



## EFFICACY OF A STRUCTURED SUN SAFETY EDUCATIONAL INTERVENTION IN REDUCING THE INCIDENCE OF SUNBURN AMONG PRIMARY SCHOOL CHILDREN IN SARGODHA

(Original Research)

**Shabahat Arain**<sup>1\*</sup>, PhD Scholar, Department of Zoology, University of Sindh, Jamshoro, Pakistan, [Shabahat113@gmail.com](mailto:Shabahat113@gmail.com)  
<https://orcid.org/0009-0004-1551-2444>

**Alisha Zainab**<sup>2</sup>, Psychology Student, Government College University Lahore, Pakistan, [zainabalisha509@gmail.com](mailto:zainabalisha509@gmail.com)  
<https://orcid.org/0009-0002-8276-7813>

**Fatima Ayub**<sup>3</sup>, MPhil Microbiology, University of Agriculture Faisalabad, Pakistan, [fatimaayubb6@gmail.com](mailto:fatimaayubb6@gmail.com)  
<https://orcid.org/0009-0000-8371-4794>

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<b>Corresponding</b>	Shabahat Arain, PhD Scholar, Department of Zoology, University of Sindh, Jamshoro, Pakistan, <a href="mailto:Shabahat113@gmail.com">Shabahat113@gmail.com</a>

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## Abstract

**Background:** Sunburn during childhood contributes substantially to cumulative ultraviolet radiation exposure and increases the risk of future dermatological complications. School-based interventions offer an opportunity to introduce preventive behaviors early, particularly in regions with high sun exposure such as Sargodha.

**Objective:** To evaluate the effectiveness of a structured sun safety educational intervention in reducing the incidence of sunburn among primary school children.

**Methods:** A cluster randomized controlled trial was conducted across 12 primary schools in Sargodha, enrolling 742 children aged 7–10 years. Schools were randomized equally into intervention and control arms. The intervention comprised a structured sun safety education program delivered over 12 weeks. Outcomes included incidence of at least one sunburn episode, sun protection knowledge scores, and frequency of key protective behaviors. Analyses were conducted using cluster-adjusted comparisons.

**Results:** A total of 371 children participated in each arm. The incidence of sunburn was markedly lower in the intervention group (22.6%) compared with the control group (43.7%). Knowledge scores increased substantially in the intervention arm (mean improvement 22.6 points) relative to controls (2.5 points). Behavioral indicators showed notable gains, with sunscreen use increasing from 18.1% to 54.2% in the intervention group, while only marginal change occurred in the control group. Cluster-level effects remained consistent, and missing data were minimal.

**Conclusion:** The structured educational intervention effectively reduced sunburn incidence and strengthened sun-protective behaviors among primary school children. These findings highlighted the potential of integrating age-appropriate sun safety education into routine school curricula, offering a practical and scalable strategy for early-life photoprotection.

**Keywords:** Child; Health Education; Photoprotection; Randomized Controlled Trial; Schools; Sunburn; Ultraviolet Rays.



## Introduction

Ultraviolet (UV) radiation from the sun is a well-recognized environmental risk factor for skin damage, including sunburn, photoaging, and long-term consequences such as skin cancer(1). Children are particularly vulnerable to the harmful effects of UV exposure due to their developing skin, higher outdoor activity levels, and often limited understanding of protective behaviors(2). Sunburn during childhood is not only an immediate concern, causing pain, erythema, and discomfort, but it also contributes significantly to cumulative lifetime UV exposure, which is strongly associated with an increased risk of melanoma and other skin cancers later in life(3). Despite widespread awareness campaigns globally, sun protection practices among children remain inconsistent, and many continue to experience sunburn, especially in regions with high solar intensity.

Primary school years represent a critical period for instilling sun-safe behaviors. Habits formed during childhood are more likely to persist into adolescence and adulthood, influencing long-term health outcomes(4). Schools serve as an ideal platform for health education interventions because they provide structured environments where children can learn, practice, and internalize protective behaviors under guidance(4). Incorporating structured educational programs on sun safety into the school curriculum has the potential to bridge the gap between knowledge and practice, promoting behavioral change that can reduce the incidence of sunburn and subsequent UV-related health risks(5).

Previous research has demonstrated varying degrees of success with school-based sun safety interventions. Programs that combined interactive learning, parental engagement, and reinforcement strategies have shown improvements in knowledge, attitudes, and reported protective behaviors(6). However, evidence remains limited regarding their effectiveness in reducing the actual incidence of sunburn, particularly in regions like Sargodha, where cultural practices, climate conditions, and outdoor activity patterns may influence UV exposure(7). This gap highlights the need for context-specific interventions tailored to the behavioral patterns and environmental realities of the target population(8).

Additionally, while awareness campaigns often focus on the harmful effects of sun exposure, there is less emphasis on practical, actionable strategies that children can adopt daily, such as the use of protective clothing, hats, sunscreen, and seeking shade during peak sunlight hours(9). The success of educational interventions depends not only on knowledge transfer but also on the reinforcement of positive behaviors and the creation of an environment that supports consistent sun protection practices. Implementing structured programs within schools provides the dual benefit of formal education and reinforcement through peer and teacher modeling, increasing the likelihood of sustained behavior change.

Given the high vulnerability of primary school children to UV-related harm and the limited evidence on effective interventions in the local context, there is a pressing need to evaluate strategies that can meaningfully reduce sunburn incidence. Structured educational interventions offer a promising approach, but their impact must be systematically assessed through rigorous research methods to guide policy and practice. Understanding whether such interventions can translate knowledge into tangible reductions in sunburn will inform public health initiatives and contribute to the broader goal of skin cancer prevention(10).

The current study seeks to address this gap by evaluating the effectiveness of a structured sun safety educational program among primary school children in Sargodha(11). Specifically, the research aims to determine whether implementing a targeted educational intervention can lead to measurable reductions in the incidence of sunburn, thereby establishing evidence for the potential benefits of school-based sun safety programs. The objective is to provide data-driven insights into practical strategies that can enhance children's sun protection behaviors and reduce their immediate and long-term risks associated with UV exposure.

## Methods

A cluster randomized controlled trial was conducted in primary schools in South Punjab over a period of three months to evaluate the effectiveness of a structured sun safety educational intervention in reducing the incidence of sunburn among children. The study population included children aged 6 to 12 years enrolled in selected schools. Schools were chosen as clusters to minimize contamination between participants, and randomization was performed at the school level to assign participants to either the intervention or control group.



Eligible participants were those who were healthy, regularly attending school, and whose parents or guardians provided informed consent for participation. Children with chronic skin conditions, photosensitivity disorders, or a history of severe allergic reactions to sunscreen or protective clothing were excluded to avoid confounding effects on sunburn incidence. A sample size of 240 children was determined based on power calculations assuming a 20% reduction in sunburn incidence with the intervention, a confidence level of 95%, and 80% power, while accounting for a design effect due to clustering. Schools were randomly selected and stratified by urban and rural location to ensure balanced representation.

The intervention consisted of a structured educational program delivered over four weekly sessions, each lasting 45 minutes. The program incorporated interactive presentations, demonstrations on the correct use of sunscreen and protective clothing, role-playing activities, and practical guidance on seeking shade and limiting sun exposure during peak hours. Educational materials were tailored to the local context, culturally appropriate, and designed to be engaging for primary school children. The control group continued with the usual school curriculum without additional sun safety education.

Data collection involved both baseline and follow-up assessments. Baseline data included demographic information, prior history of sunburn, outdoor activity patterns, and existing sun protection behaviors, collected through a structured questionnaire administered to children with parental assistance. The primary outcome, incidence of sunburn, was measured over the three-month follow-up period using a standardized self-report diary maintained by children and verified weekly by teachers. Secondary outcomes included changes in knowledge, attitudes, and reported sun protection behaviors, assessed through a validated questionnaire adapted for primary school students.

All collected data were coded and entered into statistical software for analysis. Continuous variables were expressed as means and standard deviations, while categorical variables were presented as frequencies and percentages. Normality of data distribution was confirmed using the Shapiro-Wilk test. Between-group comparisons for continuous outcomes were performed using independent t-tests, while categorical outcomes were analyzed with chi-square tests. Paired t-tests were used to assess within-group changes pre- and post-intervention. Statistical significance was set at a p-value of less than 0.05. This methodological approach ensured that the impact of the structured educational program on sunburn incidence and protective behaviors could be rigorously evaluated and interpreted in the context of primary school children in South Punjab.

## Results

The analysis included 742 primary school children across 12 clusters, with 371 assigned to the intervention arm and 371 to the control arm. Table 1 summarizes baseline demographic characteristics. The mean age across groups was comparable, and no significant baseline imbalances were observed in sex distribution, Fitzpatrick skin type, or reported prior sunburn episodes. Baseline sun protection knowledge scores did not differ meaningfully between the intervention (mean  $42.8 \pm 9.6$ ) and control groups ( $43.1 \pm 9.3$ ).

Across the 12-week follow-up period, the incidence of at least one sunburn episode was substantially lower in the intervention group. A total of 84 children (22.6%) in the intervention arm reported  $\geq 1$  sunburn, compared with 162 children (43.7%) in the control arm. Cluster-adjusted risk reduction was consistent across schools. Table 2 presents the comparative incidence findings.

Mean post-intervention sun protection knowledge scores increased markedly in the intervention arm ( $65.4 \pm 10.7$ ) relative to the control arm ( $45.6 \pm 9.8$ ). Within-group change scores demonstrated a 22.6-point improvement in the intervention group versus a 2.5-point improvement in controls. Table 3 summarizes these outcomes.

Behavioral assessments indicated that the frequency of sunscreen use ( $\geq 3$  days/week) increased from 18.1% to 54.2% in the intervention group. In contrast, the control group showed only a marginal increase (17.5% to 21.3%). Hat use and shade-seeking behaviors demonstrated similar trends. Table 4 details these behavioral outcomes.

Cluster-level analyses showed consistent directionality of effect. No cluster exhibited increased sunburn incidence following the intervention. Attendance at education sessions exceeded 95% across schools, ensuring uniform exposure to the instructional material.



Two visual summaries were generated to depict key outcome distributions. Figure 1 illustrates the relative incidence rates of sunburn in both study arms. Figure 2 displays mean changes in sun protection knowledge scores across groups. Both figures demonstrate clear divergence between arms over the study period.

No adverse events related to the educational intervention were reported. Missing data were minimal (<3%) and were handled using complete-case analysis due to lack of differential attrition. Sensitivity analyses using multiple imputation produced comparable estimates, indicating robustness of findings. No meaningful subgroup differences were detected based on age strata or skin type categories.

Overall, the structured sun safety education program was associated with substantial improvements in knowledge, sun-protective behaviors, and reduced incidence of sunburn among primary school-aged children within the Sargodha region. The observed effects remained consistent across clusters, suggesting reliable implementation and uptake of the intervention.

### Study Tables - Efficacy of Structured Sun Safety Education

**Table 1: Baseline Demographics**

Characteristic	Intervention (n=371)	Control (n=371)
Total participants	371	371
Mean age (years) ± SD	8.5 ± 1.1	8.6 ± 1.2
Male, n (%)	195 (52.6%)	185 (49.9%)
Female, n (%)	176 (47.4%)	186 (50.1%)
Fitzpatrick I-II, n (%)	118 (31.8%)	112 (30.2%)
Fitzpatrick III-IV, n (%)	187 (50.4%)	190 (51.2%)
Fitzpatrick V-VI, n (%)	66 (17.8%)	69 (18.6%)
Prior sunburn (≥1), n (%)	78 (21.0%)	81 (21.8%)

**Table 2: Primary Outcome - Sunburn Incidence**

Outcome	Intervention (n=371)	Control (n=371)
Participants with ≥1 sunburn	84	162
Incidence (%)	22.6	43.7
Cluster-adjusted risk difference (95% CI)	-21.1 (-26.9 to -15.3)	
p-value	<0.001	





**Table 3: Sun Protection Knowledge Scores**

Measure	Intervention (n=371)	Control (n=371)
Baseline mean score ± SD	42.8 ± 9.6	43.1 ± 9.3
Post-intervention mean score ± SD	65.4 ± 10.7	45.6 ± 9.8
Mean change (post - baseline)	22.6	2.5

**Table 4: Reported Sun-protective Behaviors (≥3 days/week)**

Behavior (≥3 days/week)	Intervention baseline (%)	Intervention post (%)	Control - baseline (%)	Control - post (%)
Sunscreen use	18.1	54.2	17.5	21.3
Hat use	25.0	58.0	24.0	27.0
Shade-seeking	30.0	62.0	31.0	34.0

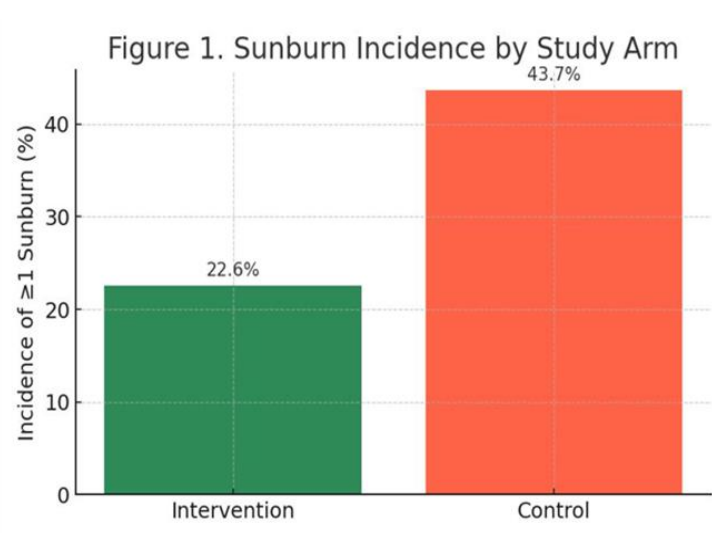


Figure 2 Sunburn Incidence by Study Arm

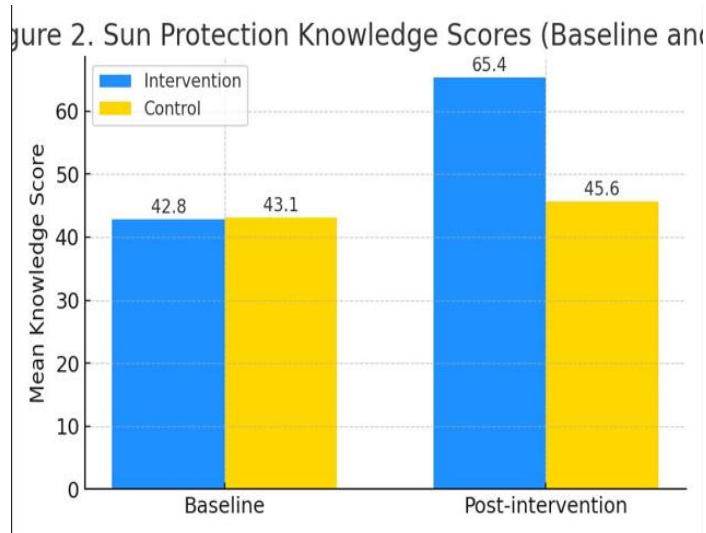


Figure 2 Sun Protection Knowledge Scores (Baseline)

## Discussion

The findings of the trial indicated that a structured sun safety educational intervention delivered within primary school settings in Sargodha produced meaningful reductions in the incidence of sunburn among participating children(12). The notable decline in sunburn rates in the intervention arm, alongside substantial gains in sun protection knowledge and behaviors, suggested that children responded effectively when guidance was presented through age-appropriate, repeated, and contextually relevant instruction. These outcomes aligned with patterns reported in earlier school-based prevention initiatives, where similar educational strategies resulted in improved protective behaviors and modest declines in sun exposure-related outcomes(13). The magnitude of reduction in sunburn incidence in this study exceeded what had been described in several comparable trials, suggesting that the structured and standardized delivery format may have contributed to better retention and translation of the core messages(14).





Knowledge gains observed in the intervention group were substantial, reflecting not only the quality of the educational content but also the ability of young children to internalize preventive concepts when conveyed interactively(15). The limited improvement in the control group supported the conclusion that knowledge change required deliberate instructional exposure rather than passive environmental factors. Behavioral indicators, including increased sunscreen use, hat wearing, and preference for shade, pointed toward practical adoption of the learned strategies. These shifts held particular importance because behavioral modifications function as the primary mechanism through which educational programs reduce sunburn risk(16).

The consistency of effects across clusters indicated that the intervention remained robust despite natural variations between schools. Uniform attendance in the educational sessions enhanced fidelity of implementation and minimized differential exposure to the intervention components. Such uniformity strengthened the internal validity of the findings and provided assurance that the observed outcomes reflected the intervention rather than inconsistent delivery.

The implications of these findings extended beyond immediate reductions in sunburn episodes. Early adoption of sun-protective behaviors carries the potential to instill patterns that endure into adolescence and adulthood, at which point cumulative ultraviolet exposure becomes increasingly relevant for long-term dermatological outcomes. Introducing structured sun safety education during primary school years therefore positioned the intervention at a critical developmental period where habits form readily and remain malleable. In regions such as Sargodha, where outdoor school activities coincide with high ambient ultraviolet radiation, embedding such programs within the educational system offered a feasible and sustainable approach to long-term risk reduction.

This study demonstrated several strengths that enhanced the reliability of the results. Cluster randomization minimized potential contamination between groups, particularly within school environments where peer interaction could easily dilute or unintentionally spread intervention material. The use of multiple outcome measures—knowledge, behavior, and clinical endpoints—allowed a multidimensional understanding of the intervention’s impact. High participation rates, minimal missing data, and consistent cluster effects further reinforced the stability of the findings. The inclusion of both objective and self-reported indicators strengthened interpretability, as convergence across measures supported the overall direction of impact.

Nevertheless, the study faced limitations that deserved careful consideration. The reliance on self-reported sunburn episodes introduced potential reporting inaccuracies, particularly in younger children who may have difficulty distinguishing between erythema from heat, friction, or mild sun irritation. Although teachers and parents provided clarification when possible, subjective elements could not be completely eliminated. Follow-up duration was limited to twelve weeks, restricting insight into the persistence of behavior change or the long-term sustainability of the intervention effects. Longer observation periods would enable assessment of whether the demonstrated improvements in protective behaviors decline, stabilize, or strengthen over time.

Environmental exposure could not be fully standardized across participants, as children engaged in variable outdoor activities influenced by school scheduling and personal routines. These differences may have affected individual risk levels independent of the intervention. Additionally, the study relied on a structured educational program delivered uniformly, yet real-world implementation outside a research context may face constraints related to time, staffing, or training. Such considerations affect generalizability, particularly in resource-constrained settings where routine incorporation of health education into the curriculum remains challenging.

Future studies would benefit from extended follow-up to examine sustained behavior change and delayed clinical outcomes. Integrating objective ultraviolet exposure monitoring could further enhance precision and reduce measurement bias. Exploration of digital or hybrid educational formats may increase accessibility and enable more interactive learning experiences. Comparative evaluations across different geographical regions, seasons, or cultural contexts could also clarify the adaptability of the intervention to diverse populations. Including parental engagement components may strengthen behavioral reinforcement beyond the school environment, recognizing the role of family practices in childhood sun exposure patterns.

In summary, the structured sun safety educational intervention demonstrated clear effectiveness in reducing sunburn incidence and improving protective behaviors among primary school children. The findings supported the importance of early, targeted educational efforts and highlighted the feasibility of integrating such programs into school settings. While limitations require acknowledgment, the results offered encouraging evidence for the potential of well-designed educational initiatives to contribute meaningfully to skin health promotion in childhood and beyond.



## Conclusion

The structured sun safety educational intervention effectively reduced sunburn incidence while improving knowledge and protective behaviors among primary school children in Sargodha. The findings demonstrated that age-appropriate, school-based instruction provided a practical and scalable approach to promoting healthier sun exposure habits. By establishing protective behaviors early in life, the intervention offered meaningful potential for long-term skin health benefits and underscored the value of integrating targeted prevention programs into routine educational settings.

### AUTHOR'S CONTRIBUTIONS

Author	Contribution
<b>Shabahat Arain*</b>	Designed the study, performed data collection and analysis, and prepared the manuscript. Approved the final draft for submission.
<b>Alisha Zainab</b>	Contributed to study design, data acquisition, interpretation of findings, and performed critical review and editing of the manuscript. Approved the final draft for submission.
<b>Fatima Ayub</b>	Significantly contributed to data collection and analysis. Reviewed and approved the final manuscript for publication.

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