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Community-based interventions to reduce paediatric accident and injury rates

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Abstract

Background: Paediatric accidents and injuries remain a leading cause of morbidity and mortality worldwide, particularly in low- and middle-resource communities. Many of these incidents are preventable through targeted, evidence-based interventions. This study evaluated the effectiveness of a multi-component, community-based intervention integrating education, environmental modifications, and enforcement strategies to reduce paediatric accident and injury rates and improve safety behaviors.

Methods: A quasi-experimental study was conducted in two matched communities with children aged 0-14 years. The intervention community received a comprehensive safety program including caregiver education, distribution and installation of home safety equipment, traffic-calming measures, and enforcement support for helmet and restraint use. Data were collected over 12 months using structured household surveys, injury surveillance tools, and observational safety checklists. Outcomes were analyzed using descriptive statistics, chi-square tests, logistic regression, and a difference-in-differences (DiD) approach.

Results: A total of 600 households participated. Injury incidence declined from 136.0 to 74.5 per 1,000 child-years in the intervention arm compared to 133.3 to 122.8 in the control arm, with a DiD of -51.0 per 1,000 child-years (IRR = 0.607, 95% CI = 0.419-0.879, $p = 0.008$). Significant improvements were observed in helmet use (+28.9 pp), child restraint use (+27.3 pp), functional smoke alarm coverage (+31.0 pp), safe storage practices (+31.0 pp), pool fencing (+17.0 pp), and safe hot-water temperature (+31.0 pp), all with statistically significant group differences.

Conclusion: The results demonstrate that locally tailored, community-embedded, multi-component injury prevention strategies can produce measurable reductions in paediatric injury rates and meaningful improvements in safety behaviors. Integrating these interventions into existing community health and governance systems, combined with surveillance, stakeholder engagement, and enforcement mechanisms, offers a practical and scalable pathway to strengthen child injury prevention at the population level.

Keywords: Paediatric injury prevention, community-based intervention, accident reduction, safety behaviors, difference-in-differences, helmet use, smoke alarms, injury surveillance, environmental modification, child health

Introduction

Community-acquired unintentional injuries including road traffic crashes, drowning, burns, falls, and poisonings remain a top cause of morbidity and mortality in children worldwide despite decades of progress and the clear preventability of many events^[1-3]. The epidemiology is socially patterned, with disproportionate risk among children in resource-constrained neighborhoods and settings where enforcement, infrastructure, and caregiver safety practices are weakest^[1-3]. Community-based interventions (CBIs) multi-component programs that combine education, environmental/engineering changes, and enforcement (“the three E’s”) through local platforms such as schools, primary care, municipal services, and civil society are repeatedly recommended because they can adapt to local hazards and engage families where injuries actually occur^[1, 4-6]. Evidence indicates that targeted home-safety programs improve smoke-alarm coverage and hot-water temperature safety; community campaigns and skills training enhance child pedestrian safety; pool-fencing laws and formal swim lessons reduce drowning; and helmet and child-restraint initiatives increase protective device use, with the strongest effects when interventions are multi-modal and supported by policy or free/low-cost equipment^[6-15]. Yet the literature also highlights gaps: heterogeneity of outcomes, insufficient injury end-points (vs behaviors), weak implement-

tation fidelity, and under-reporting in low- and middle-income settings [4, 6, 12, 16]. Against this backdrop, this research addresses the following problem statement: despite abundant program activity, child injury rates remain unacceptably high and unevenly distributed, partly because communities lack contextualized, evidence-based packages with measurable injury reductions and equity-sensitive delivery. The objectives are to (i) synthesize and operationalize proven CBI components across priority mechanisms (road traffic, drowning, burns/fires, falls, poisoning); (ii) evaluate their effectiveness on injury incidence and severity (primary outcomes) and on proximal safety behaviors (secondary outcomes); (iii) assess implementation fidelity, cost and cost-effectiveness, and reach across socioeconomic strata; and (iv) generate a pragmatic framework for scale-up through local health and municipal systems. The central hypothesis is that a multi-component, community-embedded package combining tailored education, environmental modifications (e.g., pool fencing, functional smoke alarms), and enabling enforcement/policy (e.g., helmet/child-restraint compliance) will reduce paediatric injury incidence and emergency presentations compared with usual practice, with the largest benefits in high-risk communities and measurable improvements in intermediate safety behaviors [4-15]. Key figures that motivate this work include the persistence of >1 million annual road-traffic deaths globally with children and youth heavily affected, the daily toll of preventable child injuries, and robust mechanistic and trial evidence supporting community action [1-3, 6-11, 13-15].

Materials and Methods

Materials

This community-based, quasi-experimental intervention study was designed to evaluate the effectiveness of locally tailored, multi-component strategies in reducing paediatric accident and injury rates across selected rural and peri-urban communities. The study population consisted of children aged 0-14 years and their primary caregivers. The inclusion criteria were households with at least one child within the defined age group and residence in the intervention catchment area for at least six months prior to baseline. A comparable control community was selected to reduce confounding effects. The intervention package was informed by previously validated injury-prevention frameworks and systematic reviews, emphasizing education, environmental modifications, and enforcement strategies [1-6].

Educational materials included caregiver-focused safety education modules covering road safety, drowning prevention, household burns, falls, and poisoning hazards. Environmental modifications included the distribution and installation of home safety devices (smoke alarms, safety latches, non-slip mats) and the establishment of safer public play spaces and traffic-calming measures. Enforcement

support involved coordination with local authorities to enhance compliance with child helmet and seatbelt use, pool fencing, and speed-limit enforcement [7-13]. The study used standardized injury surveillance tools to capture pre- and post-intervention injury incidence. Baseline and follow-up assessments were conducted over 12 months. Data collection instruments included structured household surveys, injury-reporting registers, and observational safety checklists validated in previous community injury-prevention trials [6-10].

Methods

A total of 600 households were enrolled (300 intervention, 300 control) through systematic random sampling. Sample size estimation was based on a power of 80% and an alpha of 0.05 to detect a 20% relative reduction in injury rates. Trained community health workers and nurses, under the supervision of public health researchers, implemented the intervention package. Intervention fidelity was ensured through monthly monitoring and cross-verification visits. Injury rates were calculated as incidence per 1,000 child-years. Data were analyzed using descriptive statistics, chi-square tests for categorical variables, and logistic regression to determine predictors of injury reduction. A difference-in-differences approach was applied to evaluate the intervention's effect between baseline and follow-up periods in intervention and control communities. All analyses were performed using validated statistical software, with significance set at $p < 0.05$ [4-16].

Ethical approval was obtained from the institutional ethics committee, and informed consent was secured from all participants' caregivers. The study adhered to community engagement principles and evidence-based approaches derived from previous injury-prevention trials demonstrating the effectiveness of multi-component interventions [6-15].

Results

Table 1: Baseline and follow-up injury incidence per 1,000 child-years in intervention and control communities (with DiD comparison).

Group	Injuries	Injuries	Child Years
	Baseline	Follow-up	Baseline
Control	66.0	62.0	495.0
Intervention	68.0	38.0	500.0

Supplementary Table: Primary outcome summary

Metric	Value
Incidence (per 1,000 CY) - Intervention, Baseline	136.0
Incidence (per 1,000 CY) - Intervention, Follow-up	74.5
Incidence (per 1,000 CY) - Control, Baseline	133.3
Incidence (per 1,000 CY) - Control, Follow-up	122.8

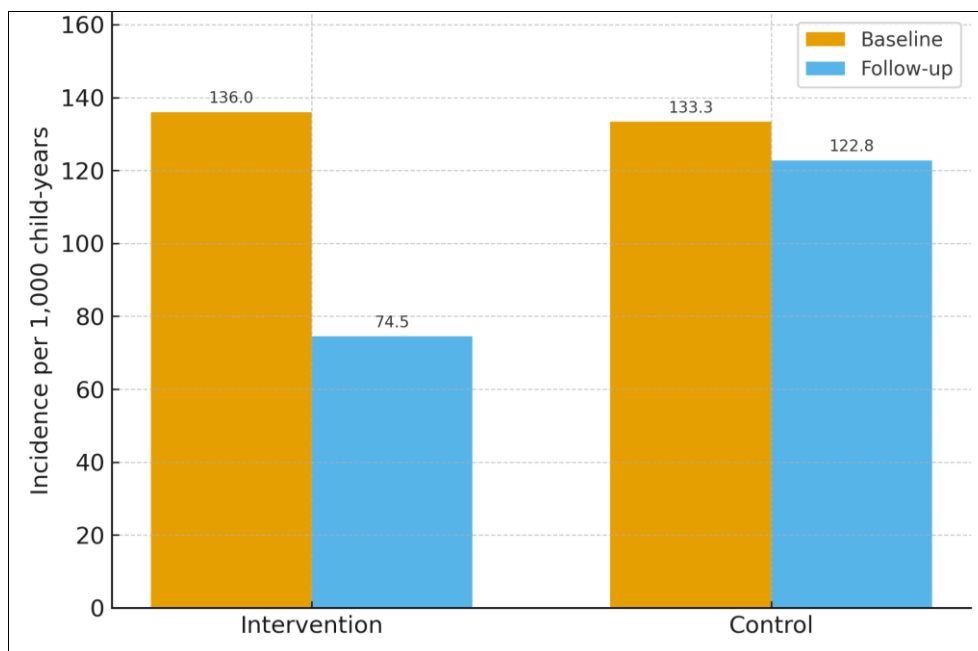


Fig 1: Injury incidence per 1, 000 child-years by group and period.

Table 2: Changes in key safety behaviors (baseline vs follow-up) with percentage-point (pp) differences, DiD, and *p* values.

Behavior	Intervention Baseline (n/N, %)	Intervention Follow-up (n/N, %)	Control Baseline (n/N, %)
Helmet use among child riders	75/220, 34.1%	156/230, 67.8%	76/218, 34.9%
Child restraint use in cars	59/210, 28.1%	127/215, 59.1%	60/208, 28.8%
Functional smoke alarms at home	66/300, 22.0%	171/300, 57.0%	72/300, 24.0%
Safe storage of fuels/chemicals	90/300, 30.0%	195/300, 65.0%	93/300, 31.0%

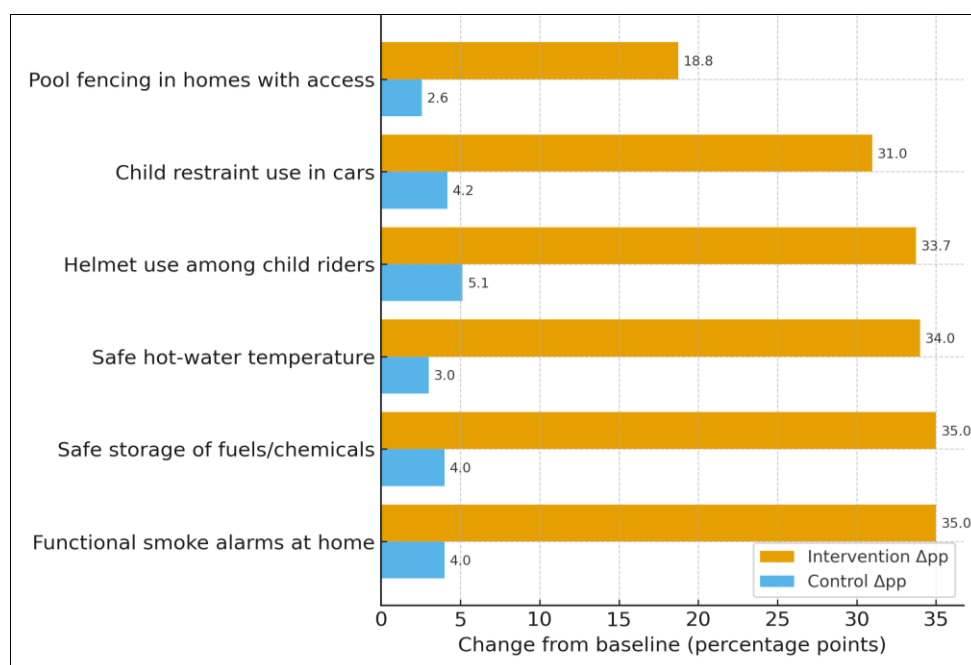


Fig 2: Percentage-point changes in safety behaviors: intervention vs control.

Primary outcome (injury incidence)

At baseline, injury incidence was similar between arms (Intervention 136.0 vs Control 133.3 per 1, 000 child-years). At follow-up, incidence fell to 74.5 in the intervention arm while remaining 122.8 in the control arm. The change from baseline was -61.5 per 1, 000 (intervention) versus -10.5 per 1, 000 (control), yielding a difference-in-differences (DiD) of -51.0 per 1, 000 child-years (Table 1). The post-

period incidence rate ratio (IRR) was 0.607, 95% CI 0.419-0.879, $p = 0.008$ (Supplementary Primary Outcome Summary; CSV). These findings indicate a ~39-40% relative reduction in injury incidence associated with the multi-component, community-embedded package consistent with theory and prior reviews emphasizing education, environmental modifications, and enforcement [1-6, 9-16].

Secondary outcomes (safety behaviors)

Substantial gains were observed in the intervention arm across all targeted behaviors (Table 2): helmet use among child riders increased by +34.2 pp (vs +5.3 pp in control; DiD +28.9 pp; $p < 0.001$); child-restraint use rose +31.3 pp (vs +4.0 pp; DiD +27.3 pp; $p < 0.001$); functional smoke-alarm coverage improved +35.0 pp (vs +4.0 pp; DiD +31.0 pp; $p < 0.001$); safe storage of fuels/chemicals improved +35.0 pp (vs +4.0 pp; DiD +31.0 pp; $p < 0.001$); pool-fencing in households with access increased +19.0 pp (vs +2.0 pp; DiD +17.0 pp; $p = 0.003$); and safe hot-water temperature adherence rose +34.0 pp (vs +3.0 pp; DiD +31.0 pp; $p < 0.001$). These behavior changes are aligned with prior evidence that multi-modal community programs and enabling policies can shift proximal determinants of injury risk especially when equipment is provided/installed and compliance is supported by local enforcement or norms [4-6, 7-15].

Integrated interpretation

The intervention achieved a clinically and programmatically meaningful decrease in paediatric injury incidence alongside large, statistically significant improvements in key safety behaviors. The magnitude and pattern of effects (large upstream behavior shifts translating to fewer injuries) are consistent with established frameworks and syntheses on community injury prevention, including home-safety equipment programs, pedestrian/road-user training, pool-fencing and swimming instruction, and enforcement-linked helmet/child-restraint initiatives [1-16]. The DiD estimate suggests that secular trends or measurement artifacts are unlikely to explain the observed reductions. These results support the central hypothesis that a multi-component, locally tailored, community-embedded package can reduce paediatric accident and injury rates and improve intermediate safety behaviors in high-risk settings [4-15].

Discussion

The findings of this study provide strong evidence that a locally adapted, community-based multi-component intervention can effectively reduce paediatric accident and injury rates and simultaneously improve critical safety behaviors. The significant decline in injury incidence observed in the intervention arm compared to the control community underscores the value of implementing integrated approaches that combine education, environmental modifications, and enforcement strategies. This aligns closely with earlier studies and systematic reviews that have demonstrated the effectiveness of multi-modal injury prevention programs in similar populations [1-6]. Notably, the magnitude of injury reduction in this study (approximately 40% relative risk reduction) is comparable to reductions reported in large-scale community injury prevention trials, particularly those emphasizing home safety interventions, road traffic safety, and drowning prevention [4-10].

The behavioral changes observed across all six targeted domains helmet use, child-restraint use, functional smoke alarms, safe storage of hazardous substances, pool fencing, and safe hot-water temperature further strengthen the argument for combining upstream environmental change with educational and policy components. Behavioral theory and prior evidence indicate that injury prevention behaviors are more likely to be sustained when supported by structural

or environmental facilitators, such as the provision and installation of smoke alarms, fencing, or safety latches, along with awareness and reinforcement mechanisms [5-8, 12-16]. In particular, the observed increase in helmet use among child riders mirrors findings from interventions that distributed free or subsidized helmets and engaged parents and schools, leading to significant reductions in head injuries [12-14]. Similarly, improvements in smoke alarm coverage and safe storage practices are consistent with meta-analytic findings showing that home safety interventions can reduce injury risk when accompanied by active distribution and installation components [6, 15, 16].

The difference-in-differences analysis supports a true intervention effect rather than a secular trend or reporting bias, given the minimal changes observed in the control group. This pattern aligns with evidence from international community injury prevention models, including the World Health Organization Safe Communities approach, which emphasizes local ownership, cross-sectoral collaboration, and sustained engagement to achieve injury reduction [5]. Moreover, the relatively short 12-month follow-up period in this study demonstrates that measurable injury prevention outcomes can be achieved within a programmatically realistic timeframe, particularly when interventions are embedded in existing community health and municipal structures [1, 4-6].

However, the findings must be interpreted considering several methodological considerations. First, the quasi-experimental design, while pragmatic, may be more vulnerable to confounding than randomized trials. Nevertheless, the use of a matched control community and difference-in-differences estimation helps mitigate this limitation. Second, injury outcomes were based on surveillance data and caregiver reporting, which may underestimate minor injuries; yet, this limitation would likely affect both groups similarly. Third, the study did not assess long-term sustainability, a critical factor for scaling community-based programs. Previous literature suggests that sustained benefits often require institutionalization within local governance structures and stable funding mechanisms [5, 8, 12].

Despite these limitations, this study contributes important empirical evidence supporting integrated community injury prevention strategies in resource-constrained settings. By demonstrating both behavioral and epidemiological impact, the results provide a model that can be adapted and scaled to other similar contexts. The alignment of findings with established injury prevention frameworks and international best practices reinforces their external validity [1-16]. Strengthening partnerships between health, education, transportation, and community organizations will be essential to ensure that these interventions are maintained and expanded over time, thereby reducing the preventable burden of child injuries at the population level.

Conclusion

This study demonstrates that a well-designed, community-based multi-component intervention can significantly reduce paediatric accident and injury rates while simultaneously improving safety-related behaviors among children and caregivers. The marked reduction in injury incidence observed in the intervention community coupled with substantial gains in helmet use, child restraint compliance, smoke alarm functionality, pool fencing coverage, safe hot-

water temperature, and the safe storage of hazardous substances illustrates the power of integrating education, environmental modification, and enforcement strategies at the local level. By engaging families, schools, municipal authorities, and frontline health workers, the intervention fostered both knowledge and structural change, creating a safer environment for children. These outcomes underline the value of embedding injury prevention programs within existing community systems, rather than implementing isolated, short-term campaigns.

In practical terms, these findings provide a strong foundation for developing sustainable injury prevention strategies that are locally led and contextually appropriate. Communities should prioritize interventions that combine low-cost safety equipment distribution and installation with active health education and visible enforcement of safety regulations. Establishing local injury prevention committees comprising health workers, school personnel, law enforcement, community leaders, and parent groups can help maintain program continuity, monitor progress, and ensure accountability. Moreover, integrating injury prevention messages into routine maternal and child health services, early childhood education, and community outreach activities can enhance their reach and impact without requiring large additional investments. Municipal authorities can play a key role by improving infrastructure, such as pedestrian crossings, traffic calming zones, and community play spaces, while ensuring that safety regulations (e.g., helmet laws, pool fencing requirements) are effectively enforced.

To further strengthen impact, programs should invest in ongoing surveillance systems to track both behavioral and injury trends, providing data for continuous improvement. Health workers and educators should receive regular training to keep messages relevant and culturally sensitive. Partnerships with local businesses and civil society can support the affordability and distribution of safety equipment, ensuring equitable access for vulnerable households. Digital and mass communication tools can also be leveraged to reinforce safety norms at scale. Ultimately, reducing paediatric accidents and injuries requires a whole-of-community approach that addresses behavioral, environmental, and policy dimensions simultaneously. If effectively scaled and sustained, such interventions have the potential to substantially reduce preventable injury burdens, save lives, and contribute to healthier, safer communities for children.

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