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Building Safer Workplaces: Effectiveness of Ergonomics Education on Occupational Health and Safety Knowledge among Construction Workers

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Abstract

Background: Construction work involves heavy lifting, repetitive movements and awkward postures that increase the risk of musculoskeletal disorders. Evidence on the effect of ergonomics education on occupational health and safety knowledge among construction workers in Harohalli, South Bengaluru, is limited. This study aimed to assess the effect of an ergonomics education programme on occupational health and safety knowledge among construction workers. **Methods:** A one-group pretest–posttest study design (no control group) was conducted among 65 construction workers selected by purposive sampling in Harohalli. Data were collected using a researcher-developed demographic proforma (11 items) and a 35-item knowledge questionnaire covering occupational hazards, personal protective equipment, safe lifting techniques and first aid. The post-test was administered on day 14. Data were analysed using descriptive statistics, paired t-test and Fisher–Freeman–Halton exact test ($p<0.05$). **Results:** At pretest, 67.7% of workers had average knowledge (mean score 16.54±3.19 out of 35). At post-test, 98.5% had good knowledge (mean 25.14±1.48); the mean difference was 8.60 (95% CI 7.73–9.47; $t=19.79$, $df=64$, $p<0.001$; Cohen's $dz=2.45$). Pre-test knowledge level was significantly associated with age, educational status, regarding occupational health hazards, and daily working hours **Conclusion:** Knowledge scores increased significantly immediately after the ergonomics education programme. Because there was no control group and follow-up was short, causality, retention of knowledge and changes in practice cannot be established. Controlled studies with longer follow-up are warranted.

Major Findings: The ergonomics education programme substantially improved construction workers' occupational health and safety knowledge, with the majority achieving a good level of knowledge at post-test. Pre-test knowledge levels were significantly associated with selected sociodemographic and occupational variables, including age, educational status, awareness regarding occupational health hazards, and daily working hours

Keywords: Construction Workers, Ergonomics, Experimental Study, Knowledge, Musculoskeletal Disorders, Occupational Health

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1. Introduction

Construction sector plays an important role in global urbanization and economic development; however, it remains one of the most hazardous sectors worldwide. Unlike, manufacturing in regulated, controlled environments, the construction sector is dynamic and uncertain. Workers face variable environmental conditions and are subject to the regular movement of large equipment and materials[1]. Constant exposure to such stressors increases the possibility of workers experiencing work-related illnesses/injuries that may result in chronic disability[2].

Work-Related Musculoskeletal Disorders (WMSDs) are among the most common occupational health problems in construction. These disorders develop progressively over time as a result of repeated manual handling, maintaining non-neutral body positions, and constantly extending the arms overhead. Therefore, many employees may sustain considerable damage to their muscles/tendons/vertebrae before the onset of symptoms[3].

Ergonomics can be defined as designing the work environment/equipment/workflow based on the physiological requirements of individual workers to offer a systematic way to reduce risk, alongside improving productivity[4]. However, the execution of ergonomic norms in developing countries appears to lag behind that in developed countries. Reported reasons for these differences include a lack of health literacy, weak enforcement of worker safety laws and lower health awareness among labourers[5].

Recent research studies in India show the magnitude of WMSDs, with some reports suggesting that more than 70% of the construction workers suffer from these disorders[6]. In India, the high prevalence of WMSDs among workers is mainly attributed to the physical stress among workers due to manual labour and inefficient organisational control[6]. Moreover, cross-sectional studies on construction workers indicate that more than 50% of them exhibit active musculoskeletal symptoms, especially in the spine region and lower limbs[7]. Community-based studies conducted in South India show that nearly 34% of construction workers suffer from musculoskeletal problems, particularly in the lower back/wrist/shoulders; daily wage workers are more frequently at greater risk[8].

Limited knowledge and awareness are important contributors to these physiological burdens. Chellappa[9] reported that the dangers of ergonomics are habitually overlooked when it comes to technical instruction in relation to other safety issues. Although most workers accept the issue of sudden muscle strain, few of them understand how constantly poor posture leads to the development of increasing trauma[10]. In the absence of well-established institutional protocols, musculoskeletal distress is generally considered an inevitable outcome of manual labour; Jaffar *et al.*[3] suggested that this significant psychological barrier to occupational health is related to poor attitudes among workers. However, well-designed training programmes may be effective in overcoming these deficits. Raharjo[11] reported that participatory ergonomic methods among staff members and identifying work-related hazards can reduce musculoskeletal pain and fatigue. Additionally, combined approaches like both physical and behavioural modifications are reported to be more sustainable/effective than isolated ones[12].

Harohalli is located in the south of Bengaluru and is home to a large number of migrant construction workers who generally have limited access to formal occupational health programmes. In major urban centres, big companies usually use mechanical aids and develop formal safety procedures; but in peri-urban settings such as Harohalli, companies may not consistently implement protective regulations, thus making the labourers depend on traditional practices which may offer little protection. Taking all this information into account, only a limited number of studies look at the ergonomic literacy/educational accessibility for the construction workers from the informal sectors in developing countries. Therefore, the present study aimed to assess the effect of an ergonomics education programme on occupational health and safety knowledge among construction workers in Harohalli.

2. Materials and Methods

2.1 Study Design and Setting

A quantitative one-group pre-test–post-test study design (without a control group) was used at selected construction sites at Harohalli, Bengaluru South, India. The study was conducted at GINA engineering company, Harohalli

2.2 Study Participants

The target population was adult construction workers currently working at selected sites in Harohalli, with

at least six months of experience in the occupation. Workers who could not speak English, Kannada or Hindi were excluded. The target population comprised adult construction workers employed at selected construction sites in Harohalli, Bengaluru South, who had at least six months of occupational experience. Workers who were unable to communicate in either Kannada or English or Hindi were excluded because the study information, informed consent process, structured knowledge questionnaire, and ergonomics education programme were administered in these languages. This criterion was intended to ensure that participants could understand the study objectives, provide informed consent, comprehend the questionnaire items, and engage meaningfully with the educational intervention.

2.3 Sample Size and Sampling Technique

A purposive sampling technique was used to recruit 65 adult construction workers from selected construction sites in Harohalli, Bengaluru South, Karnataka, India. The sites were selected based on their suitability for the study and access to eligible construction workers. The researchers approached workers who met the eligibility criteria, explained the purpose and procedures of the study, and invited them to participate voluntarily after obtaining informed consent. The sample size was evaluated using the paired-samples design, considering a two-sided significance level of 5% and statistical power of 80%. The final analysed sample included 65 participants. A total of 85 construction workers were assessed for eligibility. Of these, 75 were invited to participate based on the inclusion criteria. Five workers declined participation, and the remaining 70 participants were enrolled in the study. During the study period, five participants withdrew from participation. Consequently, 65 participants completed both pre-test and post-test assessments and were included in the final analysis.

2.4 Tools

The data collection was done using a two-part investigator-designed instrument after a thorough literature review and consultations with experts. Part A was a 11-item demographic questionnaire containing age, gender, marital status, educational status, type of work, family monthly income, years of work experience, daily work hours, previous occupational safety training, type of family and area of residence. Part B was a 35-item structured multiple-choice questionnaire containing questions on occupational hazards, personal protective equipment, occupational safety, prevention of accidents and electrical hazards, dust and noise, musculoskeletal disorders and ergonomics, proper lifting, stretching exercises, first aid, emergency preparedness and prevention of heat stress. Each correct answer scored 1 (wrong answers scored 0) ranging from 0 to 35, which was interpreted as very poor (0-7), poor (8-14), average (15-21), good (22-28) and very good (29-35). Thus, the questionnaire measures general occupational health and safety knowledge, of which ergonomics (musculoskeletal disorders, proper lifting and stretching exercises) is one domain; the primary outcome is therefore occupational health and safety knowledge rather than ergonomics knowledge alone.

The structured knowledge questionnaire was validated by a panel of seven experts with qualifications and experience in community health nursing, occupational health, ergonomics and research methodology. The experts assessed the questionnaire items for relevance, clarity, and appropriateness. The Content Validity Index (CVI) was reported as 0.714, based on the item-level CVI (I-CVI). The questionnaire was translated into Kannada and re-translated back to English. and questionnaire was translated into Hindi and re-translated back to English to assess consistency of meaning. Based on the experts' feedback, the questionnaire was reviewed for clarity, relevance, appropriateness, and comprehensiveness. Suggested revisions included simplifying technical terminology related to ergonomics and occupational health, rephrasing ambiguous questions, reviewing multiple-choice response options, and ensuring adequate coverage of key areas such as ergonomic hazards, safe lifting techniques, proper posture, personal protective equipment, and injury prevention.

Reliability was assessed through pilot testing among 10 construction workers who were not included in the main study sample. The internal consistency of the knowledge questionnaire was evaluated using the Kuder–Richardson Formula 20 (KR-20), yielding a reliability coefficient of 0.80, indicating acceptable internal consistency for the study instrument[13].

2.5 Data Collection Procedure

After obtaining the necessary administrative approval, the study objectives and procedures were explained to the

eligible construction workers, and informed consent was obtained. A pre-test was administered on Day 1 using a structured knowledge questionnaire to assess the participants' baseline knowledge regarding occupational health hazards and ergonomics. Subsequently, the participants received a structured ergonomics education programme over a two-week period. The programme consisted of 3 sessions each lasting approximately 30 minutes, delivered through lecture, interactive discussion, demonstration. The training was conducted in Kannada or English or Hindi using posters, charts, handouts, presentations.

The educational content covered correct body mechanics, proper manual lifting techniques, safe working postures, ergonomic risk reduction, and measures to prevent work-related musculoskeletal injuries. Practical demonstrations were conducted to illustrate appropriate lifting methods and correct postural techniques. Safety precautions were emphasized during the demonstrations, including avoiding excessive loads, maintaining proper body alignment, and using safe lifting techniques to minimize the risk of injury. The programme was delivered by the researcher using a structured teaching plan. Participant attendance was recorded throughout the programme. Intervention fidelity was maintained by following a standardised lesson plan and using consistent teaching materials to ensure uniform delivery of the educational content to all participant

On Day 14, a post-test was administered using the same structured knowledge questionnaire to assess changes in participants' knowledge following the educational intervention.

2.6 Data Analysis

Data were analysed using (SPSS-Version 32) both descriptive and inferential statistics where descriptive statistics entailed frequency, percentage, mean, and standard deviation while the inferential statistic included paired t-test used for comparing pretest knowledge with post-test knowledge score as well as Fisher–Freeman–Halton exact test for determining the relationship between pretest knowledge and socio-demographic variables. The mean difference with its 95% confidence interval and the standardised effect size (Cohen's dz)[14] is reported. The level of significance was set at $p<0.05$.

2.7 Ethical Approval

Administrative permission to conduct the study at the selected construction sites was obtained from GINA engineering company, Harohalli before initiating data collection. Ethical approval was obtained from the Institutional Ethics Committee/Institutional Review Board of College of Nursing, Dayananda Sagar University (DSU/NSG/235/2026 dated 22/07/2026) before data collection.

Participation in the study was entirely voluntary. The purpose, objectives, procedures, and expected duration of the study were explained to the participants in a language they could understand. Informed written consent was obtained from each participant before administering the questionnaire. Participants were informed that they had the right to refuse participation or withdraw from the study at any time without providing a reason and

Table 1. Socio-demographic characteristics of construction workers (N = 65)

Variable	Category	f	%
Age (years)	30–40	44	67.69
	41–55	14	21.54
	56–65	7	10.77
	Above 65	0	0.00
Gender	Male	53	81.54
	Female	12	18.46
Marital status	Single	6	9.23
	Married	59	90.77
Educational status	Illiterate	20	30.77
	Primary school	13	20.00
	Secondary school	32	49.23
Type of work	Mason	8	12.31
	Carpenter	25	38.46
	Electrician	12	18.46
	Helper/labourer	20	30.77
Monthly family income (₹)	10,001–20,000	22	33.85
	20,001–30,000	37	56.92
	Above 30,000	6	9.23
Years of work experience	1–5 years	32	49.23
	6–10 years	33	50.77
Working hours per day	8 hours	21	32.31
	9–10 hours	26	40.00
	More than 10 hours	18	27.69
Prior occupational safety training	Yes	45	69.23
	No	20	30.77
Type of family	Joint family	12	18.46
	Nuclear family	53	81.54
Area of residence	Urban	25	38.46
	Rural	40	61.54

The majority of participants were aged 30–40 years (67.69%), male (81.54%), and married (90.77%) (Table 1). Nearly half of the participants had completed secondary school education (49.23%). Carpenters constituted the largest occupational group (38.46%), followed by helpers/labourers (30.77%).

without any adverse consequences for their employment or workplace relationships. Participation or refusal to participate did not influence their employment status or relationship with the construction site management.

No personally identifying information was collected from the participants. Confidentiality and anonymity were maintained throughout the study. Completed questionnaires and electronic research data were stored securely, with access restricted to the authorized research team. Electronic files were password-protected, and research data were used exclusively for academic and research purposes. The findings were reported in aggregate form to prevent the identification of individual participants.

3. Result and Discussion

3.1 Socio-Demographic Characteristics

Most participants reported a monthly family income of ₹20,001–₹30,000 (56.92%). The majority belonged to nuclear families (81.54%) and resided in rural areas (61.54%). Slightly more than two-thirds (69.23%) reported having previously participated in occupational safety training programmes. Most participants worked for nine to ten hours per day (40.00%).

3.2 Effectiveness of the Ergonomics Education Programme

The majority of workers (67.7%, n = 44) demonstrated an average level of knowledge, with scores 15-21 (Figure 1). Sixteen workers (24.6%) were classified as having poor knowledge (scores 8-14), and only five (7.7%) achieved good knowledge (scores 22-28). No participant fell into either the very poor or the very good category. The mean pre-test knowledge score was 16.54 (SD = 3.19), with a median of 17 and an observed range of 11 to 23.

After the two-week ergonomics education programme, knowledge scores rose markedly. Nearly all workers (98.5%, n = 64) reached the good knowledge category, and only one worker (1.5%) remained at the average level. No participant fell into the poor, very poor, or very good categories at post-test.

The mean knowledge score increased from 16.54 (SD = 3.19) before the intervention to 25.14 (SD = 1.48) after the intervention, representing an increase of 8.60 points (95% CI 7.73–9.47) (Table 2). The increase was statistically significant according to the paired t-test ($t = 19.79$; $df = 64$; $p < 0.001$), with a large standardised effect (Cohen's $dz = 2.45$). This indicates a significant improvement in knowledge scores from pre-test to post-test; however, as

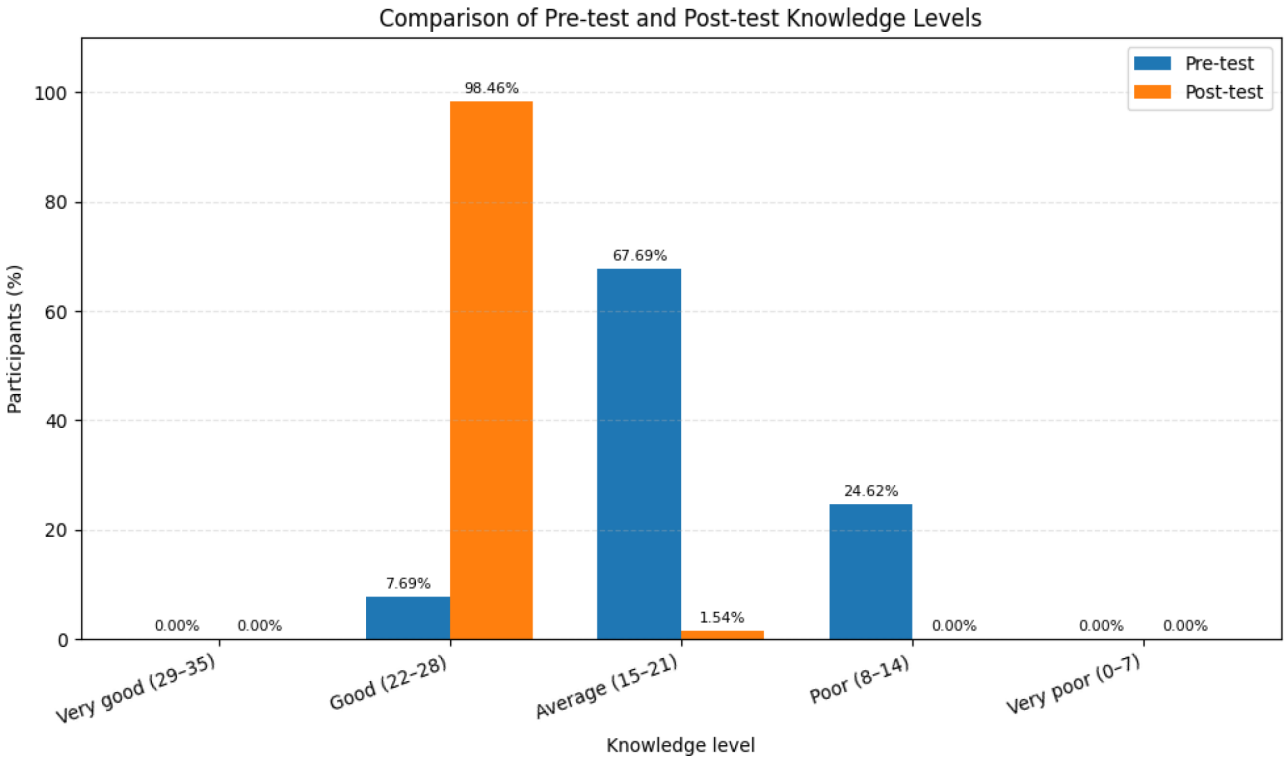


Figure 1. Distribution of pre-test and post-test knowledge levels (N = 65)

Table 2. Comparison of mean pre-test and post-test knowledge scores (N = 65)

Assessment	Mean	SD	t	df	p
Pre-test	16.54	3.19	19.79	64	<0.001*
Post-test	25.14	1.48			

*Significant at $p < 0.001$; paired t-test. SD: standard deviation; df: degrees of freedom. Mean difference = 8.60 (95% CI 7.73–9.47); Cohen's dz = 2.45

Table 3. Association between pre-test knowledge level and selected socio-demographic variables (N = 65)

Socio-demographic variable	χ^2	df	p-value*
Age	22.150	4	<0.001 (S)
Gender	2.042	2	0.506 (NS)
Marital status	3.155	2	0.275 (NS)
Educational status	8.550	4	0.044 (S)
Type of work	3.550	6	0.861 (NS)
Monthly family income	9.139	4	0.068 (NS)
Years of work experience	1.549	2	0.559 (NS)
Prior occupational safety training	0.793	2	0.610 (NS)
Type of family	1.589	2	0.586 (NS)
Area of residence	1.068	2	0.650 (NS)
Working hours per day	12.560	4	0.005 (S)

*p-values from the two-sided Fisher–Freeman–Halton exact test (Fisher's exact test for r × c tables), used because most cells had expected counts below 5; Pearson χ^2 is shown for reference. S: significant ($p < 0.05$); NS: not significant ($p > 0.05$); df: degrees of freedom.

there was no control group, the improvement cannot be attributed solely to the ergonomics education programme.

3.3 Association between Pre-Test Knowledge and Socio-Demographic Variables

The association between pre-test knowledge levels (poor, average, and good) and socio-demographic variables was assessed using the Fisher–Freeman–Halton exact test, owing to the presence of low expected cell frequencies. Statistically significant associations were observed between pre-test knowledge level and age ($p < 0.001$), educational status ($p = 0.044$), and daily working hours ($p = 0.005$). No statistically significant associations were identified with gender ($p = 0.506$), marital status ($p = 0.275$), type of work ($p = 0.861$), monthly family income ($p = 0.068$), years of work experience ($p = 0.559$), previous occupational safety training ($p = 0.610$), type of family ($p = 0.586$), or area of residence ($p = 0.650$). These findings indicate that baseline knowledge of occupational health hazards was significantly associated with selected socio-demographic characteristics.

3.4 Discussion

The present study demonstrated that construction workers in Harohalli had only an average level of baseline knowledge regarding occupational health hazards and that a short, structured ergonomics education programme was associated with a substantial and statistically significant improvement in knowledge within two weeks; the one-group design, however, limits causal interpretation.

These findings are consistent with previous studies evaluating ergonomic education among manual labor populations. Kart[15] utilized a quasi-experimental pre-test post-test control-group design among manual material handlers and demonstrated that interactive training combining on-site practical instruction with simple pictorial aids resulted in a considerable increase in ergonomic knowledge and a reduction in low back pain among participants. Similarly, Murugan *et al.*[16] reported that educational interventions accompanied by basic ergonomic aids significantly improved musculoskeletal outcomes and reduced work-related fatigue.

Alghadir and Anwer[17] demonstrated that brief educational demonstrations regarding appropriate lifting posture, combined with compulsory micro-rest periods, improved posture and reduced fatigue among construction workers. The degree of improvement observed in the present study, with mean knowledge scores increasing from 16.54 to 25.14 out of 35, is also consistent with systematic review evidence indicating that multi-component ergonomic interventions combining physical and educational components are more effective than single-strategy approaches[12]. Similarly, meta-analytic evidence has demonstrated that structured ergonomic interventions can produce statistically significant benefits across different body regions, rather than only the lower back[18].

The participatory and practical nature of the present intervention may also have contributed to

its effectiveness. Raharjo[11] found that direct worker participation in identifying hazards and developing interventions not only improved musculoskeletal outcomes but also promoted a sense of ownership that supported continued behavioural change. A similar mechanism may have occurred among the construction workers in Harohalli, many of whom may have previously considered physical strain an inevitable component of manual labor. This observation is consistent with the fatalistic attitudes toward occupational pain described by Jaffar *et al.*[3]

A further finding of the present study was that baseline knowledge was significantly associated with age, educational status, regarding occupational health hazards, and daily working hours. However, no statistically significant associations were observed with gender, marital status, type of work, monthly family income, years of work experience, previous occupational safety training, type of family, or area of residence. This finding also supports the suggestion by Matete[19] that a practical combination of low-cost tools and targeted ergonomic education may represent a viable approach to reaching informal-sector workers who otherwise have limited access to structured occupational health resources.

However, the limited follow-up period means that the present study assessed immediate knowledge acquisition rather than sustained changes in workplace behavior. Hilmi and Hamid[10] reported that although many workers could recognize muscular strain when it occurred, few understood how persistent poor posture could contribute to chronic cumulative injury. Similarly, Silverstein and Welp[20] emphasized that knowledge gains may be short-lived unless workers' misconceptions regarding physical limitations are also addressed.

Collectively, these findings reinforce a consistent message within the ergonomics literature: informal-sector construction workers are capable of acquiring new knowledge but often lack access to structured and practical occupational safety training. A brief ergonomics education programme appears to be a promising means of addressing a substantial portion of the knowledge gap identified at baseline in the present study. If confirmed in controlled studies, similar interventions incorporated into routine community and occupational health nursing practice may represent a viable and scalable strategy for enhancing safety awareness among semi-urban and unorganized construction workforces.

3.5 Limitations

This study had several limitations.

- It was conducted in a single geographical location using a purposively selected sample, which may limit the generalizability of the findings to construction workers in other settings.
- The study assessed knowledge rather than clinical, behavioural, or biomechanical outcomes.
- The follow-up period was limited to 14 days, and therefore long-term knowledge retention and sustained behavioural changes could not be assessed.
- The one-group pre-test–post-test design had no control group, so changes cannot be causally attributed to the intervention; history, maturation and testing effects may have contributed.
- The same instrument was used at pretest and post-test, which may have produced a testing (recall) effect, and responses may have been affected by social desirability bias.
- The questionnaire was researcher-developed, and it measured general occupational health and safety knowledge rather than ergonomics knowledge alone.

Consequently, the findings should be interpreted primarily as evidence of short-term improvement in occupational health knowledge rather than evidence of sustained changes in workplace practices or reductions in musculoskeletal injuries.

4. Conclusion

Construction workers in Harohalli, Bengaluru South, demonstrated a substantial and statistically significant improvement in knowledge of occupational health hazards following a brief, structured ergonomics education programme. The mean knowledge score increased from 16.54 to 25.14, with a statistically significant paired t-test result ($t = 19.79$; $df = 64$; $p < 0.001$).

The baseline knowledge was significantly associated with age, educational status, regarding occupational health hazards, and daily working hours. However, no statistically significant associations were observed with gender, marital status, type of work, monthly family income, years of work experience, previous occupational safety training, type of family, or area of residence. Given the one-group design, the increase in knowledge cannot be attributed solely to the intervention. These findings

suggest that brief, site-based ergonomic education may be a practical strategy for community and occupational health nurses seeking to enhance safety awareness among informal-sector construction workers.

Further controlled and longitudinal research is recommended to determine whether improvements in knowledge translate into sustained changes in workplace practices and reductions in work-related musculoskeletal injuries over time.

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Conflicts of interest: The authors declare that they have no competing interests.

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Author Contribution

Ravi Kulal- Contributed to conceptualization, methodology, supervision, and writing—review and editing. Ramesh S- Contributed to writing—review and editing. Chekka Shaik Maseera, Chunnu Kumar, Devaraj TS, and Darshan CS- contributed to investigation, data curation, formal analysis, and writing—original draft preparation. All authors have read and agreed to the published version of the manuscript.

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