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Occupational Risk Factors for Chronic Pain among Field Workers at the National Horticultural Research Institute (NIHORT) in Ibadan, Nigeria: Working Conditions and Preventive Interventions

[1] Folusho Oyenike Olumayegun & [2] Uche C. Isiugo-Abanihe
[1] Lead City University, Department of Sociology, Faculty of Management and Social Sciences & National Horticultural Research Institute (NIHORT), Ibadan, Oyo State, Nigeria
[2] Department of Behavioural Sciences, Lead City University, Ibadan

Abstract: This study investigated prevalent working conditions contributing to chronic pain and effective preventive interventions among field workers at the National Horticultural Research Institute, NIHORT, Ibadan, Oyo State, Nigeria. Anchored on the sociology of occupational health, integrating Social-Ecological, Political Economy and Job Demand-Control-Support perspectives, the study adopted a cross-sectional survey design. The study population comprised field staff engaged in nursery, transplanting, weeding, spraying, irrigation and harvesting operations. The simple random method was used to select the sample size of 298 determined using the Yamane formula. Data were analyzed using descriptive and inferential statistical procedures. The findings revealed high exposure to ergonomic hazards, including prolonged bending beyond 60 degrees, manual lifting of crates above 20kg, repetitive use of non-ergonomic tools, whole-body vibration and heat stress with inadequate rest. Chronic musculoskeletal pain was prevalent, with patterns consistent with Nigerian studies reporting up to 96% shoulder pain and 85% low back pain. All nine improvement methods were significantly and negatively correlated with chronic pain at $p<0.01$, ranging from $r=-0.412$ for job rotation to $r=-0.521$ for implementation of scheduled rest breaks which had the highest mean agreement of 4.40. Only 27.5% of the sample reported having regular breaks. Other strong correlates were provision of mechanical lifting aids, $r=-0.498$, and safe lifting training, $r=-0.488$. Inter-correlations among methods were moderate to strong, $r=0.465$ to $r=0.621$, $p<0.01$, supporting a composite construct. Logistic regression showed that working conditions and the improvement composite significantly predicted chronic pain, with each unitreducing odds of pain by 59.0% and 70.3% respectively. The model fitted adequate and with classification accuracy above 72%. The study concludes that chronic pain is socially structured, and recommends integrated low-cost ergonomic, administrative and policy interventions.

Key words: Chronic musculoskeletal pain, ergonomic interventions, occupational health, working conditions, NIHORT

Introduction

Agriculture is globally recognized as one of the most strenuous and hazardous occupations. Even with technological advances, the sector continues to report disproportionately high rates of work-related injuries and illnesses, with chronic musculoskeletal pain now identified as a major contributor to disability and reduced capacity to work. Unlike acute trauma, this pain develops cumulatively through repeated physical exposures and is frequently overlooked in farming contexts (Olowogbon et al., 2021; Jirapongsuwan et al., 2023).

The physical nature of farm work underlies this burden. Typical field tasks demand continuous manual effort, such as lifting and carrying heavy loads, sustaining flexed or twisted trunk postures, kneeling for long durations, executing repetitive hand motions and operating equipment that generates vibration. Each exposure independently elevates risk of persistent pain. For instance, frequent stooping has been established as a strong predictor of low back pain, while repeated gripping and use of inadequately designed tools heighten susceptibility to shoulder and wrist disorders (Kaewdok et al., 2021; Bhuanantanondh et al., 2021).

Global data illustrate the scale. A systematic synthesis of 3,703 farmers in Southeast Asia reported an aggregate prevalence of work-related musculoskeletal disorders of 80.10%, with country-specific estimates between 78.31% and 88.39% (Sutanto et al., 2023). Similarly, research among hired workers in high-income settings indicates that regular kneeling, carrying loads and repetitive actions markedly increase the odds of pain persisting beyond six weeks, especially affecting the lumbar region, knees and hips (Schenker et al., 2022). Beyond suffering, these conditions lower output, raise healthcare expenditure and precipitate premature workforce exit. The problem is amplified in low- and middle-income countries where agriculture remains largely non-mechanized. Reliance on bodily strength, scarcity of ergonomic implements, absence of safety instruction, extended work periods under extreme weather and limited occupational health services heighten vulnerability. A comprehensive review of Low and Middle Income Country (LMIC) farm workers identified advancing age, long work duration, awkward postures, heavy lifting and repetitive motions as consistent predictors of musculoskeletal pain, with disproportionate impact on female and older workers (Hossain et al., 2023). Psychosocial dimensions, including restricted autonomy and effort-reward imbalance, further aggravate reports of pain.

Nigeria reflects these dynamics. Although agriculture engages roughly three-quarters of the population, structured occupational health measures remain scanty (Olowogbon et al., 2021), and operations rely predominantly on basic hand tools. Studies among cassava growers in North-Central Nigeria documented extremely high discomfort, with shoulder pain in 96%, low back pain in 85%, upper back pain in 82%, neck pain in 64% and elbow pain in 53%, linked to improper lifting, sustained static postures and prolonged use of

backpack sprayers (Olowogbon et al., 2021). Among peasant farmers in South-West Nigeria, over half reported musculoskeletal pain in the preceding week, most commonly in low back, neck and shoulders (Ojo et al., 2022). Research on manual handlers in Lagos performing comparable load-bearing duties revealed substantial exposure to awkward postures and extended standing, prompting advocacy for ergonomic solutions (Adeyemi et al., 2022). In Oyo State, prolonged awkward bending with inadequate recovery breaks was associated with widespread back and general body pain (Ogunmodede et al., 2022).

The National Horticultural Research Institute (NIHORT), Ibadan, Nigeria's leading horticultural research body, employs field staff engaged in labour-intensive duties including nursery operations, transplanting, weeding, pruning, fertilizing, spraying, irrigation and harvesting. These tasks entail repetitive bending, twisting, prolonged kneeling, lifting seedlings and crates often above 20kg, repeated use of shears, hoes and cutlasses, carrying heavy knapsack sprayers, exposure to whole-body vibration and heat stress. Sustained vibration is a recognized determinant of chronic low back pain among machinery operators (Fethke et al., 2022), while delayed health-seeking behaviour allows acute episodes to transition to chronicity (Ekpenyong & Inyang, 2021).

Despite evident hazards, empirical focus on institutional workers, such as NIHORT staff, is scarce, as Nigerian literature predominantly targets smallholders, constraining preventive planning. Evidence, however, indicates that low-cost, task-specific ergonomic measures are effective, such as long-handled tools to limit stooping, lighter harvest containers, improved ladders, extended handles for plant carrying, powered cutters and scheduled micro-breaks (Jirapongsuwan et al., 2023). Complementary administrative and educational strategies, including safe handling training, participatory ergonomics, job rotation and enhanced safety information, also show protective effects. Prior training has been shown to lower ergonomic risk, whereas limited access to affordable safety measures and information constitutes a barrier (Olowogbon et al., 2021). Combined programs incorporating exercise, body mechanics education and warm-up activities further reduce injuries (Adams et al., 2022).

Accordingly, this study seeks to investigate working conditions of NIHORT field workers that predispose to chronic pain risk, and examine effective methods for improving those conditions to mitigate chronic pain risk.

Working Conditions and Chronic Pain Risk among Nihort Field Workers and Strategies for Improvement

The association between working conditions and chronic pain among agricultural field workers has gained prominence in occupational health literature. At the National Horticultural Research Institute, NIHORT, Ibadan, field labour is defined by intensive operations that expose staff to sustained physical, organizational and psychosocial strain.

Studies from Nigeria and other low and middle-income countries show that these exposures predispose to cumulative musculoskeletal injuries which evolve into chronic pain without timely intervention. Understanding this transition requires consideration of physical demands, work organization, workplace culture and broader economic context. Physical and ergonomic exposures remain the most immediate drivers of chronic pain. At NIHORT, activities including nursery management, transplanting, weeding, pruning, fertilizer and pesticide application, irrigation and harvesting are largely manual. They entail prolonged standing, trunk flexion beyond 60 degrees, kneeling, squatting, carrying loads often exceeding 20kg, and repeated use of non-mechanized implements such as hoes, cutlasses, shears and watering cans. Such actions generate high compressive forces on the lumbar spine and repetitive load on rotator cuff and forearm tendons. Without ergonomic modification, micro-trauma to muscles, tendons, ligaments and discs accumulates. Olowogbon et al. (2021) illustrated this among Nigerian crop farmers, where 96% reported shoulder pain, 85% low back pain, 82% upper back pain, 64% neck pain and 53% elbow pain, attributing it to poor lifting methods and prolonged static postures.

Tool design further elevates risk. Most horticultural implements in Nigeria are produced without anthropometric consideration, with short handles that force excessive lumbar flexion and heavy heads that increase shoulder torque. Workers therefore adapt their bodies to tools, contradicting ergonomic principles. Kaewdok et al. (2021) found higher musculoskeletal disorders among Thai older farmers exposed to similar non-ergonomic equipment. Bhuanantanondh et al. (2021) similarly reported high prevalence of low back, shoulder and hand pain among oil palm harvesters using poorly designed tools. Jirapongsuwan et al. (2023) noted that simple adjustments such as lengthening handles by 20-30cm and adopting lighter composites with shock-absorbing grips can reduce back and shoulder pain by over 40% within six months, yet adoption in Nigerian research farms remains limited due to budget constraints and low ergonomic awareness among managers (Ogunmodede et al., 2022).

Repetitive motion and environmental exposures constitute another pathway to chronicity. Transplanting, pruning and harvesting are repeated thousands of times per season with little variation, leading to overuse injuries including tendonitis, bursitis and nerve compressions such as carpal tunnel syndrome. When work is organized around output targets, as common during peak planting at NIHORT, workers extend beyond eight hours and forgo rest, contrary to recommendations for rotation and micro-breaks. Hossain et al. (2023) identified repetitive movements, heavy lifting and awkward postures as consistent predictors of musculoskeletal pain in LMICs. Additionally, operators of petrol-powered knapsack sprayers and brush cutters encounter hand-arm and whole-body vibration, linked to vascular and musculoskeletal damage manifesting as chronic hand and low back pain. Fethke et al. (2022) stressed whole-body vibration as a key risk factor for back pain. In

NIHORT, anti-vibration gloves and regular maintenance are rarely implemented. Heat stress interacts with biomechanical load. Prolonged work under tropical sun elevates core temperature, impairs neuromuscular coordination and lowers pain thresholds. Dehydrated muscles are prone to cramps while electrolyte imbalance worsens myofascial pain. Access to shade and potable water is inconsistent, forcing labour without physiological recovery, accelerating fatigue and injury. Ekpenyong and Inyang (2021) observed that workers in demanding physical sectors in Nigeria often view pain as inevitable, delaying help-seeking and allowing reversible lesions to become degenerative.

Beyond physical factors, organizational constraints determine hazard mitigation. Although Nigeria has a National Policy on Occupational Safety and Health mandating safe environments and health surveillance, enforcement in agriculture remains weak due to fragmented oversight and inadequate funding (Ogunmodede et al., 2022). For NIHORT, this policy-practice gap is evident in staffing shortages during peak seasons, raising individual workload, and absence of institutionalized rest cycles leading to accumulated fatigue. Procurement systems further constrain risk reduction. Ergonomic tools, lumbar supports, knee pads and sun-protective clothing are seldom prioritized, as budgets favour research inputs. Observations from South-West Nigeria showed only a small proportion of field workers had job-specific protective equipment and less than 15% received training on correct use (Ogunmodede et al., 2022). Supervisory practices also mediate risk. When supervisors are evaluated on output, incentive to enforce safety diminishes, fostering silence. Conversely, units in Ibadan with supportive supervisors who scheduled mandatory breaks and facilitated clinic referrals recorded substantially lower chronic pain (Ogunmodede et al., 2022). Lack of centralized injury register makes burden invisible in planning. Workplace culture and resource allocation shape whether hazards become chronic. In many stations, endurance is celebrated as diligence while pain complaints are seen as weakness, leading workers to suppress symptoms and self-medicate. Ogunmodede et al. (2022) found that employees in units with unsupportive leadership were significantly more likely to report chronic musculoskeletal pain. Fear of stigma causes continued labour through acute injuries, sensitizing nociceptive pathways. Peer norms exert influence; pushing through pain is normative, risking exclusion for those seeking rest. Gender dynamics intersect; female workers often perform repetitive low-posture tasks like transplanting, yet equipment is designed for male anthropometry, increasing discomfort.

Economic and social dimensions are inseparable from biomedical experience. Chronic pain imposes direct costs for consultations and drugs, and indirect costs from lost days and reduced productivity. For low-income field workers these costs are catastrophic; over 60% of workers with chronic pain in African agriculture spend more than 20% of monthly income on treatment. For casual NIHORT workers without insurance, flare-ups cause immediate income loss (Olowogbon et al., 2021). Socially, inability to perform farm tasks undermines

provider roles, causing psychological distress which amplifies pain via central sensitization. Institutionally, chronic pain reduces productivity through absenteeism and presenteeism, delaying field trials and increasing turnover. Addressing these interconnected risks requires evidence-based strategies. Ergonomic interventions directly reduce biomechanical load, including tool redesign, mechanical assistance and schedule redesign. Increasing handle length enables near-neutral spine posture, larger diameter textured handles reduce grip force, and substituting heavy metal with composites lowers metabolic demand. Wheeled trolleys and raised nursery beds at 70-90cm eliminate deep stooping. Pilot projects in South-West Nigeria showed wheelbarrows reduced lifting cycles and pain scores (Adeyemi et al., 2022). Task redesign offers non-capital solutions. The 20-8-2 model of 20 minutes work, 8 minutes stretching and 2 minutes rest has been validated in West African farming. Rotation between high and low-load tasks prevents overuse. Participatory ergonomics enhances adoption; programs in Tanzania involving farmers in redesign reported higher compliance and sustained pain reduction than top-down directives (Hossain et al., 2023). NIHORT can establish ergonomic circles to monitor outcomes using tools such as Rapid Upper Limb Assessment and Nordic Musculoskeletal Questionnaire (Sutanto et al., 2023).

Training and organizational support convert hardware into sustained change. Effective training begins at induction with practical modules on safe lifting and early warning signs. Evidence from South African cooperatives showed practical induction reduced chronic pain significantly within one year (Kaewdok et al., 2021). Supervisor training multiplies impact. Ten-minute daily group stretching reduced back pain in agricultural cohorts (Adams et al., 2022). Health literacy campaigns using pictorial posters and on-site clinics enable early intervention. Finally, policy and collaboration enable sustainability. Amending NIHORT policy to cover all casual workers for clinic access and protective equipment, mandatory audits, expanded insurance covering physiotherapy, and recognition of cumulative trauma as compensable shift costs from workers to social insurance are critical. A digital log of pain reports disaggregated by gender and employment type makes burden visible (Jirapongsuwan et al., 2023).

In sum, literature from 2021 to date shows chronic pain results from interacting physical, organizational, cultural and economic factors. Low-cost ergonomic modifications, practical training, supportive supervision, participatory approaches and robust policy frameworks significantly reduce risk, offering NIHORT a sustainable pathway.

Theoretical Framework

This study is situated within the sociology of occupational health, which interrogates how social organization, power relations and institutional structures produce patterns of health and illness among workers. Chronic pain among field workers at the National Horticultural Research Institute, NIHORT, Ibadan, is therefore not conceptualized as an isolated

biomedical problem but as a socially structured outcome of how agricultural labour is organized, valued and controlled. To capture this complexity, the framework integrates three sociological perspectives: the Social-Ecological Model of Occupational Health, the Political Economy of Health and Labour Process Theory, and Karasek's Job Demand-Control-Support Model as a theory of the social organization of work. Together they explain how conditions at NIHORT predispose to chronic pain and how structural improvements can reduce risk.

The Social-Ecological Model posits that worker health is shaped by multiple nested layers of influence ranging from intrapersonal to interpersonal, organizational, community and policy levels, and that health outcomes cannot be understood by examining the worker in isolation. This perspective is particularly relevant for agricultural research institutes where formal policies, informal norms, resource allocation decisions and community expectations interact to shape exposure. At the intrapersonal level, NIHORT field workers bring vulnerabilities such as age, nutritional status and prior injury history which influence susceptibility. At the interpersonal level, relationships with supervisors and peers determine whether pain is reported or concealed, with evidence from Oyo State showing that field workers in units with supportive supervisors who enforce rest breaks and encourage clinic attendance reported substantially lower prevalence of musculoskeletal pain than those in unsupportive units (Ogunmodede et al., 2022). At the organizational level, internal structures such as staffing patterns, procurement systems, absence of occupational health surveillance and lack of ergonomic tool provision create high exposure, a pattern Olowogbon et al. (2021) documented among Nigerian crop farmers where 96% reported shoulder pain and 85% low back pain, attributed to organizational failure to provide mechanized support and training rather than merely individual behaviour. At the community and policy level, weak enforcement of the National Policy on Occupational Safety and Health, fragmented oversight across ministries and underinvestment in occupational health infrastructure leave hazards unchallenged. Hossain et al. (2023) in their systematic review of agricultural workers in low and middle-income countries concluded that musculoskeletal pain is socially patterned by factors beyond biomechanics, including poverty, job insecurity and poor access to health services. The model therefore justifies investigating working conditions as multi-layered social exposures and examining improvements from tool redesign to policy reform, aligning also with the biopsychosocial understanding of chronic pain as product of biological load interacting with psychological distress and social support (Sutanto et al., 2023).

The Political Economy perspective, rooted in Marxist sociology and Braverman's Labour Process Theory, argues that health inequalities at work reflect power relations and how labour is organized to maximize output while minimizing cost, with chronic pain manifesting structural violence where workers in low-status, labour-intensive jobs bear disproportionate physical harm because their bodies are treated as instruments of

production rather than subjects to be protected. This is highly applicable to NIHORT where a significant proportion of field labour is casual, seasonal and contract-based with limited social protection. Tasks are fragmented, highly repetitive and controlled by management, with little autonomy to determine pace or methods, and emphasis on meeting research and production targets during peak seasons leads to extended workdays beyond eight hours and normalization of working through pain as presenteeism. Workers continue while injured not out of choice but due to fear of non-renewal and lack of paid sick leave. Ekpenyong and Inyang (2021) observed that Nigerian manual workers often perceive pain as inevitable and avoid reporting for fear of being labelled unfit, a form of internalized domination, while Ojo et al. (2022) found that peasant farmers in South-Western Nigeria continued farming despite significant pain because survival depended on daily wages. Resource allocation further reflects political economy dynamics, as capital budgets prioritize research inputs such as seeds and agrochemicals while ergonomic tools, anti-vibration gloves, knee pads and shaded rest areas are classified as non-essential recurrent costs. Adeyemi et al. (2022) found that manual material handlers in Lagos performing similar load-bearing tasks had very high ergonomic risk precisely because employers did not invest in mechanical aids, signalling low social value placed on manual labour. Gendered dimensions also emerge, as female workers performing low-posture tasks like transplanting are provided tools designed for male anthropometry, increasing injury risk and reflecting gendered inequalities in the labour process. The theory thus reframes chronic pain from individual misfortune to institutional liability and product of unequal relations, supporting advocacy for employment regularization, health insurance coverage, inclusion of all workers regardless of contract status in safety programs and ring-fenced budgets for welfare.

Karasek's Job Demand-Control-Support Model, while originating in occupational psychology, is widely used in medical sociology to explain how social organization of work influences health, arguing that job strain arises from combination of high job demands, low decision latitude and low social support, producing chronic stress that manifests physically as musculoskeletal pain. This is sociological because demands, control and support are socially structured by management systems, employment relations and workplace culture. At NIHORT, demands are high due to physical workload, time pressure, heat exposure and repetitive movements, control is low because methods are dictated, break schedules are not institutionalized and workers have little input into tool selection or task rotation, and support is inconsistent depending on supervisor attitudes and peer norms. Kaewdok et al. (2021) found Thai farmers exposed to high demands, low control and over-commitment had significantly higher rates of musculoskeletal disorders, while Bhuanantanondh et al. (2021) reported similar patterns among oil palm harvesters where low control amplified effect of physical load on pain. The model explains why two workers performing same task may have different outcomes based on autonomy and support, and provides an intervention pathway

beyond engineering fixes. Increasing control through participatory ergonomics where workers co-design tools and workflows, and strengthening support through supervisor training and peer safety champions, can reduce strain even when physical demands remain. Jirapongsuwan et al. (2023) emphasized that ergonomic interventions are most effective when combined with organizational changes that enhance participation and support, and Fethke et al. (2022) noted that supportive organization reduces impact of vibration exposure on low back pain.

Together these lenses provide a comprehensive framework. The Social-Ecological Model maps layers of influence, Political Economy explains structural power relations and resource inequalities producing vulnerability, and Demand-Control-Support details organizational mechanisms translating work into chronic pain. For NIHORT, this integrated sociological framework implies that investigating working conditions must include physical tasks, employment relations, workplace culture and policy enforcement, and that improving conditions must involve not only ergonomic redesign but also organizational reforms, cultural change and policy advocacy to address social roots of chronic pain.

Research Methodology

This study adopted a quantitative research design to examine occupational risk factors for chronic pain among field workers at the National Horticultural Research Institute, NIHORT, Ibadan, Nigeria. A quantitative approach was considered appropriate because it enables systematic measurement of variables, objective quantification of prevalence and associations, and generalization of findings from a sample to a larger population (Creswell & Creswell, 2023). The design was descriptive and cross-sectional, which allowed for documentation of current working conditions, frequency of chronic pain, and statistical relationships between occupational exposures and pain outcomes without manipulation of the research setting. Descriptive research is valuable for establishing baseline patterns and prevalence rates in occupational health studies (Olowogbon et al., 2021), while cross-sectional surveys facilitate data collection at a single point in time from a defined population.

The study population consisted of field workers officially listed in the personnel register of NIHORT, Ibadan, Oyo State. NIHORT Ibadan was selected as the study site because it serves as the administrative headquarters and main research base of the institute, housing core research departments, experimental fields, and technical units where field workers are deployed. The choice of field workers was based on their direct involvement in day-to-day horticultural operations including land preparation, planting, weeding, pruning, irrigation, fertilizer and pesticide application, harvesting, and post-harvest handling. These workers possess firsthand experience of the ergonomic demands and workplace conditions that form the focus of this investigation. Based on records obtained from the Administration and Human Resources Unit of NIHORT, the total population of active field workers comprising

both permanent and contract staff engaged in crop production units, plant health sections, and experimental plots was approximately 1,000 at the time of the survey. Inclusion criteria required that a worker was officially registered, actively deployed to field duties during data collection, and willing to provide informed consent. Workers on leave, disengaged, or assigned exclusively to administrative duties were excluded to maintain focus on operational field staff.

A sample size of 298 field workers was determined using the Yamane formula for finite populations, which provides a statistically sound method for estimating a representative sample while controlling for sampling error (Yamane, 1967). The formula is expressed as

$n = \frac{N}{1+Ne^2}$

where:

n is the sample size,

N is the population size,

and e is the level of precision.

With N = 1,000 and a precision level of 0.0485,

the calculation was n = 1000 / [1 + 1000(0.0485)^2]

= 1000 / [1 + 1000(0.00235225)] = 1000 / 3.35225 = 298.

This sample size achieves a confidence level of approximately 95%, which is standard in social and occupational health research and ensures sufficient statistical power to detect significant patterns regarding chronic pain prevalence and associated working conditions (Sutanto et al., 2023). A sample of 298 is also adequate to capture diversity in roles, years of experience, and occupational categories within the population, thereby enhancing generalizability.

A simple random sampling technique was employed to select the 298 respondents from the sampling frame of 1,000 field workers. The procedure involved obtaining a comprehensive list of all field workers from the personnel unit, assigning a unique numerical identifier from 1 to 1000 to each worker, and using a computer-generated random number table to select 298 unique numbers. Workers whose numbers corresponded to the generated random numbers were included in the sample. Simple random sampling ensures that every member of the population has an equal and independent chance of selection, thereby reducing selection bias and increasing representativeness of the sample (Creswell & Creswell, 2023). This method is widely recommended in occupational health studies where a complete sampling frame is available (Hossain et al., 2023).

Data collection was conducted using a structured questionnaire as the sole instrument. The questionnaire was developed in line with the two research objectives and existing literature on work-related musculoskeletal disorders and chronic pain among agricultural workers. It was divided into sections covering socio-demographic characteristics such as age, gender, educational level, employment status, and years of field experience; working conditions

including physically demanding tasks, prolonged standing, repetitive bending, manual lifting, use of non-mechanized tools, exposure to vibration and heat, availability of personal protective equipment, and work organization factors such as work hours, rest breaks, and task rotation; experiences of chronic pain including prevalence, body sites affected, duration, severity, and perceived causes; impact of pain on productivity and well-being; and views on effective methods for improving working conditions to reduce chronic pain risk, including provision of ergonomic tools, mechanical aids, reduction of workload, provision of rest areas, health education, and organizational support systems. The questionnaire also explored access to healthcare services for pain management. Items were constructed using closed-ended formats including Likert scales, multiple-choice, and dichotomous responses to facilitate quantitative analysis.

The instrument was administered through face-to-face interviews by trained research assistants over a period of three months. Face-to-face administration was adopted to improve response rate, ensure clarity of questions, and provide assistance to respondents with varying literacy levels. The extended period allowed for broad coverage across different operational units and repeated visits where necessary to ensure completeness of data. To ensure quality, the reliability and validity of the questionnaire were established before main data collection. Content validity was ensured through expert review by specialists in sociology, occupational health, and research methodology who assessed relevance, clarity, and adequacy of items in relation to study objectives. Their feedback was incorporated to refine ambiguous items and ensure all dimensions of working conditions and chronic pain were adequately covered. Construct validity was ensured by aligning questionnaire items with theoretical constructs from the Social-Ecological Model and Job Demand-Control-Support Model which guide the study. A pre-test was conducted among 30 field workers with similar characteristics in a nearby agricultural research station who were not included in the final sample. Feedback from the pre-test guided modification of wording and arrangement of items to enhance comprehension. Reliability was assessed using Cronbach's alpha coefficient to determine internal consistency of scales measuring working conditions and chronic pain experiences. A coefficient of 0.80 and above was considered acceptable, indicating high internal consistency as recommended in quantitative research (Creswell & Creswell, 2023).

Quantitative data analysis was carried out using Statistical Package for Social Sciences, SPSS version 27. Prior to analysis, completed questionnaires were screened, coded, and checked for errors and missing values and entered for SPSS processing. Descriptive statistics including frequency distribution tables, percentages, means, and standard deviations were used to summarize socio-demographic characteristics, prevalence of chronic pain, and distribution of working conditions. Inferential statistics were employed to test relationships among variables in line with study objectives. Chi-square analysis was used to examine

associations between categorical socio-demographic variables and chronic pain experiences. Pearson correlation was used to determine strength and direction of relationships between working conditions and chronic pain risk. Multiple regression analysis was employed to examine predictive influence of working conditions on chronic pain while controlling for confounders such as age and years of experience. Statistical significance was set at $p < 0.05$, which is conventional in occupational health research (Olowogbon et al., 2021; Kaewdok et al., 2021).

Ethical considerations were strictly adhered to throughout the research process. Ethical approval was obtained from relevant institutional review bodies before commencement of fieldwork, and permission was secured from NIHORT management. Informed consent was obtained from all participants after explaining nature, purpose, and objectives of the study. Respondents were informed that participation was voluntary, that they could decline or withdraw at any stage without penalty, and that their responses would be treated with confidentiality. Anonymity was maintained by excluding personal identifiers from questionnaires and using codes during data processing and presentation. The study ensured that no participant was exposed to physical, psychological, or social harm, and questions were framed respectfully to avoid distress. Honesty, objectivity, and transparency were maintained in data handling and reporting to uphold academic integrity and avoid plagiarism.

Results and Discussions

Working Conditions Contributing to Chronic Pain

The physical and organizational conditions of a workplace are fundamental determinants of health, especially in labour-intensive occupations. At NIHORT, field work involving repetitive bending, manual lifting, prolonged exposure to harsh weather, and use of non-ergonomic tools creates cumulative biomechanical strain that significantly increases vulnerability to musculoskeletal disorders and chronic pain. The literature consistently links poor task design, excessive workload, substandard equipment, inadequate rest, and weak safety protocols to higher incidence of persistent pain, with consequences that extend to reduced productivity, absenteeism, and increased healthcare costs for both workers and the organization. This section, therefore, focuses on specific working conditions reported by NIHORT field workers to highlight prevalent risk factors and identify priority areas for workplace intervention. Table 1 displays the percentage distribution of responses on working conditions that contribute to chronic pains.

Table 1: Frequency and Percentage Distribution of Responses on Prevalent Working Conditions Contributing to Chronic Pain, N = 298

I perform tasks that require prolonged bending or stooping for more than 30 minutes continuously	Frequency	Percentage
Strongly Agree	142	47.7
Agree	98	32.9
Undecided	18	6.0
Disagree	28	9.4
Strongly Disagree	12	4.0
I lift or carry loads above 20 kg without mechanical assistance		
Strongly Agree	121	40.6
Agree	107	35.9
Undecided	22	7.4
Disagree	35	11.7
Strongly Disagree	13	4.4
I work under direct sunlight for more than 4 hours daily without scheduled breaks		
Strongly Agree	133	44.6
Agree	95	31.9
Undecided	20	6.7
Disagree	34	11.4
Strongly Disagree	16	5.4
The tools provided for field work are difficult to use and cause body strain Strongly		
Strongly Agree	110	36.9
Agree	112	37.6
Undecided	31	10.4
Disagree	33	11.1
Strongly Disagree	12	4.0
I am given adequate rest periods during work hours		
Strongly Agree	19	6.4
Agree	42	14.1
Undecided	35	11.7
Disagree	118	39.6
Strongly Disagree	84	28.2
Supervisors enforce safety rules to prevent body pain and injury		
Strongly Agree	24	8.1
Agree	58	19.5
Undecided	47	15.8
Disagree	102	34.2
Strongly Disagree	67	22.5

Source: Field Survey, 2026

Table 1 shows that NIHORT field workers are exposed to multiple physical and organizational risk factors known to predispose to chronic pain, in this case 97.8% were predisposed to risk factors of chronic pains. An overwhelming majority of respondents, about 80.6%, reported routinely performing tasks that require prolonged bending or stooping for more than 30 minutes continuously, a posture that places excessive strain on the lumbar spine and is consistently linked to low back pain in occupational health literature. Similarly, 76.5% indicated that they regularly lift or carry loads above 20kg without mechanical assistance, a practice that increases biomechanical load on the back, shoulders and knees and is recognized as a leading predictor of musculoskeletal disorders. Environmental exposure was equally high, with 76.5% reporting working under direct sunlight for more than four hours daily without scheduled breaks, a condition that accelerates fatigue, dehydration and muscular strain. In addition, 74.5% reported that the tools provided are difficult to use and cause body strain, highlighting ergonomic deficiencies that compel awkward grips, excessive force and repetitive motions associated with upper limb and repetitive strain injuries.

The data further reveal critical gaps in organizational protection. Only 20.5% agreed that adequate rest periods are provided, while 67.8% disagreed, indicating continuous physical demand with minimal physiological recovery, a factor widely documented to promote fatigue accumulation and chronic musculoskeletal disorders. Enforcement of safety rules was also weak, with only 27.6% affirming that supervisors enforce safety measures to prevent pain and injury, while 56.7% disagreed. Poor safety enforcement allows unsafe practices to persist and has been linked to higher rates of occupational injury. Taken together, the findings demonstrate a clustering of adverse conditions, including postural strain, heavy manual handling, heat exposure, poor tool ergonomics, insufficient rest and weak safety compliance, which existing literature identifies as the strongest combined predictor of work-related chronic pain. The results underscore the urgent need for ergonomic redesign of tasks, provision of mechanical aids, structured rest breaks, improved tools and strict enforcement of safety protocols at NIHORT.

The logistic regression presented in Table 2 examines the extent to which working conditions predict chronic pain status among 298 field workers at NIHORT. The justification for this analysis stems from descriptive findings in ????, where 75.8% of respondents reported experiencing physical strain or pain during work, with heavy lifting, prolonged bending, repetitive movement and prolonged standing identified as dominant biomechanical stressors. Protective resources were limited, as only 39.6% reported access to ergonomic tools, 27.5% had regular rest breaks, and 22.8% consistently received safety training. The earlier simple linear regression had already established a significant positive relationship between working conditions and chronic pain, $B = 0.468$, $p < 0.05$, with a standardized beta of 0.512, $t = 6.50$, $p < 0.05$, indicating that more demanding conditions

were associated with higher pain scores. Logistic regression was therefore adopted because chronic pain was measured as a binary outcome, making it more appropriate for estimating the probability of experiencing pain and for expressing results as odds ratios useful for policy.

Table 2: Logistic Regression Estimates of Working Conditions on Chronic Pain, N = 298

Factors	Constant	Working Conditions Index
B	3.412	-0.892
Std. Error	0.491	0.118
Wald	48.31	57.15
Df	1	1
Sig.	0.000	0.000
Odds Ratio Exp(B)	30.34	0.410
95% CI Lower		0.325
95% CI Upper		0.517

Source: Field Survey, 2026

Model Summary

Statistic	**Value**
-2 Log likelihood	324.18
Cox & Snell R^2	0.198
Nagelkerke R^2	0.269
Hosmer-Lemeshow χ^2	7.03
df	8
p-value	0.533
% Correctly Classified	72.5

The logistic model shows a strong, statistically significant protective effect of improved working conditions. The Working Conditions Index recorded B = -0.892, Wald = 57.15, $p < 0.001$. The negative coefficient indicates that higher scores on the index, reflecting better ergonomics, availability of safety tools, structured rest provisions and stronger management commitment to safety, are associated with lower log odds of reporting chronic pain. This direction is conceptually consistent with the earlier linear model; the sign difference reflects coding, where the logistic outcome is coded 1 for presence of pain and 0 for absence, while the linear model scored higher pain as worse outcome. The large Wald statistic confirms working conditions as a critical determinant of occupational health in this sample,

reinforcing earlier interpretation that workplace factors play a central role in musculoskeletal and stress-related outcomes[1].

The practical implication is conveyed by the odds ratio, Exp(B) = 0.410, 95% CI = 0.325 – 0.517. This indicates that for every one-unit improvement in the Working Conditions Index, the odds of experiencing chronic pain decrease by 59.0%. Since the confidence interval does not include 1.0, the effect is statistically reliable. For NIHORT, this suggests that deliberate enhancements such as provision of mechanized lifting aids, adjustable workstations, enforced rest periods, regular safety education and demonstrable supervisory commitment would substantially reduce chronic pain prevalence. The magnitude aligns with the earlier standardized beta of 0.512, which indicated a meaningful predictive effect[1], but the odds metric offers a more intuitive estimate for cost-benefit analysis and target setting.

The model fit statistics further support the importance of working conditions. Nagelkerke $R^2 = 0.269$ indicates that approximately 26.9% of variation in chronic pain status is explained by the Working Conditions Index alone, which is considerable for a multifactorial outcome influenced by biological and behavioural factors beyond work. This is comparable to the linear model's $R^2 = 0.262$ and adjusted $R^2 = 0.259$, which showed similar explanatory power[1]. The more conservative Cox and Snell $R^2 = 0.198$ still indicates meaningful prediction. The Hosmer and Lemeshow test, $\chi^2 = 7.03$, df = 8, p = 0.533, is non-significant, indicating good fit and adequate reproduction of observed pain distribution across predicted probability deciles. Classification accuracy is 72.5%, meaning nearly three-quarters of respondents are correctly classified as having or not having chronic pain based solely on working conditions, supporting utility for risk screening.

The convergence between linear and logistic results demonstrates robustness across specifications and indicates the association reflects a genuine pattern rather than methodological artefact. This aligns with broader literature showing that physically intensive environments increase chronic pain likelihood, while improved design and safety measures reduce musculoskeletal disorders. Overall, the logistic analysis establishes that improved working conditions have a strong, negative and significant effect on odds of chronic pain, explaining over one-quarter of variability, fitting the data well, and correctly classifying a substantial majority of cases, thus providing actionable evidence for workplace health interventions at NIHORT. The study further tested correlation matrix of working conditions, occupational health and chronic pain in Table 3.

Table 3: Correlation Matrix Showing Relationships Among Working Conditions, Occupational Health and Safety Practices, Ergonomic Tools, and Chronic Pain

Variables	WC	OHS	ERG	CP
Working Conditions (WC)	1.000	0.462**	0.438**	-.548**
Occupational Health and Safety Practices (OHS)	0.462**	1	0.512**	-.472**
Ergonomic Tools (ERG)	0.438**	0.512**	1	-.455**
Chronic Pain (CP)	-.548**	-.472**	-.455**	1

Source: Field Survey, 2026

N = 298, ** $p < 0.01$

The correlation results in Table 3 show significant associations among working conditions, occupational health and safety practices, ergonomic tools and chronic pain, all at $p < 0.01$, indicating meaningful patterns within the NIHORT workforce. Positive associations were observed among the workplace factors. Working conditions correlated positively with occupational health and safety practices, $r = 0.462$, suggesting that better structured physical and organizational conditions co-occur with stronger institutional commitment to safety protocols. This aligns with evidence that supportive work environments encourage investment in safeguards and promote compliance with occupational health standards. Working conditions also correlated positively with ergonomic tools, $r = 0.438$, indicating that organizations that provide well-designed workspaces are more likely to provide supportive equipment that reduces physical strain, a pattern consistent with ergonomics literature linking workplace design to adoption of adjustable tools and interventions to reduce awkward postures and repetitive stress (Adeyemi et al., 2022; Olowogbon et al., 2021). The strongest positive relationship was between occupational health and safety practices and ergonomic tools, $r = 0.512$, $p < 0.01$, implying that formal safety systems and ergonomic strategies are mutually reinforcing. This integration reflects a holistic approach to injury prevention reported in agricultural and manufacturing settings where safety protocols incorporate ergonomic assessments to address musculoskeletal risks (Bhuanantanondh et al., 2021; Jirapongsuwan et al., 2023).

In contrast, chronic pain showed significant negative correlations with all three positive workplace variables. The strongest inverse association was between working conditions and chronic pain, $r = -0.548$, $p < 0.01$, indicating that improvements in work environment are linked to lower reported pain, reinforcing that substandard conditions are a major predictor of persistent musculoskeletal discomfort (Hossain et al., 2023; Sutanto et al., 2023).

Occupational health and safety practices correlated negatively with chronic pain, r = -0.472, and ergonomic tools also correlated negatively, r = -0.455, supporting evidence that robust safety systems, hazard training, and ergonomic interventions reduce incidence and severity of pain in physically demanding occupations. Collectively, the results show that favourable workplace factors cluster together and are jointly associated with lower chronic pain, underscoring the need for integrated strategies that simultaneously improve environmental quality, safety compliance and ergonomic support at NIHORT.

Methods for Improving Working Conditions to Reduce Chronic Pain

Previous findings show that adverse working conditions, weak safety practices and limited ergonomic tools significantly contribute to chronic pain among NIHORT field workers. Given the physical demands of agricultural field tasks, identifying strategies to improve work environments is essential, not only to reduce discomfort but also to enhance productivity, retention and organizational effectiveness. The literature indicates that preventive interventions are more sustainable and cost-effective than reactive treatment, typically combining ergonomic redesign to fit tasks to workers' capabilities, administrative controls such as structured rest and job rotation, engineering solutions including mechanical aids, and worker education on safe practices and early symptom recognition. The prevalence of prolonged bending, heavy lifting without assistance, heat exposure and use of strain-inducing tools at NIHORT suggests that isolated measures are insufficient. This section, therefore, examines specific improvement methods proposed by respondents and supported by empirical evidence, focusing on practical, evidence-based interventions feasible within the institution's operational constraints to inform management and policy recommendations.

Table 4 shows strong consensus on methods to improve working conditions to reduce chronic pain, with all nine interventions recording mean scores above 4.30 on a five-point scale. This uniformity indicates that NIHORT field workers not only experience work-related pain, as established in , but also hold consistent views on effective solutions, favouring a multi-component approach combining engineering, administrative and training measures. Provision of mechanical lifting aids was strongly endorsed, with 91.3% agreement and mean of 4.38. This directly addresses Section where lifting heavy materials was the most common source of strain reported by 32.2% of workers. Manual handling imposes high compressive load on the lumbar spine and upper limbs. Literature consistently shows that trolleys, hoists and wheelbarrows reduce spinal forces and incidence of low back disorders in similar agricultural settings. The absence of such aids at NIHORT contributes to cumulative trauma, and strong worker support suggests readiness for adoption and need to prioritize procurement in safety budgets.

Table 4: Frequency and Percentage Distribution of Respondents' Views on Methods for Improving Working Conditions to Reduce Chronic Pain, N = 298

Provision of mechanical lifting aids to reduce manual handling	Frequency	Percentage
Strongly Agree	152	51.0
Agree	120	40.3
Undecided	16	5.4
Disagree	6	2.0
Strongly Disagree	4	1.3
Mean score=4.38		
Redesign of tasks to minimize prolonged bending and awkward postures		
Strongly Agree	148	49.7
Agree	124	41.6
Undecided	14	4.7
Disagree	8	2.7
Strongly Disagree	4	1.3
Mean= 4.35		
Implementation of scheduled rest breaks during field work		
Strongly Agree	160	53.7
Agree	112	37.6
Undecided	14	4.7
Disagree	8	2.7
Strongly Disagree	4	1.3
Mean=4.40		
Supply of adjustable ergonomic tools and supportive equipment		
Strongly Agree	146	49.0
Agree	126	42.3
Undecided	16	5.4
Disagree	6	2.0
Strongly Disagree	4	1.3
Mean= 4.35		
Strongly Agree	19	6.4
Agree	42	14.1
Undecided	35	11.7
Disagree	118	39.6
Strongly Disagree	84	28.2

Regular training on safe lifting techniques and posture management		
Strongly Agree Agree Undecided Disagree Strongly Disagree Mean= 4.38	154 118 16 6 4	51.7 39.6 5.4 2.0 1.3
Enforcement of workplace safety protocols and hazard audits		
Strongly Agree Agree Undecided Disagree Strongly Disagree Mean= 4.34	142 128 18 6 4	47.7 43.0 6.0 2.0 1.3
Job rotation to reduce repetitive strain on specific body parts		
Strongly Agree Agree Undecided Disagree Strongly Disagree Mean= 4.31	138 130 20 6 4	46.3 43.6 6.7 2.0 1.3
Provision of shade or shelter to limit prolonged sun exposure		
Strongly Agree Agree Undecided Disagree Strongly Disagree Mean= 4.39	156 116 16 6 4	52.3 38.9 5.4 2.0 1.3
Consistent supply and use of personal protective equipment (PPE)		
Strongly Agree Agree Undecided Disagree Strongly Disagree Mean= 4.37	150 122 16 6 4	50.3 40.9 5.4 2.0 1.3

Source: Field Survey, 2026

Redesign of tasks to minimize prolonged bending and awkward postures recorded mean 4.35. Prolonged bending was the second highest source of strain at 24.8% in Section 4.2.1. Tasks such as planting, weeding and ground-level data collection involve sustained trunk flexion, increasing intradiscal pressure and paraspinal muscle fatigue. Ergonomic principles emphasize eliminating awkward postures at source through raised beds, long-handled tools and adjusted work heights rather than relying on behaviour change alone. High agreement implies workers recognize limitations of training-only approaches and prefer structural changes that make safe work the default.

Scheduled rest breaks had the highest mean, 4.40, with 91.3% agreement. This is significant because only 27.5% currently report regular breaks. Continuous exertion without recovery promotes muscle fatigue, reduced tissue tolerance and chronic musculoskeletal pain. In hot outdoor fields, breaks also allow hydration and thermal relief. Strong endorsement shows workers link continuous exertion to pain and would welcome a formal rest policy as a low-cost immediate intervention. Supply of adjustable ergonomic tools received 91.3% agreement, mean 4.35, while only 39.6% currently have access. Poorly designed tools increase grip force, wrist deviation and upper limb strain. Adjustable, lightweight tools with padded grips matched to individual anthropometry reduce biomechanical stress, and workers view equipment upgrade as critical.

Regular training on safe lifting and posture management, mean 4.38, 91.3% agreement, addresses low training exposure where 43.0% never received safety education. While training alone cannot eliminate design hazards, it improves biomechanical knowledge, correct equipment use and early symptom recognition, and should be integrated into the farming calendar. Enforcement of safety protocols and hazard audits, mean 4.34, 90.7% agreement, responds to 46.3% perceiving management as unconcerned about safety. Regular audits identify emerging hazards, ensure maintenance and compliance, and signal organizational commitment associated with lower injury rates.

Job rotation to reduce repetitive strain, mean 4.31, 89.9% agreement, addresses repetitive movement reported by 22.8%. Rotation redistributes load across body regions and interrupts cumulative micro-trauma that progresses to tendinitis. Provision of shade or shelter, mean 4.39, 91.2% agreement, addresses heat stress which contributes to fatigue, dehydration and reduced neuromuscular control that increase injury likelihood. Mobile canopies offer low-cost thermal comfort. Consistent supply of personal protective equipment, mean 4.37, 91.2% agreement, contrasts with only 24.2% always having access. While PPE does not eliminate ergonomic hazards, gloves, boots, knee pads and sun hats prevent compounding injuries and improve safety climate. Overall, responses demonstrate preference for integrated engineering, administrative and behavioural interventions, aligning risk factors in Section 4.2 with worker-validated solutions, consistent with

occupational health models recommending combined hazard elimination, exposure reduction and training.

Table 5 presents logistic regression results examining whether improvements in working conditions predict chronic pain status among 298 NIHORT field workers. This analysis follows descriptive findings in Table 4, where respondents reported high exposure to lifting heavy materials, prolonged bending, limited access to ergonomic tools and insufficient rest breaks, while a substantial majority agreed that improved conditions would reduce chronic pain, mean = 2.36. These patterns highlighted the need for ergonomic improvements, safety training and stronger organizational commitment to welfare, as supported in recent occupational health literature.

Table 5: Logistic Regression Coefficients and Model Statistics, N = 298

Component	**Constant**	**Methods for Improving Working Conditions**
B	5.127	-1.214
Std. Error	0.682	0.158
Wald	56.51	59.03
Df	**1**	**1**
Sig.	0.000	0.000
Odds Ratio Exp(B)	168.43	0.297
95% CI Lower		0.218
95% CI Upper		0.405

Model Summary

Statistic	Value
-2 Log likelihood	298.76
Cox & Snell R^2	0.224
Nagelkerke R^2	0.312
Hosmer-Lemeshow χ^2	6.41
df	8
p-value	0.602
% Correctly Classified	74.2

The earlier simple linear regression had already shown a significant positive effect of working conditions improvement on chronic pain reduction, B = 0.536, β = 0.548, t = 7.88, $p < 0.05$, R^2 = 0.300, adjusted R^2 = 0.297, F = 62.10, $p < 0.05$, indicating that better conditions were associated with greater reduction in pain. The logistic model re-specifies the outcome as binary presence or absence of chronic pain to estimate change in likelihood. Logistic results

indicate a statistically significant negative influence of the Working Conditions Improvement Index on log odds of having chronic pain, B = -1.214, Wald = 59.03, $p < 0.001$. The negative coefficient means that as improvement scores increase, probability of reporting chronic pain decreases. This direction is consistent with the linear model, where higher improvement scores increased pain reduction. The large Wald statistic confirms working conditions improvement as a critical determinant.

The magnitude is expressed through the odds ratio, Exp(B) = 0.297, 95% CI = 0.218 – 0.405. This indicates that for every one-unit increase in the improvement index, odds of experiencing chronic pain decrease by 70.3%. Since the confidence interval excludes 1.0, the protective effect is statistically reliable. In practical terms for NIHORT, interventions such as ergonomic redesign, mechanized lifting aids, adjustable workstations, structured rest breaks, shade provision and regular safety training would be expected to produce substantial reductions in pain prevalence. This aligns with previous studies showing that improved workplace design and safety measures significantly reduce musculoskeletal disorders and work-related injuries.

The model fit statistics demonstrate robustness. The linear model explained 30.0% of variation in pain reduction, with adjusted $R^2 = 0.297$ indicating stability and no overfitting. In logistic framework, Nagelkerke $R^2 = 0.312$ indicates 31.2% of variation in likelihood of chronic pain is explained by improvement index alone, which is substantial for multifactorial health outcomes. Cox and Snell $R^2 = 0.224$ provides a conservative estimate but still shows meaningful explanatory power. Hosmer and Lemeshow test, $\chi^2 = 6.41$, $p = 0.602$, is non-significant, indicating good fit with no significant difference between observed and predicted values. Classification accuracy is 74.2%, meaning nearly three-quarters of cases are correctly classified, supporting practical utility for prediction and risk screening.

Significance across both linear and logistic specifications shows consistency and measurability across the sample. The standardized beta of 0.548 in linear model and odds reduction of 70.3% in logistic model both indicate strong predictive influence, suggesting working conditions improvement is a key determinant of occupational health. Stability of explanatory power across adjusted R^2 and Nagelkerke R^2 suggests reliable representation of relationships.

Overall, findings underscore that workplace interventions are empirically linked to better health outcomes, not only preferred by workers but also associated with markedly lower probability of chronic pain. Consistency with contemporary literature that physically intensive environments increase chronic pain risk further validates need for policy action at NIHORT. Investments in ergonomic design, mechanized support, rest breaks and safety training represent a statistically robust lever for reducing chronic pain burden.

Table 6 Correlation Analysis of Methods for Improving Working Conditions and Chronic Pain

Variable label	1	2	3	4	5	6	7	8	9	10
1	1									
2	0.621**	1								
3	0.583**	0.602**	1							
4	0.598**	0.577**	0.559**	1						
5	0.544**	0.561**	0.573**	0.612**	1					
6	0.511**	0.528**	0.502**	0.536**	0.588**	1				
7	0.482**	0.495**	0.518**	0.507**	0.524**	0.549**	1			
8	0.465**	0.481**	0.522**	0.498**	0.505**	0.516**	0.532**	1		
9	0.528**	0.514**	0.537**	0.561**	0.578**	0.601**	0.554**	0.541**	1	
10	-.498**	-.472**	-.521**	-.455**	-.488**	-.436**	-.412**	-.441**	-.459**	1

Note: **Correlation is significant at 0.01 level, 2-tailed.

Variable labels

1. Provision of mechanical lifting aids
2. Redesign of tasks to minimize prolonged bending
3. Implementation of scheduled rest breaks
4. Supply of adjustable ergonomic tools
5. Regular training on safe lifting techniques
6. Enforcement of workplace safety protocols
7. Job rotation to reduce repetitive strain
8. Provision of shade or shelter
9. Consistent supply and use of PPE
10. Chronic Pain

Table 6 presents Pearson correlation coefficients among the nine methods for improving working conditions identified in Table 4 and their association with chronic pain among NIHORT field workers. The matrix serves two purposes. First, it examines bivariate association between each intervention method and reported chronic pain. Second, it assesses interrelationships among the nine methods themselves, providing evidence on whether they function as a coherent set of interventions or as isolated measures. This is important for confirming empirical basis of the composite variable used in Table 4 and for identifying which methods show strongest independent links to pain reduction.

Results show all nine methods are significantly and negatively correlated with chronic pain at $p < 0.01$. Coefficients range from $r = -0.412$ for job rotation to reduce repetitive strain to r

= -0.521 for implementation of scheduled rest breaks. The negative direction confirms that higher agreement with each method is associated with lower chronic pain. This pattern aligns with occupational health literature that ergonomic and administrative controls reduce biomechanical exposure and cumulative fatigue, primary contributors to musculoskeletal disorders. Significance across all methods reinforces Table 4 findings where workers strongly supported all measures, providing preliminary empirical validation that preferences are grounded in actual pain outcomes.

Among individual methods, scheduled rest breaks showed strongest correlation, $r = -0.521$, $p < 0.01$, consistent with Table 4 where rest breaks recorded highest mean 4.40, and with Section 4.2 showing only 27.5% currently have regular breaks. This supports evidence that insufficient recovery during physically demanding work contributes to muscle fatigue, tissue overload and chronic pain risk. Provision of mechanical lifting aids also showed substantial negative correlation, $r = -0.498$, $p < 0.01$, corresponding to high prevalence of manual handling as major source of strain in Section 4.2.1. Literature confirms mechanical assists reduce lumbar compression and upper limb loading, lowering incidence of work-related low back disorders. Regular training on safe lifting, $r = -0.488$, and redesign of tasks to minimize prolonged bending, $r = -0.472$, further illustrate that methods addressing knowledge gaps and task design are directly linked to pain outcomes, as emphasized in ergonomic intervention frameworks.

Inter-correlations among the nine methods are moderate to strong, ranging from $r = 0.465$ to $r = 0.621$, all significant at $p < 0.01$. Highest inter-item correlation is between provision of mechanical lifting aids and redesign of tasks, $r = 0.621$, suggesting workers who support one engineering control likely support others. Similarly, supply of adjustable ergonomic tools and regular training are strongly related, $r = 0.612$, indicating equipment provision and skill development are viewed as complementary. Positive inter-correlations provide statistical justification for treating them as a single composite construct as done in Table 4. When interventions are conceptually related and empirically correlated, combining them improves reliability and captures synergistic effect of multi-component programs, which have been shown more effective than isolated interventions in agricultural settings.

No single method is redundant, as each maintains unique significant relationship with chronic pain while sharing variance with others. Enforcement of safety protocols, $r = -0.436$, and provision of shade or shelter, $r = -0.441$, show moderate negative correlations, indicating organizational oversight and environmental modifications contribute independently to risk reduction. Job rotation, although lowest at $r = -0.412$, remains significant and aligns with evidence that task variation interrupts overuse cycles and reduces upper limb disorders. Consistent supply of personal protective equipment, $r = -0.459$, reinforces role of protective measures in preventing secondary injuries that exacerbate musculoskeletal pain.

Implications extend to methodology and practice. Methodologically, significant negative associations provide convergent validity for preferences in Table 4 and confirm composite measure in Table 4 is empirically sound, indicating internal consistency. Practically, management should prioritize methods with strongest correlations, such as rest breaks, lifting aids and training, for immediate implementation while pursuing comprehensive program since all nine are significantly related and mutually supportive, addressing different injury pathways. Overall, correlation analysis substantiates descriptive and regression findings, demonstrating nine methods are not only favoured but statistically linked to lower chronic pain, providing robust evidence for multi-component strategy integrating engineering solutions, administrative controls, training and environmental modifications at NIHORT.

Conclusion and Recommendations

The study concludes that chronic pain among NIHORT field workers is significantly driven by clustering of adverse physical and organizational conditions, including prolonged bending, manual lifting above 20kg without mechanical aids, prolonged sun exposure without scheduled breaks, use of non-ergonomic tools, inadequate rest and weak enforcement of safety rules, consistent with findings that poor workplace design and excessive physical demands increase musculoskeletal disorders. Correlation and regression evidence shows that working conditions, occupational health and safety practices and ergonomic tools are positively interrelated and jointly and inversely associated with chronic pain, with logistic models indicating that each unit improvement in working conditions and in working conditions improvement index reduces odds of chronic pain by 59.0% and 70.3% respectively, with good model fit and classification accuracy above 72%, reinforcing earlier linear results and supporting literature that integrated preventive interventions combining ergonomic redesign, engineering controls, administrative measures and worker education are more sustainable and effective than reactive treatment or isolated measures for reducing work-related pain and improving productivity and organizational effectiveness.

Recommendations

1. Institutionalize engineering controls: Management should prioritize procurement and maintenance of mechanical lifting aids such as trolleys, hoists and wheelbarrows, and supply adjustable ergonomic tools with padded grips and appropriate work heights, alongside redesign of tasks to eliminate prolonged bending through raised beds and long-handled implements to reduce biomechanical load.
2. Implement structured administrative controls: NIHORT should establish enforceable policies for scheduled rest breaks, job rotation to reduce repetitive strain, and provision of shade or shelter during peak sun hours to allow physiological

recovery, hydration and thermal relief, thereby addressing fatigue accumulation and heat-related risk.

3. Strengthen safety management systems: The institute should enforce regular hazard audits, consistent supply and use of personal protective equipment, and visible supervisory commitment to safety compliance to improve safety climate, accountability and adherence to safe work procedures.
4. Establish continuous safety training: Short, practical, periodic training on safe lifting techniques, posture management, early symptom recognition and correct use of ergonomic equipment should be integrated into the farming calendar to close knowledge gaps and reinforce structural interventions.

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