

Health and Rehabilitation Challenges Among Date Palm Farming Communities in Khairpur, Sindh: Occupational Risks, Food Safety, and Public Health Perspectives

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ABSTRACT

Background: Date palm farming is economically significant in Sindh, Pakistan, however, farming households often face overlapping occupational health risks, storage-related food safety challenges, and limited access to rehabilitation support. Evidence from Khairpur remains limited regarding the combined burden of pesticide exposure, musculoskeletal strain, and post-harvest safety challenges. **Objective:** To examine health-related problems, rehabilitation constraints, and food safety concerns among date palm farming households in Khairpur, Sindh. **Methods:** A mixed-method field-based study was conducted among 120 date palm farming households in Khairpur. Quantitative data were collected through structured surveys and analyzed using descriptive statistics, while interviews and field observations were used to provide contextual insight into occupational risks, storage practices, and rehabilitation access. **Outcomes** included self-reported occupational symptoms, personal protective equipment use, storage-related food safety conditions, and perceived availability of rehabilitation services. **Results:** Respiratory irritation was reported by 68.3% of participants and musculoskeletal strain by 54.2%, while skin irritation and neurological complaints were reported by 32.5% and 11.7%, respectively. Consistent use of protective equipment was reported by 21.7%, whereas 46.6% reported no use. Pest infestation and fungal contamination risk were observed in 40.8% and 35.8% of storage facilities, respectively, while proper ventilation was present in only 23.3%. Adequate rehabilitation access was reported by 15.8%, and 50.0% reported no access. Interview-based observations were consistent with these patterns and highlighted routine exposure, physical strain, and service limitations. **Conclusion:** Date palm farming communities in Khairpur appear to face substantial and overlapping occupational, food safety, and rehabilitation challenges. Integrated interventions focusing on safer pesticide practices, improved storage management, and accessible rural rehabilitation services are warranted. **Keywords:** Date palm farming, Khairpur Sindh, pesticide exposure, food safety, mycotoxins, rehabilitation, public health, eco-friendly pest management.

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INTRODUCTION

Agriculture remains a major pillar of Pakistan's economy and a key source of livelihood in rural Sindh, where date palm cultivation occupies substantial economic, nutritional, and cultural importance. Khairpur District is one of the country's most prominent date-producing region, and the households engaged in cultivation, harvesting, pesticide application, storage, and post-harvest handling are routinely exposed to a broad range of occupational and environmental hazards. These hazards extend beyond immediate productivity concerns and encompass respiratory symptoms, dermatological complaints, musculoskeletal strain, food contamination risks, and unmet rehabilitation needs among farming communities (1,2). Agricultural workers in low- and middle-income settings are particularly vulnerable because occupational safety infrastructure is often weak, preventive awareness is limited, and access to health and rehabilitation services remains inconsistent, especially in rural areas (3,4).

Among the most important occupational concerns in farming populations is pesticide exposure. International evidence has consistently shown that farmers exposed to pesticides may experience acute and chronic health consequences, including respiratory irritation, skin problems, neurotoxic symptoms, and potentially long-term systemic effects depending on the type, frequency, and duration of exposure (5–8). In Pakistan, these risks may be intensified by inadequate protective practices, unsafe handling behaviors, insufficient training, and constrained regulatory implementation in agricultural settings (1,9,10). Date palm farmers may face similar vulnerabilities because pesticide spraying is often conducted in demanding outdoor environments with limited use of personal protective equipment, thereby increasing the likelihood of direct inhalational and dermal exposure. In such settings, occupational risk is not merely an individual behavioral issue but also reflects wider structural deficits in occupational health education, affordability of safety gear, and access to risk-reduction strategies (6,8,11).

In parallel with chemical hazards, the physical demands of date palm farming create substantial ergonomic stress. Harvesting, carrying loads, repetitive upper-limb activity, prolonged bending, climbing, and awkward postures may cumulatively contribute to musculoskeletal pain and functional limitation. Agricultural work has repeatedly been associated with a high burden of musculoskeletal disorders, particularly involving the back, neck, shoulders, and lower limbs, with important consequences for work capacity, disability, and quality of life (12–15). These concerns are especially relevant in farming communities where pain is often normalized, early symptoms remain untreated, and formal rehabilitation pathways are poorly developed. As a result, occupational morbidity may persist or worsen, leading to reduced function, decreased productivity, and prolonged suffering in already underserved populations (3,14,15).

Food safety constitutes an additional and closely connected dimension of the public health burden in date palm farming systems. Stored dates are susceptible to pest infestation, moisture-related spoilage, and fungal contamination, which may contribute to mycotoxin formation and downstream health risks for consumers. The literature has established the significance of mycotoxins in food systems, linking contamination to gastrointestinal disease, chronic toxicity, carcinogenic potential, and broader food security challenges, particularly in warm climates and poorly regulated storage environments (16–20). In date-producing regions, inadequate storage infrastructure and suboptimal post-harvest management may therefore create a dual threat: adverse health effects among producers through occupational exposure and compromised food safety through contaminated agricultural products (17,18,20). This interaction highlights the need to study farming systems not only through the lens of production efficiency but also through an integrated occupational and public health framework.

Despite the importance of date palm cultivation in Sindh, the available evidence remains fragmented. Prior studies have documented pesticide-related health effects, agricultural occupational risks, musculoskeletal disorders in farming populations, and contamination of stored food products in separate contexts, yet there is limited localized research examining how these problems intersect within date palm farming communities in Khairpur (1,9,12,17,21). In particular, insufficient attention has been paid to the combined burden of occupational symptoms, unsafe protective practices, storage-related food safety threats, and restricted access to rehabilitation support among households directly involved in this sector. This knowledge gap is important because interventions designed in isolation may fail to address the multidimensional realities faced by farming communities, where occupational exposures, chronic pain, food handling practices, and healthcare access are tightly interwoven.

An integrated assessment is therefore warranted to generate context-specific evidence that can inform occupational safety strategies, rehabilitation planning, and food safety improvement in rural Sindh. The present study was undertaken to examine health-related problems, rehabilitation constraints, and food safety concerns among date palm farming households in Khairpur, Sindh, with particular attention to occupational symptoms, protective practices, storage conditions, and perceived access to rehabilitation

services. It was anticipated that farming households would demonstrate a substantial burden of respiratory and musculoskeletal complaints, low uptake of protective equipment, and notable food safety vulnerabilities within storage facilities, thereby underscoring the need for coordinated public health and rehabilitation interventions (1–21).

MATERIALS AND METHODS

This study employed a mixed-method field-based design to investigate occupational health risks, rehabilitation constraints, and food safety concerns among date palm farming communities in Khairpur District, Sindh, Pakistan. The study combined quantitative household survey data with qualitative interview-based inquiry and direct field observation in order to obtain both measurable estimates of health and safety problems and contextual insight into farmer experiences, coping practices, and service limitations. The research was conducted across agricultural fields, household environments, and date storage facilities within the district, reflecting the principal settings in which occupational exposure, physical strain, and post-harvest food safety risks occur (22).

The study population comprised farming households actively engaged in date palm cultivation and related activities. Participants included farmers, laborers, and household members involved in harvesting, pesticide application, handling, and storage. A stratified random sampling approach was used to select 120 farming households, with selection intended to capture households directly participating in the date palm production chain. Households were considered eligible if they were actively involved in cultivation or associated field and storage activities during the study period. Individuals not engaged in these activities were not included. Both male and female participants were represented where they contributed to the relevant occupational or household farming tasks (22).

Data collection was undertaken using multiple complementary approaches. Structured surveys were administered to document pesticide handling practices, patterns of personal protective equipment use, self-reported health symptoms, and access to rehabilitation support. Interviews were conducted to explore participant perceptions regarding occupational hazards, rehabilitation needs, and awareness of food safety concerns in the context of date farming. In addition, field observations were carried out in storage facilities to assess environmental conditions relevant to food safety, including pest infestation, ventilation status, and visible indicators suggestive of fungal contamination risk. The use of these three approaches enabled triangulation across self-reported practices, experiential accounts, and observable storage conditions, thereby strengthening the descriptive validity of the findings (22).

The principal study variables included occupational health symptoms, protective practices during pesticide application, storage facility conditions, and access to rehabilitation services. Occupational health outcomes included respiratory irritation, musculoskeletal strain, skin irritation, and neurological complaints as reported by participants. Protective practice variables captured whether personal protective equipment was used consistently, occasionally, or not at all during pesticide handling. Food safety-related variables included the observed presence of pest infestation, fungal contamination risk, and proper ventilation within storage settings. Rehabilitation access was categorized according to participant perception of service availability as adequate, limited, or absent. These variables were selected to reflect the interconnected domains of occupational exposure, post-harvest safety, and functional health support within the farming environment (22).

Quantitative data were entered and analyzed using SPSS version 25. Descriptive statistics were used to summarize participant responses and field observations, with results presented as frequencies and percentages. The analytical plan also included chi-square testing to assess associations between occupational exposures and reported symptoms, while analysis of variance was specified to compare musculoskeletal strain across farming tasks. Statistical significance was defined at $p < 0.05$, and a 95% confidence interval framework was adopted for inferential interpretation. Because the present manuscript version primarily reports descriptive findings, the revised text preserves the stated analytical

approach while aligning the methods more clearly with the variables under study (22). Qualitative interview material was used to provide contextual understanding of occupational risks, rehabilitation challenges, and food safety awareness, with responses reviewed thematically to identify recurrent concerns and coping patterns emerging from participant accounts (22).

Several steps were incorporated to enhance data quality and procedural consistency. Data were collected across households and field sites using structured instruments and direct observation, allowing the research team to compare reported practices with storage-related conditions observed on site. The inclusion of multiple participant roles within farming households helped capture variation in exposure and task responsibilities, while the combination of survey, interview, and observation methods reduced reliance on a single information source. Nevertheless, as with most field-based community surveys, symptom reporting depended partly on participant recall and subjective experience, which was considered during data interpretation.

Ethical principles were observed throughout the study. Informed consent was obtained from all participants before data collection, and confidentiality of responses was maintained. The study followed established field survey principles relevant to agricultural health research, with participant information handled in a manner intended to protect privacy and support voluntary participation (22).

RESULTS

A total of 120 participants from date palm farming households in Khairpur, Sindh, were included in the study. The findings demonstrated a substantial burden of occupational symptoms, limited adherence to protective practices during pesticide application, notable deficiencies in storage-related food safety conditions, and inadequate access to rehabilitation services. Respiratory irritation was the most frequently reported health complaint, affecting more than two-thirds of participants, followed by musculoskeletal strain, which was reported by more than half of the surveyed population. Skin irritation and neurological complaints were less frequently reported but remained important in the context of repeated occupational exposure. Overall, the results indicate that both exposure-related symptoms and cumulative physical strain were common among farming households engaged in date palm cultivation.

Protective practices during pesticide handling were suboptimal. Less than one-quarter of participants reported consistent use of personal protective equipment, while nearly half reported that they did not use any protective gear during pesticide application. This pattern suggests a marked occupational safety gap within the study population. Field observations further showed that storage environments were frequently characterized by pest infestation, fungal contamination risk, and inadequate ventilation, indicating that food safety concerns were also widespread at the post-harvest stage. Access to rehabilitation services was limited, with only a small minority reporting adequate availability, whereas half of the participants stated that no such services were accessible to them. When considered together, these findings show that occupational health risks, food safety vulnerabilities, and gaps in rehabilitation support coexisted within the same farming communities.

In addition to the quantitative findings, the interview component provided contextual support for the observed patterns. Participants reportedly described routine exposure to agricultural chemicals, physically demanding manual work, concerns regarding unsafe storage conditions, and difficulty obtaining healthcare or rehabilitation support in rural settings. As no interview transcripts or verbatim quotations were included in the manuscript text, these qualitative findings can only be presented here as a brief contextual complement rather than as a full thematic analysis. Nevertheless, the interview-based observations were consistent with the quantitative results and reinforced the interpretation that the burden experienced by these farming households was multidimensional, affecting both health and daily functioning.

Although the original methods section stated that chi-square analysis and analysis of variance were planned, the available manuscript data were presented only in aggregated descriptive form. Accordingly, the revised results below report frequencies, percentages, and approximate 95% confidence intervals derived from the available totals, while avoiding unsupported inferential claims.

Table 1. Occupational Health Symptoms Reported by Date Palm Farmers in Khairpur (n = 120)

Symptom	Frequency (n)	Percentage (%)	95% CI for Proportion*
Respiratory irritation	82	68.3	59.3-76.1
Musculoskeletal strain	65	54.2	45.3-62.8
Skin irritation	39	32.5	24.8-41.3
Neurological complaints	14	11.7	7.0-18.8

Table 2. Use of Personal Protective Equipment During Pesticide Application (n = 120)

Practice Category	Frequency (n)	Percentage (%)	95% CI for Proportion*
Consistent use of protective gear	26	21.7	15.2-30.1
Occasional use	38	31.7	24.0-40.6
No use	56	46.6	38.0-55.5

Table 3. Storage Facility Conditions and Food Safety Risks in Date Storage Settings (n = 120)

Storage Condition	Frequency (n)	Percentage (%)	95% CI for Proportion*
Pest infestation observed	49	40.8	32.5-49.8
Fungal contamination risk	43	35.8	27.9-44.6
Proper ventilation present	28	23.3	16.5-31.8

Table 4. Availability of Rehabilitation Services Among Date Palm Farming Participants (n = 120)

Rehabilitation Access Category	Frequency (n)	Percentage (%)	95% CI for Proportion*
Adequate access	19	15.8	10.3-23.5
Limited access	41	34.2	26.3-43.0
No access	60	50.0	41.2-58.8

Table 1 shows that respiratory irritation was the most common occupational symptom, reported by 82 of 120 participants, corresponding to 68.3% of the study population. The 95% confidence interval ranged from 59.3% to 76.1%, indicating that respiratory complaints affected a clear majority of the surveyed farmers. Musculoskeletal strain was the second most prevalent complaint, affecting 65 participants or 54.2% of the sample, with a 95% confidence interval of 45.3% to 62.8%. Skin irritation was reported by 39 participants, representing 32.5%, whereas neurological complaints were reported by 14 participants, representing 11.7%. These findings indicate that occupational morbidity in this population extended across respiratory, musculoskeletal, dermatological, and neurological domains rather than being confined to a single symptom category.

Table 2 demonstrates limited use of personal protective equipment during pesticide application. Only 26 participants, representing 21.7%, reported consistent use of protective gear, while 38 participants, or 31.7%, reported occasional use. The largest group consisted of 56 participants, accounting for 46.6%, who reported no use of protective equipment. This means that non-use of protective gear was more than twice as frequent as consistent use. In practical terms, the pattern suggests that a substantial proportion of workers remained routinely exposed to pesticide-related hazards without adequate personal protection, which is consistent with the high burden of respiratory and skin-related complaints described in Table 1.

Table 3 presents the observed storage-related food safety conditions. Pest infestation was identified in 49 of 120 storage settings, corresponding to 40.8%, while fungal contamination risk was observed in 43 settings, corresponding to 35.8%. In contrast, proper ventilation was present in only 28 storage facilities, or 23.3%. Thus, potentially unsafe storage characteristics were numerically more frequent than protective environmental conditions. Pest infestation exceeded proper ventilation by 17.5 percentage points, and fungal contamination risk exceeded proper ventilation by 12.5 percentage points, indicating

that food safety vulnerabilities were common and that storage infrastructure was frequently inadequate for safe post-harvest handling.

Table 4 highlights major limitations in rehabilitation access. Adequate rehabilitation availability was reported by only 19 participants, representing 15.8% of the sample. Another 41 participants, or 34.2%, reported limited access, while 60 participants, representing exactly half of the study population, reported no access at all. The proportion reporting no access was therefore more than three times the proportion reporting adequate access. When interpreted alongside the high prevalence of musculoskeletal strain, these findings suggest that a considerable number of farmers may have experienced functionally relevant physical complaints without meaningful access to rehabilitative support.

The brief qualitative component aligned with these quantitative patterns. Participants were reported to describe chemical exposure as part of routine farming practice, to identify prolonged physical work as a source of bodily strain, and to note limitations in both safe storage conditions and rehabilitation availability. Although the absence of transcripts precludes detailed thematic coding, the interview-based observations support the overall interpretation that the farming communities studied were facing layered occupational and public health challenges that extended from the point of exposure to the level of downstream care and support.



Figure 1. Layered Burden Profile of Occupational Symptoms, Storage-Related Food Safety Risks, and Rehabilitation Gaps Among Date Palm Farming Communities in Khairpur

A publication-ready figure based on the available aggregated data should compare adverse indicators and protective indicators across the three study domains. The adverse indicators include respiratory irritation (68.3%), musculoskeletal strain (54.2%), no protective gear use (46.6%), pest infestation (40.8%), fungal contamination risk (35.8%), and no access to rehabilitation services (50.0%). These may be visually contrasted with protective indicators such as consistent protective gear use (21.7%), proper ventilation in storage facilities (23.3%), and adequate rehabilitation access (15.8%). A grouped gradient bar figure is most appropriate because it allows direct comparison of burdens across domains without introducing fabricated relationships or unsupported trend patterns. The integrated burden profile shows that adverse conditions consistently exceeded protective or supportive conditions across all measured domains. Respiratory irritation was the highest single indicator at 68.3%, followed by musculoskeletal strain at 54.2% and complete lack of rehabilitation access at 50.0%. Non-use of protective gear remained high at 46.6%, while pest infestation and fungal contamination risk affected 40.8% and 35.8% of storage settings, respectively. By comparison, proper ventilation was present in only 23.3% of facilities, consistent protective gear use in 21.7% of participants, and adequate rehabilitation access in only 15.8%. Collectively, these findings indicate a pronounced mismatch between exposure burden and protective

capacity, suggesting that health risks in these farming communities were cumulative, overlapping, and insufficiently addressed by existing preventive and support systems.

DISCUSSION

The present study highlights the coexistence of occupational health risks, storage-related food safety vulnerabilities, and restricted rehabilitation access among date palm farming communities in Khairpur, Sindh. The predominance of respiratory irritation and musculoskeletal strain suggests that both chemical exposure and repetitive physical labor represent major health burdens in this agricultural setting. These findings are consistent with previous literature showing that agricultural workers are disproportionately affected by pesticide-related respiratory symptoms, dermal exposure, and chronic ergonomic strain, especially in low-resource environments where occupational safeguards are limited and preventive practices are inconsistently adopted (1,7,10,27,28). The high frequency of respiratory complaints observed in the present study is particularly important because it aligns with the broader evidence base linking pesticide exposure to airway irritation and other acute occupational symptoms in farming populations (5,7,16). At the same time, the high burden of musculoskeletal strain reinforces the understanding that agricultural work is not only chemically hazardous but also physically taxing, with repetitive postures, lifting demands, and prolonged manual labor contributing to pain and functional limitation over time (3,15,18,21).

The pattern of personal protective equipment use further strengthens the interpretation that occupational exposure in this population may be intensified by behavioral and structural gaps in farm safety. Less than one-quarter of participants reported consistent use of protective gear, while nearly half reported no use at all, indicating that unsafe exposure conditions were likely to be routine rather than exceptional. Similar observations have been reported in other agricultural contexts, where limited affordability, poor awareness, discomfort during field work, and lack of formal occupational safety enforcement reduce the uptake of protective practices (6,8,13,14). In this context, the findings should not be interpreted solely as individual non-compliance; rather, they reflect a broader systems problem involving insufficient training, low-risk perception, and inadequate support for safer agricultural practice. The interview-based observations reported in the manuscript, although not detailed enough for full thematic analysis, were broadly consistent with this interpretation by indicating that routine pesticide exposure formed part of everyday farming practice and that protective behavior was not optimally embedded within local work routines.

The food safety findings are equally important because they show that the burden associated with date palm farming extends beyond the health of workers to the safety of stored agricultural products. The frequent observation of pest infestation and fungal contamination risk, together with the relatively low presence of proper ventilation, suggests that post-harvest storage conditions were often inadequate to maintain safe product quality. These observations align with the literature on mycotoxin risk in stored food commodities, particularly in warm and humid environments where pest activity, moisture retention, and poor infrastructure may facilitate fungal growth and toxin production (4,9,11,17,20,24,25). In agricultural systems such as date palm farming, unsafe storage conditions may therefore produce a dual public health concern: direct occupational strain among those involved in handling and storage, and indirect foodborne risk among consumers exposed to contaminated produce. This integrated perspective is valuable because it highlights that occupational safety and food safety should not be treated as separate silos in rural agricultural policy, especially in communities where production, storage, and household use occur within overlapping environments (17,23).

A particularly concerning finding of the present study was the limited availability of rehabilitation services. Half of the participants reported no access to rehabilitation support, and only a small minority reported adequate service availability. This observation is especially relevant when interpreted alongside the high frequency of musculoskeletal complaints, as it suggests that many individuals experiencing

occupational pain or strain may have had little opportunity for timely assessment, physical rehabilitation, ergonomic guidance, or functional recovery support. Prior evidence has shown that agricultural workers frequently remain underserved by rehabilitation systems, particularly in rural and low-resource settings where healthcare infrastructure is concentrated in urban areas and preventive occupational rehabilitation is poorly developed (3,15,21,28). The practical implication is that musculoskeletal morbidity in farming communities may become prolonged and disabling not only because of exposure intensity but also because of delayed or absent rehabilitative intervention. In this respect, the findings support the need for stronger integration of rural rehabilitation services into community and primary healthcare frameworks, including accessible physiotherapy referral pathways, ergonomic education, and community-level functional support initiatives.

From an implementation perspective, the study points toward several actionable priorities. Occupational health training tailored to pesticide handling and field safety should be strengthened, with emphasis on feasible and context-appropriate protective measures that farming households can realistically adopt. Eco-friendly pest management and integrated pest management strategies may help reduce chemical exposure while simultaneously improving agricultural sustainability, as suggested in prior literature on safer crop protection approaches (6,19). At the storage level, interventions should focus on ventilation improvement, pest control, routine monitoring, and better post-harvest handling practices to reduce fungal contamination risk and protect food quality. Rehabilitation strategies should include not only service expansion but also awareness-building so that farmers recognize musculoskeletal symptoms as treatable health concerns rather than inevitable consequences of labor.

The findings should, however, be interpreted in light of several limitations. First, the study was based primarily on aggregated descriptive data, and although inferential analyses were stated in the methodology, the necessary cross-tabulated outputs were not reported in the manuscript, limiting deeper statistical interpretation. Second, several health variables were based on participant self-report, which may be affected by recall bias or subjective symptom perception. Third, the qualitative component was only briefly described, and the absence of interview transcripts, coded data, or verbatim quotations prevented full thematic synthesis and restricted the integration of qualitative evidence into the interpretive framework. Fourth, the study design does not permit causal inference, and the observed patterns should therefore be interpreted as indicative of important associations and service gaps rather than proof of direct cause-and-effect relationships. Despite these limitations, the study provides valuable baseline evidence from an under-researched agricultural population and contributes an integrated perspective on occupational risk, food safety, and rehabilitation need within rural Sindh.

CONCLUSION

Date palm farming communities in Khairpur, Sindh, appear to experience a layered burden of occupational symptoms, unsafe protective practices, storage-related food safety concerns, and restricted access to rehabilitation services. The findings suggest that respiratory irritation and musculoskeletal strain are common health problems in this setting, while poor use of personal protective equipment, frequent pest infestation and fungal contamination risk in storage facilities, and limited rehabilitation availability may further intensify vulnerability. These patterns support the need for integrated interventions that combine occupational safety training, safer pest management, improved storage infrastructure, food safety monitoring, and accessible rural rehabilitation support. Such measures are likely to be important not only for protecting farmer health and function but also for strengthening the broader public health value and sustainability of agricultural production in Sindh.

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