# Survey on Modern Pesticides: Exposure Levels and their Emerging Trends

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**Abstract**

Pesticides are integral to modern agriculture, enhancing crop production by controlling pests. However, their extensive use, particularly in countries like India, raises serious health concerns for farmers due to prolonged exposure. This study investigates the health impacts of pesticide exposure among farmers in Sonipat District, Haryana, India, through a survey of 300 participants from five villages. Ethical clearance was obtained, and data collection focused on pesticide usage, exposure levels, and health outcomes. Statistical analysis and visual representations, such as bubble plots, identified significant correlations between prolonged exposure and adverse health effects. Farmers with over 15 years of exposure exhibited higher risks of respiratory and skin-related conditions, largely due to inadequate use of protective gear. Spray application methods were linked to more severe symptoms compared to manual techniques. A direct relationship was observed between work hours and health deterioration, with extended exposure intensifying symptoms.

Additionally, pesticide exposure was found to exacerbate pre-existing lifestyle disorders, notably affecting kidney and liver functions. The study highlights the pressing need for awareness programs on safe pesticide practices and the consistent use of protective measures. Future research should focus on long-term health assessments and interventions to safeguard agricultural workers and promote sustainable farming.

**Key Words**

Pesticide Exposure, Occupational Health Risks, Agricultural Toxicology, Risk Mitigation Strategies, Epidemiology of Pesticide Exposure

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## Introduction

"Pesticides, primarily employed to control pests such as insects, fungi, and weeds in agricultural production, are typically composed of chemical or biological agents (Pathak et al., 2022). Their widespread use, particularly in developing Asian nations like India, is substantial (Banerjee et al., 2024). Global pesticide consumption reached 3.5 million tonnes in 2020, a significant increase from 2 million tonnes in previous years (Sharma et al., 2019). To meet the escalating food demands of a growing population, reliance on pesticides has intensified. Asia, a major agricultural hub, leads in pesticide usage (Nayak et al., 2021). Within Asia, India ranks third and twelfth globally in pesticide consumption (Sharma et al., 2019).

Pesticides, renowned for their toxicity, pose significant health risks. They can adversely affect the nervous system, potentially leading to severe consequences such as cancer, cytotoxic effects, organ damage, respiratory problems, and developmental issues (Zhou, W., 2025). Furthermore, they can disrupt the reproductive (Jain et al., 2023) and endocrine systems (Silva et al., 2023) and interfere with metabolic processes. Numerous studies have linked pesticide exposure to increased cancer risk in certain populations (Tanja et al., 2013). This risk is particularly pronounced among agricultural workers (Sookhanion et al., 2022).

The proposed study aims to comprehensively evaluate pesticide exposure and its associated health impacts through rigorous research methodology to generate reliable findings for future investigations. Pesticide exposure varies significantly depending on application methods and duration of field work.

Pesticides exhibit diverse clinical manifestations, including neurological symptoms such as insomnia, Alzheimer's disease, and hyperactivity disorder (Mazuryk et al., 2024). They can also disrupt the endocrine system, affecting reproductive and growth hormones (Kahn et al., 2020). Additionally, gastrointestinal problems are common among agricultural workers exposed to pesticides (Xie et al., 2020). Pesticide spraying can lead to respiratory issues (Tarmure et al., 2020), while further research is needed to confirm links to certain cancers (Rani et al., 2021). Vascular and cardiac disorders have also been associated with pesticide exposure (Rajawat et al., 2022).

Pesticide exposure can result in both acute and chronic poisoning, potentially leading to severe health consequences and, in some cases, death (Adeyemi et al., 2021). The proposed study will contribute to a better understanding of pesticide-related symptoms and inform the development of effective mitigation strategies.

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A questionnaire-based survey will be conducted to collect data from agricultural workers. The study will investigate the relationship between pesticide exposure, associated symptoms, awareness levels, and safety precautions. It will also examine pesticide usage patterns in rural areas, exploring potential correlations with farmer literacy and understanding the level of awareness and adherence to safety protocols during pesticide management.

## Methods

*Area and Population of the study*

Here's the rephrased version of the provided text in a more formal and concise style:

### Study Area and Population

This study encompassed 300 farmers residing in five villages within Sonipat District, Haryana, India. Data collection was conducted through face-to-face interviews using a paper-based questionnaire. Farmers who consented to participate were invited for in-person interviews.

### Data Collection

The survey instrument included sections on participant demographics, agricultural practices, pesticide exposure, and related health issues. Questions were designed to be easily comprehensible. For illiterate participants, the questionnaire was translated into Hindi and their local language to facilitate understanding and responses. Written and informed consent was obtained from all participating farmers/farmworkers before data collection. Ethical approval for the study was granted by the University Ethical Committee of Shree Guru Gobind Singh Tricentenary University, Gurugram, Haryana, India (reference number: SGTU/FOSC/2023/1482).

*Pesticide Exposure Assessment*

Pesticide exposure was assessed based on data collected from agricultural workers. Recognizing the heightened risk of exposure and associated health disorders among this population, the following factors were considered: (1) pesticide spraying practices, (2) use of protective equipment (gloves, masks, etc.), (3) duration of fieldwork, (4) type of pesticide used, (5) frequency of pesticide application, (6) application techniques, (7) symptoms experienced during exposure, and (8) organ-specific illnesses. Statistical analyses were employed to

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evaluate the statistical significance of these factors and their relationship to pesticide exposure levels among all applicators.

**Graphical Interpretation**

1. **Work and medium of Exposure**

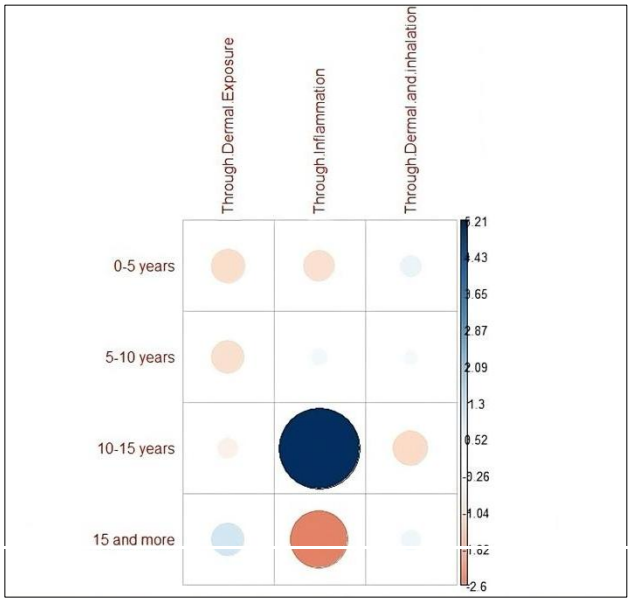


*Figure 1: Statistical Plot of correlation between total work experience and the route of pesticide exposure*

A bubble plot was generated to visualize the relationship between work duration in agriculture (0-15+ years) and different routes of pesticide exposure, including inhalation, dermal contact, and mixed exposures. In this plot, color and circle size represent the intensity and extent of pesticide exposure, respectively. Red circles indicate lower exposure levels, while blue circles represent higher levels.

The analysis revealed a strong correlation between prolonged work duration (more than 10 years) and high levels of dermal pesticide exposure. Individuals with 15+ years of experience demonstrated high levels of mixed exposure, involving both inhalation and dermal routes. Conversely, individuals with shorter work durations exhibited lower levels of pesticide exposure, represented by smaller and lighter-colored circles on the plot.

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## 2. Symptoms and Techniques used in pesticide application

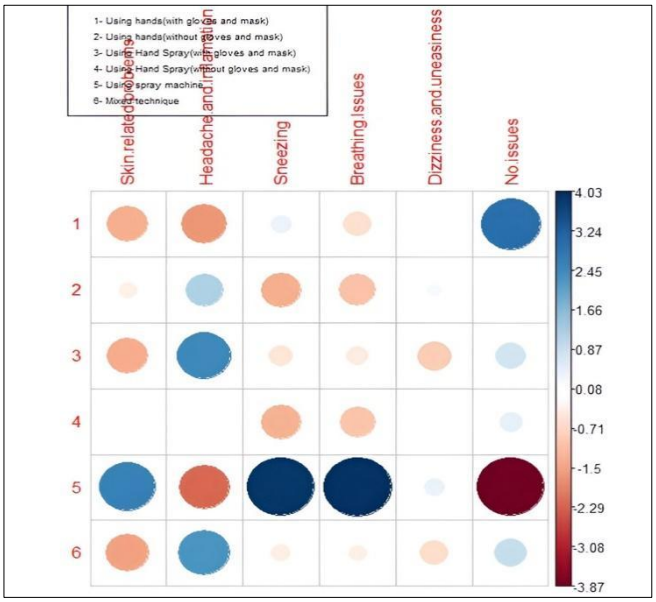


*Figure 2: Statistical Plot of correlation between Symptoms and Techniques used for pesticide application.*

The bubble plot analyzed the correlation between pesticide application methods and associated health symptoms (e.g., skin irritation, nausea, headaches) experienced by agricultural workers. A range of application techniques, from simple to more complex methods, were observed. Red and blue shades within the plot represented the intensity of the correlation between application methods and symptom severity.

The analysis revealed a strong association between the use of spray machines and the occurrence of more severe symptoms. Furthermore, pesticide application without protective equipment was significantly linked to a higher frequency and severity of adverse health outcomes. These findings underscore the critical importance of utilizing appropriate protective equipment to mitigate the health risks associated with pesticide application.


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### 3. Working Hours and Symptoms occurred during pesticide exposure

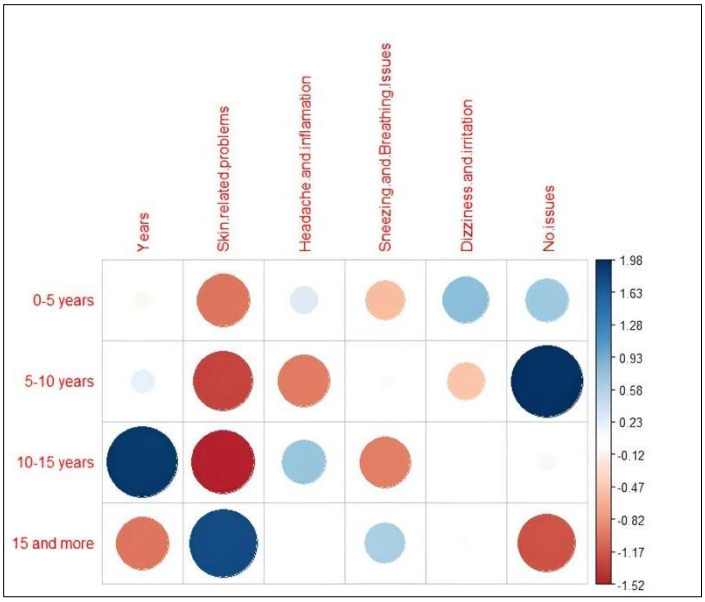


*Figure 3: Statistical Plot of correlation between the Working Hours and Symptoms occurred during pesticide exposure*

A bubble plot was used to investigate the correlation between working hours in agricultural fields (0-2, 2-4, 4-6, and 6-8 hours) and the development of symptoms such as respiratory problems, skin irritation, and other adverse health effects. Results indicated that even short-term exposures (less than 2 hours) could lead to symptoms like sneezing and minor skin irritation in some individuals. However, individuals working for 2-4 hours experienced a greater intensity of symptoms compared to those exposed for less than 2 hours. Notably, the most significant health impacts were observed among workers with exposure durations exceeding 6 hours, demonstrating a clear dose-response relationship between working hours and the severity of pesticide-related symptoms.


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## 4. Organs and Lifestyle Disorder

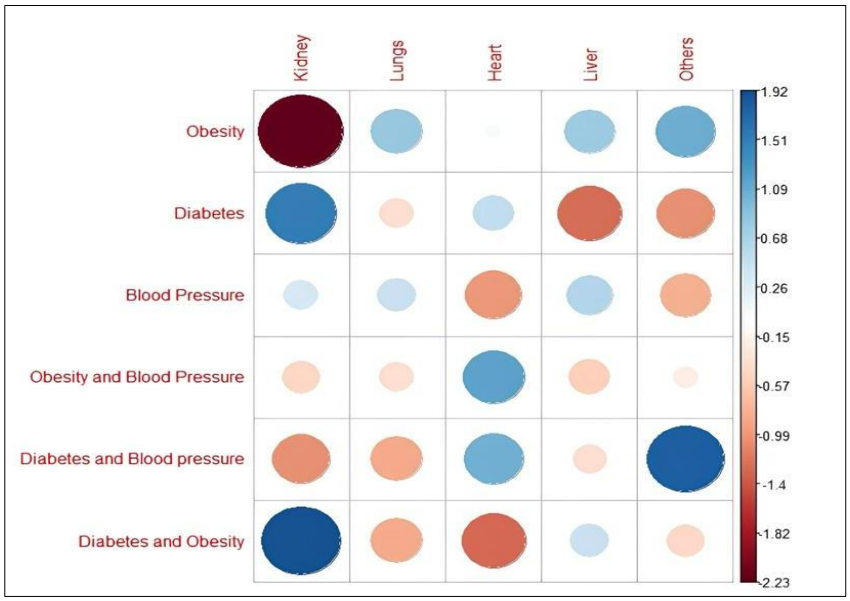


*Figure 4: Statistical Plot of correlation between Lifestyle disorders of agricultural workers and the impact of exposure on their organs*

The plot analysis demonstrates a significant correlation between lifestyle disorders (obesity, diabetes, hypertension) and their impact on various organs (kidneys, lungs, heart, liver). The size and color of the data points on the plot represent the severity and frequency of organ impact. While diabetes and hypertension were strongly associated with liver complications, the combination of diabetes and obesity, as well as obesity alone, exhibited a more pronounced impact on kidney function and potentially multiple organ systems.

## 5. Age and Lifestyle Disorders

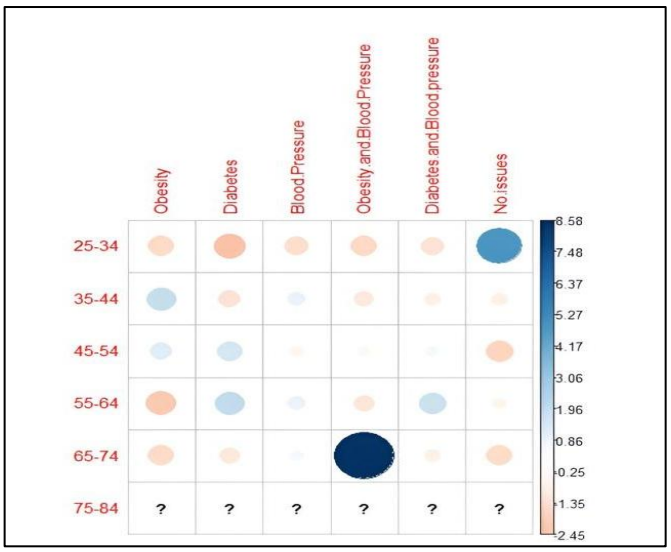


*Figure 5: Statistical plot of correlation between the Age of agricultural workers and their Lifestyle Disorders*


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The plot analysis revealed a significant correlation between age and the prevalence of lifestyle disorders. Notably, diabetes and hypertension exhibited a strong association with kidney dysfunction. However, the combination of diabetes and obesity, as well as obesity alone, demonstrated a more pronounced impact on multiple organ systems, as indicated by larger data points on the plot. Among the lifestyle disorders analyzed, obesity emerged as the most significant contributor to multi-organ health complications.

### 6. Work Duration and Symptoms Occurred during Pesticide Exposure

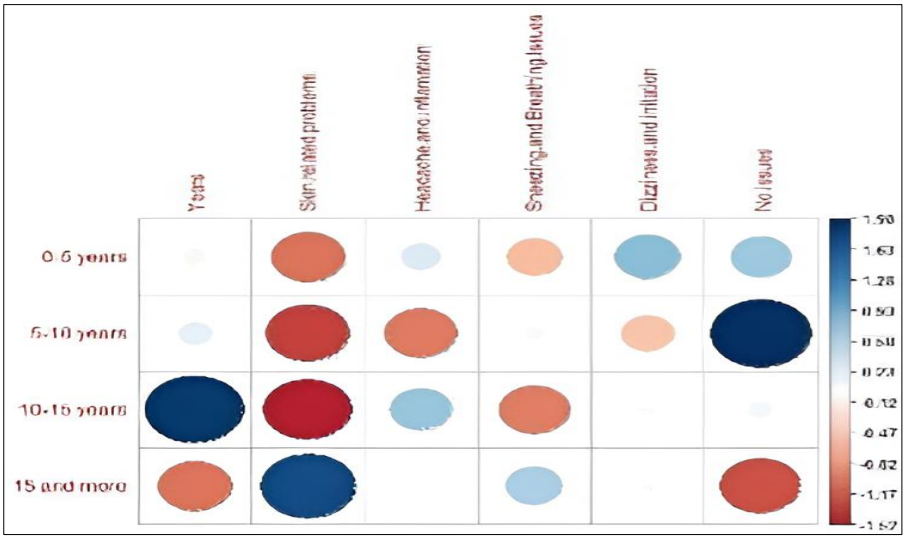


*Figure 6: Statistical Plot of correlation between Relationship between the duration of work and the symptoms developed while working in the field.*

A plot analysis investigated the relationship between work duration in agriculture (0-5, 5-10, 10-15, and 15+ years) and the development of symptoms such as skin irritation, dizziness, and respiratory issues. Results indicated that individuals with 0-5 and 5-10 years of experience primarily reported mild skin-related problems and few other symptoms. Conversely, those with 15+ years of agricultural experience exhibited a higher prevalence of long-term respiratory and skin-related issues, as evidenced by larger, red-colored plots on the graph

## Conclusion

The increased risk of pesticide poisoning underscores the critical need for enhanced educational initiatives to raise awareness among agricultural workers regarding safe pesticide handling practices and self-care measures to mitigate the associated health risks. This study investigates the relationship between pesticide usage patterns, educational awareness, and

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literacy levels within the Sonipat district of Haryana, India, aiming to identify correlations with specific health disorders.

Findings indicate that individuals engaged in long-term agricultural activities are more susceptible to acute symptoms such as irritation, nausea, and breathing difficulties, as well as chronic conditions affecting vital organs like the liver and kidneys. The inadequate use of protective gear and uncontrolled pesticide application significantly exacerbate these health risks. Notably, individuals with more than 15 years of agricultural experience demonstrate a higher risk of severe complications.

This study emphasizes the necessity of widespread awareness campaigns promoting the proper use of protective equipment, safe application techniques, and responsible pesticide handling practices to minimize health risks and ensure sustainable agricultural practices. Further research is warranted to comprehensively evaluate the long-term and short-term health effects of pesticide exposure and develop more effective risk assessment strategies.

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