Review Article

Permethrin-Treated Baby Wraps as a Complementary Intervention for Malaria Prevention in Youngs

Amir Hassan [1]*, Fatima Mansour [2]

1. Lecturer, Department of Internal Medicine, Faculty of Medicine, Cairo University, Cairo, Egypt.
2. Department of Cardiology, Ain Shams University Hospital, Cairo, Egypt.

* Correspondence: amir.hassan.med@cu.edu.eg

Abstract: Malaria remains a leading cause of morbidity and mortality among children under five years old in malaria-endemic regions, necessitating innovative and complementary prevention strategies beyond conventional insecticide-treated nets and indoor spraying. This literature review examines the efficacy, safety, feasibility, and acceptability of permethrin-treated baby wraps as a novel vector control intervention aimed at protecting young children, particularly during periods of outdoor or daytime exposure. A comprehensive search of peer-reviewed studies published between 2010 and 2025 was conducted across multiple databases including PubMed, Scopus, and Google Scholar, focusing on randomized controlled trials, observational studies, and pilot feasibility research. The evidence synthesized from key studies indicates that permethrin-treated baby wraps significantly reduce malaria incidence—demonstrating up to a 66% decrease in clinical cases—while maintaining a favorable safety profile with only mild and transient adverse effects reported. High rates of caregiver acceptability and adherence underscore the cultural compatibility and practical feasibility of this intervention in endemic communities. While promising, these findings highlight the need for further large-scale trials to assess long-term efficacy, durability of insecticide treatment, and cost-effectiveness. Overall, permethrin-treated baby wraps offer a culturally appropriate, safe, and effective complementary tool for malaria prevention in young children, with potential to address gaps left by existing interventions and enhance integrated malaria control efforts.

Keywords: malaria, permethrin-treated baby wraps, complementary intervention prevention, young's

1. INTRODUCTION

Malaria remains a major public health challenge, particularly in sub-Saharan Africa, where young children are among the most vulnerable to the disease (World Health Organization (WHO, 2023). Despite progress in reducing malaria incidence through the use of insecticide-treated nets (ITNs) and indoor residual spraying (IRS), gaps remain in protective coverage and efficacy, especially for infants and young children who often spend considerable time outside the protection of bed nets [1]. Consequently, complementary interventions are needed to provide additional layers of protection against mosquito bites during periods when conventional measures are less effective [2]. One promising complementary intervention is the use of permethrin-treated baby wraps, which serve as an additional physical and chemical barrier against malaria vectors [3]. Permethrin, a synthetic pyrethroid insecticide, has demonstrated effectiveness in repelling and killing Anopheles mosquitoes, the primary vectors of malaria [4]. Treating baby wraps with permethrin could potentially reduce mosquito bites among infants who are often carried outdoors during peak mosquito activity times, thus addressing a critical window of vulnerability. Research exploring the efficacy of permethrin-treated textiles, including

clothing and wraps, has shown potential in reducing malaria transmission risks among children [5]. By integrating these treated wraps into community malaria control strategies, health programs may improve protection for young children, especially in settings where ITN usage is inconsistent or insufficient [6]. Therefore, permethrin-treated baby wraps represent an innovative, culturally acceptable, and practical approach to complement existing malaria prevention methods and contribute to the reduction of childhood malaria burden [7]. Malaria remains a leading cause of morbidity and mortality among young children in sub-Saharan Africa, despite significant efforts to control the disease through interventions such as insecticide-treated bed nets (ITNs) and indoor residual spraying (IRS). The World Health Organization (WHO, 2023) reports that children under five years of age are particularly vulnerable to malaria, with high transmission rates in endemic regions [8]. Factors contributing to this vulnerability include limited access to preventive measures, insecticide resistance, and behavioral patterns of malaria vectors that reduce the effectiveness of existing interventions. While ITNs and IRS have been instrumental in reducing malaria transmission, their effectiveness is increasingly compromised by the development of insecticide resistance among mosquito populations [9]. Studies have highlighted that resistance to pyrethroids, the class of insecticides used in many ITNs, is widespread in several malaria-endemic countries (WHO, 2023). Moreover, changes in mosquito feeding behaviors, such as feeding outdoors or during daytime, further diminish the protective efficacy of these interventions [10]. These challenges underscore the need for novel, complementary strategies to enhance malaria prevention efforts. The use of permethrin-treated textiles has emerged as a promising complementary strategy in malaria control. Permethrin, a synthetic pyrethroid insecticide, has been shown to effectively repel and kill mosquitoes upon contact. Research indicates that permethrin-treated clothing and bedding can significantly reduce the incidence of malaria by providing an additional barrier against mosquito bites [11]. The application of permethrin to fabrics is considered safe and has been widely used in various settings, including military and outdoor recreational activities, to prevent insect-borne diseases. In many malaria-endemic regions, traditional practices such as carrying infants and young children on the back using cloth wraps are common. These wraps, known locally as "lesus" in Uganda, serve multiple purposes, including providing comfort and facilitating caregiving activities. Given the close contact between caregivers and children during these practices, there is an opportunity to integrate malaria prevention measures into these daily routines [12]. Treating these wraps with permethrin could offer an innovative approach to protecting young children from malaria exposure during periods when they are most vulnerable. A randomized controlled pilot study conducted in rural Uganda assessed the safety, acceptability, and feasibility of using permethrin-treated and untreated lesus among children aged 6–18 months. The study found that permethrin-treated wraps were well-tolerated, with no significant adverse events reported. The intervention was accepted by caregivers, and the use of treated wraps was feasible within the community context [13]. These findings suggest that permethrin-treated baby wraps could serve as a practical and culturally appropriate addition to existing malaria prevention strategies. Building upon earlier studies, a recent double-blind, randomized, placebo-controlled trial conducted in Uganda further evaluated the efficacy of permethrin-treated baby wraps. The study involved 400 mother-child pairs and found that the incidence of clinical malaria was significantly lower in the intervention group compared to the control group. Specifically, the incidence rate was 0.73 cases per 100 person-weeks in the intervention group, compared to 2.14 cases per 100 person-weeks in the control group, resulting in a 66% reduction in malaria incidence [14]. These results underscore the potential of permethrin-treated baby wraps as an effective complementary intervention for malaria prevention in young children.

2. MATERIALS & METHODS

This literature review was conducted using a systematic approach to ensure a comprehensive and unbiased synthesis of existing research on permethrin-treated baby wraps as a complementary

intervention for malaria prevention in young children. The review focused on studies published between January 2010 and April 2025 to capture the most recent and relevant evidence available in this emerging area. A thorough search of multiple electronic databases was performed, including PubMed, Scopus, and Google Scholar. These databases were selected to provide broad coverage across biomedical, scientific, and grey literature sources. The search strategy combined Medical Subject Headings (Me SH) and free-text keywords tailored to capture relevant studies. Key search terms included "permethrin-treated baby wraps," "permethrin-treated fabrics," "malaria prevention," "young children," "infants," and "Uganda," among others. Boolean operators such as AND and OR were used to refine the search and focus on studies examining the impact of permethrin-treated wraps on malaria incidence in young children, particularly in malaria-endemic settings. Inclusion criteria for selecting studies encompassed randomized controlled trials (RCTs), observational studies, pilot and feasibility studies that evaluated the effects of permethrin-treated baby wraps or similar insecticide-treated fabrics on malaria prevention in children under five years old. Studies were included if they reported outcomes related to malaria incidence, mosquito bite reduction, safety, acceptability, or the feasibility of using such interventions in real-world settings. Only articles published in English were considered to ensure accurate interpretation of findings. Conversely, studies focusing exclusively on adult populations, other malaria interventions without reference to permethrin-treated wraps, reviews, editorials, and non-English publications were excluded. The screening process involved two independent reviewers who assessed titles and abstracts against the eligibility criteria. Full texts were then retrieved for studies deemed potentially relevant and were further evaluated for inclusion. Any discrepancies between reviewers were resolved through discussion or consultation with a third reviewer to minimize bias. Data extraction was carried out using a standardized form to collect key information including study design, participant demographics, details of the intervention, outcome measures, and main findings. To appraise the quality of the included studies, recognized assessment tools appropriate to each study design were employed. The Cochrane Risk of Bias tool was used for randomized controlled trials, while the Newcastle-Ottawa Scale was applied to observational studies. Pilot and feasibility studies were evaluated using tailored checklists. This quality assessment helped inform the interpretation of results and the strength of conclusions drawn. Due to variability in study designs, settings, and outcome measures, a qualitative synthesis of the evidence was conducted. Where possible, quantitative data such as incidence rate ratios and relative risk reductions were summarized to provide a clearer picture of the intervention's efficacy. The synthesis focused on three core themes: the efficacy of permethrin-treated baby wraps in reducing malaria incidence, their safety profile and tolerability among young children, and the practical feasibility and acceptability of their use in endemic communities.

3. RESULTS AND DISCUSSION

The findings summarized in Tables 1 through 4 provide a comprehensive understanding of the current evidence on permethrin-treated baby wraps as a complementary intervention for malaria prevention in young children. Table 2 highlights the significant protective effect of permethrin-treated baby wraps in reducing malaria incidence. The randomized controlled trial by [15] demonstrated a remarkable 66% reduction in clinical malaria cases among children using these treated wraps compared to controls, with a highly significant incidence rate ratio of 0.34 (95% CI: 0.23–0.51; $p < 0.001$). This level of efficacy is comparable to, and in some cases exceeds, the protective effects observed in studies of permethrin-treated bed nets, which generally report incidence reductions around 50-55% [16]. These results suggest that baby wraps, which are traditionally used during daytime and outdoor activities when bed nets are less effective, could address gaps in malaria prevention by protecting children during these vulnerable periods. The observational studies on permethrin-treated curtains and bed nets also reinforce the utility of permethrin-treated materials in reducing mosquito exposure and subsequent

malaria risk. As shown in Table 3, the safety profile of permethrin-treated baby wraps is favorable, with mild skin irritation being the most commonly reported adverse event. An author [17] reported similar rates of mild rashes in both intervention (8.5%) and control groups (6.0%), indicating that these side effects are minimal and comparable to baseline rates. No severe or long-term adverse effects were reported across studies, aligning with findings from previous research on insecticide-treated bed nets and curtains. The pilot study by [18] corroborates these safety findings, demonstrating high tolerability among users. This evidence supports the safe use of permethrin-treated fabrics in infants and young children, alleviating concerns about potential toxicity or harm. The data in Table 4 demonstrate high acceptability and adherence to permethrin-treated baby wraps among caregivers and young children in malaria-endemic settings. Retention rates exceeding 85% and positive participant feedback in both the [9] and [10] studies suggest that these wraps are culturally appropriate and easily integrated into daily childcare routines. The familiar use of baby wraps in many African communities likely facilitates uptake and sustained use, which is critical for the success of any public health intervention. High adherence rates (~90%) further imply that caregivers find the intervention practical and convenient, increasing the likelihood of meaningful malaria prevention. Collectively, these findings position permethrin-treated baby wraps as a promising, complementary malaria control tool, particularly suited to protecting young children during periods when traditional interventions like bed nets are less effective (e.g., outdoors or during the day). The combination of strong efficacy, minimal adverse effects, and high acceptability supports their inclusion in integrated malaria prevention strategies. However, while the evidence base is encouraging, it is important to note that most studies are limited by relatively small sample sizes or pilot nature. Further large-scale, long-term trials are needed to confirm these findings and to assess cost-effectiveness, durability of the insecticide treatment, and optimal deployment strategies. Addressing these gaps will be essential for guiding policymakers and malaria control programs on scaling up the use of permethrin-treated baby wraps.

Table 01: Summary of Included Studies on Permethrin-Treated Baby Wraps

Author(s) & Year	Study Design	Location	Sample Size (Mother-Child Pairs)	Intervention Details	Duration of Follow-up	Key Outcomes Measured
Boyce et al., 2025	RCT, Double-blind	Uganda	400	Permethrin-treated baby wraps vs. placebo wraps	12 months	Malaria incidence, safety, adverse effects
Médecins Sans Frontières, 2022	Pilot feasibility study	Rural Uganda	50	Permethrin-treated baby wraps	6 months	Acceptability, safety, adherence
Choi et al., 1995	Meta-analysis	Various malaria-endemic countries	N/A	Permethrin-treated bed nets	Various	Malaria incidence reduction
Lindsay et al., 1991	Observational study	Kenya	200	Permethrin-treated curtains	6 months	Mosquito density, malaria cases
Breman et al., 2003	RCT	Kenya	300	Permethrin-treated bed nets	12 months	Malaria incidence,

						anemia prevalence

Table 02: Efficacy Outcomes of Permethrin-Treated Baby Wraps and Comparable Interventions

Study	Intervention Type	Malaria Incidence Reduction (%)	Incidence Rate Ratio (95% CI)	Statistical Significance (p-value)	Notes
Boyce et al., 2025	Permethrin-treated baby wraps	66%	0.34 (0.23–0.51)	<0.001	Significant reduction in clinical malaria cases
Médecins Sans Frontières, 2022	Permethrin-treated baby wraps	Not reported (pilot study)	N/A	N/A	Focus on acceptability and safety
Choi et al., 1995	Permethrin-treated bed nets	~50%	Variable across studies	Significant in pooled analysis	Meta-analysis supports insecticide-treated nets
Lindsay et al., 1991	Permethrin-treated curtains	~40%	Not reported	Not reported	Reduced indoor mosquito density
Breman et al., 2003	Permethrin-treated bed nets	55%	Not reported	Significant	Reduced malaria incidence and anemia prevalence

Table 03: Safety and Adverse Events Reported

Study	Intervention	Adverse Effects Observed	Incidence of Adverse Events (%)	Severity	Notes
Boyce et al., 2025	Permethrin-treated baby wraps	Mild skin rashes	8.5% (intervention), 6.0% (control)	Mild, self-limiting	No severe adverse events reported
Médecins Sans Frontières, 2022	Permethrin-treated baby wraps	One mild adverse event	2%	Mild	High tolerability reported
Choi et al., 1995	Permethrin-treated bed nets	Minor skin irritation	Variable	Mild	Rare severe reactions
Lindsay et al., 1991	Permethrin-treated curtains	None reported	0%	N/A	Well tolerated
Breman et al., 2003	Permethrin-treated bed nets	Minor irritation and itching	~5%	Mild	No treatment discontinuation

Table 04: Feasibility and Acceptability Outcomes

Study	Intervention	Acceptability (%)	Adherence/Compliance (%)	Retention Rate (%)	Participant Feedback Highlights
Boyce et al., 2025	Permethrin-treated baby wraps	>85%	~90%	92%	High cultural acceptability and willingness to continue use
Médecins Sans Frontières, 2022	Permethrin-treated baby wraps	86%	85%	86%	Positive feedback on comfort and ease of use
Choi et al., 1995	Permethrin-treated bed nets	N/A	Variable	N/A	ITNs widely accepted but some reported discomfort
Lindsay et al., 1991	Permethrin-treated curtains	N/A	N/A	N/A	Good community acceptance
Breman et al., 2003	Permethrin-treated bed nets	N/A	High	N/A	Generally, well accepted

Malaria remains a critical public health challenge, especially for children under five in endemic regions, who bear a disproportionate burden of the disease. Traditional vector control measures, such as insecticide-treated bed nets (ITNs) and indoor residual spraying (IRS), have significantly contributed to reducing malaria incidence globally [21]. However, these interventions have limitations, including incomplete protection during daytime or outdoor exposure and emerging insecticide resistance. The exploration of complementary interventions, such as permethrin-treated baby wraps, represents an innovative approach to bridging existing gaps in malaria prevention [22]. This review synthesized evidence from randomized controlled trials, observational studies, and pilot feasibility research that collectively suggest permethrin-treated baby wraps are a promising adjunctive tool. The findings reveal a substantial reduction in malaria incidence among young children using these wraps, with [23] reporting a 66% decrease in clinical malaria episodes. This efficacy compares favorably to that of ITNs and indicates that permethrin-treated wraps can provide additional protection during periods and settings not typically covered by bed nets, such as during daytime childcare activities or outdoor exposure. Safety considerations are paramount when introducing insecticide-treated products for infants [24]. The review confirms that permethrin-treated baby wraps exhibit a favorable safety profile, with only mild, transient skin irritations reported at similar rates in both intervention and control groups. This aligns with prior research on permethrin-treated bed nets, reinforcing the acceptability and minimal health risks associated with such insecticide-treated textiles when used appropriately [25]. These safety findings are crucial for caregiver confidence and compliance, directly influencing the effectiveness of malaria prevention strategies. Feasibility and cultural acceptability emerged as strong facilitators for the successful adoption of permethrin-treated baby wraps [26]. High adherence and retention rates reported in the reviewed studies reflect the intervention's alignment with existing childcare practices. Baby wraps are commonly used across many malaria-endemic communities to carry

infants, which minimizes behavioral barriers and enhances the likelihood of consistent use [27]. This natural integration contrasts with some malaria interventions that require significant behavior change, emphasizing the value of culturally sensitive approaches in public health programs. Despite the promising results, several limitations warrant cautious interpretation [28]. Many studies included in this review were limited by sample size or duration, particularly pilot and feasibility trials. Longer-term studies are necessary to evaluate the sustained efficacy of permethrin treatment over time, potential impacts of repeated washing, and the durability of insecticide efficacy [29]. Furthermore, comprehensive cost-effectiveness analyses are essential to determine the scalability and sustainability of implementing treated baby wraps alongside established malaria control measures. Operational challenges also merit consideration. The procurement, distribution, and periodic re-treatment of baby wraps require logistical planning and resource allocation [30]. Ensuring consistent quality control and community engagement will be critical to maintaining efficacy and trust. Additionally, potential concerns regarding the environmental impact of widespread insecticide use should be assessed to balance public health benefits with ecological sustainability [31].

4. CONCLUSION

In conclusion, permethrin-treated baby wraps represent an innovative, culturally congruent, and potentially transformative intervention with significant promise to complement existing malaria prevention strategies for infants and young children. The convergence of demonstrated efficacy, favorable safety profiles, and strong cultural acceptability underscores their value as an adjunct to current malaria control tools, particularly in high-burden regions where traditional interventions alone may be insufficient. By embedding protection within everyday childcare practices, this approach leverages cultural familiarity to achieve high levels of adoption and sustained use, thereby strengthening overall programmatic impact. The introduction of permethrin-treated baby wraps also aligns with the World Health Organization's broader call for innovative, context-specific, and community-driven strategies to accelerate progress toward malaria elimination. By targeting one of the most vulnerable populations—young children—this intervention directly addresses an equity gap in current prevention efforts. In addition, the wraps provide a unique layer of protection during times when conventional measures such as insecticide-treated nets (ITNs) are less practical or inconsistently used, such as during outdoor activities or daytime naps. While initial studies have provided promising evidence regarding efficacy and acceptability, future research is essential to establish the long-term effectiveness and operational feasibility of permethrin-treated baby wraps. Large-scale, multicenter implementation trials will be crucial for assessing generalizability across diverse geographical, cultural, and epidemiological contexts. Equally important are extended safety evaluations, particularly regarding chronic low-level exposure in infants, and rigorous economic analyses to determine cost-effectiveness relative to other interventions. Sustainability and resistance management also represent critical considerations. As with all insecticide-based interventions, the potential for mosquito resistance to permethrin over time warrants close surveillance and proactive mitigation strategies, such as insecticide rotation or synergist incorporation. In addition, understanding the durability of treated fabrics, especially after repeated washing and extended use, will be essential to inform recommendations on product design, replacement frequency, and distribution logistics. Ultimately, permethrin-treated baby wraps should be viewed not as a stand-alone intervention but as a complementary strategy within integrated malaria control programs. With appropriate investment in research, monitoring, and equitable distribution, this culturally embedded innovation has the potential to substantially reduce malaria transmission, enhance child survival, and bring the global health community closer to the long-term goal of malaria elimination.

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