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Personal Protective Equipment Use and Occupational Health Risks Among Farmers in Trinidad and Tobago: Preliminary Findings From an Agricultural Safety Study

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ABSTRACT

Trinidad and Tobago's agricultural sector comprises approximately 32,000 farmers facing unique occupational hazards, including year-round pesticide application, sustained manual labor in tropical heat, and economic pressures limiting safety investments. Despite widespread PPE availability, compliance rates remain low due to cost, heat discomfort, limited access, and inadequate training. No comprehensive occupational safety and health data exists for Trinidad and Tobago's farming population, representing a critical knowledge gap. This study examines PPE usage patterns and their relationship with pesticide symptoms, musculoskeletal disorders, and mental health outcomes among Caribbean farmers. A cross-sectional survey was administered to n = 170 farmers in January 2026, assessing PPE usage, pesticide exposure symptoms, musculoskeletal disorders with work limitations, and mental health symptoms. Regular PPE use was reported for 87.5% (foot protection) to 55.0% (hand protection), with an overall mean PPE score of 4.11 (SD = 0.90). Pesticide symptoms were prevalent: 24.3% eye irritation, 20.6% headaches/dizziness. Musculoskeletal disorders were high: 48.8% lower back pain, with 35-52% reporting work limitation. Mental health burden was substantial: 51.2% depression symptoms, 42.9% anxiety. Spearman correlations revealed that higher PPE scores significantly negatively correlated with pesticide symptoms ($\rho = -0.174$, $p = 0.024$) and MSD severity ($\rho = -.216$, $p = 0.005$), but not with mental health ($\rho = 0.135$, $p = 0.081$). Pesticide symptoms and MSDs were positively correlated ($\rho = 0.479$, $p<0.001$). These findings inform the development of culturally appropriate, climate-adapted safety interventions for Caribbean farming populations.

Keywords: Occupational safety and health, Agricultural ergonomics, Personal protective equipment, Work system design, Musculoskeletal disorders, Caribbean farmers

INTRODUCTION

Trinidad and Tobago's agricultural sector comprises approximately 32,000 farmers producing vegetables, fruits, livestock, and cash crops. Farmers in tropical Caribbean climates face unique and persistent occupational hazards that distinguish their work environment from temperate regions. These hazards

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include year-round pesticide application driven by tropical growing conditions, sustained manual labor performed in continuous heat and high humidity, and significant economic pressures that limit investments in occupational safety and health (OSH) measures (Parasram and Choudhury, 2025).

Despite the widespread availability of personal protective equipment (PPE), compliance rates remain low in small-scale farming contexts globally and particularly in Caribbean agriculture. Multiple barriers to PPE adoption have been documented, including prohibitive costs, physical discomfort in tropical heat, limited local access to appropriate equipment, and inadequate training on proper use and maintenance (Sookhtanlou and Allahyari, 2021). More fundamentally, critical reviews have questioned the real-world effectiveness of prescribed PPE under actual farming conditions, particularly noting that equipment designed for temperate climates often fails to account for prolonged use in hot, humid conditions combined with the intense physical demands of agricultural work (Garrigou et al., 2020). Understanding the interplay between protective behaviors and multiple health outcomes is essential for developing comprehensive interventions appropriate to Caribbean contexts.

No comprehensive occupational safety and health assessment data exist for Trinidad and Tobago's farming population, representing a critical knowledge gap that impairs policy development and intervention design. Previous studies have identified barriers to safety improvements beyond cost, including inadequate training programs, limited equipment availability, and cultural and economic factors influencing risk perception (Okoffo et al., 2016). However, very limited research has examined the relationships between PPE usage and broader occupational health outcomes, including musculoskeletal disorders and mental health among Caribbean farmers specifically. This study addresses this gap by examining PPE usage patterns and their relationship with multiple occupational health outcomes: pesticide exposure symptoms, musculoskeletal disorders, and mental health among farmers in Trinidad and Tobago, providing the first comprehensive regional OSH assessment for this population. This exploratory quantitative study builds on our prior qualitative research exploring occupational health risks among farmers in Trinidad and Tobago (Parasram and Choudhury, 2025) and Guyana (Parasram and Choudhury, 2025), as well as findings from a comprehensive systematic review identifying major contributing factors to pesticide exposure and associated health outcomes globally (Parasram and Choudhury, 2026). Because validation is ongoing with the full target population (n = 2,000), this preliminary analysis (n = 170) is presented as exploratory evidence to inform future comprehensive analysis.

LITERATURE REVIEW

Musculoskeletal disorders (MSDs) represent the most prevalent occupational health problem among agricultural workers globally. A systematic review of 64 studies across 23 countries found that 52% of farmers reported low back pain in the previous 12 months, with prevalence rates reaching 62% in Africa and 54% in Asia (Shivakumar et al., 2024). Other studies have documented overall MSD prevalence rates of 60-80% among farming populations in South Asia and East Asia (Akbar et al., 2023). Beyond physical pain,

substantial proportions of affected farmers experience work limitation, the inability to perform normal farm work, due to MSD severity, creating both health and economic consequences.

Mental health problems, including depression, anxiety, and stress, are increasingly recognized as significant occupational health issues in agricultural populations, with prevalence rates consistently exceeding those in general populations. Research has found that 71% of young farmers meet criteria for generalized anxiety disorder and 53% for major depressive disorder, compared to 18-19% prevalence rates in general populations (Rudolphi et al., 2020). These elevated rates likely reflect the unique psychosocial stressors of agricultural work, including financial uncertainty, climatic variability, social isolation, and occupational unpredictability, stressors distinct from those of typical occupational settings.

Research has demonstrated that consistent PPE use can significantly reduce pesticide exposure. Studies have shown that gloves alone reduced dermal pesticide exposure by 27% among citrus farmers, with combined use of gloves and coveralls reducing exposure by 65% (Damalas and Koutroubas, 2016). Intervention studies have confirmed that 90 days of systematic PPE use significantly reduced biomarkers of pesticide toxicity among farmworkers (Lari et al., 2023). However, implementation of PPE in tropical climates remains challenging due to environmental barriers. Heat stress, created by the combined effects of ambient temperature, humidity, and protective clothing, substantially reduces the comfort and feasibility of wearing PPE for extended periods. This challenge is particularly acute in tropical agricultural settings (Xiang et al., 2015), where high temperatures are sustained year-round, creating significant adoption and compliance barriers to consistent PPE use.

Limited research has examined the relationship between PPE use and broader occupational health outcomes beyond pesticide exposure, particularly among Caribbean farmers. No studies have simultaneously examined PPE's relationship with pesticide symptoms, musculoskeletal disorders, and mental health in a Caribbean population. Understanding these relationships is essential for developing comprehensive safety interventions adapted to tropical agricultural contexts and informed by local occupational health evidence. To better understand these complex relationships between work system factors, individual behaviors, and health outcomes, several integrated theoretical frameworks provide useful conceptual lenses. These theoretical frameworks, including Social Learning Theory (Bandura, 1977), COM-B Model (Michie et al., 2011), SEIPS 3.0 systems approach (Carayon et al., 2020), and Institutional Theory (Scott, 2014), provide integrated conceptual lenses for understanding the complex relationships between work system factors, individual behaviors, organizational context, and occupational health outcomes

METHOD

Study Design and Sample

A cross-sectional survey was administered to farmers in Trinidad and Tobago in January 2026. The sample comprised n = 170 farmers representing approximately 8.5% of the target population of 2,000 farmers across the

country. The survey assessed current occupational safety practices, exposures, and health outcomes during a single time point.

Survey Instrument

The survey consisted of five sections addressing key occupational safety and health domains: Section A: Demographic characteristics, including age, gender, years of farming experience, farm size, and primary crop type. Section B: Safety training history and attitudes, assessed using 6 items on a frequency scale, evaluating prior training exposure and attitudes toward occupational safety. Section C: Institutional support for safety, comprising 19 items measured on 5-point Likert scales (Strongly Disagree to Strongly Agree), assessing organizational support, resource availability, and policy enforcement. Section D: Safety behaviors and practices, including 13 items measured on 5-point frequency scales (Never to Always). The first four items assessed PPE usage across four categories: (1) hand protection (gloves), (2) respiratory protection (masks/respirators), (3) body protection (coveralls/protective clothing), and (4) foot protection (safety boots/closed shoes). Items 5-13 assessed other safety practices, including safe pesticide handling, equipment maintenance, and ergonomic work practices. Section E: Health outcomes, comprising 19 items assessing: (1) pesticide exposure symptoms in the past 3 months using binary (yes/no) responses for five symptoms (headache/dizziness, breathing difficulties, skin irritation, eye irritation, and poisoning requiring medical attention); (2) musculoskeletal disorders in the past 12 months using binary responses for four body regions (lower back, shoulder, hand/wrist, knee) with follow-up questions on work limitation; and (3) mental health symptoms in the past week using 4-point severity scales (Did not apply, Some degree, Considerable degree, Very much) for three items (feeling down/hopeless, worried/anxious, difficulty relaxing), adapted from DASS-21.

Data Analysis

Composite scores were calculated for key constructs: PPE usage (mean score across 4 PPE items, range 1-5); pesticide symptoms (count of symptoms experienced, range 0-5); MSD severity (sum of pain occurrence and work limitation across 4 body regions, range 0-8); and mental health symptoms (sum of 3 items coded 0-3, range 0-9). Descriptive statistics (frequencies, percentages, means, and standard deviations) were calculated for all variables. Normality was assessed using Shapiro-Wilk tests. Non-parametric Spearman rank-order correlations examined bivariate relationships between PPE usage and health outcomes, with statistical significance set at $p<0.05$. Data were analyzed using JASP statistical software.

RESULTS

Participant Characteristics

Participants were predominantly male (70.1%) with a mean age in the 36-55 year range (46.3%), substantial farming experience (mean 21.3 years), and

diverse farm operations including vegetable cultivation, livestock rearing, and mixed farming. The sample represented both smallholder and larger-scale farming operations across Trinidad and Tobago.

PPE Usage

PPE usage varied considerably across protective equipment categories. Regular use (often or always) was reported for foot protection (87.5%), body protection (77.0%), respiratory protection (60.7%), and hand protection (55.0%). The overall mean PPE composite score was 4.11 (SD = 0.90) on a scale of 1-5, indicating relatively high overall PPE adoption among study participants. Despite these relatively high adoption rates, substantial variation existed between farmers, with some using equipment consistently and others using it infrequently or not at all.

Health Outcome Prevalence

Pesticide-related symptoms in the past three months were prevalent. Eye irritation was most common (24.3%), followed by headaches or dizziness (20.6%), skin irritation (18.2%), breathing difficulties (9.4%), and pesticide poisoning requiring medical attention (6.5%). This symptom prevalence occurred despite reported high PPE usage, suggesting either inconsistent compliance, gaps in equipment effectiveness in tropical conditions, or exposure to pesticides through routes not protected by the PPE used.

Musculoskeletal disorders were highly prevalent in the past 12 months. Lower back pain was most common (48.8%), followed by shoulder pain (26.2%), knee pain (19.4%), and hand/wrist pain (18.5%). Among farmers experiencing pain in each body region, work limitation was substantial: 51.5% with knee pain, 45.5% with shoulder pain, 38.7% with hand/wrist pain, and 34.9% with lower back pain reported that pain prevented them from performing normal farm work. This high prevalence of work-limiting pain indicates significant functional impact on agricultural productivity and quality of life.

Mental health symptom burden was considerable. In the past week, 51.2% of farmers reported any degree of feeling down or hopeless about their farm situation, 42.9% felt worried or anxious about their health or ability to work, and 37.1% found it difficult to relax or calm down. These prevalence rates substantially exceed those typically reported in general populations, indicating a significant mental health burden in this agricultural population.

Relationships Between PPE Usage and Health Outcomes

Spearman rank-order correlations examined relationships between PPE usage and health outcomes (Table 1). Higher PPE scores were significantly negatively correlated with pesticide symptoms ($\rho = -0.174$, $p = 0.024$), indicating that farmers with higher PPE compliance experienced fewer pesticide-related health problems. This correlation, though statistically significant, demonstrates a modest effect size, suggesting that while PPE is protective, other factors also influence pesticide symptom prevalence.

PPE usage was also significantly negatively correlated with musculoskeletal disorder severity ($\rho = -0.216$, $p = 0.005$), suggesting that PPE use may be associated with broader safety-conscious behaviors that reduce work-related pain. This stronger correlation coefficient may sugg that farmers who use PPE consistently may also engage in other safety practices that reduce MSD risk, such as proper equipment use, better workplace organization, or more ergonomic work procedures.

PPE usage showed no significant correlation with mental health symptoms ($\rho = 0.135$, $p = 0.081$), indicating that mental health outcomes are influenced by factors beyond protective equipment use. This null finding is important because it suggests that psychological well-being in farming populations cannot be addressed through equipment interventions alone.

An additional significant correlation emerged: pesticide symptoms and musculoskeletal disorders were positively and substantially correlated ($\rho = 0.479$, $p < 0.001$), suggesting that farmers experiencing high pesticide exposure also face elevated musculoskeletal health risks. This strong correlation may suggest possible shared risk factors such as poor work conditions, inadequate resources, or unsafe work practices, or that chemical exposure may exacerbate physical strain through neurological or inflammatory mechanisms.

Table 1: Spearman's rank order correlations between PPE usage and health outcomes.

Relationship	Spearman's p	p-value	Significance
PPE Usage ↔ Pesticide Symptoms	–0.174	0.024	*
PPE Usage ↔ MSD Severity	–0.216	0.005	**
PPE Usage ↔ Mental Health Symptoms	0.135	0.081	NS
Pesticide Symptoms ↔ MSD Severity	0.479	<0.001	**

Note: * $p<0.05$, ** $p<0.01$, NS = not significant

DISCUSSION

This preliminary study provides initial occupational safety and health data specifically for Trinidad and Tobago's farming population, addressing a critical knowledge gap. Despite relatively high reported PPE adoption rates (mean 4.11 on a 1-5 scale), occupational health problems remain highly prevalent. These findings extend our prior qualitative (Parasram and Choudhury, 2025) and systematic review work (Parasram and Choudhury, 2026) by providing preliminary quantitative epidemiological evidence from a Caribbean farming population and examining relationships between protective behaviors and multiple occupational health outcomes. However, these exploratory findings from a cross-sectional sample require validation with our full n = 2,000 dataset before definitive conclusions can be drawn. This has important implications for understanding occupational safety in Caribbean agriculture, though broader applicability warrants further investigation.

The observed negative correlation between PPE use and pesticide symptoms ($p = 0.024$) suggests a protective value of consistent PPE adoption in reducing chemical exposure health effects. This finding is particularly important given Trinidad and Tobago's year-round growing season, which necessitates continuous pesticide application throughout the year. The effect size, while statistically significant, was modest ($\rho = -0.174$), indicating that PPE alone does not eliminate pesticide exposure risk. This may reflect equipment gaps (such as inadequate facial protection), inconsistent compliance (farmers using equipment sometimes but not always), or pesticide exposure routes not protected by the equipment used (such as dermal absorption through gaps in coverage or inhalation of residual vapors).

The observed relationship between PPE use and reduced musculoskeletal disorder severity ($p = 0.005$) highlights the importance of PPE, which is not specifically designed to prevent MSDs. This correlation may indicate that PPE adoption serves as a proxy measure for broader safety culture. Farmers who consistently use protective equipment may also engage in better ergonomic practices, maintain equipment properly, take appropriate breaks, and organize their work more safely. Alternatively, farmers in better economic positions to purchase and maintain quality PPE may work on better-equipped farms with more ergonomic conditions. This finding highlights the importance of viewing occupational safety through a systems lens rather than focusing solely on individual equipment use.

However, the high prevalence of work-limiting musculoskeletal pain (35-52% among those with pain) indicates that protective equipment alone is insufficient to address MSD risk in farming. Comprehensive ergonomic interventions are needed that address the work system factors underlying MSD risk: repetitive bending and lifting inherent in vegetable farming, prolonged standing, heavy manual tasks, inadequate tool design, and lack of mechanical assistance for physically demanding tasks. These interventions require engineering controls (tool and equipment design), administrative controls (work procedures and task rotation), and potentially technological solutions suited to smallholder farming contexts.

The substantial mental health burden (51.2% depression symptoms, 42.9% anxiety), combined with the complete lack of correlation between PPE use and mental health outcomes, indicates that psychological well-being in farming populations cannot be addressed through occupational protective equipment. Instead, mental health requires interventions addressing the unique psychosocial stressors of agricultural work: financial uncertainty and income volatility, vulnerability to climatic variability and crop failure, social isolation from limited community integration, and occupational stress from unpredictable work conditions. These may include financial support programs, crop insurance, cooperative marketing arrangements, improved social connections, and mental health services tailored to agricultural populations.

The strong positive correlation between pesticide symptoms and MSD severity ($\rho = 0.479$, $p < 0.001$) suggests either shared risk factors or biological interaction. Farmers with high pesticide exposure may simultaneously work

under conditions of poor safety practices, limited resources, and unsafe ergonomics. Alternatively, chemical exposure may physiologically exacerbate physical strain through mechanisms such as neuroinflammation affecting pain perception, neurotoxicity affecting postural control, or general systemic toxicity reducing the body's capacity to tolerate physical demands. Future research could investigate these mechanisms.

This study has several important limitations that should be considered when interpreting the findings. First, the cross-sectional design prevents causal inference; we cannot determine whether PPE use reduces health problems, whether healthier farmers are more able to maintain PPE use, or whether other unmeasured variables confound these relationships. Second, the n = 170 sample represents preliminary findings from an ongoing larger study; subsequent analyses of the full n = 2,000 dataset may reveal different patterns or validate these exploratory findings. Third, data are based on self-reports, which may be subject to recall bias or social desirability bias, particularly for occupational health symptoms and safety practices. Fourth, data collection in January captures only a seasonal snapshot; patterns may differ considerably across other seasons or climatic periods in Trinidad and Tobago's year-round growing season. Fifth, the study is limited to Trinidad and Tobago, and findings may not generalize to other Caribbean regions or tropical agricultural contexts with different climates, crop types, economic conditions, or occupational health infrastructure. Sixth, the study did not assess important confounding variables such as farm size, mechanization level, access to healthcare, training history, or socioeconomic status, which may influence health outcomes. Finally, validation of these preliminary findings requires analysis of the full n = 2,000 dataset and prospective investigation before definitive conclusions can be established.

These exploratory findings may suggest the need for comprehensive, multi-level interventions in Caribbean agriculture, pending validation with the full dataset. Occupational health may not be addressed through PPE alone. Instead, potential evidence-based interventions could include: (1) equipment interventions (improved PPE design and training specific to tropical conditions), (2) engineering interventions (ergonomic tool and equipment design, mechanization of heavy tasks), (3) administrative and organizational interventions (safe work procedures, training, protective policies), (4) psychosocial support (mental health services, financial security, community connection), and (5) systems-level changes (improved labour standards, occupational health enforcement, agricultural modernization). These potential interventions may require collaboration between occupational health professionals, agricultural extension services, government agencies, and farming communities, though further investigation is needed to validate their effectiveness in Caribbean contexts.

CONCLUSION

This exploratory study provides preliminary occupational safety and health data for Trinidad and Tobago's farming population, demonstrating that despite relatively high PPE adoption reported in this n = 170 sample, significant occupational health burdens are evident. The significant negative

correlation between PPE use and pesticide symptoms ($p = 0.024$) may indicate protective values of consistent PPE adoption in reducing chemical exposure health effects, and its association with reduced MSD severity ($p = 0.005$) suggests potential indirect protective mechanisms. However, these preliminary findings from a cross-sectional sample should be interpreted cautiously, as they require validation with the full $n = 2000$ dataset before definitive conclusions are drawn.

These findings directly inform occupational safety practice in Caribbean agriculture and have relevance for tropical agricultural regions globally. The evidence demonstrates that equipment-focused interventions alone are insufficient; comprehensive approaches addressing work system design, psychosocial factors, and occupational health infrastructure are necessary. Full-scale data collection (target $n = 2{,}000$) is ongoing to examine additional risk factors, country differences, and the complex relationships between work system factors and health outcomes. Future analyses will employ structural equation modelling in future analyses to develop comprehensive causal models informing evidence-based intervention development for sustainable occupational health improvement in Caribbean farming populations.

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