity: the perception of workers and monitoring officers at the field level during implementation was how difficult this intervention was for workers to follow the technical steps of both intervention installations.
- Participant responsiveness: the degree of engagement, cooperation, and acceptance of the interventions among stakeholders (monitoring officers, community people, house owners, and workers).
- School readiness: the extent to which the existing school roof and structure are suitable for interventions without requiring major repairs.

3.8 Data collection and procedures

3.8.1 Data collection tools

Quantitative tool: Two structured tools were designed and administered using KoBoToolbox on tablets with built-in skip logic and validation checks. Tool 1: An "observation checklist" for both interventions by trained field researchers during and immediately after installation was completed on-site. It covered detailed intervention specifications into observable items content (steps and materials), coverage (proportion of completed area), and quality of delivery (workmanship and safety). Tool 2: A "school-level questionnaire" is administered face-to-face to monitoring officers at each school. It includes facilitation strategies (training, supervision, and feedback), school-level factors, perceived implementation difficulty, and contextual factors (rain and heat/humidity).

For the qualitative component, semi-structured KII guidelines were developed separately for intervention coordinators, monitoring officers, painters, and carpenters. These guides followed the Carroll-Hasson fidelity framework and were complemented by the Theoretical Domains

Framework (Cane et al., 2012) to explore the behavioral and contextual factors that influenced fidelity.

3.8.2 Pretesting

Before the main data collection, all study tools were pilot-tested at two BRAC primary schools. This testing assessed language clarity, logical flow, response options, interview duration, and specific issues such as timing and access. Based on feedback from data collectors and participants, revisions were made to the wording, ordering, and structure of the questions. Once the tool was revised fully, all tools were translated into Bengali and back-translated into English to ensure accuracy and consistency.

3.8.3 Data collection procedure

To reduce the risk of bias, trained field researchers who were not part of the cRCT implementation collected qualitative and quantitative data in Bangla. Before data collection began, observers and interviewers received structured training on the study protocol, tools, ethical procedures and informed consent, and how to use KoBoToolbox for data entry. In each intervention school, observers conducted on-site visits during the SRP and BCPF installations and completed structured observation checklists. To accurately capture implementation details that could only be observed at specific stages (such as the drying time of the primer or the correct placement of the foam), observations were conducted during active construction. The checklist items were grouped into process indicators (observed in real time) and outcome indicators (assessed after completion). With permission, observers also took photographs to document key aspects of implementation and site conditions. In addition, face-to-face school-level surveys were conducted with monitoring officers in a private and quiet setting to ensure accurate responses.

Experienced qualitative researchers conducted the KIIs in Bangla. To ensure confidentiality and reduce distractions, these interviews took place in private locations, such as near the schoolhouses and in BRAC offices. With the participants' consent, all interviews were audio-recorded, and the researchers also took nonverbal cues and contextual details.

3.9 Data management and quality assurance

Quantitative data collected through KoBoToolbox. Collected data were uploaded daily to a secure server with password-protected access limited to the research team members only. To maintain confidentiality, unique identification codes were assigned to schools, observations, and participants. During the daily data collection, quality checks were performed to identify missing values and inconsistencies. Any detected issues were resolved through immediate follow-up with data collectors.

Qualitative data, including audio recordings and transcripts, were stored securely in password-protected and encrypted folders. Access to these folders was restricted to the qualitative analysis research team only. Interviews were first transcribed in Bengali and then translated into English. To ensure accuracy, selected transcripts were checked against the original audio recordings. A coding framework and codebook were developed and refined over time. All transcripts were coded systematically using a structured Google spreadsheet. Any differences in coding were discussed within the team, and code definitions were revised when needed. To maintain confidentiality, all identifying information was removed from the transcripts and replaced with unique participant codes.

3.10 Data analysis

3.10.1 Quantitative

All quantitative analyses were performed using Stata version 17.0 (StataCorp, College Station, TX, USA). The analysis was structured into four stages, each of which is described in detail below: (i) construction of dimension-level fidelity scores; (ii) construction of a composite fidelity score; (iii) descriptive summarisation of fidelity outcomes; (iv) bivariate distribution of moderators; and (v) multivariable regression modeling of the determinants of composite fidelity. The same outline was applied independently to the SRP and BCPF intervention.

Stage 1: Construction of dimension-level fidelity scores.

For each observed intervention event, three dimension-level fidelity scores were constructed corresponding to the a priori conceptual dimensions of content, coverage, and quality of delivery.

Within each dimension, item-level responses were summed, divided by the maximum attainable score on that dimension, and multiplied by 100 to produce a continuous percentage score bounded on the [0, 100] interval. The general computational form, applied to both interventions, was

$$S(d, i) = (\Sigma_j x(i,j,d) / \Sigma_j x\_max(j,d)) \times 100$$

where S(d, i) is the score percentage for dimension d during intervention event i. The term x(i,j,d) represents the score for item j within that dimension and event. While x_max(j,d) is the maximum possible score for that item. That total score is calculated by summing all items within the dimension.

Stage 2: Construction of the composite fidelity score:

A composite fidelity score was calculated for each intervention event as the unweighted arithmetic mean of its three-dimension percentage scores.

$$C(i) = (S\_content(i) + S\_coverage(i) + S\_quality(i)) / 3$$

Where C(i) is the composite fidelity score percentage for intervention event i. This approach applied equal weighting across three dimensions.

Stage 3: Descriptive analysis: continuous fidelity scores for each of the three dimensions and the composite were summarized separately for SRP and BCPF using the mean, standard deviation (SD), and minimum and maximum values. District variation in composite fidelity was presented as a box plot. Where the box spans the interquartile range (IQR), the horizontal line indicates the median, and the whiskers extend to the most extreme observation within 1.5 × IQR of the quartiles.

Stage 4: Multivariable hierarchical regression

To identify multivariable correlates of fidelity, a hierarchical linear regression was used. Three nested models were estimated separately for both interventions using the composite fidelity score as the continuous outcome:

$$C(i) = \beta_0 + \Sigma_k \beta_k X(k,i) + \varepsilon(i)$$

where C(i) is the composite fidelity score for event i and X(k, i) is the k-th predictor. The regression coefficient (β_k) represents the adjusted percentage-point change in composite fidelity for a one-unit change in X(k, i), holding all other predictors constant. β_0 is the intercept, and $\varepsilon(i)$ is the independent error term. The three model specifications were:

- Model 1 (School readiness): Composite fidelity was regressed on roof structural soundness, material storage adequacy, and timely classroom vacating.
- Model 2 (School readiness + implementer factors): Model 1 was extended by adding supervisor presence during installation and perceived implementation difficulty.
- Model 3 (School readiness + implementer factors + extraneous factors): Model 2 was further extended by adding rain disruption, heat disruption, and districts.

All models were estimated by ordinary least squares with heteroscedasticity-consistent (Huber–White) robust standard errors. For each model and predictor, the analysis reports the coefficient estimate (β), its 95% confidence interval, and the associated p-value.

3.10.2 Qualitative

The qualitative data were analyzed using thematic analysis with a combined deductive and inductive approach (Braun and Clarke, 2006). The initial coding was guided by the Carroll-Hasson implementation fidelity framework and the TDF framework. While new themes emerged from interviews, allowed by the inductive approach.

Researchers first familiarized themselves with the transcriptions by repeatedly reading. An initial codebook was developed and continuously refined during transcription coding. All transcriptions were coded line by line in a structured Google spreadsheet. The resulting codes were grouped into categories and broader themes. Finally, all the themes were compared across different stakeholder groups and intervention types.

3.10.3 Mixed-Method Integration

Mixed-method integration followed a convergent design principle (Fetters et al. 2013) and a joint display approach (Guetterman et al. 2015). Integration occurred at two stages:

- Method level: KII guides structurally mapped to the quantitative fidelity dimensions to ensure the same concept across both strands.
- Interpretation level: Quantitative fidelity scores and qualitative themes were merged using a side-by-side joint display matrix. Where each row represented a fidelity construct and the column presented quantitative scores alongside qualitative quotations.

3.11 Ethical considerations

The study protocol (IRB protocol No. MPH-2025-016) was approved by the institutional review board of BRAC James P. Grant School of Public Health at BRAC University. This study adhered to all relevant national and institutional ethical guidelines for research involving human participants.

All participants were informed about the purpose of the study, the method, the risks and benefits, the data protection measures, and their right to withdraw at any time without consequences. Written consent was obtained from the participants. To maintain confidentiality, personal identifiers were removed from all analysis datasets and transcripts, and unique identification codes were assigned to schools and participants. All electronic files, recordings, and transcripts were stored securely in password-protected devices and servers, accessible only to authorized members of the study team.

The study posed minimal risk because it was primarily observational and did not interfere with the implementation of the interventions. Participants were assured that their information would not be used to evaluate their performance and would be reported only in aggregated or anonymized form. No financial incentives were offered for participation. The participants were further informed that the findings of the study are expected to help improve future infrastructure interventions and contribute to creating safer and more comfortable learning environments for children.

Chapter 4: Results

4.1 Quantitative findings

Section 4.1.1 shows details about the analytical sample. Section 4.1.2 shows the dimension-level and composite fidelity scores for the two interventions, whereas Section 4.1.3 shows composite fidelity scores for the two interventions by geographical district. Section 4.1.4 presents the distribution of the moderating factors. Section 4.1.5 presents the hierarchical regression analysis of the determinants of composite fidelity, estimated separately for SRF and BCPF.

4.1.1 Analytical sample

All 69 intervention schools from the parent cRCT were included in the quantitative analysis. Because 23 schools received both interventions, the study generated a total of 92 intervention-event observations: 46 for the Solar Reflective Paint (SRP) intervention and 46 for the bamboo ceilings with polyethylene foam (BCPF) intervention. Among the participating schools, 29 (42.0%) were in Kurigram and 40 (58.0%) in Gaibandha. As planned in the trial design, each intervention arm included 23 schools. A summary of the analytic sample is presented in Table 3.

Table 3: Analytical sample by intervention arm and district (N = 69 schools, 92 intervention events).

Characteristic	**SRP only (n=23)**	**BCPF only (n=23)**	**Combined (n=23)**	**Total (n=69)**
District, n (%)				
Kurigram	10 (43.5%)	8 (34.8%)	11 (47.8%)	24 (42.0)
Gaibandha	13 (56.5%)	15 (65.2%)	12 (52.2%)	40 (58.0)
Intervention events analysed	23 SRP	23 BCPF	23 SRP + 23 BCPF	46 SRP + 46 BCPF

Monitoring officers interviewed	23	23	23	69

Note: Per intervention, SRP events totaled 46 (23 SRP-only + 23 combined; 21 in Kurigram, 25 in Gaibandha), and BCPF events totaled 46 (23 BCPF-only + 23 combined; 19 in Kurigram, 27 in Gaibandha).

4.1.2 Dimension-Level and Composite Fidelity Scores

4.1.2.1 Solar-Reflective Paint (SRP) fidelity scores

Overall implementation fidelity was high across the 46 observed SRP installation events. However, some variations were observed through content, coverage, and quality of delivery (Table 4). The composite fidelity score was calculated using the average of these three dimension scores. It was calculated as an equally weighted mean of the three-dimensional scores with a mean of 86.2% (SD=6.4). The scores ranged from 73.5% to 100%. It shows that, on average, schools got nearly 86% of the maximum possible fidelity for the SRP intervention.

Content adherence shows how precisely the working team followed the specified protocols. It had a mean score of 96.7% (SD = 4.9), with a range of 82.4% to 100%. A low SD indicates high consistency across all the schools in SRP installation. In the majority of cases, the installation teams attained all the necessary protocols. It indicates that the intervention was carried out in close alignment with the plan. Coverage indicates how much of the planned roof surface was coated and whether the coating was applied at the recommended rate. It had an average score of 85.5% (SD = 10.3), ranging from 66.7% to 100%.

This means that schools achieved, on average, about 86% of the intended SRP coverage. Quality of delivery, capturing the technical execution of the installation, including finish, evenness, and worker conduct was the lowest scoring of the three dimensions at 76.6% (SD = 10.9), with values ranging from 57.1% to 100.0%.

Table 4: SRP fidelity scores by dimension (n = 46 intervention events).

Fidelity Dimension	Mean % (SD)	Range
Content	96.7% (4.9)	82.4-100.0
Coverage	85.5% (10.3)	66.7-100.0
Quality of Delivery	76.6% (10.9)	57.1-100.0
Composite (Equal-Weight)	86.2% (6.4)	73.5-100.0

Note. SD = standard deviation. All scores are expressed as a percentage of the maximum attainable on that dimension.

4.1.2.2 Bamboo Ceiling with Polyethylene Foam (BCPF) fidelity scores

Across the 46 observed installation events for the BCPF intervention, overall implementation fidelity was high, although some differences were seen across the three main dimensions: content, coverage, and quality of delivery (Table 5). The composite fidelity score, computed as the equally weighted mean of the three-dimensional scores, had a mean of 88.8% (SD = 9.9) and ranged from 61.9% to 100.0%. This indicates that, on average, schools achieved about 89% of the highest possible fidelity score for the BCPF intervention.

Content adherence indicates how precisely the installation teams followed the protocols for installing BCPF. It has a mean score of 92.2%. (SD=8.5). Scores ranged from 71.4% to 100%. It indicates that most schools complied with the majority of the recommended installation steps. Coverage addresses the extent to which the intended BCPF installation was actually completed. It had an average score of 91.3%, within a range of 50% to 100%. It showed the greatest variation among all fidelity measures.

These findings indicate that, although the average level of coverage was high, there were substantial differences between schools. In particular, at least one school completed only half of the intended BCPF installation, while many others achieved full coverage.

Quality of delivery, which reflects how well the BCPF installation was carried out, including frame stability, secure fixing, overall finish, and workers' conduct, was the lowest scoring of the three fidelity dimensions. It had a mean score of 82.9% (SD = 13.2), with values ranging from 57.1% to 100.0%. The cross-intervention regularity that quality of delivery is the weakest fidelity dimension is therefore preserved in BCPF, although BCPF outperformed SRP on this dimension by approximately 6 percentage points.

Table 5: BCPF fidelity scores by dimension (n = 46 intervention events).

Fidelity Dimension	**Mean % (SD)**	**Range**
Content	92.2% (8.5)	71.4-100.0
Coverage	91.3% (19.2)	50.0-100.0
Quality of Delivery	82.9% (13.2)	57.1-100.0
Composite (Equal-Weight)	88.8% (9.9)	61.9-100.0

Note. SD = standard deviation. All scores are expressed as a percentage of the maximum attainable on that dimension.

4.1.3 Intervention by district

4.1.3.1 SRP fidelity by district

Figure 3 shows two box plots side by side, comparing how well the SRP intervention was implemented across the two study districts: Kurigram (21 installations) and Gaibandha (25). The y-axis shows the composite fidelity score as a percentage of the maximum, in the 60-100% range, showing the variation.

The Kurigram box sits noticeably lower than the Gaibandha box, indicating that implementation fidelity was generally weaker there. The median for Kurigram is around 83%. Most schools fall between 79% and 86%. The whiskers range from 73% to 95%. Gaibandha runs higher across the board. It has a median of around 90%. The middle 50% lies roughly between 85% and 93%. Whiskers range from 77% to a whole 100%.

Neither district had any schools outside the 1.5x IQR range. So, there are no formal outliers in the data. The differences within each district are just normal variations among schools, not due to unusual values or outliers.

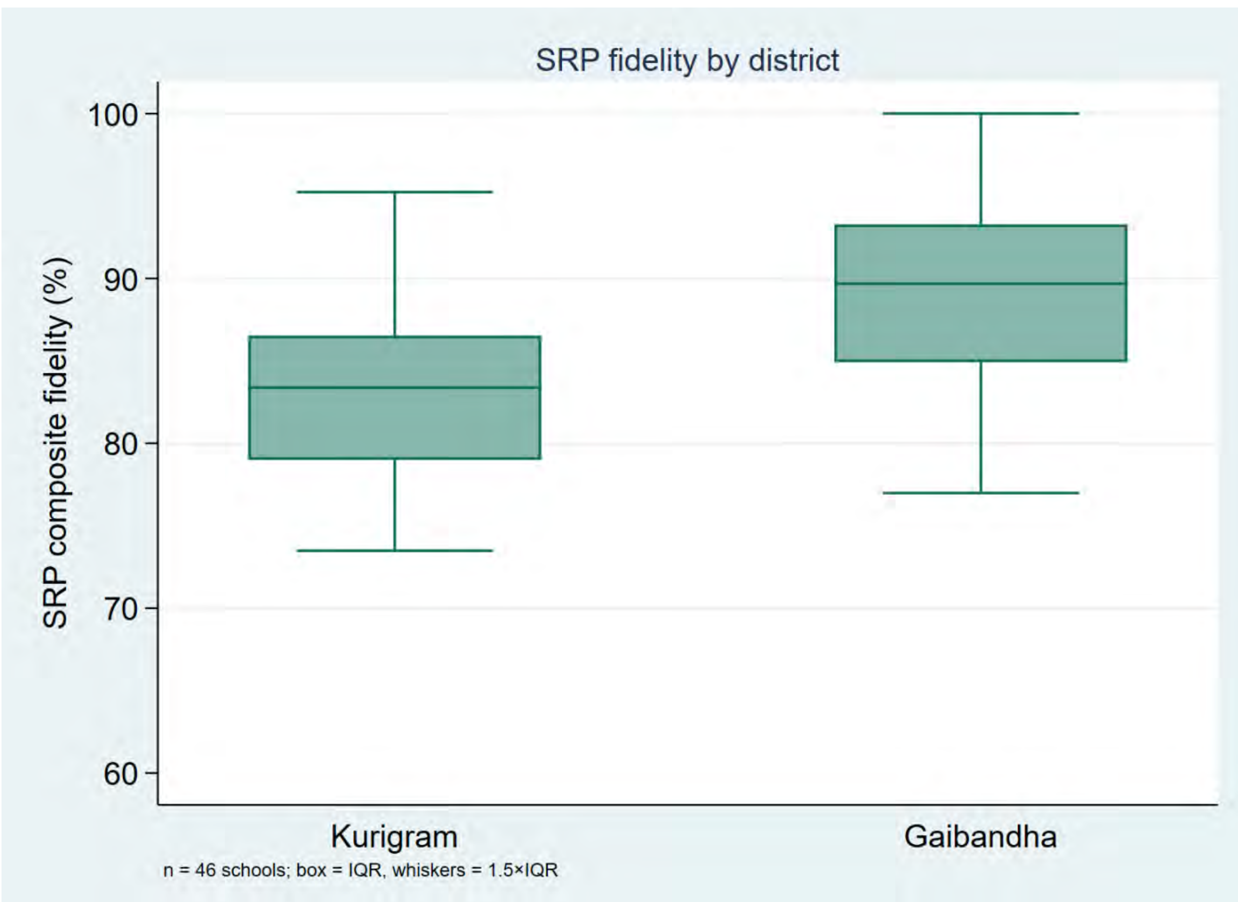

Figure 3: Distribution of SRP composite fidelity score by district (n=46 intervention events).

Note. Box = interquartile range (Q1-Q3); horizontal line within box = median; whiskers = 1.5 x IQR

4.1.3.2 BCPF fidelity by district

Figure 4 shows the distribution of BCPF composite fidelity scores in the two study districts (n = 46 schools total). The difference between the districts is clear and follows the same pattern as the SRP results, but it is more pronounced here.

Schools in Gaibandha consistently achieved high BCPF composite fidelity scores. It clustered near the top of the scale. The median score was about 95%. The median score was about 95%. The IQR is 92% and 98%. Several schools achieved the maximum score of 100%. It shows that most schools in Gaibandha implemented the BCPF intervention precisely, following standard protocols with minor variations.

A different pattern was seen in Kurigram. The median score was approximately 84%, which is 11% lower than in Gaibandha. The middle 50% of schools lie between 79% and 90%. The minimum score was 62%. It indicates that at least one school conducted a BCPF intervention of substantially low quality. No outliers were identified. It suggests these lower scores were part of the district's normal variation.

Gaibandha comprised four outliers with scores ranging from 69% to 78%. The performance of these schools was below the typical level in Gaibandha. However, even these underperforming schools had scores in the middle range, seen in Kurigram. It signifies that they were unusual only compared with other schools in Gaibandha, not when contrasted with all schools taken in the study.

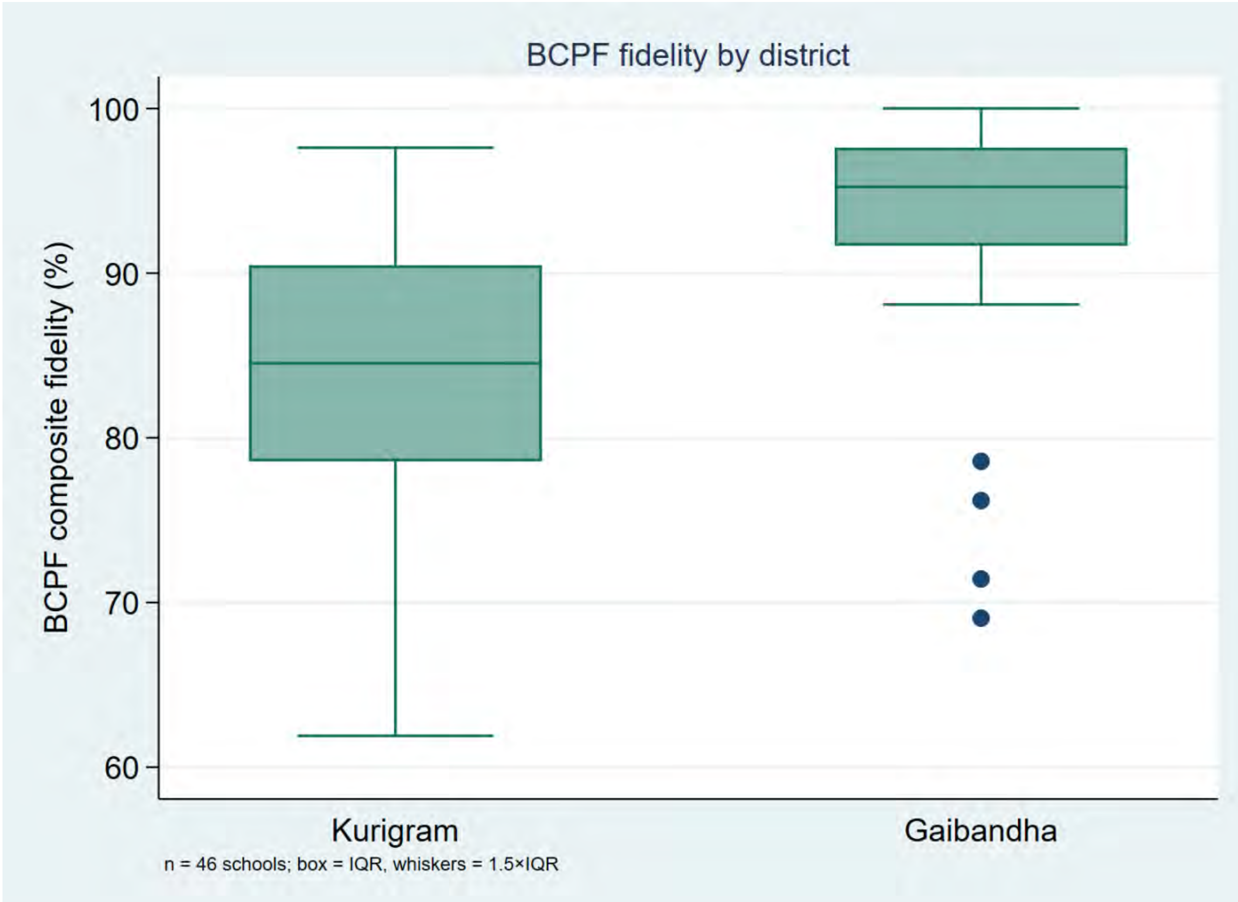

Figure 4: Distribution of BCPF composite fidelity score by district (n = 46 intervention events).

Note. Box = interquartile range (Q1–Q3); horizontal line within box = median; whiskers = 1.5 × IQR.

4.1.4 Determinants of moderating factors

Table 6 presents the distribution of the fidelity moderator variables included in the regression models, shown separately for the 46 SRP and 46 BCPF intervention events. For each moderator, the table reports the number and percentage of events in each category.

Within the school-readiness domain, the structural condition of school roofs was evenly distributed across categories. Specifically, 24 SRP events (52.17%) and 26 BCPF events (56.52%) occurred in schools classified as not fully ready, compared with 22 (47.83%) and 20 (43.48%) in structurally ready schools, respectively. In contrast, both the adequacy of material storage and the timely vacating of the classroom were strongly skewed toward the adequate category. Adequate material storage was observed in 38 SRP events (82.61%) and 37 BCPF events (80.43%), while classrooms were vacated on time in 40 of 46 events (86.96%) in both interventions. This imbalance is substantively meaningful, suggesting that most participating schools were operationally well prepared. However, it also has implications for inference: the reference (inadequate) category includes only 6 to 9 events per intervention, which is likely to result in relatively large standard errors for the corresponding regression estimates.

Within the implementer-level domain, full supervisor presence during installation was the predominant condition in both interventions, observed in 41 of 46 SRP events (89.13%) and 40 of 46 BCPF events (86.96%). In contrast, perceived implementation difficulty showed a more balanced distribution, with 26 SRP events (56.52%) and 27 BCPF events (58.70%) reported as involving some degree of difficulty.

In the contextual domain, disruption from rain during installation or drying was reported in 22 SRP events (47.83%) and 15 BCPF events (32.61%). This difference suggests that the two intervention rounds were conducted under somewhat different weather conditions, with BCPF installations more often taking place during drier periods than SRP installations. In contrast, heat or humidity affecting worker performance was reported at similar levels across interventions, with 19 SRP events (41.30%) and 18 BCPF events (39.13%) affected. At the district level, the SRP sample included 20 schools in Kurigram (43.48%) and 26 in Gaibandha (56.52%), while the BCPF sample included 18 schools in Kurigram (39.13%) and 28 in Gaibandha (60.87%).

Table 6: Distribution of moderating factors by intervention type (n = 46 per arm).

Variables	**SRP, n (%)**	**BCPF, n(%)**
School readiness		
Structural soundness of the school roof		
Not ready	24 (52.17%)	26 (56.52%)
Structurally ready	22 (47.83%)	20 (43.48%)

Adequacy of material storage		
Not adequate	8 (17.39%)	9 (19.57%)
Adequate	38 (82.61%)	37 (80.43%)
Timely classroom vacating		
Not adequate	6 (13.04%)	6 (13.04%)
Adequate	40 (86.96%)	40 (86.96%)
Facilitation Strategies		
Supervisor presence during installation		
Partially present	5 (10.87%)	6 (13.04%)
Fully present	41 (89.13%)	40 (86.96%)
Perceived implementation difficulty		
Not difficult	20 (43.48%)	19 (41.30%)
Difficult	26 (56.52%)	27 (58.70%)
Contextual Factors		
Rain disruption to installation or drying		
No disturbance	24 (52.17%)	31 (67.39%)
Disturbance	22 (47.83%)	15 (32.61%)
Heat/humidity disrupting worker performance		
No disturbance	27 (58.70%)	28 (60.87%)
Disturbance	19 (41.30%)	18 (39.13%)

District		
Kurigram	20 (43.48%)	18 (39.13%)
Gaibandha	26 (56.52%)	28 (60.87%)

4.1.5 Multivariable Determinants of Composite Fidelity

To identify the multivariable correlates of composite fidelity, three nested regression models with Huber–White robust standard errors were estimated separately for SRP and BCPF, using an analytical sample of 46 events per intervention. Each coefficient represents the adjusted difference in composite fidelity (in percentage points) associated with a given predictor category relative to its reference category, while holding all other variables in the model constant.

4.1.5.1 Regression of composite SRP fidelity

Three school-level readiness variables were included in Model 1 and retained in Models 2 and 3. None of these variables reached the statistical significance threshold of $p < 0.005$ across the models. Although one showed a consistently borderline positive association. Specifically, schools in which classrooms were adequately vacated on time scored, on average, 4.07 percentage points higher in composite SRP fidelity than schools with inadequate vacating (Model 1: 95% CI: −0.08 to 8.23; $p = 0.055$), just above the conventional 5% significance threshold.

When variables related to implementers were added in Model 2, the estimated effect remained similar ($\beta = 3.97$). However, the confidence interval widened, and the result had less precision (95% CI - 0.64 to 8.60; $p = 0.090$). After adjusting for all given variables in Model 3, the effect was substantially reduced ($\beta = 0.83$; 95% CI −5.23 to 6.91; $p = 0.782$). It indicates that the apparent association was well explained by contextual and district-level factors. Structural roof readiness was positively associated with implementation fidelity across all three models. However, none of the estimates were statistically significant (Model 1 $\beta = 2.46$; Model 2 $\beta = 3.77$; Model 3 $\beta = 3.01$). The result in Model 2 was close to significance (p=0.099). It suggests a possible but uncertain effect. Adequate material storage showed small, inconsistent associations across the models. In Model 3, the estimate became negative (β = −2.74; 95% CI −10.99 to 5.51; p = 0.505). The wide confidence intervals show that no clear relationship with implementation fidelity could be established.

Implementer-level factors were used in Model 2 and retained in Model 3. However, neither of them was statistically significant in either specification. Supervisor presence during installation was associated with small, negative, and non-significant effects in both Model 2 (β = −2.19; p = 0.388) and Model 3 (β = −1.58; p = 0.471). Similarly, perceived implementation difficulty showed small, positive but non-significant associations with fidelity (Model 2: β = 2.90, p = 0.257; Model 3: β = 1.38, p = 0.542). In Model 3, adding contextual and district-level variables did not change the direction of the relationships. However, the effects became weaker.

In Model 3, rain disruption and heat or humidity disruption showed small positive associations with fidelity. However, neither was significantly associated with the fidelity score. On the other hand, the district variable was the only significant predictor in the fully adjusted model. Also, it had its largest effect in the analysis. Schools in Gaibandha scored, on average, 5.98 percentage points higher in composite SRP fidelity than those in Kurigram, after adjusting for school-level readiness, implementer level, and contextual factors (95% CI 2.20–9.76; p = 0.003). Across all eight predictors examined in the nested models, district was the only variable with sufficient evidence to distinguish its effect from chance variation at the available sample size.

Table 7: Robust hierarchical regression analysis findings of composite SRP fidelity score (n = 46 events).

Variable	**Model 1**		**Model 2**		**Model 3**	
	Coefficient (95% CI)	**p-value**	**Coefficient (95% CI)**	**p-value**	**Coefficient (95% CI)**	**p-value**
School-level						
Structural soundness of school roof						
Not ready	Reference		Reference		Reference	

Structurally ready	2.46 (-1.45, 6.37)	0.211	3.77 (-0.73, 8.28)	0.099	3.01(-1.62, 7.65)	0.196
Adequacy of material storage						
Inadequate	Reference		Reference		Reference	
Adequate	-0.68 (-6.39, 5.02)	0.810	-0.08 (-7.14, 6.98)	0.981	-2.74 (-10.99, 5.51)	0.505
Timely classroom vacating						
Inadequate	Reference		Reference		Reference	
Adequate	4.07(-0.08, 8.23).	**0.055**	3.97 (-0.64, 8.60)	0.090	0.83(-5.23, 6.91)	0.782
Implementer-level factors						
Supervisor presence during installation						
Partially present	-	-	Reference		Reference	
Fully present	-	-	-2.19 (-7.28, 2.88)	0.388	-1.58 (-5.97, 2.81)	0.471
Perceived implementation difficulty						
Not difficult	-	-	Reference		Reference	
Difficult	-	-	2.90 (-2.20, 8.01)	0.257	1.38 (-3.15, 5.91)	0.542

Contextual Factors						
Rain disruption to installation or drying						
No disturbance	-	-	-	-	Reference	
Disturbance	-	-	-	-	0.66 (-2.87, 4.21)	0.705
Heat/humidity disrupting worker performance						
No disturbance	-	-	-	-	Reference	
Disturbance	-	-	-	-	1.22 (-3.10, 5.54)	0.570
District						
Kurigram	-	-	-	-	Reference	
Gaibandha	-	-	-	-	5.98 (2.20, 9.76)	**0.003**

Note: Robust (Huber-White) heteroscedasticity-consistent standard errors. β = coefficient interpreted as the adjusted percentage-point change in composite SRP fidelity relative to the reference category. An em dash (—) indicates that the variable did not enter the corresponding model. Bold typeface indicates $p < 0.05$.

4.1.5.2 Regression of composite BCPF fidelity

As in the SRP intervention, none of the three school-readiness variables reached statistical significance across the three BCPF models, and their estimated effects were inconsistent across specifications (Table 8). Structural roof readiness showed small, negative, and non-significant coefficients in all models (Model 1 $\beta = -2.37$; Model 2 $\beta = -2.27$; Model 3 $\beta = -0.51$), with confidence intervals that consistently included zero. Material storage adequacy produced positive effects of similar magnitude in Models 1 and 2 (approximately 2.8 percentage points), but the direction of the association reversed in the fully adjusted Model 3 ($\beta = -5.01$; 95% CI −12.07 to 2.04; $p = 0.159$). This change in sign, along with the widening confidence interval in Model 3, suggests instability in the estimate rather than evidence of a consistent effect. Timely classroom vacating, by contrast, showed a stable positive association across all three models ($\beta = 2.87$, 3.02, and 2.93), but the estimates were imprecise, with wide confidence intervals (approximately ±8 percentage points) that meant none of the associations reached statistical significance at any stage (all $p > 0.46$).

Implementer-related factors were added in Model 2 and kept in Model 3. However, none were statistically significant. The presence of a supervisor during installation showed small, negative effects in both models. Despite that, these were not meaningful. Perceived implementation difficulty had minor and inconsistent effects. It was slightly positive in Model 2 and somewhat negative in Model 3. There was no clear evidence of a significant association.

The two context factors added in Model 3 had larger effects than the implementer factors. However, neither showed statistical significance. Rain disruption was linked to a +6.04 percentage point effect (95% CI −1.74 to 13.84; $p = 0.125$). Heat or humidity disruption showed a −3.76 percentage point effect (95% CI −10.90 to 3.36; $p = 0.292$). Despite that, neither result shows clear evidence of a real impact. The estimate for rain disruption is the second largest in the table and approaches statistical significance, but remains imprecisely estimated and should be interpreted with caution, as it may reflect residual confounding in a relatively small sample rather than a true underlying effect. As in the SRP analysis, the district variable was the only predictor in the fully adjusted model whose confidence interval excluded zero, and it also represented the largest effect. Schools in Gaibandha scored, on average, 8.75 percentage points higher in composite BCPF fidelity than those in Kurigram after adjusting for school-level readiness, implementer-level, and contextual factors (95% CI 2.23–15.27; $p = 0.010$).

Table 8: Robust hierarchical regression of composite BCPF fidelity score (n = 46 events).

Variable	Model 1		Model 2		Model 3	
	Coefficient (95% CI)	**p-value**	**Coefficient (95% CI)**	**p-value**	**Coefficient (95% CI)**	**p-value**
School-level						
Structural soundness of school roof						
Not ready	Reference		Reference		Reference	
Structurally ready	-2.37 (-8.79, 4.05)	0.461	-2.27 (-9.68, 5.14)	0.540	-0.51 (-7.87, 6.85)	0.888
Adequacy of material storage						
Not adequate	Reference		Reference		Reference	
Adequate	2.77 (-4.58, 10.13)	0.451	2.76 (-5.09, 10.62)	0.481	-5.01 (-12.07, 2.04)	0.159
Timely classroom vacating						
Not adequate	Reference		Reference		Reference	
Adequate	2.87 (-5.53, 11.28)	0.494	3.02 (-5.21, 11.26)	0.463	2.93 (-5.31, 11.17)	0.476
Implementer-level factors						
Supervisor presence during installation						

Partially present	-	-	Reference		Reference	
Fully present	-	-	-3.07 (-8.87, 2.72)	0.290	-1.18 (-6.34, 3.98)	0.646
Perceived implementation difficulty						
Not difficult	-	-	Reference		Reference	
Difficult	-	-	0.54(-6.51, 7.60)	0.877	-1.22 (-9.24, 6.79)	0.759
Contextual Factors						
Rain disruption to installation or drying						
No disturbance	-	-	-	-	Reference	
Disturbance	-	-	-	-	6.04 (-1.74, 13.84)	0.125
Heat/humidity disrupting worker performance						
No disturbance	-	-	-	-	Reference	
Disturbance	-	-	-	-	-3.76 (-10.90, 3.36)	0.292
District						
Kurigram	-	-	-	-	Reference	

Gaibandha	-	-	-	-	8.75 (2.23, 15.27)	**0.010**

Note. Robust (Huber–White) heteroscedasticity-consistent standard errors. β = coefficient interpreted as the adjusted percentage-point change in composite SRP fidelity relative to the reference category. An em-dash (—) indicates that the variable did not enter the corresponding model. Bold typeface indicates $p < 0.05$.

Across both interventions, the three nested models show that only the district variable reached statistical significance in the fully adjusted specification among the eight predictors examined. The district effect was larger for BCPF (8.75 percentage points) than for SRP (5.98 percentage points), but the direction and ranking of effects were consistent across interventions, with schools in Gaibandha outperforming those in Kurigram in both cases. All other predictors, including three school-readiness factors, two implementer-level factors, and two contextual factors, had confidence intervals that included zero in both interventions. This indicates that, given the current sample size of 46 events per intervention, there is insufficient evidence to distinguish their adjusted effects from random variation. However, several of these estimates were still substantively meaningful in size (for example, rain disruption in the BCPF model, β = 6.04) and should not be interpreted as evidence of no effect. Instead, they were more likely to reflect effects that the study was not sufficiently powered to estimate precisely.

4.2 Qualitative findings

Qualitative findings from 15 key informant interviews are organized into eight themes that map onto the Carroll–Hasson framework dimensions and moderating factors. Themes 1–3 address the three adherence dimensions (content, coverage, and quality of delivery). Themes 4–7 address the moderators (participant responsiveness, facilitation strategies, intervention complexity, and contextual factors). Theme 8 addresses secondary outcomes (perceived effectiveness and sustainability).

Table 9: Socio-demographic characteristics of the qualitative participants.

Variable	Category	n
Project team member	Implementation co-ordinator	1
District	Gaibandha	7
	Kurigram	7
Role of participant	Project coordinator	1
	Painter	4
	Worker	4
	Monitoring officers	6
Gender of participant	Male	13
	Female	2
Completed educational level	Master	6
	Bachelor	1
	Secondary level (6 to 10)	2
	Primary level (1-5)	4

	Unable to read and write	2

Theme 1: Adherence to Technical Protocol (Content)

Surface Preparation

Most respondents stated that the surface preparation process was carried out carefully. For SRP, tasks included evacuating classrooms; securing the roof entry; assessing structural and electrical safety; sanding down rust and debris from the tin surface; and ensuring the surface is dry before applying primer. For ceiling insulation, BCPF, the preparation, along with SRP, also involved calculating the rafters' load-bearing capacity and carefully removing tin sheets before applying the foam.

—First, after coming from the office, we sanded the surface properly using sandpaper. After sanding, we cleaned it using a broom and a cloth to remove dust. After the dust is cleared, we applied the primer.” ID_1004

—We emptied the school rooms, removed anything harmful, and disconnected electrical lines so that no harm would occur during work. If there were any wires or tin sheets, we checked and marked those.” ID_10010

Monitoring officers shared that the level of school preparedness differed across schools. In some schools, classrooms had not been fully vacated, which led to delays in preparing implementation work.

—Not all schools were fully vacant… We had to remove books and furniture before starting the work.” ID_1009

Procedural Sequence Adherence

Participants reported that every procedure in both interventions had been followed. Supervisors shared that there were some early deviations, especially in the case of SRP. Painters followed a project-specified process: cleaning and standing the surface, waiting two to three hours, then applying the first coat of SRP horizontally. After that, a drying time of 4 to 5 hrs passed, and the second coating was applied vertically in a vertical pattern.

―After applying the primer, we left it to dry. We applied the first coat of paint. After that, the second coat is applied about three and a half to four hours later. "_ID_1004

For BCFP, the workers sequentially removed the tin sheets and then inserted P-foam with precision from one end to the other, ensuring a tight fit. The joints were sealed with duct tape, and then the tin sheets were nailed back in an orderly manner.

―We first install the foam sheets evenly. If there are any gaps, we press and seal them and then fix the tin sheet over them. We follow the instructions exactly as they were given. We do not do anything extra beyond that. Everything is done according to the guidelines." _ID_1006

Differences were observed in the early phase of the process for both interventions. Although the workers reported following the full instructions, the monitoring officers and the field coordinator described an early-phase implementation that required active correction. A know-do gap occurs when workers know what they should do but revert to habitual methods.

―In the early days, when I instructed them to paint from left to right, they sometimes did it the opposite way. Some workers even responded, "Sir, you understand your work, and I understand mine." However, as professionals, we remained patient and corrected them." _ID_1003

―Although after providing training, workers often wanted to do the work in their own way. By repeatedly guiding them, we ensured the work was done according to our manual. "_ID_10010

However, supervisors noted significant improvements after a few days of implementation, as workers became familiar with the required protocols and became aware of their errors. In addition, direct sun exposure causing fatigue was another factor that hampered the work performance, especially while workers were positioned on top of the tin-sheet roofs.

―They do not need to read or be reminded of the manual every day. Since they have been working for a long time, they are following the manual. However, if any mistakes occur due to excessive workload or fatigue, we correct them." ID_1003

The gap between knowledge and action was mostly seen during the early phases of work among helper workers. This difference shows a significant threat to maintaining consistency during the expansion of work, which demands in-person monitoring, especially during the initial period of intervention.

Theme 2: Adherence to coverage

The implementation process included measuring and cutting the polyethylene foam to the size of the roof shapes of the individual schools. Carpenter also reported that the foam was properly installed without any deliberate gaps. Supervisors ensured the foam coverage was properly placed before installing the tin sheets. Field coordinators and monitoring officers reported satisfactory intervention coverage across most of the schools. Painters stated that they applied the paint thoroughly over the tin and described complete visibility of paint coverage.

—When three coats of paint and primer are applied, then the tin is no longer visible. Then it is understood that my painting is completed; 100% paint is visible from far."_ID_10012

Supervisors stated that applying foam in schools with unusual room shapes, such as L-shaped layouts, makes it difficult to achieve uniform coverage. Supervisors from 2 sites also shared that the PE-foam cut alignment is not aligned. They are sharing that it might be a defect either on the company's side or during import into our country.

—In the case of P-foam, some houses had irregular structures, such as L-shaped designs, which differed from standard school layouts. In such cases, even after installation, there were areas where air could pass through. These structural limitations could not always be fully addressed, especially where part of the structure belonged to the homeowner rather than the school. ..., it was not possible to cover those additional areas." ID_10015

—...cutting size of the foam was sometimes slightly inaccurate (19/20 variation); small gaps appeared. To fix this, we used wider tape to cover those areas." ID_1003

Theme 3: Adherence to the quality of delivery

Workmanship Quality

Overall, participants shared positive feedback on workmanship, highlighting uniform paint application, well-sealed foam joints, and efforts to correct visible imperfections. In the BCPF intervention, workers are proactive in ensuring quality, such as identifying gaps after foam installation, adjusting foam placement by reopening tin sheets, and using duct tape and binding wire to seal joints.

―Taking extra time is not a problem; the important thing is to complete work properly. We installed one piece of P-foam and then one sheet of tin, likewise. After installation, we ensured that all the joints aligned properly. If the P-foam was not fitted properly, we reopened the tin sheet and adjusted." _ID_1007

According to the monitoring officers, some worker groups consistently followed the protocol. Although achieving 100% compliance across all the teams and school sites was difficult during the actual implementation of the work.

―From my observation,…… Ensuring 100% compliance across all teams was challenging. Some teams followed all the rules, while others did not. "_ID_10015

<u>Safety Compliance During Installation</u>

Safety rules and personal protective equipment (PPE) were clearly mentioned during the training period. These include the use of body protection, gloves, masks, and helmets; safe use of ladders and ropes; and clearing hazards before work. Workers were aware of these measures and willing to follow all of them throughout the intervention process. Four minor injuries, a hand cut, and a foot cut, were reported. Three of the injuries were managed with first aid on the school site, and one was referred to nearby higher facilities.

―If I mention yesterday's incident while installing the P-foam, one of my workers cut his hand quite badly. .... I always keep first-aid safety materials with me. At that moment, I provided immediate first-aid treatment. I used Savlon cream, Dettol, and Hexisol, which were provided by the office." _ID_10011

Nevertheless, adherence to PPE was higher in the presence of supervisors. Workers tried to remove gloves, masks, and helmets when supervisors were not present, citing heat and discomfort, and said certain items were unnecessary. Workers are habitual about not wearing PPE in their everyday work.

"Many workers felt uncomfortable wearing PPE. When we were on-site in front of them, they followed safety measures, but if we went to another place for 10 to 15 minutes, they removed PPE. When we asked them, they said it was too hot." — ID_1003

—They gave masks, Dettol, clothing, and helmets, though those were not needed. We always do tin work; we are experienced workers. "_ID_10014

Workers mentioned that PPE use is not always needed. This perception may create challenges during large-scale implementation and increase the risk of accidents. So, training sessions before work begins should emphasize the importance of protection instead of focusing on rule enforcement.

Theme 4: Participant Responsiveness

Stakeholder Engagement

Community reactions to this implementation project were positive after the project team explained the objectives and the anticipated thermal benefits of heat regulation. Ten participants elaborated on how the community got properly involved. Parents, house owners, and community members expressed their sincere gratitude for the expected reduction in classroom heat. Many community members expressed a willingness to provide practical support during the implementation phase, such as ladders and bamboo.

—School committee members were very helpful and took responsibility for supporting the work. Sometimes, if we needed an extra broom or a ladder, they would provide it. "_ID_1004

—In many cases, out of curiosity, community people themselves came to the intervention site and asked what would happen if paint were applied or if foam were used and whether it would make the room like an AC room or feel cooler. Then we explained the benefits." _ID_1003

—The neighbor praised it and said it was a very good initiative and should be run everywhere. " Many people were willing to try to take it into their homes. They were even asking me about the cost of this intervention." _ID_1001

However, there were instances of negative experiences from the community. Issues arose, such as property boundaries and concerns about pruning nearby mango trees during their blooming phase. In one notable case, a homeowner initially expressed refusal to allow the work to start.

"There were trees or branches over the tin roofs in most of the school. We had to clear them. The owner kept saying, "No, we are not allowing any work..." I tried many ways to convince the owner. When I saw that I could not convince them, I informed our field coordinator about the situation. After a long discussion, we repeatedly assured them that if any damage occurred during the work, we would repair or replace it. After that, the owner agreed. "_ID_10010

Some community members even demanded that whole houses be renovated instead of prioritizing schools. A few were dissatisfied with the paint's white color. To handle these demands, clear communication about the project boundaries was established.

—House owners had some influence on our work. They wanted our masons to do additional work beyond the intervention. While our target was to install tin and foam, they wanted their houses to be fully renovated. At times, they tried to interfere with the work of the masons. We tried to accommodate their demands as much as possible; in some cases, we provided additional wood, and our masons did as much extra work as feasible to satisfy them. However, school teachers had a very positive role and did not create any negative influence. ”_ID_10015

—House owners were saying, 'Why is the color white? Why not green or red?" I said that the white color reflects more, so the white color is chosen. ”_ID_1009

<u>Acceptability of the Completed Intervention</u>

Post-installation acceptability from the community was highly positive. They observed noticeable cooling improvements in classrooms, enhanced visual appearance, and positive responses from homeowners and children.

—They said the intervention work was very good. Many community members entered the school rooms and observed that they actually felt cooler. They expressed that the rooms felt significantly cooler. Even the painters and carpenters mentioned that after applying these materials, the rooms felt much cooler. ”_ID_1002

—The most important change is the classroom environment; the room is comparatively cooler, which we can understand. Earlier, the room was in poor condition, but now we have fixed it with P-foam and made proper fittings. Another thing is that the appearance or beauty of the classroom has increased." _ID_1009

Theme 5: Facilitation Strategies

<u>Training Quality and Adequacy</u>

The training before installation was seen as practical, relevant, and well-structured. It consisted of all steps necessary for both SRP and BCPF, including avoiding mixing water with SRP paint, drying periods needed, proper directions, avoiding gaps, and safety protocols.

—Through training, the workers received hands-on training and understood the processes well. " _ID_1008

—Before starting the intervention, we brought in an expert from the company for the solar reflective paint to help determine the required timing. Based on the pilot study experience, we developed a training manual for the workers." ID_10015

Most participants shared that the training was sufficient for this intervention work. Workers mentioned the training was simple, mainly introducing the project's specified technical steps and procedures. This suggests that the training was appropriate, especially for workers with prior experience.

—The training provided was adequate for this work. It doesn't seem difficult, but after work, everything seems easy. "_ID_1005

—The training mainly introduced them to our specific system. So, in my opinion, there was no need to provide the training a second time for the workers." ID_1008

<u>Supervision Mechanisms and Feedback Loops</u>

Participants described supervision as frequent and highly engaged throughout implementation. Among all participants, all 15 participants provided coded content. Supervisors visited often and used observation checklists, photographs, and videographs. Immediate feedback was provided, with frequent revisions to adjust foam and paint strokes. In addition, those who are not on-site are monitored remotely through online media by sharing photos along with in-person visits.

“I had to check whether the joints were being properly connected and whether they were following the correct installation system. Whenever I felt that certain areas needed correction, I provided instructions to the workers so that they could carry out the tasks properly.” _ID_1008

"He supervises by checking the things that can be used or not used. He stays with me all the time to monitor the work. He checks three times a day, every day, in every school." — ID_1006

“Whenever we saw that the work was not being done correctly or mistakes were happening, we guided them and corrected the work accordingly. There were cases where they had already installed the tin sheets but then had to remove them again, set the form correctly, and reinstall the tin sheets.” _ID_10015

Communication and Coordination

Communication among the project team, school representatives, and workers was effective and thorough. Information about the project schedule and expected roles was shared in advance. Field supervisors and workers held a daily meeting to pre-plan for the next day. There was a swift system for addressing the problems encountered, passed down the chain from workers to supervisors to the project coordinator.

“When we face challenges, we immediately inform the project coordinator. From the root level to the top, we communicate and inform each other while working.” _ID_1008

“One day before visiting a school, we talked to the teachers and room owners and informed them that we would come the next day to apply foam and paint. We also asked for their cooperation if needed, and they prepared accordingly. Every evening, we would sit together and plan which school we would go to, what tasks would be done, and in what pattern.”_ID_1003

Participants reported low internal conflict about the team structure and working hierarchy. Any disagreements encountered were successfully resolved through effective communication.

Theme 6: Intervention Complexity

Technical Difficulty of Specific Steps

Participants agreed that the interventions were doable with proper practice. They observed that certain tasks needed accuracy, especially in challenging physical situations. The most challenging tasks of SRP were keeping the right directions while on a sloped roof in the sun, managing drying cycles on days with changing weather, and painting roof edges and undersides using ropes.

—We used to do it easily in a vertical pattern, but since they told us to give two coats horizontally and then vertically, it takes more time. We have to stay on the tin longer, and when the tin becomes hot, it burns our feet. We are doing it the way we were told, even if it is difficult. "_ID_10012

—Cleaning the dirt on the tin by rubbing was difficult, and when stepping on the tin, the heat feels very strong on the feet. The problem is climbing onto the tin roof and working there." _ID_10011

The major difficulties reported by BCPF were precisely modeling foams to fit corners and rough areas, the physical exhaustion of holding foam panels above the head through a roof opening, and reinstalling large tin sheets numerous times without causing harm.

—First of all, this work cannot be done without experienced workers. One side of the tin is about two and a half feet, and one side of the foam is about four feet. A person's hand reach is at most 2 to 2.5 feet. The remaining one foot has to be done by standing with risk." _ID_10014

—Those who installed the PE form had to remove the tin sheets first, then reinstall them. After that, they had to cut the forms according to the size of the tin and then adjust and fit them properly. So, they faced more difficulties in this case. On the other hand, those who did the painting had fewer difficulties because their task was mainly just painting." _ID_10015

BCPF intervention was consistently described as more physically demanding, time-consuming, and technically complex than SRP. Because it required opening and reinstalling the roof carefully.

School Infrastructure Constraints on Complexity

14 out of 15 participants reported that poor school infrastructure was the main challenge for some of the work. Old, rusted, thin tin sheets, damaged rafters, and irregular room designs make work more difficult and time-consuming than expected. In some schools, additional structural issues are visible when the tin sheet is removed for foam placement, which leads to more time required than expected to prepare the school rather than actual work.

―In ... school, schoolrooms were not prepared and were not in a condition suitable for work. They had to be repaired first. The wood and tin were damaged. These repairs took time and caused some delays. ”_ID_1008

―Some tins were very thin, some were rusted, some had holes, and many had multiple joints. Although some tin replacements were estimated during the assessment phase, in reality, more replacements were needed. ”_ID_10015

―Initially, we planned to replace only four tin sheets. However, during the work, we found that the entire structure needed replacement because the sheets kept breaking and workers were falling through.” _ID_1003

In places with good infrastructure, tasks were performed better, faster, and to a higher standard. Whereas in areas with poor infrastructure, results were inconsistent, workers faced greater physical risks, and interventions took much longer. Supervisors recognized the link between infrastructure and work quality as a common issue identified before work began.

―Where the infrastructure was good, we were able to carry out the work smoothly. Where the infrastructure was poor, the level of risk was higher during implementation. Locations with strong and stable structures completed the work more effectively and maintained good quality. ”_ID_1001

Theme 7: Contextual Factors

The majority of participants (14 out of 15) reported weather as a major obstacle. Rain disrupted the SRP drying process, causing delays and sometimes repainting when wet coats were affected. Severe heat led to fatigue and shortened the time available for work on the roof.

—There were weather-related issues. From the day we started the work, the weather was unfavorable. Because of this, our work got delayed. If the weather had remained good during that time, our work would have been completed. We carried out the work whenever we got the opportunity." _ID_1008

"The biggest problem in this project was the weather. Because of the rain, workers sometimes had to stop work for long periods. When the tin roofs are opened, rainwater enters the rooms." _ID_1003

Teams managed disruptions by moving between schools when the weather was favorable and covering surfaces with plastic sheets to protect them during unexpected rainfall.

—Yesterday, it suddenly started raining within four to five minutes while we were working. At that moment, I collected polyethylene sheets from nearby neighbors and covered both sides of the work area." _ID_1004

Theme 8: Secondary Outcomes

<u>Perceived Effectiveness</u>

Perceived effectiveness was a major and consistently positive aspect reported by 13 participants. All stakeholders believed that the interventions would reduce classroom heat, increase comfort, and produce health and learning advantages for children.

—The paint we used reflects radiation; basically, white reflects light rays. For this reason, the white color is given more. Below is the P-foam and, again, the ceiling. It will definitely minimize the heat, no doubt about it. It will work 100%, sure." _ID_1001

Many participants reported feeling more comfortable in terms of temperature during and immediately after the installation.

—The workers told me, 'There is so much sunlight, but our feet are not getting hot; we are not feeling heat on the ground, only on our bodies.'" _ID_1003

—When I went inside the room after installation, it felt much cooler, almost like entering an air-conditioned room. That's why I think it's very good and effective." ID_100_13

Participants also described the expected outcomes of reducing heat on children's well-being, school attendance records, focus, and academic achievement.

―Schools had to remain closed frequently because of excessive heat in previous years, 2023, 2024, and 2025. With this intervention, such closures may no longer be necessary. If heat can be minimized, heat-related illnesses may also be reduced, leading to fewer disruptions in schooling and an improved learning environment with more consistent attendance." _ID_1001

Sustainability and Maintenance

Participants proposed several strategies to improve long-term sustainability and maintenance of the interventions. They highlighted the following points:

1. Regularly cleaning tin roofs to get rid of leaves, dirt, and dust piling up and making the reflective surface less effective.

2. Restricting walking on the roof for unnecessary purposes to prevent damaging the foam and other physical structures.

3. Applying chemicals to prevent foam panels from being damaged by rodents and insects.

4. Appointing someone responsible from the school or house owners, like a teacher or a community member, to check and balance things regularly.

"To make these last longer, it would be good to assign responsibility to someone for maintenance. That way, when small problems occur, quick repair measures can be taken." _ID_10010

―For long-term sustainability, we need supervision checking every day at the school. That is number one. Number two is ensuring that rats do not cut and damage the P-foam. Leaves should not accumulate on the tin roof; it should be cleaned regularly. Also, ensure that no one climbs on the tin roof unnecessarily." _ID_1003

4.3 Mixed-Methods Integration: Joint Display

Table 10: Joint display findings across quantitative fidelity scores and qualitative themes

Domains	**Quantitative (SRP / BCPF)**	**Qualitative**
Content Adherence to Technical Protocol	SRP: M = 96.7% (SD 4.9), range 82.4–100% BCPF: M = 92.2% (SD 8.5), range 71.4–100%	*―After applying the primer, that day is left to dry. The next day, we come and apply the first coat of paint. After that, the second coat is applied about three and a half to four hours later. ID_1004 (SRP)* *"We first install the foam sheets evenly. If there are any gaps, we press and seal them and then fix the tin sheet over them. We follow the instructions exactly as they were given." ID_1006 (BCPF)*
Coverage of Intended Surface / Area	SRP: M = 85.5% (SD 10.3), range 66.7–100% BCPF: M = 91.3% (SD 19.2), range 50.0–100%	*"When three coats of paint and primer are applied, then the tin is no longer visible. Then it is understood that my painting is completed." ID_10012 (SRP)* *"In the case of P-foam, some houses had irregular structures, such as L-shaped designs... even after installation, there were areas where air could pass through. Since foam allocation was based on school measurements, it was not possible to extend coverage to those additional areas."ID_10015 (BCPF)*
Quality of Delivery: Technical Execution & Safety	SRP: M = 76.6% (SD 10.9), range 57.1–100% BCPF: M = 82.9% (SD 13.2), range 57.1–100%	*"Laborers generally try to complete the work as quickly according to their habitual pattern... Additionally, in some bundles, PE foam cutting is not straight... It is difficult to ensure 100% quality... Ensuring 100% across all teams was challenging." ID_10015*

		"When we were on-site in front of them, they followed safety measures, but if we went to another place for 10–15 minutes, they removed PPE. When we asked them, they said it was too hot." ID_1003
Facilitation: Supervisor Presence During Installation	SRP: β = −1.58 (95% CI −5.97, 2.81); p = 0.471 BCPF: β = −1.18 (95% CI −6.34, 3.98); p = 0.646	*"He supervises by checking the things…. He stays with me all the time to monitor the work. He checks multiple times a day, every day, in every school." ID_1006* *"If they made mistakes or skipped something, we corrected them immediately, and they followed accordingly." ID_1003*
School Readiness: Structural Soundness of Roof	SRP: β = 3.01 (95% CI −1.62, 7.65); p = 0.196 BCPF: β = −0.51 (95% CI −7.87, 6.85); p = 0.888	*"Where the infrastructure was good, we were able to carry out the work smoothly. Where the infrastructure was poor, the level of risk was higher …… Locations with strong and stable structures completed the work more effectively." ID_1001* *"Some tins were very thin, some were rusted, some had holes… more replacements were needed than estimated." ID_10015*
Context: Rain Disruption to Installation or Drying	SRP: β = 0.66 (95% CI −2.87, 4.21); p = 0.705 BCPF: β = 6.04 (95% CI −1.74, 13.84); p = 0.125	*"The biggest problem during implementation was the weather. Because of the rain, workers sometimes had to stop work for long periods." ID_1003* *"Yesterday, it suddenly started raining within*

		four to five minutes while we were working. At that moment, I collected polyethylene sheets from nearby neighbors and covered both sides of the work area. "ID_1004

Chapter 5: Discussion

5.1 Principal findings

This study assessed how two passive-cooling interventions, solar-reflective paint (SRP) and a bamboo ceiling lined with polyethylene foam (BCPF), were delivered in 69 BRAC primary schools across two climate-vulnerable districts of Bangladesh. Using a convergent parallel mixed-methods design, quantitative and qualitative strands were used alongside each other and findings were merged to draw a comprehensive conclusion on the research topic.

Mean composite fidelity was high in absolute terms for both interventions (SRP 86.2%, SD 6.4; BCPF 88.8%, SD 9.9), and both exceeded the 80% threshold commonly used in the implementation science and prevention literature to indicate high fidelity (Mihalic, 2004; Durlak & DuPre, 2008; Fixsen et al., 2005). Both interventions showed the same pattern across fidelity dimensions. Content adherence was the strongest, quality of delivery was the weakest, and coverage fell in between. Several factors explain the consistently lower performance in the –Quality of delivery." These include inconsistent use of PPE, worker fatigue because of heat, and a lack of supervision coverage during finishing work. In fully adjusted hierarchical regression models, only one of the eight prespecified predictors, "district," was significantly associated with composite fidelity in either intervention. While qualitative findings indicated that supervisor presence, school readiness, and weather disruptions influenced implementation. Across both interventions, schools in Gaibandha show higher composite fidelity scores than schools in Kurigram. Factors such as variation in supervisor experience, team coordination, baseline school assessment, and weather conditions during the installation time can also make a difference between two districts.

All the predictors, three school-readiness variables, two implementer variables, and two weather variables, show no statistically significant association with composite fidelity in the final models in regression. This might happen for two reasons. First, real effects may exist, but because of the small sample size of 46, per intervention, it limits statistical power to examine the relation. The absence of a significant association should therefore be seen as evidence that the variable has no effect on fidelity (Amrhein et al., 2019; Wasserstein & Lazar, 2016). Second, these factors may have little influence on overall quality because the pre-installation training was intense, supervision was always present on-site, and the BRAC standardized model minimized differences between schools. While these two explanations cannot be separated in the present sample, they align with the qualitative evidence, where supervisors and workers noted that weather and school readiness affected the work.

5.2 Comparison of the study findings with the existing knowledge base

The mean composite fidelity scores reported in this study are at the higher end of values typically found in peer-reviewed mixed-methods process evaluations of complex public health interventions. School-based prevention programmes have reported average adherence levels between 60% and 75% under routine implementation conditions (Durlak & DuPre, 2008; Dusenbury et al., 2003). In LMIC settings, reported fidelity levels vary more widely, typically ranging from 40% to 80%, depending on intervention complexity and the strength of supervision (Lebina et al., 2019; Hill et al., 2014). The composite fidelity (86–89%) observed in this study aligns with the higher end of the range reported in hybrid effectiveness–implementation trials (Curran et al., 2012; Curran et al., 2022), particularly those delivered by a single well-resourced implementing organisation under close supervision. As such, these findings should be interpreted cautiously when considering their generalisability to settings involving multiple implementers' delivery.

The dimension-level pattern observed in both interventions, content adherence being strongest, quality of delivery weakest, and coverage in between, closely aligns with findings from the broader fidelity literature. Carroll et al. (2007) suggest that content adherence is typically the easiest dimension to achieve because protocol steps are concrete and observable and can be monitored using checklists. In contrast, quality of delivery relies on tacit skills, situational judgement, and sustained attention in the field. This makes it more variable and difficult to measure reliably. This same pattern has been reported in other applied health contexts, including psychosocial stroke rehabilitation (Eriksson et al., 2019) and chronic care delivery for frail older adults (Doekhie et al., 2015). The replication of the pattern across two technically distinct physical infrastructure interventions suggests that it is a structural feature of how front-line implementers prioritise their effort under time and physical-discomfort constraints, rather than something specific to a particular intervention.

The findings related to quality of delivery, particularly the inconsistent use of personal protective equipment (PPE) when supervisors were absent, are closely aligned with the long-standing “know–do gap” described in the implementation literature (Pablos-Méndez & Shademani, 2006). In this study, workers were able to correctly describe the required procedures during interviews, but often reverted to more expedient practices when supervision was absent. This pattern has been widely documented across both clinical and non-clinical settings in low- and middle-income countries and has been identified in systematic reviews as a key target for strengthening supervision systems (Hill et al., 2014; Bailey et al., 2021). The main contribution of the present study is that it extends this know–do gap beyond clinical practice into physical construction work, where “doing” refers to technical workmanship rather than healthcare delivery.

Findings on the district effect should be interpreted considering emerging peer-reviewed evidence on cool-roof implementation in South Asia. A randomized crossover trial in garment factories from Bangladesh also found that green and insulated roofs reduced indoor temperatures by around 2.5 degrees Celsius. This also helps in reductions in psychological and perceived heat strain (Sundar et al., 2025). A study from the Dhaka Karail slum in Bangladesh also reported temperature reductions of approximately 7 degrees Celsius, though implementation faced challenges such as limited availability of high-reflectivity paint (BRAC University Department of Architecture, 2021). Similarly, a cRCT in rural Burkina Faso highlighted that the feasibility of cool roofs in low-income settings depends heavily on local craftsmanship, supervision intensity, and planning for weather disruptions (Bunker et al., 2024). Taken together, these studies align with the present qualitative findings, which emphasize the operational sensitivity of cool roofs and ceiling-insulation interventions to material supply chains, roof structural conditions, and weather exposure.

5.3 Strengths of the study

This study has several methodological strengths that enhance the credibility of its findings. The convergent parallel mixed-methods design (Fetters et al., 2013) was chosen on substantive rather than pragmatic grounds and implemented with strong alignment between the qualitative and quantitative strands. In particular, the qualitative interview guides were explicitly mapped onto the same fidelity constructs measured in the quantitative component, and integration was carried out at both the methodological and interpretive levels using a pre-specified side-by-side joint display matrix (Guetterman et al., 2015; Fetters & Tajima, 2022). This approach is consistent with current best practice in mixed-methods implementation research and supports the development of meta-inferences through structured comparison of the two datasets rather than narrative synthesis alone. Quantitatively, census sampling at the school level helps to eliminate selection bias. Because this study was nested in a cRCT design, it provided a strong framework. To reduce confirmation bias, independent field researchers observed the intervention rather than intervention team members.

This study also adapts the Carroll-Hasson fidelity framework for complex interventions. This addresses a literature gap, as fidelity measurements for physical infrastructure adaptations have been relatively underdeveloped (Hasson, 2010; Pérez et al., 2016). Beyond the specific findings on SRP and BCPF delivery, this study contributes to implementation science that can apply outside of Bangladesh. It extends Carroll et al.'s (2007) and Hasson's (2010) multidimensional fidelity framework to physical construction and the built environment. This framework was created for and used in behavioural, educational, and clinical interventions. By applying its three dimensions: "Content adherence, Coverage, and Quality of delivery" to two different physical interventions. This study supports that the fidelity theory works for climate-adaptation infrastructure. This expansion is highly valuable, as climate-resilient infrastructure is becoming central to global health, education, and resilience programs.

5.4 Limitations of the study

Limitations of this study are illustrated below:

- First, observation-based fidelity measurement may be affected by observer reactivity, also known as the Hawthorne effect. This occurs when implementers can modify their behavior because they are being observed (Mihalic, 2004). This means that in this study, fidelity scores reported may be somewhat inflated.
- Second, the questionnaire and interviews relied on self-reports from monitoring officers and workers. This introduces potential bias, where participants may over-report how closely they followed protocols and under-report deviations, especially the use of PPE.

- Third, the regression sample size of 46 events per intervention is small. This limits the statistical power to detect non-significant findings that represent imprecise estimates rather than proof that no relationship exists (Wasserstein & Lazar, 2016).

- Fourth, Fidelity was assessed only once during the intervention implementation active phase. This cross-sectional design does not capture the long-term durability of the intervention.

- Fifth, the generalizability of the study is limited. The results may not apply to other settings because the study took place within a single, well-resourced organization (BRAC) under close supervision. These findings may not translate directly to government or other institution-based models with different levels of supervision, supply chain reliability, or worker skills.

- Sixth, inter-rater reliability could not be assessed because each installation was scored by only one monitoring officer instead of multiple independent observers. This means we cannot tell if differences in checklist scores were due to real variations between schools or because some observers were stricter than others. This issue is most concerning for the "Quality of delivery" dimension, which is the most subjective part of the evaluation.

5.5 Unanswered questions and further research

- The observed district-level effect requires closer investigation through a comparative study. This should include explicit measurement of factors such as supervisor experience, baseline school conditions, community engagement, and workforce composition to better understand the underlying mechanisms of differences between districts.

- An outcome-linked study is needed to assess whether the fidelity composite score estimated in this study actually predicts downstream outcomes such as indoor temperature reduction, health effects, and learning outcomes measured in the parent trial. Until this relationship is established, the composite fidelity score should be treated as methodological conventions rather than fully validated benchmarks (Proctor et al., 2011).

- Multi-organisation comparative implementation research is required to test whether the high fidelity observed in this single-organisation setting can be replicated under more diverse delivery systems, including government-led and contractor-based implementation, where the intensive supervision used in this study may not be feasible.

Chapter 6: Conclusion and recommendations

6.1 Conclusion

This study assessed how accurately two low-cost cooling interventions, SRP and BCPF, were installed in 69 BRAC primary schools across two climate-vulnerable districts in two northern districts of Bangladesh. Both interventions were implemented with overall high accuracy, with an average score of 86.2% for SRP and 88.8% for BCPF. In both interventions, Content adherence was the strongest, Coverage was moderate, and the Quality of delivery was the weakest dimension in the fidelity score. Only the pre-specified determinant, "district," was significantly associated with composite fidelity in the fully adjusted models. Gaibandha achieved scores of 5.98 percentage points higher for SRP and 8.75 percentage points higher compared to schools in Kurigram.

These findings show that installing both passive-cooling interventions in low-resource, climate-vulnerable schools is highly feasible. However, they do not establish actual effectiveness. The parent study and future research need to confirm how these implementation scores link to actual temperature reductions, health benefits, and learning outcomes. Therefore, scaling climate-resilient school infrastructure in Bangladesh is less about technical limits and more about maintaining the organizational systems, such as supervision, structural assessments, weather-adaptive scheduling, and community engagement, which enable high accuracy. It also requires understanding the district-level differences that caused the main variations in school scores.

6.2 Recommendations

Recommendations from this study were divided into three time frames.

1. Short term
    - Mandate use of PPE and safety measures requiring close supervision and a daily PPE checklist before and during the installation process. To address workers' discomfort, provide lightweight, climate-appropriate safety gear rather than relying on enforcement alone.

- Conduct a mandatory roof assessment with the help of expert workers, such as carpenters and painters, before intervention installation. This inspection must include rafter, tin-sheet thickness, rust, leaks, and structural joint integrity.
- Build a weather-window planning schedule. Schedule in the dry season rather than during the rainy and early monsoon season.

2. Medium term
    - Introduced structured coaching and peer-supervision protocols for monitoring officers, focusing especially on improving the Quality of delivery. Real-time feedback techniques and same-day correction of substandard finishing.
    - Develop standard operating procedures (SOPs) for installations in non-rectangular classrooms, such as L-shaped or shared boundary layouts, which should include the use of prefabricated foam templates and specialized edge-sealing materials.
3. Long-term
    - Test the fidelity protocols in a comparative study across multiple organizations. This will help to establish whether the high fidelity achieved under BRAC supervision can be replicated in other similar settings.
    - Link the fidelity scores to downstream outcomes, such as indoor temperature, child health, and learning, by combining the dataset with the parent study outcome data. This will help generate an empirically validated cutoff point to distinguish ―high” from ―moderate” fidelity for cool-roof interventions.

Declaration of GenAI Use

I, Asmita Adhikari, declare that in preparing this assignment, I used ChatGPT (OpenAI, version, and date) as a support tool to assist with brainstorming ideas, organising the structure of my writing, overcoming writer’s block, and improving clarity and language in the text that I drafted myself. GenAI was not used to generate original arguments, interpret results, or produce final academic content. All substantive ideas, judgments, references, and conclusions are my own and have been independently verified in line with JPGSPH academic integrity guidelines.

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Appendix A: Data collection Instrument

A.1: Quantitative tools

Tool 1: Observational Checklist

Section 1. Identification Information

Code	**Questions**	**Response**	**Logic**
idin 1	Unique ID		
idin 2	Observer name		
idin 3	Date of visit (dd/mm/yyyy)	…/…/…	
idin 4	GPS Coordinates	Lat: ______ Long: ______	
idin 5	Name of district	1 = Kurigram 2 = Gaibandha	If 1, skip Idinf 8 & 9 If 2, skip Idinf 6 & 7
idin 6	In which upazila of Kurigram district?	1 = Kurigram Sadar 2 = Ulipur 3 = Nageshwari 4 = Fulbari	
idin 7	Name of School of Kurigram district	1 = Uttor Kumorpur 2 = Garuhara 3 = Jotinerhat 4 = Ververy 5 = Patersori 6 = Katermor 7 = Bania Para 8 = Monir more	

		9 = Sarkar Para 10 = Mondol Para 11 = Miaji Para 12 = Ram Prosad 13 = Doldoliya 14 = Kishamot Modhupur 15 = Boalmari 16 = Moddho Gobordhon Kuty 17 = Boaler Dara 18 = Member para 19 = Malvanga 20 = Sukhati 21 = Mesnirpar 22 = Baniatari 23 = Bahubol 24 = Kagzi tari 25 = Poscim vangamore 26 = Sit Rabaitari 27 = Sen para 28 = Brigerpar 29 = Prodip bazar	
idin 8	In which upazila of Gaibandha district?	1 = Gaibandha Sadar 2 = Gobindagonj 3 = Saghata 4 = Sadullapur	
idin 9	Name of school of Gaibandha district	1 = Moddom Komed pur 2 = Possim Mosgider Par 3 = Uttor Baroipara 4 = Radhakrisnopur	

		5 = Baguria 6 = Ramposad 7 = Gobindopur Kutipara 8 = Kuptola 9 = Kisamot Malibari Charpara 10 = Jamudanga 11 = Hamindopur purbo para 12 = Dokhin Sontola 13 = Horinathpur 14 = Bujruk Jamalpur 15 = Bujrukruhia 16 = Sontola 17 = Esobpur 18 = Luxmipur 19 = Poshin Noyanpur 20 = Voritkhali 21 = dimla Podomshor 22 = Dhangora 23 = Gachabari Poshcimpara 24 = Doldolia 25 = Amtoli 26 = Anantapur 27 = Boraykandi 28 = Narshiapara 29 = Ghuridoho 30 = Jordova 31 = Agkochua 32 = Bogdha bottola 33 = Doslal 34 = Polupara	

		35 = Dhormopur 36 = Mothura 37 = Nodhapara 38 = Fokirgonj 39 = Basudebpur 40 = Komol narayonpur	
idin 11	Weather conditions during the observation time (multiple response)	1 = Sunny 2 = Partly cloudy 3 = Overcast 4 = Rainy	
idin 12	Which infrastructural interventions are received by the school?	1 = Solar-reflective paint (SRP) 2 = Bamboo ceiling with polyethylene foam (BCPF) 3 = Both SRP and BCPF	If 1, skip tool 2. If 2, skip tool 1. If 3, open both tools 1 & 2.

Part 1: Observation checklist for Solar Reflective Paint (SRP) Intervention

Purpose: To objectively measure the degree to which the Solar Reflective Paint (SRP) intervention is implemented as indicated in the protocol.

Timing: During installation or immediately after SRP application.

Code	**Indicators**	**Implementation status**
Section A: Core Fidelity: Adherence: content *Focus: Were the technical steps followed exactly as designed?*		
A.1 Surface preparation		
adp1	Site Prep: The classroom was emptied.	0 = No

		1 = Yes, exactly as per protocol
adp2	Site Prep: Access to the roof was unobstructed.	0 = No 1 = Yes, exactly as per protocol
adp3	Structural audit: Pre-installation assessment of the roof and rafters was completed.	0 = No 1 = Yes, exactly as per protocol
adp4	Electrical clearance: Electrical appliances (e.g., ceiling fans, lights, and switchboards) attached to the application surface were safely removed or fully sealed before work began.	0 = No 1 = Yes, exactly as per protocol
adp5	Roof Repair: Leaks or holes were repaired before application.	0 = No 1 = Yes, exactly as per protocol
adp6	Clean: Roof thoroughly cleaned (dust, debris, and bird droppings removed).	0 = No 1 = Yes, exactly as per protocol
adp 7	Treat: Major rust or old peeling paint was treated/removed.	0 = No 1 = Yes, exactly as per protocol
adp8	Safety mitigation: Installation risks (loose nails, sharp edges) were addressed before work began.	0 = No 1 = Yes, exactly as per protocol
adp9	Dryness: Surface verified as completely dry before primer application.	0 = No 1 = Yes, exactly as per protocol
A.2 Primer Application		
adp10	Primer Product: Approved SRP primer product used.	0 = No 1 = Yes, exactly as per protocol

adp11	Primer Method: Primer applied evenly across the entire surface.	0 = No 1 = Yes, exactly as per protocol
adp12	Primer Timing: A drying interval of 2 to 3 hours is maintained before the 1st coat.	0 = No 1 = Yes, exactly as per protocol
A.3 Painting application		
adp13	Paint Product: Approved SRP product used.	0 = No 1 = Yes, exactly as per protocol
adp14	Mixing: Paint stirred/thinned properly per the protocol.	0 = No 1 = Yes, exactly as per protocol
adp15	1st Coat: Applied horizontally across the roof surface.	0 = No 1 = Yes, exactly as per protocol
adp16	Paint Timing: A drying interval of 4–5 hours is maintained between every coat.	0 = No 1 = Yes, exactly as per protocol
adp 17	2nd Coat: Applied vertically in a cross-pattern over the 1st coat.	0 = No 1 = Yes, exactly as per protocol

Code	**Section B: Core Fidelity: Coverage** *Focus: Was the "full coverage" of the physical intervention delivered?*	
dcp1	Two coats of SRP were applied as specified.	0 = Not applied 1 = Partially applied (only 1 coat) 2 = Yes, exactly as per protocol (2 coats)
dcp2	The targeted roof area was fully covered with SRP.	0 = Not adequate covered (<90% area covered) 1 = Partially covered (90-99% area covered) 2 = Fully covered (100% area coverage)

dcp3	The recommended coverage rate (1 liter per 72 square feet) was maintained during SRP application.	0 = Not followed at all (<1 liter per 72 sq. ft.; major deviation from standard) 1 = Partially followed (1 liter per 72 sq. ft. but with minor variation ±10–20%) 2 = Completely followed (1 liter per 72 sq. ft. with no observable deviation)

Code	Section C: Quality of Delivery and Safety (Workmanship & Outcomes) *Focuses on the "how well" of evaluating the skill of the painter and the physical result.*	
C.1. Outcomes (Physical Result)		
qdp1	Uniformity: Even thickness and consistent color across the roof surface.	0 = Poor uniformity (<90% uneven thickness and/or noticeable color) 1 = Acceptable uniformity (90-99% minor variation in thickness or color, but overall acceptable) 2 = High uniformity (100% even thickness and consistent color)
qdp2	Surface Integrity: Absence of bubbles, drips, cracks, or pinholes.	0 = Major surface defects present (> four or more defects are present) 1 = Minor surface defects present (2-3 defects are present) 2 = No visible surface defects
qdp3	Precision: Clean edges; no paint spilled on walls, windows, or ground.	0 = Major imprecision (Paint is spilled on multiple surfaces; edges are messy and untidy) 1 = Minor imprecision (Some paint spills or

		uneven edges, but limited and mostly acceptable) 2 = High precision (Edges are clean and well-defined; no paint spills on surrounding surfaces)
qdp4	Visual Comparison: The reflectivity visibly distinct from the pre-intervention surface	0 = Not visibly distinct 1 = Moderately distinct 2 = Highly distinct
C.2 Safety Compliance		
qdp5	Workers actively used appropriate PPE (gloves/masks/helmets).	0 = Not used at all 1 = Partially used (workers used it or used it incorrectly) 2 = Fully used
qdp6	Ladders and working platforms (barriers/warning signs) were secured safely during the process.	0 = No 1 = Partially safe 2 = Fully safe
qdp7	Hazard Control: No sharp hazardous leftover materials/debris left behind on site.	0 = Major hazard (Hazardous materials or sharp debris remain on site) 1 = Minor hazard (Some hazardous materials removed, but remnants still present) 2 = Fully safe (All hazardous materials and sharp debris removed; site hazard-free)
qdp8	Any safety incidents observed or reported?	0 = No 1 = Yes
qdp9	If yes, describe ……………………………	

Code	Section D: Program Differentiation *Focus: Ensuring the intervention is distinctly the SRP protocol and not local "business as usual."*	
dfp1	Non-Project Materials: Unapproved paints or primers used instead of project materials.	0 = No 1 = Yes
dfp2	Co-Intervention: Other painting material applied to the roof simultaneously alongside SRP intervention.	0 = No 1 = Yes
dfp3	Manual Isolation: Implementers strictly follow the project manual rather than reverting to their "usual" painting habits.	0 = No 1 = Yes

Code	Section E: Context *Identifying variables that might explain why adherence or quality scores were high or low.*	
cop1	What was the weather condition during painting? (multiple response)	0 = Sunny 1 = Partly cloudy 2 = Overcast 3 = Rainy
cop2	How suitable was the surrounding environment during implementation?	0 = Very challenging (dense vegetation, congested area, limited road access) 1 = Challenging (some vegetation, moderate space limitation, limited but usable road access) 2= Not challenging at all (clear surroundings, adequate space, easy access for materials, no disturbance)

cop3	How appropriate were the per-day working hours of painters?	0 = Not appropriate (less than 6 hours) 1= Partially appropriate (6-8 hours) 2= Appropriate (8 hours and above)

Code	Section F: Facilitation strategies	
fap1	Supervisor presence during installation	0 = Not present 1 = Present partially (arrived during visit) 2 = Present fully
fap2	Manual/guideline availability on site	0 = Not available on site 1 = Manual available but not used 2 = Manual available and used

Final Observation Note: (Document any, community interference, adaptations, implementation delays, material shortages, or other critical contextual notes that the numerical data does not capture.)

Part 2: Observation checklist for Bamboo Ceiling with Polyethylene Foam (BCPF)

Purpose: To objectively measure the degree to which the Bamboo Ceiling with Polyethylene Foam intervention is implemented as indicated in the protocol.

Timing: During installation or immediately after BCPF completion.

Section 1. Identification Information

Code	Indicators	Implementation status

Section A: Core Fidelity: Adherence : Content *Focus: Were the technical steps and material requirements followed exactly as designed?*		
A.1 Surface preparation		
adb1	Surface prep: The classroom was emptied.	0 = No 1 = Yes, exactly as per protocol
adb2	Site Prep: Access to the roof was unobstructed.	0 = No 1 = Yes, exactly as per protocol
adb 3	Structural audit: Pre-installation assessment of the roof and rafters for load-bearing capacity was completed.	0 = No 1 = Yes, exactly as per protocol
adb4	Electrical clearance: Electrical appliances (e.g., ceiling fans, lights, and switchboards) attached to the application surface were safely removed or fully sealed before work began.	0 = No 1 = Yes, exactly as per protocol
adb5	Roof and rafter repair: Leaks or holes were repaired before P-foam placement.	0 = No 1 = Yes, exactly as per protocol
adb6	Clean: Roof and rafter thoroughly cleaned (dust/debris/bird droppings removed).	0 = No 1 = Yes, exactly as per protocol
adb7	Safety mitigation: Installation risk (sharp edges, loose nails, or unstable rafters) was addressed before work began.	0 = No 1 = Yes, exactly as per protocol
A.2 Material quality		
adb8	Material: Approved materials were used, the	0 = No

	correct bamboo type and size and polyethylene P-foam with the thickness.	1 = Yes, exactly as per protocol
A.3 Adherence to Technical Protocol		
adb9	Tin Opening: Roof sheets were properly opened for P-foam insertion.	0 = No 1 = Yes, exactly as per protocol
adb10	Ceiling Fixing: Bamboo panels securely anchored below the P-foam using fasteners.	0 = No 1 = Yes, exactly as per protocol
adb11	Foam Alignment: P-foam placed evenly across the roof frame without gaps, folds, or tears.	0 = No 1 = Yes, exactly as per protocol
adb12	Foam Sealing: Joints/overlaps between P-foam sheets were taped/sealed for a tight thermal seal.	0 = No 1 = Yes, exactly as per protocol
adb 13	Tin Resealing: Roof sheets were securely reinstalled.	0 = No 1 = Yes, exactly as per protocol

Code	**Section B: Core Fidelity: Coverage (The "How Much")** *Focus: Was the "full coverage" of the physical intervention delivered to the space?*	
dcb1	Target Coverage: The targeted roof surface is fully covered with the BCPF.	0 = Not adequate covered (<90% area covered) 1 = Partially covered (90-99% area covered) 2 = Fully covered (100% area coverage)
dcb2	Measurement: Correct measurements were taken before cutting materials.	0 = No 1 = Yes

Code	**Section C: Quality of Delivery and Safety (The "How Well") (Workmanship & Outcomes)** *Focuses on the "how well" of evaluating the skill of the painter and the physical result.*	
C.1 Outcome (Result)		
qdb1	Structural Firmness: No sagging, warping, or loose bamboo panels.	0 = Major structural issue (Panels show clearly sagging, warped, or loose; structure feels unstable.) 1 = Minor structural issue (Some minor sagging, slight warping, or minor looseness; structure mostly stable) 2 = Fully stable (Panels are firm, straight, firm, and securely fixed; fully stable)
qdb2	Visual Uniformity: Consistent ceiling height and level across the classroom.	0 = Poor inconsistency (<90% ceiling is visibly uneven or sloped in several areas. 1 = Acceptable inconsistency (90-99% small unevenness in one or two areas; overall ceiling mostly level) 2 = High uniformity (100% ceiling is completely level and even across the classroom.)
qdb3	Precision: Clean edges; no protruding bamboo or installation debris.	0 = Major imprecision (edges are rough; protruding bamboo or visible installation debris present) 1 = Minor imprecision (small rough edges or minimal debris; no major safety concern)

		2 = High precision (edges are clean and smooth; no protruding bamboo or debris visible)
qdb4	Finish Neatness: Smooth panel overlap; no exposed foam.	0 = Poor finish 1 = Acceptable finish 2 = Standard finish
C.2 Safety Compliance		
qdb5	Workers actively used appropriate PPE (gloves/masks/helmets).	0 = Not used at all 1 = Partially used (workers used it or used it incorrectly) 2 = Fully used
qdb6	Ladders and working platforms (barriers/warning signs) were secured safely during the process.	0 = No 1 = Partially safe 2 = Fully safe
qdb7	Hazard Control: No sharp splinters, protruding nails, or loose wires left behind on site.	0 = Major hazard (Hazardous materials or sharp debris remain on site) 1 = Minor hazard (Some hazardous materials removed, but remnants still present) 2 = Fully safe (All hazardous materials and sharp debris removed; site hazard-free)
qdb 8	Any safety incidents observed or reported?	0 = No 1 = Yes
qdb9	If yes, describe	……………………………

Code	Section D: Program Differentiation *Focus: Ensuring the intervention is distinctly the BCPF protocol and not local "business as usual."*	
dfb1	Non-Project Materials: Plywood, cloth, or unapproved materials used instead of project materials.	0 = No 1 = Yes
dfb2	Contamination: There is a pre-existing ceiling in the room that interferes with the intervention.	0 = No 1 = Yes
dfb3	Co-Intervention: Bamboo or P-foam materials applied to the roof simultaneously alongside BCPF intervention.	0 = No 1 = Yes
dfb4	Uniqueness: The BCPF is clearly visually distinguishable from local roofing structures.	0 = No 1 = Yes
dfb5	Manual Isolation: Implementers follow the project manual rather than reverting to usual procedures.	0 = No 1 = Yes

Code	Section E: Context *Identifying variables that might explain why adherence or quality scores were high or low.*	
cob1	What was the weather condition during installation? (multiple response)	0 = Sunny 1 = Partly cloudy 2 = Overcast 3 = Rainy
cob2	How suitable was the surrounding environment during implementation?	0 = Very challenging (dense vegetation, congested area, limited road access)

		1 = Challenging (some vegetation, moderate space limitation, limited but usable road access) 2 = Not challenging at all (clear surroundings, adequate space, easy access for materials, no disturbance)
cob3	How appropriate were the per-day working hours of installation?	0 = Not appropriate (less than 6 hours) 1 = Partially appropriate (6-8 hours) 2 = Appropriate (8 hours and above)

Code	**Section F: Facilitation strategies**	
fab1	Supervisor presence during installation	0 = Not present 1 = Present partially (arrived during visit) 2 = Present fully
fab 2	Manual/guideline availability on site	0 = Not available on site 1 = Manual available but not used 2 = Manual available and used

Final Observation Note:
(Document any, community interference, material shortage, adaptations, implementation delays, or other critical contextual notes that the numerical data does not capture.)

Tool 2: School level questionnaire

Purpose: To assess moderators influencing the implementation fidelity of the infrastructure interventions.

Respondents: Intervention monitoring officers

Section I: Identification information

Code	Items	Response	Logic
ids1	Unique survey ID		
ids2	Date of Interview (DD/MM/YYYY)	…/…/…	
ids3	Interviewer name/ID		
ids4	Name of district	1 = Kurigram 2 = Gaibandha	
ids5	Upazila of Kurigram district	1 = Kurigram Sadar 2 = Ulipur 3 = Nageshwari 4 = Fulbari	
ids6	Name of School of Kurigram district	1 = Uttor Kumorpur 2 = Garuhara 3 = Jotinerhat 4 = Ververy 5 = Patersori 6 = Katermor 7 = Bania Para 8 = Monir more 9 = Sarkar Para 10 = Mondol Para	

		11 = Miaji Para 12 = Ram Prosad 13 = Doldoliya 14 = Kishamot Modhupur 15 = Boalmari 16 = Moddho Gobordhon Kuty 17 = Boaler Dara 18 = Member para 19 = Malvanga 20 = Sukhati 21 = Mesnirpar 22 = Baniatari 23 = Bahubol 24 = Kagzi tari 25 = Poscim vangamore 26 = Sit Rabaitari 27 = Sen para 28 = Brigerpar 29 = Prodip bazar	
ids7	Upazila of Gaibandha district	1 = Gaibandha Sadar 2 = Gobindagonj 3 = Saghata 4 = Sadullapur	
ids8	Name of school of Gaibandha district	1 = Moddom Komed pur 2 = Possim Mosgider Par 3 = Uttor Baroipara 4 = Radhakrisnopur 5 = Baguria 6 = Ramposad	

		7 = Gobindopur Kutipara 8 = Kuptola 9 = Kisamot Malibari Charpara 10 = Jamudanga 11 = Hamindopur purbo para 12 = Dokhin Sontola 13 = Horinathpur 14 = Bujruk Jamalpur 15 = Bujrukruhia 16 = Sontola 17 = Esobpur 18 = Luxmipur 19 = Poshin Noyanpur 20 = Voritkhali 21 = dimla Podomshor 22 = Dhangora 23 = Gachabari Poshcimpara 24 = Doldolia 25 = Amtoli 26 = Anantapur 27 = Boraykandi 28 = Narshiapara 29 = Ghuridoho 30 = Jordova 31 = Agkochua 32 = Bogdha bottola 33 = Doslal 34 = Polupara 35 = Dhormopur 36 = Mothura	

		37 = Nodhapara 38 = Fokirgonj 39 = Basudebpur 40 = Komol narayonpur	
ids9	Respondent	1 = School teacher 2 = BEP staff 3 = SMC members 4 = Program officer 5 = Field coordinate 6 = Data collector 99 = Others (Specify…………..)	
ids10	Age of respondent (yrs)		
ids11	Gender of respondent	1 = Male 2 = Female 99 = Others (Specify…………..)	
ids12	Completed educational level		
ids13	Years of working in this school (Years)		
ids14	Which infrastructure intervention(s) did this school receive?	1 = Solar-reflective paint (SRP) 2 = Bamboo ceiling with polyethylene foam (BCPF) 3 = Both SRP and BCPF	If 2, skip ad3 & ad4. If 2, skip ad5 & ad6. If 3 show ad3, ad4, ad5, ad6.

S.N.	Questions	Response	logic
Section II: Basic School Infrastructure Profile			
si1	Main classroom building structure	1 = Single-story 2 = Multi-story 99 = Others (specify) _______	
si2	Primary roof material	1 = Corrugated iron sheet (tin) 2 = Concrete slab 3 = Semi-concrete + corrugated iron sheet	If 2 & 3 → Skip si3
si3	If Corrugated Iron Sheet: Roof Shape	1 = Ek-chala (single slope) 2 = Do-chala (double slope) 3 = Three-chala (triple slope) 4 = Chou-chala (four-sided) 5 = Flat 6 = Others (specify) _______	
si4	Floor type	1 = Soil (kuccha) 2 = Concrete (Puccha) 3 = Mixed (concrete + soil) 99 = Others (specify) _______	
si5	Primary wall material	1 = Brick 2 = Mud 3 = Concrete 4 = Corrugated iron sheet 99 = Others (specify) ________	
si6	Existing cooling measures	1 = Electric fan	

	in classrooms (multiple response)	2 = Ventilation windows 3 = None 99 = Others (specify) _________	
si7	External heat-mitigating features around classrooms (multiple response)	1 = Trees/natural shades 2 = Shaded Balcony (Baranda) 3 = Pond/water body nearby 4 = Open field (no shade) 5 = None 99 = Others (specify) ___	

Section A: Facilitation Strategies *Focus: Did the project team provide necessary support, training, and oversight?*		
Code	**Questions**	**Response**
fa1	The supervisor receives a formal training session regarding these interventions.	0 = Not at all 1= Partially 2 = Completely
fa3	Communication: The main research team communicates (with the school) about the timeline and the "dos and don’ts" during the installation phase.	0 = Poorly 1 = Adequately 2 = Excellent
fa4	Feedback Loop: The team discusses the final quality of the work with you after the installation's completion.	0 = No feedback 1 = Informal or partial feedback 2 = Formal and structured feedback

Section B: School Readiness & Complexity *Focus: Inner-setting factors and the perceived difficulty of the intervention.*		
Code	**Questions**	**Response**
re1	Structural Suitability: The existing school roof is structurally sound for intervention without requiring major repairs.	0 = No (required repairs) 1 = Minor issues 2 = Structurally ready
re2	Space: The school has sufficient space to store all intervention materials safely.	0 = No 1 = Partial 2 = Adequate
re3	Space Management: The classrooms were vacated on time for the workers to maintain technical steps.	0 = No 1 = Partial 2 = Adequate
re4	Intervention Complexity: Based on your observation, it looks difficult for workers to follow the technical steps.	0 = Not difficulty (Easy) 1 = Somewhat difficult 2 = Very difficult

Code	**Questions**	**Response**
Section C: Perceived Adherence *Focus: Did the respondent (PO, FC) observe the workers following the "essential" steps?*		
During the installation, did you observe the following?		
ad1	Workers thoroughly clean/repair the roof before starting.	0 = No 1 = Yes 2 = Don't know
ad2	Workers are using safety equipment (e.g., ladders,	0 = No

	gloves, masks).	1 = Yes 2 = Don't know
For SRP		
ad3	Workers use the specific project materials (primer & paint).	0 = No 1 = Yes 2 = Don't know
ad4	Workers apply two distinct coats of paint with a drying period in between.	0 = No 1 = Yes 2 = Don't know
For BCPF		
ad5	Workers use the specific project materials (polyethylene foam & bamboo).	0 = No 1 = Yes 2 = Don't know
ad6	Workers properly seal the foam and securely fix the final bamboo ceiling.	0 = No 1 = Yes 2 = Don't know

Code	**Section D: PARTICIPANT RESPONSIVENESS** *Focus: stakeholder (house owner/a member from the community observing the implementation of intervention) support for the intervention*	
pr1	Staff Cooperation: The workers/project staff were cooperative on-site.	0 = Uncooperative 1 = Somewhat Cooperative 2 = Very Cooperative
pr2	Felt comfortable raising concerns to the team during work.	0 = Not comfortable 1 = Somewhat Comfortable

		2 = Very Comfortable
Section E: Program Differentiation *Focus: Distinguishing the intervention from routine work.*		
pd1	Differentiation: This intervention is clearly distinct from routine school repairs.	0 = No 1 = Yes
pd2	Contamination: Since the start of the project, the school applied some non-project materials (e.g., local paint or foam) on the roofs.	0 = No 1 = Yes
	If yes, please describe……………….	
Section F: Contextual factors *Focus: External factors (Outer Setting) that influenced implementation*		
To what extent did the following disrupt the installation quality or speed?		
cf1	Rain affecting drying (SRP) or installation (BCPF).	0 = Not at all 1 = Moderately 2 = Severely
cf2	Extreme heat/humidity affecting worker performance.	0 = Not at all 1 = Moderately 2 = Severely
cf3	Material Flow: Delays in receiving paint, bamboo, or foam.	0 = Not at all 1 = Moderately 2 = Severely
cf4	School Schedule: School-related events forcing workers to rush.	0 = Not at all 1 = Moderately 2 = Severely

cf5	External Influence (Political/Local): Strikes and transport issues disrupt the intervention work.	0 = Not at all 1 = Moderately 2 = Severely

Code	Section G: Sustainability Capacity		Logic
su1	Confidence that the installation will be properly maintained by the school.	0 = Low 1 = Moderately 2 = High	
su2	The school's understanding of how to maintain the materials.	0 = Low 1 = Moderately 2 = High	
su3	There is a designated person for maintenance.	0 = No 1= Yes	
SECTION H. Overall Implementation Assessment			
oa1	Overall, how would you rate the success of the implementation?	0 = Poor 1 = Average 2 = Excellent	
oa2	Overall, how satisfied are you with the intervention that was carried out?	0 = Dissatisfied 1 = Average 2 = Satisfied	
oa3	Adaptations: Did you observe the workers making any changes to the original plan?	0 = No 1 = Yes	If 1, go to oa4 If 0, end section
oa4	If yes, explain. What changed, and		

	why do you think they changed it?		

A.2 Qualitative tools

Section A: Characteristics of interview participants for KIIs.

S.N	**Items**	**Response**
1	Date of interview (dd/mm/yyyy)	…/…/…
2	Interviewer name	
3	Name of district	1 = Kurigram 2 = Gaibandha
4	Name of provider type	1 = Carpenter 2 = Painter 3 = Project officer 4 = Field coordinator 5 = BEP member 6 = Architecture department 7 = JPG
5	Gender of participant	1= Male 2 = Female 99 = Others (Specify)...
6	Completed age (yrs) of participant	
7	Completed educational level of participant	
8	Years of experience in respective field of participant	

Tool 3: Key Informant Interviews (KIIs) Guidelines

Tool 3.1: Key Informant Interviews (KIIs) Guideline – Intervention co-ordinator

Respondent: Intervention co-ordinator

Proposed: To evaluate the implementation process, technical adherence, and the moderators influencing fidelity in the infrastructure interventions (SRP & BCPF).

Section B: Introduction and Informed Consent

Greeting & Context: Introduce the researcher and the specific focus on the SRP/BCPF interventions.

Anonymity & Voluntary Participation: Explain that insights will be used to improve future scaling and that their identity will remain confidential.

Recording Consent: Secure verbal/written permission to record the audio.

Section 1: Role and Responsibilities

1. Can you describe your specific role in overseeing the SRP and BCPF installations?
    - Probes: Were you primarily responsible for planning, on-site supervision, quality assurance, or reporting?
2. Operationalizing Fidelity: From your perspective within the project team, what did you define as "high-quality implementation" for these specific interventions?
    - Probes: Were there specific written technical standards or checklists used to define a "successful" installation? How did you communicate these standards to the field teams?

Section 2: Facilitation Strategies (training & oversight)

3. Implementer Preparation: How were the implementers (painters/carpenters) prepared to deliver the intervention according to the research protocol?
    - Probes:
        - Would you describe the nature and depth of the training provided (duration and content covered: technical steps and quality standards)
        - How did you determine if an implementer’s technical skills were sufficient before they began on-site?

        - Any differences between experienced vs. inexperienced implementers' responses during training (if anyone worked in school previously)

4. Supervision Mechanisms: How would you describe the supervision process during the actual installations?
    - Probes: In what ways did the use of structured checklists or frequency of site visits influence the work?
5. Correction & Feedback: When a deviation from the protocol was identified, what was the process for addressing it?
    - Probes:
        - How did the feedback loop function between the field and central management?
        - To what extent were these deviations documented?

Section 3: Adherence and quality of delivery

6. Observed Adherence: Based on your observation, how closely were the implementers able to follow the technical protocol?
    - Probes:
        - Which steps were most frequently modified or skipped?
        - Why do you think those specific deviations occurred (e.g., time, skill, or materials)?
7. Coverage: To what extent were you able to achieve full completion of the assigned classrooms as planned?
    - Probes: In cases where "partial completion" occurred, what were the primary drivers? How was final completion verified across different school sites?
    - Were materials ever substituted due to cost? Was there any time when the quality was compromised?

Section 4: Intervention Complexity

8. Technical Complexity: Looking at the implementation manuals, which specific technical steps proved to be the most challenging for the teams?

- Probes: How did the complexity of the Bamboo Ceiling (BCPF) compare to the Solar Paint (SRP)? Why might one have been more difficult to implement than the other? Were the skill requirements too high for the available local workforce?
- What was the mitigation strategy?

9. Technical Disagreements: How were technical disagreements, such as those between field teams/architects, handled during the implementation?
    - Probes: What was the nature of these conflicts? How did the resolution of these disagreements result in the permanent protocol change?

Section 5: Participant Responsiveness (school level)

(to assess how the "Inner" and "Outer" settings influenced fidelity)

10. School-Level Readiness: How did the physical conditions of the schools influence the team's ability to follow the protocol?
    - Probes: In what ways did factors like roof condition, space, or water access facilitate or hinder the work?
11. Community Buy-in: How did the level of engagement from schoolteachers and School Management Committees (SMCs) affect the quality of the intervention?
    - Probes: What were the most common reactions (praises or concerns) you heard from school staff/community members/parents?

Section 6: Contextual factors and District variations

12. External Barriers: Beyond technical skills, what external factors had the most significant impact on the quality of implementation?
    - Probes: How did weather patterns (monsoon/extreme heat), material supply chain issues, or local socio-political events (strikes and festivals) disrupt the workflow?
13. District-Level Variation: Did you notice structural differences in implementation experience between Kurigram and Gaibandha?
    - Probes: How did differences in workforce capacity/skills, administrative efficiency, or school cooperation between the two districts? Any other external factors that make any differences?

Section 8: Sustainability, scale-up, and lessons learned

To capture "practice-based evidence" for future iterations.

14. Lessons Learned: Reflecting on this pilot, what is the most critical lesson you learned about maintaining implementation delivered as intended by its developers in the field? How should the strategy for recruiting and managing implementers evolve in future iterations to ensure higher research rigor
15. Manual 2.0: If you were tasked with revising the "Implementation Manual" for a national scale-up, what specific changes would you recommend to ensure better adherence?

Closing (Final reflection):

Final Reflection: Is there anything else regarding the implementation process or the challenges of maintaining fidelity that we haven't discussed? Or any experiences?

Closing Statement: —Thank you for your time and for providing these valuable insights into the implementation of the project.”

Tool 3.2: Key Informant Interviews (KIIs) Guideline_ Intervention monitoring officers

Section B: Introduction and Consent

Section 1: Understanding of the intervention

1. Perceived Purpose: How was this project first described to you, and what was the main purpose of the project that you understood?
    - Probes: In your view, how did this project differ from a standard government renovation? To what extent was it clear that this work was part of a formal research study?
2. Clarity of Roles: Before the work began, how would you describe the clarity of the school’s roles and responsibilities?
    - Probes: What kind of information or timelines were shared with the School Management Committee (SMC)?

Section 2: Facilitation Strategies (Co-ordination)

3. Preparation: What kind of preparation or orientation did the school receive before the painters and carpenters arrived?
    - Probes: How were the technical standards or the importance of the research protocol explained to you?
4. Coordination Quality: How would you characterize the communication between the project team and your school during the installation phase?

    - Probes: How informed did you feel about the daily progress? If you had a concern or a question, what was the process for raising it?

Section 3: Observation Adherence and quality

5. Technical Adherence: From your observations, how would you describe the way the workers followed the technical plan?
    - Probes: Did you notice any instances where the process seemed to be shortened or changed (e.g., number of coats, type of materials)? Did anything about the installation process cause you concern?
6. Adaptations: Were there any "local adjustments" or changes made to the design once the work started at your school?
    - Probes: What led to these changes (e.g., condition of the roof, school schedule)? How do you feel these adjustments affected the final result?
7. Overall Finish: How would you describe the final quality of the installation in terms of neatness, safety, and durability?

Section 4: Participant Responsiveness and Readiness

8. Stakeholder Engagement: How did the teachers, parents, and the SMC engage with the project as it was happening?
    - Probes: In what ways did the school staff assist in monitoring or facilitating the workers?

Section 5: Organizational/structural readiness

9. Organizational Readiness: How would you describe the school's readiness to host this construction work?
    - Probes:
        - What were the challenges in vacating classrooms or adjusting schedules?
        - How did the existing condition of the building (e.g., rusted tin, weak rafters) impact the work?
10. Scheduling Pressure: In what ways did the school calendar, such as exams or festivals, impact the pace of the construction?
    - Probes: To what extent do you think scheduling pressures forced the workers to move faster than the technical steps (like drying times) allowed?

Section 6: Intervention Complexity

11. From the school's perspective, how complex or disruptive did the installation process appear?
    - Probes: What were the most "difficult" aspects of having this intervention implemented during the school day? (Technical difficulty, Time required)

Section 7: Contextual Moderators Factors and barriers

12. Environmental & External Barriers: What were the biggest external challenges the school and the workers faced during the project?
    - Probes: How did weather (rain/extreme heat) or local community events disrupt the quality or timing of the work?

Section 8: Differences & Variation

13. Since the project was completed, how has the school community (parents, staff, SMC) reacted to the new infrastructure?
    - Probes:
    - Perceived temperature reduction, acceptability concern
    - Classroom comfort
    - Are there any concerns that have been raised?
    - Has the school tried any other cooling methods (like fans or trees) since the project started?
14. In your view, does implementation quality vary between schools? why might the quality of implementation vary from one school to another?

- Probes: What role do you think leadership, building conditions, or community support play in a "successful" installation?

Section 10: Sustainability & Scale-up

15. Sustainability: What do you believe is necessary to ensure this infrastructure remains functional and safe ?
    - Probes: Who do you feel is responsible for maintenance? What kind of guidance does the school need to handle minor repairs?
16. Future Recommendations: Would you recommend this cooling intervention to other

schools? Why or why not?

- Probes: What specific advice would you give to the organizers to make the process smoother if they were to do this in every school? (e.g., changes in design, timing, or coordination).

Closing: Final reflections

Final Reflection: "Is there a specific experience or 'story' from the installation days—either a success or a challenge—that stands out in your memory?"
Closing Statement: "Thank you for sharing your experience. Your insights are essential for helping us improve heat mitigation for schools across the country."

Tool 3.3: Key Informant Interviews (KIIs) Guideline – Painters

Intervention type: Solar Reflective Paint (SRP) Implementation

Respondent: Painters

Purpose: To explore the determinants of implementation fidelity, including technical adherence and the "Know-Do" gap in a field setting.

Section B: Introduction and consent

Icebreaker: How many years have you worked as a professional painter? In your view, how did this "Solar Reflective Paint" project differ from a standard commercial roof painting job?

Section 1: Understanding of the intervention design

1. Technical Workflow: Could you walk me through the application process at a school from start to finish, exactly as you performed it?
    - Probes:
        - How did you handle surface preparation?
        - How many layers did you apply?
        - How did you manage the drying times between coats?
        - What safety procedures were used?
2. The "Non-Negotiables": What were the "non-negotiable" technical rules you were instructed to follow for this specific research project?
    - Probes: Probes: Use of specified materials only; cleaning/rust treatment; specific thickness coverage.

3. Training Clarity: How clearly were these technical standards explained to you during orientation?
    - Probes:
        - To what extent did the training match the reality of the schools?
        - How easy was it to use the manuals or drawings while you were actually working on the roof?

Section 2: Adherence to technical protocol

4. Protocol Fidelity: In the actual school environment, how closely were you able to follow the manual?
    - Probes:
        - Which steps were easiest to follow?
        - Which was physically difficult on a tin roof?
5. Can you describe a situation where you had to change or skip a step?
    - Probes: What were the main drivers (e.g., time, weather, material limits, or pressure from the school)?
6. Coverage: How did you ensure that 100% of the assigned roof area was covered as intended?
    - Probes:
        - Were any classrooms left partially completed? What caused those gaps (e.g., access issues, material shortage)?
7. Intentional Adaptation: Did you make any "on-site" changes or adaptations to the protocol to get a better result?
    - Probes:
        - Why did you feel that change was necessary?
        - Who approved it?
        - In your opinion, how did that change affect the final heat reduction?

Section 3: Facilitation strategies

8. Training Effectiveness: Reflecting on the training you received, how well did it prepare you for the challenges of a rusted or high-heat school roof?

- Probes: What was missing from the training? Was it too much lecture and not enough practice?

9. Supervisory Feedback: How would you describe the supervision process while you were working?
    - Probes:
        - How often were checks performed?
        - Did they specifically check for things like paint thickness or surface moisture before the next coat?
10. Correction Mechanism: When a mistake or a deviation was found by a supervisor, how was it addressed?
    - Probes:
        - Was it an immediate correction?
        - How often were you required to do "rework"?

Section 4: Intervention Complexity

11. Technical Demands: Compared to your usual painting work, how would you describe the complexity of this SRP protocol?
    - Probes: Was the drying time (waiting hours between coats) realistic? Was the surface preparation too demanding for the time provided?
12. High-Skill Components: Which part of the job required the most skill or gave you the most trouble?
    - Probes: Achieving even coverage on corners/edges; ensuring a level finish.
13. Time Sufficiency: On average, how much time did you spend per classroom? Was this enough time to do the job exactly as the protocol intended?

Section 5: Participant Responsiveness

14. School-Level Pressure: How did school activities (class reopening dates) influence the quality of your work?
    - Probes: Did you ever feel pressured to finish faster than the paint could properly dry?
15. Infrastructure Constraints: In what ways did the condition of the roofs (rust, damage, stability) prevent you from following the protocol?
16. Support Access: When you faced technical problems on-site, how easy was it to get a

solution from the project team or the school?

Section 6: Contextual factors

17. What were the biggest challenges that you faced in hosting this construction work?
    - Probes:
        - How did extreme heat, rain, or humidity affect the paint's adhesion or your ability to work?
        - Administrative or political factors (local authority involvement, school governance changes)
        - Resources constraints
18. In your experience, what were the biggest factors that helped you do your work properly? Probes: School cooperation; Community support; Availability of materials, and Good weather

Section 8: Perceived Effectiveness and Scale-Up

19. Professional Opinion: As a professional painter, what is your opinion on this specific paint and method?
    - Probes: Do you believe it actually reduces heat? How does it compare to standard paint in terms of durability and quality?
20. Scale-up Advice: If this project was expanded to every school in the country, what should be changed to make it easier for painters to follow the rules "perfectly"?
    - Probes: Better training? Different tools? More flexible scheduling?

Closing

Final reflections: "Is there a specific experience or 'story' from a school site—either a success or a challenge—that we haven't discussed?"

Closing Statement: ~~"~~Thank you for sharing your experience. Your insights as a professional are essential for improving school infrastructure from heat across Bangladesh."

Tool 3.4: Key Informant Interviews (KIIs) Guideline – Carpenters

Intervention type: Bamboo Ceiling with Polyethylene Foam Installation

Respondent: Carpenters

Purpose: To explore determinants of implementation fidelity, technical adherence, the "Know-Do" gap, and structural challenges in ceiling installation.

Section B: Introduction and Consent Script

Contextual Icebreaker: You have experience with bamboo work, but this project combines it with polyethylene foam for heat insulation. How does this specific "multi-layer" approach differ from the traditional bamboo ceilings you usually build?

Section 1: Understanding of the intervention design

1. Technical Workflow: Can you walk me through the installation process at a school from start to finish, exactly as you performed it?
    - Probes: How did you handle the frame preparation and foam placement before anchoring the bamboo? How did you manage the sealing of the edges?
2. The "Non-Negotiables": What were the most important technical "rules" you were instructed to follow strictly for this research project?
    - Probes: Specifics on foam thickness; ensuring 100% coverage with no gaps; spacing between bamboo supports; safety standards.
3. Training Clarity: How clearly were these technical standards explained to you during your orientation?
    - Probes:
        - To what extent did the training match the actual conditions of the schools?
        - How helpful were the written manuals or technical drawings while you were doing the actual work?

Section 2: Adherence to technical protocol

4. Protocol Fidelity: In the actual school environment, how closely were you able to follow the technical manual?
    - Probes: Which steps were easy to execute? Which were difficult? Describe a situation where you had to deviate from the manual (e.g., due to time, material quality, or the shape of the roof).
5. Seal & Insulation Integrity: How did you ensure the insulation (foam layer) was installed "perfectly" before it was covered by the bamboo?
    - Probes: How did you check for gaps between the foam and the wall? How did you ensure the ceiling wouldn't sag over time?
6. Intentional Adaptation: Did you make any "on-site" changes or adaptations to the protocol to get a better result?

- Probes: Why was it changed (e.g., to accommodate a ceiling fan or a broken rafter)? Who approved the change? How do you think this change affected the ceiling's ability to block heat?

Section 3: Facilitation strategies (tranning and oversight)

7. Training Quality: Reflecting on your training, what was missing that would have better prepared you for the challenges of a school installation?
    - Probes: Did you receive enough hands-on practice? Did you understand the reason for the foam (the insulation principle), or just the steps to put it up?
8. Supervision & Verification: How would you describe the way your work was monitored by supervisors?
    - Probes: How often were checks performed? Did they specifically inspect the foam thickness and joints before the final bamboo panels were closed?
9. Correction Mechanism: When a mistake or gap was identified by a supervisor, what was the process for correcting it? (e.g., a gap in the foam or loose wiring)?
    - Probes:
        - Was it an immediate correction?
        - How often were you required to do "rework"?

Section 4: Intervention Complexity

10. Technical Demands: Compared to your usual carpentry work, how "complex" was this specific bamboo-foam installation?
    - Probes: How difficult was the precision measurement or fitting foam around corners/edges?
11. High-Skill Components: Which part of the job required the most skill or gave you the most trouble?
    - Probes: frame alignment, ensuring a level finish, and integration with existing school rafters.
12. Time Sufficiency: On average, how much time did you spend per classroom? Was this enough time to do the job exactly as intended?

Section 5: Participant Responsiveness

13. School-Level Pressure: How did school activities or the condition of the building affect your ability to follow the protocol?

- Probes: Did you feel pressured to finish faster than recommended? Did damaged rafters or rusted tin make the installation harder?

14. Infrastructure Constraints: Did the condition of the school (e.g., damaged rafters, rusted tin, or lack of electricity) affect your ability to follow the protocol?
15. Support Access: When you faced technical problems on-site, how easy was it to get a solution from the project team or the school?

Section 6: Contextual factors

16. What were the biggest challenges the school faced in hosting this construction work?
    - Probes:
        - How did extreme heat, rain, or humidity affect your ability to work?
        - Administrative or political factors (local authority involvement, school governance changes)
        - Resources constraints
17. In your experience, what were the biggest factors that helped you do your work properly?
    - Probes: School cooperation; Community support; Availability of materials, and Good weather

Section 8: Perceived Effectiveness and Scale-Up

18. Professional Opinion: As a carpenter, how effective do you believe this "bamboo-foam sandwich" will be at blocking heat compared to a standard ceiling?
19. Durability Concerns: What factors might affect the long-term performance of this ceiling? (e.g., moisture, insects, or maintenance).
20. Scale-up Advice: If this project was expanded to a national level, what changes would you recommend to the design or schedule to ensure higher quality?
    - Probes: Better training? Different tools? More flexible scheduling?

Closing Statement: ―Thank you for sharing your experience. Your insights as a skilled professional are essential for improving school infrastructure projects across Bangladesh.”

Appendix B: Informed Consent Form

B.1 Intervention co-ordinator

Implementation Fidelity of Heat-Mitigation Infrastructure Interventions in Primary Schools in Climate-Vulnerable Districts of Bangladesh

Key Informant Interview

Information Sheet

Greetings,

My name is ______________. I am from the **BRAC James P Grant School of Public Health (BRAC JPGSPH), BRAC University**. BRAC JPGSPH, conducting a study titled ―Implementation Fidelity of Heat-Mitigation Infrastructure Interventions in Primary Schools in Climate-Vulnerable Districts of Bangladesh.” You are invited to participate in this study because of your role in overseeing, supervising, coordinating, or supporting the implementation of these interventions.

Purpose of the Study: The purpose of this study is to evaluate how closely the solar-reflective paint and bamboo ceiling with polyethylene foam interventions were implemented as planned in BRAC primary schools. This study focuses on the interventions of training, supervision, and monitoring mechanisms; adherence to implementation protocols; quality assurance processes; challenges and contextual barriers in the field; and variations in implementation across schools: lessons learned for scaling and sustainability. The study does not evaluate individual performance or job outcomes.

Participation: If you accept being a participant in this study, then I will conduct an in-depth interview lasting approximately 30–45 minutes. The interview will include questions focused on your experience and observations related to implementation oversight. Your participation is completely voluntary. You may decline to answer any question or stop the interview at any time.

Facilities: You will not be given any sort of financial assistance for participating in this study, nor will you get any other direct facilities. However, your input will contribute to improving implementation quality in future school infrastructure projects, strengthening supervision and accountability systems, and supporting evidence-based scale-up of climate-resilient school interventions.

Risk: Your participation in this study does not pose any risk of physical or mental harm. However, some questions may involve discussing work-related challenges or constraints. If at any point you begin to feel uneasy, please remember that your participation is completely voluntary. You have the option to skip any question or withdraw from the interview entirely without any consequences. Our goal is to ensure that you feel comfortable and well-informed throughout the study.

Confidentiality and Data Protection: All information of the participants of this interview will be kept confidential. We want to inform you that, during the interview, we will take some photographs of you and record the interviews with your permission. Information collected for the study will be enlisted through identification numbers and will be kept confidential. All the information will be saved as a digital signal, which nobody except authorized research workers will have access to. Your name or confidentiality-related information will not be mentioned in any of the publications or reports of this research. The institutional review board of BRAC James P. Grant School of Public Health (BRAC JPGSPH) reserves the right to access all the information of the study. If this information needs to be used in the future, we will only share that information that is selected by the IRB so that the anonymity, confidentiality, and fairness of the study participants remain assured.

Voluntary Participation: Your participation in this study is wholly dependent upon your own will. You have all the rights to know the research process, risks, and facilities of this study. Even if you had taken the decision to participate in this study, you can change your decision anytime at any moment and withdraw yourself from the study. Whatever decision you take, that will not create any problems for you.

Answering your questions/ Contact information: If you have any further queries about the research project, then please contact Asmita Adhikari, MPH student, BRAC James P. Grant School of Public Health, through this phone number: +88-02-9827501.

Consent Form

Title of the Study: Implementation Fidelity of Heat-Mitigation Infrastructure Interventions in Primary Schools in Climate-Vulnerable Districts of Bangladesh

If you agree to participate in this study, please confirm that by putting your signature or fingerprint of the left thumb in the specific boxes given below

Thank you for your cordial cooperation.

Do you give permission for the interview to be audio recorded? Yes No

Please note that at any point during the interview, you can ask the interviewer to turn off the recording device.

Do you give permission to share your findings? Yes No

Do you give permission to take photos? Yes No

Do you give permission to share the photos? Yes No

(If you need to contact or collect data from the respondent again, need to state here and ask permission ...)

Do you have any questions? Yes No

State the question

Participant Information	
Name of the participant	
Participant's ID	
Participant's signature or fingerprint of the left thumb	
Researcher Information	
Researcher's Name:	
Researcher's signature:	
Date:	

B.2 Monitoring officers

Implementation Fidelity of Heat-Mitigation Infrastructure Interventions in Primary Schools in Climate-Vulnerable Districts of Bangladesh

Key Informant Interview

Information Sheet

Greetings,

My name is ______________. I am from the **BRAC James P Grant School of Public Health (BRAC JPGSPH), BRAC University**. BRAC JPGSPH is conducting a study titled “Implementation Fidelity of Heat-Mitigation Infrastructure Interventions in Primary Schools in Climate-Vulnerable Districts of Bangladesh.” You are invited to participate in this study because of your role as a teacher and/or BEP staff member involved with the implementation of the school infrastructure interventions.

Purpose of the Study: The purpose of this study is to evaluate how closely the solar-reflective paint and bamboo ceiling with polyethylene foam interventions were implemented as planned in BRAC primary schools. This study focuses on how the interventions were planned, coordinated, and implemented at the school level, including communication and coordination with implementers, school involvement during implementation, perceived quality and completeness of the work, responsiveness of painters, carpenters, and supervisors, and any challenges faced by the school during implementation. The study does not evaluate individual performance or job outcomes.

Participation: If you accept being a participant in this study, then I will conduct an interview lasting approximately 30–45 minutes. The interview will include questions focused on your experience and observations related to implementation. Your participation is completely voluntary. You may decline to answer any question or stop the interview at any time.

Facilities: You will not be given any sort of financial assistance for participating in this study, nor will you get any other direct facilities. However, the findings from this study may improve future school infrastructure implementation and support better coordination between schools and project teams, informing the scale-up of heat-mitigation interventions in schools.

Risk: Your participation in this study does not pose any risk of physical or mental harm. However, some questions may involve discussing work-related challenges or constraints. If at any point you begin to feel uneasy, please remember that your participation is completely voluntary. You have the option to skip any question or withdraw from the interview entirely without any consequences. Our goal is to ensure that you feel comfortable and well-informed throughout the study.

Confidentiality and Data Protection: All information of the participants of this interview will be kept confidential. We want to inform you that, during the interview, we will take some photographs of you and record the interviews with your permission. Information collected for the study will be enlisted through identification numbers and will be kept confidential. All the information will be saved as a digital signal, which nobody except authorized research workers will have access to. Your name or confidentiality-related information will not be mentioned in any of the publications or reports of this research. The institutional review board of BRAC James P. Grant School of Public Health (BRAC JPGSPH) reserves the right to access all the information of the study. If this information needs to be used in the future, we will only share that information that is selected by the IRB so that the anonymity, confidentiality, and fairness of the study participants remain assured.

Voluntary Participation: Your participation in this study is wholly dependent upon your own will. You have all the rights to know the research process, risks, and facilities of this study. Even if you had taken the decision to participate in this study, you can change your decision anytime at any moment and withdraw yourself from the study. Whatever decision you take, that will not create any problems for you.

Answering your questions/ Contact information: If you have any further queries about the research project, then please contact Asmita Adhikari, MPH student, BRAC James P. Grant School of Public Health, through this phone number: +88-02-9827501.

Consent Form

Title of the Study: Implementation Fidelity of Heat-Mitigation Infrastructure Interventions in Primary Schools in Climate-Vulnerable Districts of Bangladesh

If you agree to participate in this study, please confirm that by putting your signature or fingerprint of the left thumb in the specific boxes given below

Thank you for your cordial cooperation.

Do you give permission for the interview to be audio recorded? Yes No

Please note that at any point during the interview, you can ask the interviewer to turn off the recording device.

Do you give permission to share your findings? Yes No

Do you give permission to take photos? Yes No

Do you give permission to share the photos? Yes No

(If you need to contact or collect data from the respondent again, need to state here and ask permission. ...)

Do you have any questions? Yes No

State the question

Participant Information	
Name of the participant	
Participant's ID	
Participant's signature or fingerprint of the left thumb	
Researcher Information	
Researcher's Name:	
Researcher's signature:	
Date:	

B.3 Workers

Implementation Fidelity of Heat-Mitigation Infrastructure Interventions in Primary Schools in Climate-Vulnerable Districts of Bangladesh

Key Informant Interview

Information Sheet

Greetings,

My name is ______________. I am from the **BRAC James P Grant School of Public Health (BRAC JPGSPH), BRAC University**. BRAC JPGSPH, in coordination with the BRAC Education Program (BEP), is conducting a study titled "Implementation Fidelity of Heat-Mitigation Infrastructure Interventions in Primary Schools in Climate-Vulnerable Districts of Bangladesh." You are being invited to participate because of your role in implementing school-based infrastructure interventions.

Purpose of the Study: The purpose of this study is to evaluate how closely the solar-reflective paint and bamboo ceiling with polyethylene foam interventions were implemented as planned in BRAC primary schools. Specifically, this interview aims to understand implementation processes and work practices, adherence to technical guidelines, quality of installation and supervision, challenges, adaptations, and facilitators during implementation, and coordination among project teams, implementers, and schools. The study does not evaluate individual performance or job outcomes.

Participation: If you accept being a participant in this study, then I will conduct an interview lasting approximately 30–40 minutes. The interview will include questions related to your experience, responsibilities, and observations during implementation. Your participation is completely voluntary. You may decline to answer any question or stop the interview at any time.

Facilities: You will not be given any sort of financial assistance for participating in this study, nor will you get any other direct facilities.

Risk: Your participation in this study does not pose any risk of physical or mental harm. However, some questions may involve discussing work-related challenges or constraints. If at any point you begin to feel uneasy, please remember that your participation is completely voluntary. You have the option to skip any question or withdraw from the interview entirely without any consequences. Our goal is to ensure that you feel comfortable and well-informed throughout the study.

Confidentiality and Data Protection: All information of the participants of this interview will be kept confidential. We want to inform you that, during the interview, we will take some photographs of you and record the interviews with your permission. Information collected for the study will be enlisted through identification numbers and will be kept confidential. All the information will be saved as a digital signal, which nobody except authorized research workers will have access to. Your name or confidentiality-related information will not be mentioned in any of the publications or reports of this research. The institutional review board of BRAC James P. Grant School of Public Health (BRAC JPGSPH) reserves the right to access all the information of the study. If this information needs to be used in the future, we will only share that information that is selected by the IRB so that the anonymity, confidentiality, and fairness of the study participants remain assured.

Voluntary Participation: Your participation in this study is wholly dependent upon your own will. You have all the rights to know the research process, risks, and facilities of this study. Even if you had taken the decision to participate in this study, you can change your decision anytime at any moment and withdraw yourself from the study. Whatever decision you take, that will not create any problems for you.

Answering your questions/ Contact information: If you have any further queries about the research project, then please contact Asmita Adhikari, MPH student, BRAC James P. Grant School of Public Health, through this phone number: +88-02-9827501.

Consent Form

Title of the Study: "Implementation Fidelity of Heat-Mitigation Infrastructure Interventions in Primary Schools in Climate-Vulnerable Districts of Bangladesh"

If you agree to participate in this study, please confirm that by putting your signature or fingerprint of the left thumb in the specific boxes given below

Thank you for your cordial cooperation.

Do you give permission for the interview to be audio recorded? Yes No

Please note that at any point during the interview, you can ask

the interviewer to turn off the recording device.

Do you give permission to share your findings? Yes No

Do you give permission to take photos? Yes No

Do you give permission to share the photos? Yes No

(If you need to contact or collect data from the respondent again, need to state here and ask permission ...)

Do you have any questions? Yes No

State the question

Participant Information	
Name of the participant	
Participant's ID	
Participant's signature or fingerprint of the left thumb	
Researcher Information	
Researcher's Name:	
Researcher's signature:	
Date:	