

Identification of Ergonomic Hazards among House Construction Workers Using- The PLIBEL Method

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Abstract

Construction workers are highly vulnerable to work-related musculoskeletal disorders (WMSDs) due to repetitive tasks, awkward postures, and manual material handling. A cross-sectional study was conducted among 30 house construction workers in Hisar, Haryana. Data were collected using a structured questionnaire and the PLIBEL checklist. The findings revealed that neck bending greater than 30°, squatting posture, and poor footing or unstable surfaces were the most prevalent ergonomic risk factors, each affecting 76.70% of the respondents. Upper back pain and hip/thigh pain were the most frequently reported musculoskeletal complaints (76.70% each), followed by elbow pain and wrist/hand pain (73.30% each). The majority of workers (80.00%) were involved in manual lifting activities, and 56.67% had experienced occupational injuries during the previous 12 months. Correlation analysis showed no significant relationship between total PLIBEL scores and age or work experience. House construction workers face substantial ergonomic hazards and musculoskeletal problems, emphasizing the need for ergonomic interventions, worker training, and regular health surveillance.

Keywords: PLIBEL method, ergonomic hazards, construction workers, musculoskeletal disorders, occupational health.

1. Introduction

The construction industry is one of the most labor-intensive and physically demanding sectors in the world. In India, the construction sector employs approximately 51 million workers, constituting the second-largest employer after agriculture (Ministry of Labour & Employment, 2022). Workers in this industry are routinely exposed to a wide range of occupational hazards-physical, chemical, biological, and psychosocial-making them particularly susceptible to occupational injuries and diseases.

Among these hazards, ergonomic risks are of paramount importance. Work-related musculoskeletal disorders (WMSDs) are the most prevalent occupational health problem globally, accounting for approximately 37% of all back pain and 16% of hearing loss attributable to occupational exposures (World Health Organization, 2021). Construction workers, specifically those engaged in house construction, are exposed to ergonomic stressors daily: manual handling of heavy materials such as bricks, sand, and cement bags; awkward, prolonged postures during masonry, plastering, and carpentry; repetitive upper limb movements; and work at heights or confined spaces.

Haryana, an economically developing state in northern India, is witnessing rapid urbanization, with construction activity expanding significantly in cities such as Hisar, Rohtak, and Gurugram. Despite this growth, occupational health services for unorganized construction labourers remain largely inadequate. Most workers in Hisar are daily-wage migrants or semi-skilled local laborers who lack access to health screenings, ergonomic assessments, or protective interventions.

Ergonomic risk assessment tools provide a systematic, structured means of identifying and quantifying hazardous work exposures before they manifest as injury or chronic disease. Several validated tools exist-RULA (Rapid Upper Limb Assessment), REBA (Rapid Entire Body Assessment), OWAS (Ovako Working posture Analysing System), and PLIBEL—each with specific strengths and target populations.

The PLIBEL method (Planering av Lämpliga Belastningsergonomiska åtgärder, or 'Checklist for the Identification and Analysis of Ergonomic Risks') was developed by Kemmlert (1995) in Sweden. It is a comprehensive, validated ergonomic screening tool designed to assess musculoskeletal risk factors across five body regions and linked to fourteen categories of potentially hazardous physical conditions. PLIBEL is particularly suitable for field-level assessments in developing-country contexts because it requires no specialized equipment, can be administered by trained public health personnel, and covers a broad spectrum of ergonomic risk factors relevant to manual trades.

Despite the growing recognition of ergonomic hazards in Indian construction, quantitative PLIBEL-based studies targeting house construction workers in semi-urban Haryana are absent from the published literature. This study therefore aimed to apply the PLIBEL method to systematically identify and characterize ergonomic hazards among house construction workers in Hisar, Haryana, and to describe the pattern of risk across body regions and demographic subgroups.

2. Objectives

- To assess ergonomic risk factors among house construction workers in Hisar, Haryana using the PLIBEL method.
- To identify the body regions most frequently exposed to ergonomic hazards in this population.
- To study the relationship between PLIBEL scores and age and work experience of house construction workers.

3. Review of literature

Thakurta and Iqbal (2021) conducted a study among ageing construction workers in Mumbai, India, to evaluate occupational health risks and musculoskeletal disorders. And found that more than 60 per cent of workers were exposed to repetitive lifting and manual material handling, while approximately 55 per cent reported working in awkward postures for prolonged periods. Lower back pain was reported by 68 per cent of respondents, followed by knee pain (54%) and shoulder pain (47%). Also concluded that heavy physical workload and poor ergonomic practices significantly increased the risk of musculoskeletal disorders among construction workers.

Kemmlert (1995) developed the PLIBEL method for the identification and analysis of ergonomic hazards associated with musculoskeletal disorders in occupational settings. Repetitive work, prolonged static postures, awkward body positions, heavy lifting, and inadequate recovery periods were identified as major ergonomic risk factors contributing to work-related musculoskeletal disorders. The PLIBEL checklist demonstrated its usefulness as a practical screening tool for detecting workplace ergonomic hazards and facilitating preventive interventions in physically demanding occupations.

Gajbhiye et al. (2023) investigated work-related musculoskeletal disorders among 465 Indian construction workers. Reported that the lower back was the most affected body region (72.90%), followed by the shoulders (49.68%), arms/hands (47.31%), wrists (30.75%), neck (24.09%), and knees (16.13%). And observed that workers exposed to awkward postures and repetitive movements had significantly higher prevalence of musculoskeletal symptoms.

Umer et al. (2018) conducted a systematic review and meta-analysis on musculoskeletal disorders among construction workers. Lower back pain emerged as the most prevalent musculoskeletal complaint, with reported prevalence ranging from 50 to 80 per cent across the included studies. Knee, shoulder, and neck disorders were also frequently reported among construction workers. Repetitive manual material handling, prolonged standing, and awkward working postures were recognized as major occupational risk factors contributing to musculoskeletal disorders, particularly in the lower back, knees, shoulders, and neck regions.

Reddy et al. (2016) conducted a community-based cross-sectional study among 308 construction workers in Chennai to assess musculoskeletal morbidity and associated occupational factors. Musculoskeletal disorders were reported by 33.8 per cent of the workers. A progressive increase in musculoskeletal complaints was observed with advancing age, longer duration of employment, and extended daily working hours. Workers above 40 years of age experienced a higher prevalence of lower back and shoulder pain compared to younger workers, indicating the influence of cumulative occupational exposure on musculoskeletal health.

Holmström and Engholm (2003) examined musculoskeletal disorders among 85,191 Swedish construction workers across different occupational trades. Higher prevalence of lower back, neck, shoulder, and knee disorders was observed among workers engaged in physically demanding construction activities. The occurrence of musculoskeletal disorders increased with age and years of employment, suggesting a cumulative effect of long-term biomechanical loading.

Construction workers involved in manual trades experienced considerably greater musculoskeletal morbidity than those employed in supervisory or administrative occupations.

3. MATERIALS AND METHODS

3.1 Area of Study

The present study was conducted to assess ergonomic hazards among workers engaged in house construction work using a descriptive observational research design. The study was carried out in selected village areas of Hisar district, Haryana, where active house construction work was in progress during the period of investigation. The selected worksites included both single-storey and double-storey houses under construction, where workers were engaged in routine manual activities such as brick carrying, brick laying, cement mixing, plastering, sand transportation, loading and unloading of construction materials, and stair climbing while carrying loads. These sites were purposively selected because they provided a natural occupational setting involving repetitive movements, awkward body postures, prolonged standing, forceful exertion, and manual material handling, all of which are recognized as important ergonomic risk factors among construction workers (Schneider, 2001; Mohan & Patel, 1992). “Similar occupational settings and observational ergonomic assessment procedures have been reported in earlier studies by Yadav (2020) among construction workers, Sangma (2020) while assessing workers engaged in ironing activity, Kumari (2017) in ergonomic assessment of institutional environments, Chahal and Mehta (2021) in human factors and workplace assessment, and Rani and Chahal (2024) in ergonomic risk assessment using standardized observational tools.



3.2 Selection of Respondents

A total of 30 construction workers both male and female engaged in house construction activities were selected purposively for the present investigation. Purposive sampling was adopted because only those respondents were included who were directly involved in physically demanding manual work at the selected sites. Workers performing supervisory duties or those not engaged in physical labour were excluded from the study. The selected respondents had a minimum of one-year work experience and were actively involved in tasks such as lifting, carrying, bending, squatting, plastering, and repetitive handling of construction materials. The respondents belonged to the age group of 22 to 55 years, with an average age of 36 years. Most respondents reported working approximately 8 to 10 hours daily, primarily under outdoor environmental conditions, exposing them to continuous physical workload and environmental stress (Punnett & Wegman, 2004; Yadav et al., 2020).

Before initiating the study, rapport was developed with the respondents through informal interaction at the worksite. The purpose and importance of the study were explained in simple language to ensure voluntary participation and cooperation. Respondents were assured that the information collected would remain confidential and would be used strictly for academic purposes, which helped in maintaining natural work behaviour during observation (Kothari, 2004).



3.3 Tools and Data Collection

The major tool used for data collection was the PLIBEL checklist (Plan för Identifiering av Belastningsfaktorer) developed by Kemmlert (1995). The PLIBEL checklist is a standardized ergonomic assessment tool widely used for identifying work-related musculoskeletal and postural hazards. It was selected for the present study because it enables systematic assessment of ergonomic risks related to awkward postures, repetitive movements, forceful exertion, lifting and carrying loads, and workplace environmental conditions. The checklist specifically evaluates stress on different body regions including neck, shoulders, upper and lower back, arms and hands, legs, and feet, along with work-related movements and load handling (Kemmlert, 1995). The PLIBEL checklist used in the present study consisted of 22 items covering different ergonomic risk factors related to awkward postures, repetitive movements, manual material handling, and physical workload. Each item was assessed on a dichotomous scale, where the presence of a risk factor was assigned a score of '1' (Yes) and its absence was assigned a score of '0' (No). The scores obtained for all 22 items were summed to obtain the total PLIBEL score for each respondent.

Thus, the minimum possible PLIBEL score was 0, indicating no exposure to ergonomic risk factors, whereas the maximum possible score was 22, indicating exposure to all the identified ergonomic hazards. Higher PLIBEL scores represented greater exposure to ergonomic risk factors and consequently a higher likelihood of developing musculoskeletal problems.

In addition to the PLIBEL checklist, a structured observation schedule was developed by the investigator to record supplementary field-level information related to the respondents and worksite conditions. This schedule included details such as age, work experience, duration of work, type of activity performed, and average load carried by workers, which ranged approximately from 20 to 50 kilograms, depending on the nature of work such as carrying bricks, cement bags, or sand containers. Information regarding work-rest schedule was also recorded, including total working hours, tea breaks, lunch breaks, and short pauses taken during work. It was observed that most workers took one tea break of about 10–15 minutes, one lunch break of approximately 30–40 minutes, and occasional short rest pauses depending upon workload. Recording these details was important because inadequate rest and prolonged work duration contribute significantly to muscular fatigue and ergonomic strain (Grandjean & Kroemer, 2007).

The observation schedule further included recording of presence and absence during work, particularly whether workers had missed work due to pain, injury, or illness related to occupational strain. In addition, visible health indicators such as cuts, abrasions, calluses on hands, swelling in feet, cracked heels, limping, signs of muscular fatigue, and visible discomfort while working were carefully noted. Similar ergonomic assessments involving body discomfort and occupational strain have been reported in previous Family Resource Management studies conducted at CCSHAU (Yadav, 2020; Devi, Rani & Mehta, 2020).

3.4 Procedure of Data Collection

Data collection was carried out over a period of three consecutive days, and observations were conducted daily from 11:00 a.m. to 2:00 p.m., as this period represented peak work intensity and maximum physical exertion at the selected house construction sites. Each respondent was observed individually while performing routine house construction activities without interruption or any modification in work style. Repeated observations were conducted wherever necessary to obtain a more reliable understanding of work patterns and ergonomic exposure.

During the observation period, detailed attention was given to all major house construction activities. This included brick carrying, where workers manually lifted and transported bricks using hands, shoulders, and occasionally head support; cement mixing, which involved repeated bending, shovelling, and trunk twisting; material transportation, including manual carrying of sand, cement bags, and bricks; brick laying, involving prolonged squatting and repetitive hand movement; and plastering, requiring sustained overhead arm movement and neck extension. Particular attention was paid to awkward body posture, repetitive movement, static load on body parts, forceful exertion, and unsafe manual handling techniques, as these are major contributors to work-related musculoskeletal problems (Schneider, 2001; Punnett & Wegman, 2004).

Special emphasis was also placed on observing occupational injuries and discomfort experienced by workers during work. The investigator noted visible cuts on fingers and palms, abrasions caused by handling rough construction materials, shoulder discomfort while carrying heavy loads, lower back pain during repeated bending, swelling of feet

due to prolonged standing, and signs of physical exhaustion during peak working hours. Workers were informally asked whether these injuries or pain episodes caused temporary absence from work or affected their work efficiency. Simultaneously, workplace environmental conditions such as uneven work surfaces, excessive dust exposure, high ambient temperature, inadequate shade, insufficient drinking water, poor rest facilities, and limited use of protective equipment such as gloves and proper footwear were also systematically observed and recorded, as these environmental factors significantly influence ergonomic risk and occupational health (Bridger, 2003; Mohan & Patel, 1992).

3.5 Method of Analysis

The information collected through the PLIBEL checklist and structured observation schedule was analysed using descriptive statistical techniques. The collected data were classified, tabulated, and summarized using frequency, percentage, and correlation to understand the distribution and prevalence of ergonomic hazards among the selected respondents. The analysis focused on identifying work-related risk factors associated with different house construction activities, body regions affected, visible occupational injuries, work-rest patterns, and workplace environmental conditions. Similar descriptive analytical procedures have been used in earlier ergonomic investigations (Yadav, 2020; Yadav et al., 2020; Devi et al., 2020).

4. RESULTS

Table 4.1 Socio-demographic profile of respondents (N=30)

Variables	Categories	Frequency	Percentage (%)
Age (Years)	18–25	3	10.00
	26–35	6	20.00
	36–45	12	40.00
	46–55	6	20.00
	Above 55	3	10.00
Gender	Male	27	90.00
	Female	3	10.00
Marital Status	Married	18	60.00
	Unmarried	12	40.00
Educational Status	Illiterate	3	10.00
	Primary	3	10.00
	Middle	9	30.00
	Secondary	8	26.70
	Senior Secondary	2	6.70
	Graduate and Above	1	3.30
Family Type	Nuclear	10	33.30
	Joint	20	66.70
Family Size	1–4 Members	7	23.30
	5–8 Members	15	50.00
	Above 8 Members	8	26.70

Majority of the house construction workers (40.00%) belonged to the age group of 36–45 years and were predominantly male (90.00%). More than half of the respondents were married (60.00%) and belonged to joint families (66.70%). The educational level of the workers was generally low, with most respondents having completed only middle (30.00%) or secondary education (26.70%). In terms of family size, half of the respondents (50.00%) had families consisting of 5–8 members.

Table 4.2 Distribution of Respondents According to Type of Construction (N=30)

Type of Construction	Frequency	Percentage (%)
Single-storey Residential House	13	43.30
Double-storey Residential House	10	33.30
Triple-storey Residential House	7	23.40

The findings indicate that nearly half of the respondents (43.30%) were engaged in the construction of single-storey residential houses, followed by (33.30%) working on double-storey residential houses. The remaining (23.40%) were involved in the construction of triple-storey residential houses. This suggests that single-storey residential construction was the most common type of construction activity undertaken by the respondents in the study area.

Table 4.3 Availability of Safety Facilities at Construction Sites (N=30)

Safety Facility	Frequency	Percentage (%)
Drinking Water	14	46.70
First Aid Box	15	50.00
Toilet Facility	21	70.00
Resting Area	15	50.00
Safety Helmets	15	50.00
Gloves	10	33.30
Safety Shoes	0	00.00
Safety Belt	0	00.00

The findings revealed that toilet facilities were available at most construction sites (70.00%). Half of the respondents reported the availability of first aid boxes, resting areas, and safety helmets (50.00% each), whereas drinking water facilities were available to only (46.70%) of the workers. Gloves were available to only one-third of the respondents (33.30%). Notably, none of the workers reported the availability of safety shoes or safety belts, indicating inadequate provision of personal protective equipment at the construction sites.

Table 4.4 Occupational Characteristics of House Construction Workers (N = 30)

Variables	Categories	Frequency (n)	Percentage (%)
Occupation	Mason	8	26.70
	Helper	5	16.70
	Brick Carrier	4	13.30
	Concrete Worker	3	10.00
	Plaster Worker	6	20.00
	Carpenter	3	10.00
	Painter	1	3.30
Work Experience	Less than 5 years	3	10.00
	5–10 years	7	23.30
	11–15 years	9	30.00
	16–20 years	6	20.00
	Above 20 years	5	16.70
Daily Wage	₹501–700	7	23.30
	₹701–900	11	36.70
	₹901–1100	7	23.30
	Above ₹1100	5	16.70
Nature of Employment	Permanent	4	13.30
	Contract	7	23.30
	Casual	19	63.40

Masons constituted the largest occupational group (26.70%), followed by plaster workers (20.00%) and helpers (16.70%). Regarding work experience, the highest proportion of respondents (30.00%) had 11–15 years of experience, indicating that most workers had been engaged in construction work for a considerable period. In terms of daily wages, more than one-third of the respondents (36.70%) earned between ₹701–900 per day, while (23.30%) each earned ₹501–700 and ₹901–1100 per day. Furthermore, the majority of the workers (63.40%) were employed on a casual basis, whereas only a small proportion had permanent employment (13.30%).

Table 4.5 Distribution of Respondents According to Reporting Time

Reporting Time	Frequency	Percentage (%)
Before 7:00 AM	8	26.7
7:00–8:00 AM	11	36.7
8:01–9:00 AM	4	13.3
After 9:00 AM	7	23.3

The highest proportion of respondents (36.70%) reported to work between 7:00 and 8:00 AM, followed by (26.70%) who started work before 7:00 AM. About 23.30% reported after 9:00 AM, while only (13.30%) started work between 8:01 and 9:00 AM. The findings indicate that most construction workers began their work early in the morning.

Table 4.6 Distribution of Respondents According to Closing Time

Closing Time	Frequency	Percentage (%)
Before 4:00 PM	2	6.7
4:00–5:00 PM	4	13.3
5:01–6:00 PM	12	40.0
After 6:00 PM	12	40.0

The findings indicate that the highest proportion of respondents (40.00% each) completed their work between 5:01–6:00 PM and after 6:00 PM, suggesting that most workers had long working days. Only (6.70%) of the respondents finished work before 4:00 PM.

Table 4.7 Distribution of Respondents According to Tea Break Duration (N=30)

Tea Break Duration	Frequency	Percentage (%)
No Tea Break	4	13.30
Less than 15 Minutes	4	13.30
15–30 Minutes	12	40.00
31–45 Minutes	6	20.00
More than 45 Minutes	4	13.30

The majority of the respondents (40.00%) had a tea break of 15–30 minutes, while (20.00%) had a break of 31–45 minutes. Notably, (13.30%) of the workers did not receive any tea break, indicating inadequate rest opportunities for some workers.

Table 4.8 Distribution of Respondents According to Lunch Break Duration

Lunch Break Duration	Frequency	Percentage (%)
Less than 30 Minutes	8	26.70
30–45 Minutes	9	30.00
46–60 Minutes	10	33.30
More than 60 Minutes	3	10.00

One-third of the respondents (33.30%) had a lunch break of 46–60 minutes, followed by (30.00%) who had a break of 30–45 minutes. About (26.70%) had less than 30 minutes for lunch, suggesting that a considerable proportion of workers had relatively short meal breaks during the workday.

Table 4.9 Working Conditions of House Construction Workers (N = 30)

Variables	Categories	Frequency (n)	Percentage (%)
Working Days/Week	5 Days	3	10.00
	6 Days	16	53.30
	7 Days	11	36.70
Working Hours/Day	Less than 8 Hours	2	6.70
	8–9 Hours	6	20.00
	9–10 Hours	8	26.70

Overtime Work	10–11 Hours	11	36.70
	More than 11 Hours	3	10.00
	Yes	20	66.67
	No	10	33.33

More than half of the respondents (53.30%) worked for six days a week, while (36.70%) worked throughout the week for seven days, indicating limited opportunities for weekly rest. Regarding daily working hours, the highest proportion of workers (36.70%) worked for 10–11 hours per day, followed by (26.70%) who worked for 9–10 hours per day. Only a small proportion of workers (6.70%) worked for less than eight hours a day. Furthermore, two-thirds of the respondents (66.67%) reported doing overtime work, whereas 33.33 per cent did not.

Table 4.10 Material Handling Characteristics of House Construction Workers (N = 30)

Variables	Categories	Frequency (n)	Percentage (%)
Manual Lifting	Yes	24	80.00
	No	6	20.00
Average Load Handled	Less than 10 kg	2	6.70
	10–20 kg	6	20.00
	21–30 kg	10	33.30
	31–40 kg	7	23.30
	More than 40 kg	5	16.70
Method of Carrying	Head	8	26.70
	Shoulder	8	26.70
	Back	5	16.70
	Hands	6	20.00
	Wheelbarrow	3	10.00
Frequency of Lifting	Rarely	3	10.00
	Sometimes	6	20.00
	Frequently	11	36.70
	Very Frequently	10	33.30

The majority of the respondents (80.00%) were involved in manual lifting activities. Most workers (33.30%) handled loads weighing 21–30 kg, while 23.30 per cent carried 31–40 kg. Materials were mainly carried on the head and shoulders (26.70% each). Furthermore, 36.70 per cent of the workers lifted loads frequently and 33.30 per cent did so very frequently, indicating a high level of exposure to manual material handling and physical strain.

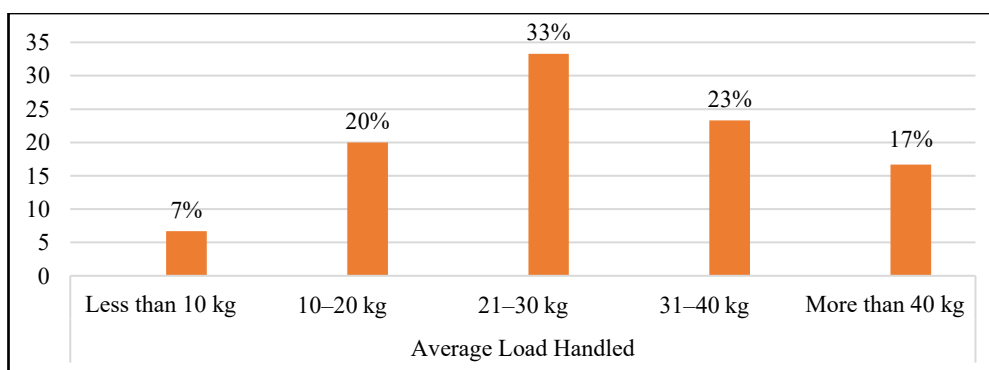
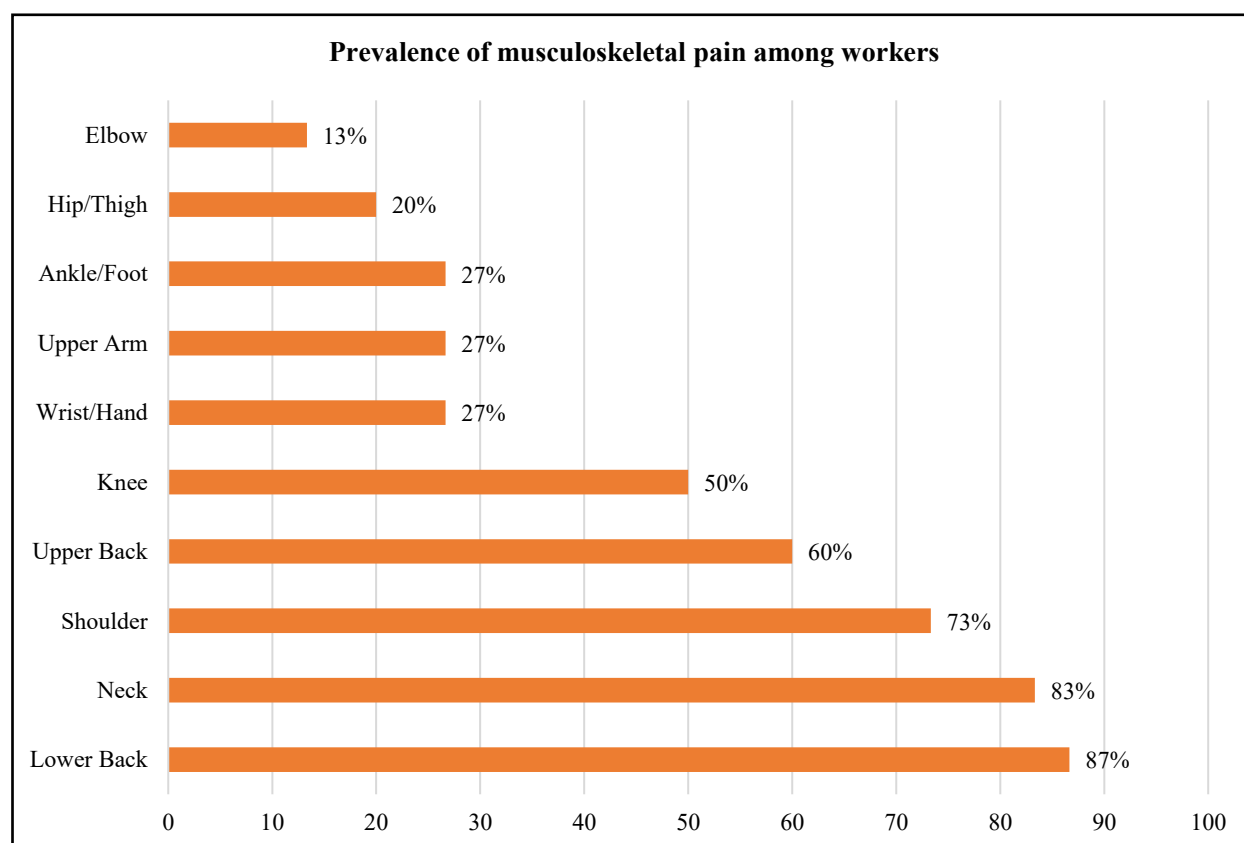


Table 4.11 Prevalence of Musculoskeletal Disorders

Body Region	Frequency	Percentage (%)
Lower Back	26	86.67
Neck	25	83.33
Shoulder	22	73.33
Upper Back	18	60.00

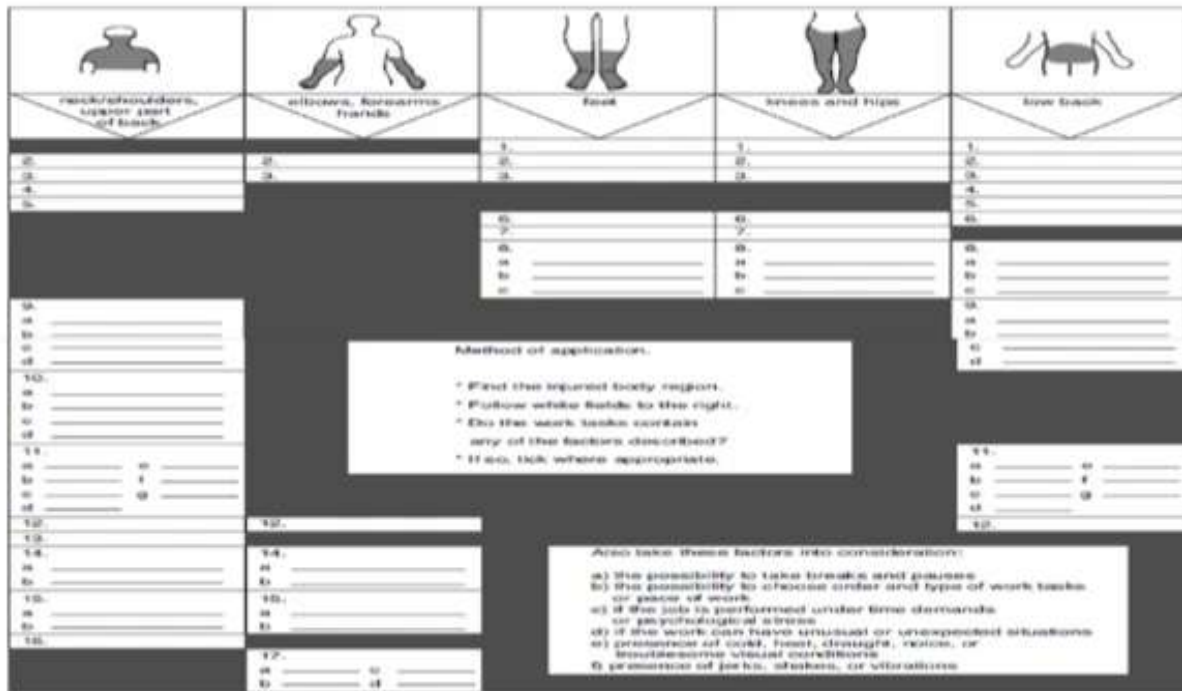
Knee	15	50.00
Wrist/Hand	8	26.67
Upper Arm	8	26.67
Ankle/Foot	8	26.67
Hip/Thigh	6	20.00
Elbow	4	13.33

Lower back pain was the most prevalent musculoskeletal complaint (86.67%), followed by neck pain (83.33%) and shoulder pain (73.33%). The high prevalence of spinal discomfort indicates excessive trunk flexion, repetitive lifting, and prolonged static postures during construction activities. Similar findings have been reported among construction workers in developing countries where manual material handling remains predominant.



Multiple responses were recorded; therefore, percentages are calculated based on the total number of respondents ($n = 30$), and the cumulative percentage exceeds 100.

PLIBEL - The Method Assigned for Identification of Ergonomic Hazards



The PLIBEL form is a comprehensive tool for identifying ergonomic hazards. It is divided into five main sections, each with a corresponding icon and a list of factors to be observed:

- Neck/shoulders, upper part of back:** Includes factors like neck bent forward more than 30°, neck twisted, shoulders elevated, and arms above shoulder level.
- Elbows, forearms, wrists:** Includes factors like repetitive hand movements, forceful gripping, and wrist deviation.
- Trunk:** Includes factors like forward bending of trunk, twisting of trunk, and side bending of trunk.
- Arms and legs:** Includes factors like heavy lifting, carrying loads on head, carrying loads on shoulder, prolonged standing, prolonged walking, squatting posture, and kneeling posture.
- Low back:** Includes factors like climbing ladders or scaffolds, sudden forceful movements, poor footing or unstable surface, use of vibrating tools, and inadequate rest periods.

The form also includes a central box for the 'Method of application' and a bottom box for 'Also take these factors into consideration'.

Table 4.12 PLIBEL Ergonomic Risk Assessment Items and Scoring Pattern

S. No.	PLIBEL Item	Scoring
1	Neck bent forward more than 30°	Yes = 1, No = 0
2	Neck twisted	Yes = 1, No = 0
3	Shoulders elevated	Yes = 1, No = 0
4	Arms above shoulder level	Yes = 1, No = 0
5	Repetitive hand movements	Yes = 1, No = 0
6	Forceful gripping	Yes = 1, No = 0
7	Wrist deviation	Yes = 1, No = 0
8	Forward bending of trunk	Yes = 1, No = 0
9	Twisting of trunk	Yes = 1, No = 0
10	Side bending of trunk	Yes = 1, No = 0
11	Heavy lifting	Yes = 1, No = 0
12	Carrying loads on head	Yes = 1, No = 0
13	Carrying loads on shoulder	Yes = 1, No = 0
14	Prolonged standing	Yes = 1, No = 0
15	Prolonged walking	Yes = 1, No = 0
16	Squatting posture	Yes = 1, No = 0
17	Kneeling posture	Yes = 1, No = 0
18	Climbing ladders or scaffolds	Yes = 1, No = 0
19	Sudden forceful movements	Yes = 1, No = 0
20	Poor footing or unstable surface	Yes = 1, No = 0
21	Use of vibrating tools	Yes = 1, No = 0
22	Inadequate rest periods	Yes = 1, No = 0

Table 4.13 PLIBEL Ergonomic Risk Assessment

S. No.	Ergonomic Risk Factor	Frequency (n)	Percentage (%)
1	Neck bent forward >30°	23	76.70
2	Neck twisted	21	70.00
3	Shoulders elevated	19	63.30
4	Arms above shoulder level	18	60.00
5	Repetitive hand movements	19	63.30
6	Forceful gripping	21	70.00
7	Wrist deviation	22	73.30
8	Forward bending of trunk	17	56.70
9	Twisting of trunk	19	63.30
10	Side bending of trunk	17	56.70
11	Heavy lifting	22	73.30
12	Carrying loads on head	20	66.70
13	Carrying loads on shoulder	18	60.00
14	Prolonged standing	20	66.70
15	Prolonged walking	19	63.30
16	Squatting posture	23	76.70
17	Kneeling posture	21	70.00
18	Climbing ladders/scaffolds	16	53.30
19	Sudden forceful movements	15	50.00
20	Poor footing/unstable surface	23	76.70
21	Use of vibrating tools	12	40.00
22	Inadequate rest periods	14	46.70

The ergonomic risk factors identified among house construction workers using the PLIBEL method. The findings indicate that neck bending greater than 30°, squatting posture, and poor footing or unstable surfaces were the most common ergonomic hazards, each reported by 76.70 per cent of the respondents and ranked first. Wrist deviation and heavy lifting were the next most prevalent risk factors, affecting 73.30 per cent of the workers, followed by neck twisting, forceful gripping, and kneeling posture (70.00%). Furthermore, a considerable proportion of workers reported prolonged standing, carrying loads on the head, repetitive hand movements, and trunk twisting, highlighting the physically demanding nature of construction work. The least frequently reported risk factor was the use of vibrating tools (40.00%), followed by inadequate rest periods (46.70%).

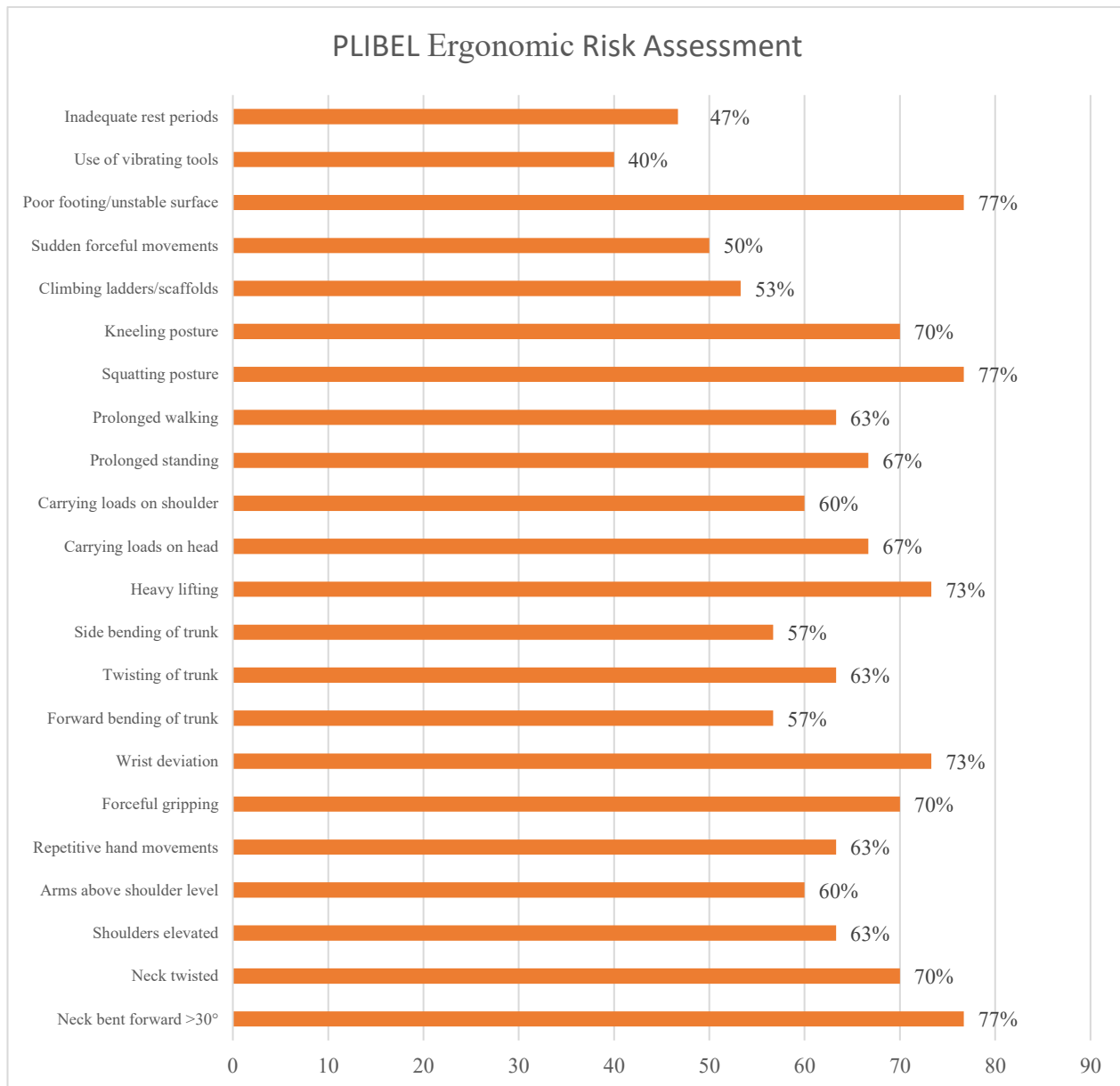


Table 4.14 Occupational Injuries and Absenteeism

Variable	Frequency	Percentage (%)
Injured During Last 12 Months	12	40.00
Hospitalization Required	3	10.00
Surgery Required	0	0.00
Absent Due to Pain/Injury	11	36.67

Forty per cent of workers experienced at least one occupational injury during the previous 12 months. Heavy lifting emerged as the leading cause of injury, primarily resulting in strains and sprains. More than one-third of workers reported absence from work due to pain or injury, highlighting the productivity implications of poor ergonomic conditions.

Table 4.15 Fatigue Pattern Among Construction Workers

Variable	Category	Frequency	Percentage (%)
Fatigue Frequency	Sometimes	8	26.67
	Often	15	50.00
	Always	7	23.33
Time of Maximum Fatigue	Afternoon	10	33.33
	Evening	20	66.67

Half of the respondents reported experiencing fatigue often, while nearly one-fourth experienced fatigue continuously. Evening hours were identified as the period of maximum fatigue by two-thirds of the workers. This pattern suggests cumulative muscular loading throughout the workday, particularly affecting the back, neck, and shoulder regions.

Table 4.16 Mean PLIBEL Scores Across Age Categories (N = 30)

Age Group	Frequency (n)	Mean PLIBEL Score
18–25 years	3	14.00
26–35 years	6	16.00
36–45 years	12	14.50
46–55 years	6	13.33
Above 55 years	3	14.00
Total	30	14.47

The findings indicate that the mean PLIBEL score varied across different age groups of house construction workers. The highest mean PLIBEL score was observed among workers aged 26–35 years (16.00), followed by those in the 36–45 years' age group (14.50). Workers aged 18–25 years and above 55 years had similar mean scores of 14.00, while the lowest mean score was recorded among workers aged 46–55 years (13.33).

Table 4.17 Mean PLIBEL Scores Across Work Experience Categories (N = 30)

Work Experience Group	Frequency (n)	Mean PLIBEL Score
Less than 5 years	3	14.00
5–10 years	7	15.14
11–15 years	6	13.33
16–20 years	9	14.89
Above 20 years	5	14.40
Total	30	14.47

The mean PLIBEL scores also showed slight variations across different work experience groups. Workers with 5–10 years of experience had the highest mean PLIBEL score (15.14), followed by those with 16–20 years of experience (14.89) and above 20 years of experience (14.40). Respondents with less than 5 years of experience had a mean score of 14.00, whereas the lowest mean score (13.33) was observed among workers with 11–15 years of experience. The differences in mean scores among the experience groups were small and did not indicate a clear trend of increasing ergonomic risk with increasing years of work experience.

Table 4.18 Correlation Between Total PLIBEL Score and Socio-demographic Variables (N = 30)

Variable	Pearson's Correlation Coefficient (r)	p-value	Interpretation
Age	-0.240	0.202	Weak negative and non-significant relationship
Work Experience	0.008	0.965	Very weak positive and non-significant relationship

The findings revealed that total PLIBEL scores had a weak negative relationship with age ($r = -0.240$) and a very weak positive relationship with work experience ($r = 0.008$). However, both relationships were statistically non-significant ($p > 0.05$), indicating that age and years of work experience did not significantly influence the ergonomic risk exposure of the house construction workers.

Major Findings

- The majority of the respondents (40.00%) belonged to the age group of 36–45 years, and most of them were males (90.00%).
- Nearly two-thirds of the respondents (66.70%) belonged to nuclear families, and 60.00 per cent were married.

- Masons constituted the largest occupational group (26.70%), and 30.00 per cent of the workers had 11–15 years of work experience.
- More than one-third of the respondents (36.70%) worked for 10–11 hours per day, and 66.67 per cent reported doing overtime work.
- The majority of workers (80.00%) were involved in manual lifting activities, and 70.00 per cent lifted loads frequently or very frequently.
- Toilet facilities were available at 70.00 per cent of the construction sites, whereas safety shoes and safety belts were not available at any site.
- The most prevalent ergonomic risk factors identified through the PLIBEL method were neck bending greater than 30°, squatting posture, and poor footing or unstable surfaces (76.70% each).
- Upper back pain and hip/thigh pain were the most frequently reported musculoskeletal complaints (76.70% each), followed by elbow pain and wrist/hand pain (73.30% each).
- More than half of the respondents (56.67%) had experienced occupational injuries during the previous 12 months.
- The mean PLIBEL score was 14.47 ± 2.13 , indicating a moderate to high level of ergonomic risk exposure among the workers.
- No significant relationship was observed between total PLIBEL scores and age or work experience of the respondents.

Discussion

Upper Back and Hip/Thigh Pain

The present study showed that upper back pain and hip/thigh pain were the most common musculoskeletal complaints, each reported by 76.67 per cent of the respondents. These symptoms are likely related to frequent bending, prolonged standing, squatting, and manual handling of construction materials. Similar findings have been reported by Gajbhiye et al. (2023), who observed a high prevalence of musculoskeletal symptoms among Indian construction workers due to awkward postures and physically demanding tasks. Holmström and Engholm (2003) also reported that construction workers performing strenuous activities were at a greater risk of developing musculoskeletal disorders.

Elbow and Wrist/Hand Pain

Elbow pain and wrist/hand pain affected 73.33 per cent of the respondents. The high prevalence of these complaints may be associated with repetitive hand movements, forceful gripping, wrist deviation, and continuous use of construction tools. Boschman et al. (2012) similarly reported a high occurrence of upper limb disorders among construction workers engaged in repetitive and forceful tasks. Other studies have also identified repetitive movements and manual material handling as important risk factors for upper extremity musculoskeletal disorders.

Ergonomic Hazards and Awkward Postures

The PLIBEL assessment revealed that neck bending greater than 30°, squatting posture, and poor footing or unstable surfaces were the most prevalent ergonomic hazards, each affecting 76.67 per cent of the workers. Wrist deviation and heavy lifting were also commonly reported (73.33%). These findings indicate that construction workers are frequently exposed to awkward postures and physically demanding work conditions. Gajbhiye et al. (2023) similarly reported that awkward postures and repetitive activities significantly contribute to musculoskeletal problems among construction workers. Kemmlert (1995) also emphasized that awkward working postures and inadequate recovery periods are major ergonomic risk factors.

Heavy Lifting and Manual Material Handling

Heavy lifting was identified as a major ergonomic hazard, affecting 73.33 per cent of the respondents. Furthermore, 80.00 per cent of the workers were involved in manual lifting activities, and many frequently handled loads weighing

between 21 and 30 kg. These findings are consistent with those of Gajbhiye et al. (2023), who reported that manual material handling and repetitive lifting were important determinants of musculoskeletal disorders among construction workers. Sobeih et al. (2006) also concluded that physically demanding tasks and manual material handling substantially increase the risk of work-related musculoskeletal disorders.

Occupational Injuries

More than half of the respondents (56.67%) had experienced occupational injuries during the previous 12 months. Occupational injuries and musculoskeletal symptoms can negatively affect workers' health, productivity, and work performance. Previous Indian studies have also reported a high burden of occupational injuries among construction workers, particularly among those engaged in physically demanding work and repetitive activities. International studies similarly indicate that musculoskeletal disorders are among the leading causes of reduced productivity and work absence in the construction industry.

Fatigue

The present study found that 50.00 per cent of the respondents often experienced fatigue after work, while 26.67 per cent always experienced fatigue. The high prevalence of fatigue may be due to long working hours, manual material handling, repetitive tasks, and exposure to multiple ergonomic hazards. Similar findings have been reported by Gajbhiye et al. (2023), who observed that prolonged work in awkward postures and physically demanding activities resulted in considerable muscular fatigue among construction workers. International ergonomic studies have also identified cumulative physical workload as an important predictor of fatigue and musculoskeletal symptoms.

6. RECOMMENDATIONS

6.1 Engineering Controls

- Introduce mechanised mixing devices and motor-driven hoists to reduce manual load-carrying and minimise spinal loading.
- Provide height-adjustable scaffolding and working platforms to prevent sustained overhead and floor-level awkward postures.
- Supply properly designed wheelbarrows and trolleys for material transport to reduce low back strain.

6.2 Administrative Controls

- Implement mandatory job rotation to distribute biomechanical loads across muscle groups and reduce cumulative strain on any single body region.
- Enforce scheduled rest breaks of at least 10 minutes per 2 hours of heavy work to allow musculoskeletal recovery.
- Limit daily manual lifting shifts to 8 hours and prohibit overtime for tasks involving heavy repetitive lifting.

7. CONCLUSION

This cross-sectional PLIBEL-based study demonstrates that house construction workers in Hisar, Haryana face significant ergonomic hazards, with 85% of the study population at moderate-to-high risk of work-related musculoskeletal disorders. The low back, neck/shoulder, and knee regions are the most at-risk body areas. Ergonomic risk exposure increases markedly with cumulative work experience, underscoring the urgency of early-career preventive intervention. The PLIBEL method is a feasible and informative tool for ergonomic risk screening in this occupational setting. A multi-pronged strategy encompassing engineering controls, administrative measures, worker training, and regular health surveillance is essential to protect the health and productivity of construction workers in semi-urban Haryana. Larger, multi-site studies are warranted to provide stronger epidemiological evidence and to guide state-level occupational health policy for the construction sector.

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