

From Field to Fork: Examining Pesticides, Food, and Human Health for Enhanced Well-being

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Abstract

Background: We conducted this study to critically examine the nexus of pesticides, food and human health. For this purpose, we conducted 30 face-to-face interviews with males and 15 with females on an open-ended interview guide, later on, thematic analysis was used to derive themes and interpret the nexus. We confirmed that pesticide use has become imperative for high levels of food crop production such as wheat and important vegetables like tomatoes, potatoes and cauliflower. The use of pesticides is undue and more than the requirements without seeking safe health guidelines and adopting safety measures. Food is heavily pesticide-contaminated which is being consumed on households' level. Inadequate education in the community and unawareness about safe food are exaggerating the health risks. Human health issues in women, children and men are mounting subject to pesticide exposure and contaminated food. Women

in particular were vulnerable to hormonal function of the female reproductive system, leading to menstrual cycle disturbances, reduced fertility, prolonged time-to-pregnancy, spontaneous abortion, stillbirths, and developmental defects. Overall, the results are summarized into four key themes (i) overreliance on pesticides (ii) vulnerabilities to Food systems (iii) problems of consumer protection (iv) health issues of spray men. There is a need to promote decreasing the toxicity being caused by undue pesticides. Community awareness of safer food production is much needed.

Introduction

Understanding the interconnections between pesticides, food, and human health is paramount for safeguarding public well-being and promoting sustainable agricultural practices.

According to the most recent United Nations estimates, it is anticipated that the global population may reach approximately 8.5 billion by 2030 and 9.7 billion by 2050, with a peak of around 10.4 billion individuals expected to occur during the 2080s. This population level is projected to remain relatively stable until the year 2100 (UN Report, 2021). This is a notion that more food is required for such an increasing population. Pesticides play a pivotal role in modern agriculture by controlling pests and increasing crop yields (Tudi et al., 2021; Billah et al., 2023). The agricultural pesticides market is expected to experience a significant increase, with an anticipated growth of \$26.23 billion between 2021 and 2025. By 2023, it is forecasted to expand at a compound annual growth rate (CAGR) of 11.5%, reaching nearly \$130.7 billion (Sălceanu et al., 2022).

Approximately 385 million instances of pesticide poisoning occur annually worldwide, with a disproportionate impact on individuals in rural regions of the Global South. Despite being prohibited in Europe due to ecological or health concerns, pesticides are still manufactured within the region and exported to other nations, a trade in which European companies are also involved. While the European Union (EU) maintains stringent criteria for pesticide authorization, the broader detrimental effects of these chemicals on ecosystems are often overlooked. Pesticide-active ingredients typically exhibit mobility beyond their application sites, seeping into soil and groundwater, becoming airborne, or dispersing over considerable distances—some have been detected more than 1,000 kilometers away, as noted by Bär et al. (2022). However, the widespread use of pesticides raises concerns about their potential impact on food safety and human health. Pesticides can be harmful to human health due to their persistent nature and widespread exposure through various pathways, including occupational exposure, water contamination, and food chain concentrations

(Blair et al., 2014). Chronic and sub-lethal exposure to pesticides is associated with a higher prevalence of persistent diseases like cancers, neurodegenerative disorders, respiratory, reproductive, developmental, and metabolic disorders (Mostafalou and Abdollahi, 2017).

Pesticide residues can accumulate in food crops, entering the food chain and posing risks to consumers. Exposure to these chemicals has been linked to a range of health problems, including neurological disorders, reproductive issues, and cancer. Pesticides pose acute risks to human health and the environment, causing negative effects on agricultural workers, neighboring communities, and triggering social conflicts when used extensively without safety measures (Rani et al., 2020). Pesticide exposure in both rural and urban areas can cause adverse health outcomes, ranging from neurodevelopmental effects in newborns to various types of cancers (Dahiri et al., 2021). Chronic pesticide exposure is associated with cognitive dysfunction, dementia, and Alzheimer's disease, with potential mechanisms through neurotoxicity and neurodegeneration (Aloizou et al., 2020).

Excessive use of pesticides can lead to environmental pollution, contaminating soil, water, and ecosystems. This not only affects biodiversity but also poses risks to human health through the consumption of contaminated food and water sources. Additionally, pesticides can harm non-target organisms, including beneficial insects and wildlife, disrupting ecological balance. By exploring the complex interactions between pesticides, food production, and human health, researchers can inform policies and practices that prioritize environmental sustainability while ensuring food security and safety for present and future generations.

Methodology

Punjab, Khyber-Pakhtunkhwa, Sindh and Baluchistan are four provinces of Pakistan; however, Punjab province is considered as bread and basket by contributing more towards food production. The environment in Punjab province is conducive to food production due to fertile lands, diverse culture and vast irrigation network. In Punjab, a large number of major and minor food crops are grown under different cropping systems. Considering the importance of food crops like wheat and important vegetables like tomatoes, potatoes and cauliflower, we planned face-to-face open-ended interviews with the farming communities. Punjab province is the largest in terms of population. The total households in Punjab are 19855902 with 127688922 population growing at a rate of 2.53. average household size is 6.43 (Government of Pakistan, 2023).

Punjab has a total of thirty-six districts. Of the total, we conducted interviews in the districts Rahim Yar Khan, Muzaffargarh and Multan which are regarded as prominent in terms of vegetable production in the southern part of Punjab. We interviewed purposively selected 10 males and 5 females from each district on an interview guide. Thus, a total of 30 interviews with males and 15 interviews with females were conducted. One agriculture officer from each district was also interviewed to explore the trend of pesticide use and community response and behaviour towards

pesticides. Data collected were analyzed using a thematic analysis approach, which is one of the well-established techniques of qualitative data. Thematic analysis is a powerful and flexible method for qualitative data analysis, with its advantages and disadvantages outlined in this guide, empowering researchers to conduct it rigorously and thoughtfully (Kiger and Varpio, 2020).

While conducting interviews ethical considerations were kept intact. Formal verbal consent was obtained from the male and female participants. They were assured that their identity, and personal information would not be disclosed. The information received will only be used purely for research purposes. Respondents were also given the right to withdraw at any stage, although, none of the participants withdrew, all collaborated and interviews were conducted in a comfortable environment using local language.

Results

Based on the in-depth probing from the study participants, the following four themes are extracted (i) overreliance on pesticides (ii) vulnerabilities to Food systems (iii) problems of consumer protection (iv) health issues of spray men. Interconnected themes are portrayed in causal loop diagram (Figure 1).

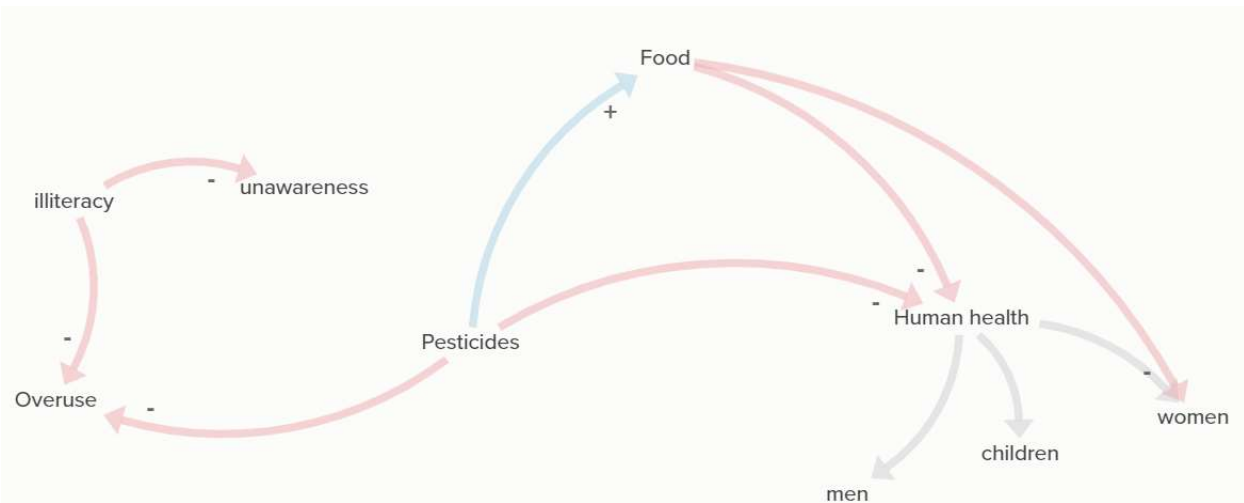


Figure 1. Interconnected themes. Pesticide use had a positive impact on food production by controlling attacks of insect pests and diseases. Due to the overuse of pesticides due to unawareness and poor level of education, food was contaminated, which had negative impacts on human health including women, children and men. Pesticide use also had a direct negative impact on human health through pesticide exposure. This is deduced that pesticide use had inverse impacts on human health through pesticide exposure and food contamination.

Overreliance on pesticides

To meet the food requirements, and attain high production of food farmers have started using abundant quantities of chemicals on the food crops. Food crops especially wheat, and vegetables are absorbing a huge quantity of chemicals, which are hazardous to health. During the discussion, farmers arbitrated that;We do not have other options except to use chemicals to combat insect pests and disease infestation on the crop to improve production. Although, we know this is injurious to our health what other option do we have? In a potato crop, farmers were applying chemicals as a preventive control. This implies

that farmers were applying fungicide weekly to just prevent the likely attack of fungus which could destroy the entire crop. In this strategy, around multifold increase in the use of fungicides was witnessed.

During the informal discussion, women participants reported that men usually decide about the spray and they had a common belief that the production of crops is directly associated with some applications of pesticides. It was acknowledged that the use of chemicals was readily available and the most convenient option for controlling insect pests. Farmers had a consensus that:

.....We are aware of the side effects of the chemicals, even though we are also consuming the same food, but achieving higher yields is our main concern in earning income.

Over the period the reliance on pesticides is increasing and pertinent to this overwhelmed application threats to human health are increasing. On the other hand, the resurgence of pests is occurring followed by the development of resistance in insect pests which requires a high dose of chemicals to control timely. Overdose and underdose application of chemicals have adverse impacts in both ways. The expert from the Agriculture Department explained the scenario of how chemical

applications are becoming more injurious to health. He explained that;

.....Farmers are more inclined towards using Knapsack sprayers and tractor-mounted boom sprayers. Often, they had limited knowledge of specific nozzle and spraying techniques. Consequently, the chemicals applied drift into the environment and are directly inhaled by humans. This results in numerous human diseases.

Technical knowledge within farm families regarding the selection of the right chemical and the right technique of application can curtail the incidences of human health issues associated with chemicals. Unfortunately, due to lower levels of education and a lack of training in pesticide management, farmers may lack this necessary knowledge. As a result, they may engage in unhealthy and improper practices by not adhering to the recommended guidelines for the safe usage of pesticides.

Vulnerabilities to Food systems

Food systems revolve around cereals, vegetables and fruits, which have become absorbent of a hefty amount of chemicals. Wheat and vegetables are the primary food crops in the study area, and the application of pesticides on these crops was reported to make them unsafe for consumption. Wheat was the only crop which was not applied with chemicals; however, 1-2 applications of fungicides have become obligatory. Similarly, on vegetables like tomatoes, chemicals are applied daily. These tomatoes are marketed and consumed without any particular precautionary measures. Whereas, other vegetables are also marketed after dipping in chemical solutions. As explained by the expert during the discussion:

..... farmers do not consider the preharvest interval (PHI) while applying chemicals. This confirms that humans are consuming vegetables which are absorbent of excessive chemicals.

When inquired from the farmers, it was unveiled that we are not guided nor do we have an understanding of PHI, we just apply pesticides just to protect our crop from pests. This unwise application of chemicals had a significant percussion on human health as polluted food is being consumed. Similarly, when women bring vegetables home, they do not know the duration between pesticide application and harvest. Consequently, these vegetables are perceived as unsafe and can have significant adverse effects on health. Women expressed their concerns about their vulnerability in various aspects, from working in the fields to consuming vegetables. While having discussions with men, women and experts it was concluded that:

..... the entire food chain is more or less polluted by the chemicals, because the production is reliant on chemicals. Polluted produce is being produced and marketed which is consumed on households' level. Pertinent to this consumption the threats to human health are increasing over time.

Problems of consumer protection

Like men, women are also the equally important pillar of the food production system by working in the field and serving in different farm operations including picking vegetables, and application of fertilizers and chemicals. It was unveiled that women had not followed the safety measures nor did they have adequate knowledge regarding safety guidelines. Women had to work in the field when the application of chemicals was commencing in the vegetable field. Similarly, they have to do the picking of cotton which is a highly pesticide-intensive crop. From there, women remain most vulnerable towards the pesticides' adverse impacts on their health. This had more severe implications as women had to manage households and have to take care of children. Impacts can also be transferred to the coming generation when they give birth and feed the

adolescents. During the discussion, women reported that:

.....We had faced the problems of breathing, food poisoning and skin allergy due to pesticide exposure. Our mend also faced adverse impacts of pesticides especially when they came back home after spraying in the field. Women perceived our kids are more critical due to pesticide exposure coming from field to fork.

Women acknowledged that their men did not adhere to safety measures such as wearing masks, gloves, or appropriate footwear while spraying pesticides. Moreover, they lacked awareness about proper safety measures themselves. Many times, the men experienced adverse health effects due to pesticide exposure. Additionally, women did not know how to keep food safe and minimize the impacts of pesticides on the food they consume.

Health issues of spray men

In this study, spray men were seen as significantly vulnerable towards pesticide poisoning. The common trend explored across the study areas was not following the safety guidelines. Spray men and farmers did not wear safety kits while applying pesticides and often practised those practices which they refrained from doing while applying chemicals. For instance, many of the participants reported that farmers used to smoke, drink water and eat while spraying. They were involved in eating, greeting children and roaming across the home without following the proper sanitary measures. Men, women and experts had a common agreement that;

.....We have seen many times the serious attack of pesticides on spray men. Vomiting, skin allergy and lung issues were observed. Most of the time they had to get medical assistance from the hospital. A couple of

deaths were reported subject to chemicals by the participants.

It was perceived that stereotypic behaviour towards chemicals was persistent across the study area. This mindset, coupled with a lack of access to the right information from the services providers increased the vulnerability. Farmers had limited knowledge about the appropriate chemicals, their recommended dosage, and safe application methods. Women also raised concerns about the improper storage of pesticides. They reported that pesticide bottles were often kept within reach of children at home, and it was common for children to play with empty pesticide bottles as toys. Additionally, after using pesticides, proper disposal practices were not followed. Bottles were frequently left in the fields, thrown into water channels, or discarded in sewage lines. These actions pose direct risks to human health and contribute to environmental pollution. This behaviour had a direct impact on the health of the spray me and women working in the field. In addition, this unwise application of chemicals had more toxicity in the vegetables being consumed. This implies that the application of chemicals on vegetables had a direct relationship with food contamination and the resurgence of human health issues.

Discussion

We examined the pesticides, food, and human health nexus using a qualitative discussion with men, women and experts involved in farming. Based on the discussion four themes (i) overreliance on pesticides (ii) vulnerabilities to food systems (iii) problems of consumer protection (iv) health issues of spray men are extracted. These themes are interrelated and endorse the nexus that pesticide use, food and human health are well related.

First, their overreliance on pesticides indicated that farming communities are employing a quantity of pesticides than they require.

Excessive usage has adverse impacts on the food quality which is consumed by humans. Pesticides can enter the food chain and negatively impact human and animal health, causing damage to the nervous system, lung damage, reproductive organs, immune dysfunction, birth defects, and cancer (Terziev and Petkova-Georgieva, 2020). Pesticides play a crucial role in agricultural development, but their use can also harm non-target organisms and the environment, resulting in environmental pollution and potential health risks for humans (Tudi et al., 2021). Many pesticides used in Europe, including organophosphates, carbamates, pyrethroids, ethylenebisdithiocarbamates, and chlorophenoxy herbicides, can cause neurodevelopmental toxicity, requiring public health prioritization for prevention (Bjørning-Poulsen et al., 2008).

Another theme that emerged was vulnerabilities to the food system due to excessive use of pesticides. This theme explains that food systems have become vulnerable due to the continuous excessive application of chemicals especially on food crops like wheat and vegetables. This contamination of food had serious concerns over human health. Organophosphate pesticides, which are widely used in agriculture, pose health risks such as acute neurological disorders and pose a threat to living strata exposed to them (Kaushal et al., 2020). In another study, Kim et al. (2017) stated that pesticides can cause environmental risks such as residues in food and drinking water, and their risks are difficult to elucidate due to various factors. Serious concerns have been raised about health risks resulting from occupational exposure and residues in food and drinking water. (Damalas and Eleftherohorinos, 2011). Overuse and misuse of agricultural pesticides in Africa pose serious exposure and health risks for farm workers and the population, with most consumed staple

foods being contaminated by pesticide residues (Bertrand, 2019).

In the third theme, we identified that consumer protection is at stake especially due to pesticide-contaminated food. The health of women and children in particular is vulnerable towards contaminated food. Pesticides cause headaches, nausea, skin and eye irritation, and chronic problems like cancer and neurological disorders in humans, contaminating water, soil, and plants (Gomes et al., 2020). In another study, Gerage et al. (2017) stated that pesticide-contaminated food can cause adverse health effects such as birth defects, hearing loss, cancer, infertility, and acute intoxication symptoms. Food safety is threatened due to contamination by chemicals throughout various stages of food production, including pesticides and persistent organic pollutants (Lebelo et al., 2021).

Our study found particular vulnerabilities in women and children due to pesticide-intensive food. This contaminated food is likely to have adverse impacts on their physical and physiological development. Pesticide exposure may disrupt the hormonal function of the female reproductive system, leading to menstrual cycle disturbances, reduced fertility, prolonged time-to-pregnancy, spontaneous abortion, stillbirths, and developmental defects (Bretveld et al., 2006). Prenatal pesticide exposure may cause lasting neurotoxic damage and add to the adverse effects of malnutrition in developing countries (Grandjean et al., 2006). High intake levels of organophosphate insecticides (chlorpyrifos, pirimiphos-methyl, and dimethoate) in fruits and cereals may pose a significant cumulative risk for neurochemical effects in pregnant women (Gavelle et al., 2016). Early-life exposure to organophosphates and organochlorine pesticides is linked to adverse effects on neurodevelopment and behaviour, including poorer mental development and increased scores on

developmental disorders (Roberts and Karr, 2012).

The fourth theme of study was the health issues of the spray men. This implies that spray men had to face more adverse impacts as they were directly in contact with the poison especially when non-adopting the safety measures. In a study, Pathak et al. (2013) found that spray men who had exposure towards pesticides during spraying activity led to a significant decline in lung function and acetylcholinesterase levels, with no significant change in motor and sensory nerve conduction velocity. Exposure to pesticides significantly increases chromosomal aberrations in the peripheral lymphocytes of cotton field workers compared to controls (Rupa et al., 1989). Excessive sweating, burning/stinging/itching of eyes, dry/sore throat, and excessive salivation are more prevalent among sprayers, with eye and throat problems significantly associated with exposure (Chitra et al., 2006). Delgado et al. (2004) reported that 62% of workers reported at least one illness associated with mixing or spraying pesticides, with the most frequent symptoms being headache, nausea, vomiting, dizziness, skin irritation, and blurred vision.

Based on the four themes, this study is of consensus that understanding the nexus of pesticides, food and human health is of great worth. This study had a significant contribution to the existing body of literature with the argument that dealing with all the stakeholders while formulating the food safety, food security and community health programs viewpoint of all stakeholders is critical. In this study, opinions from men, women, and agricultural experts were sought using qualitative inquiry, which makes these findings of high generalizability.

Conclusion

Our examination of the pesticides, food, and human health nexus through qualitative discussions with farmers, men, women, and agricultural experts revealed four key themes: overreliance on pesticides, vulnerabilities to food systems, problems of consumer protection, and health issues of spray men. These themes underscore the interconnectedness of pesticide use, food production, and human health. The overuse of pesticides not only affects food quality but also poses serious health risks to humans and animals, including neurological damage and cancer. Additionally, the excessive application of pesticides on food crops renders food systems vulnerable, leading to contamination and health concerns. Consumer protection is compromised due to pesticide-contaminated food, particularly impacting the health of women and children. The study highlights the disproportionate impact on women and children's physical and physiological development due to pesticide exposure. Furthermore, spray men face significant health risks from direct contact with pesticides. Overall, this study emphasizes the importance of addressing the nexus between pesticides, food, and human health, advocating for comprehensive approaches that involve all stakeholders in formulating food safety, security, and community health programs. The inclusion of perspectives from diverse stakeholders enhances the generalizability and relevance of these findings to broader agricultural and public health contexts.

References

- Aloizou, A., Siokas, V., Vogiatzi, C., Peristeri, E., Docea, A., Petrakis, D., Provatas, A., Folia, V., Chalkia, C., Vinceti, M., Wilks, M., Izotov, B., Tsatsakis, A., Bogdanos, D., & Dardiotis, E. (2020). Pesticides, cognitive functions and dementia: A review.. *Toxicology letters*. <https://doi.org/10.1016/j.toxlet.2020.03.005>.
- Bertrand, P. (2019). Uses and Misuses of Agricultural Pesticides in Africa: Neglected Public Health Threats for Workers and Population. *Pesticides - Use and Misuse and Their Impact in the Environment*. <https://doi.org/10.5772/INTECHOPEN.84566>.
- Billah, M. M., Rahman, M., & Naidu, R. (2023). Effect of excessive use of agrochemicals on farming practices: Bangladesh perspectives. *International Journal of Agricultural Extension*, 11(1), 79-90.
- Bjørning-Poulsen, M., Andersen, H., & Grandjean, P. (2008). Potential developmental neurotoxicity of pesticides used in Europe. *Environmental Health*, 7, 50 - 50. <https://doi.org/10.1186/1476-069X-7-50>.
- Blair, A., Ritz, B., Wesseling, C., & Freeman, L. (2014). Pesticides and human health. *Occupational and Environmental Medicine*, 72, 81 - 82. <https://doi.org/10.1136/oemed-2014-102454>.
- Bretveld, R., Thomas, C., Scheepers, P., Zielhuis, G., & Roeleveld, N. (2006). Pesticide exposure: the hormonal function of the female reproductive system disrupted?. *Reproductive Biology and Endocrinology*, 4, 30 - 30. <https://doi.org/10.1186/1477-7827-4-30>.
- Chitra, G., Muraleedharan, V., Swaminathan, T., & Veeraraghavan, D. (2006). Use of Pesticides and Its Impact on Health of Farmers in South India. *International Journal of Occupational and Environmental Health*, 12, 228 - 233. <https://doi.org/10.1179/oeh.2006.12.3.228>.
- Dahiri, B., Martín-Reina, J., Carbonero-Aguilar, P., Aguilera-Velázquez, J., Bautista, J., & Moreno, I. (2021). Impact of Pesticide Exposure among Rural and Urban Female Population. An Overview. *International Journal of Environmental Research and Public Health*, 18. <https://doi.org/10.3390/ijerph18189907>.
- Damalas, C., & Eleftherohorinos, I. (2011). Pesticide Exposure, Safety Issues, and Risk Assessment Indicators. *International Journal of Environmental Research and Public Health*, 8, 1402 - 1419. <https://doi.org/10.3390/ijerph8051402>.
- Delgado, I., & Paumgarten, F. (2004). [Pesticide use and poisoning among farmers from the county of Paty do Alferes, Rio de Janeiro, Brazil].. *Cadernos de saude publica*, 20 1, 180-6. <https://doi.org/10.1590/S0102-311X2004000100034>.
- Gavelle, E., Lauzon-Guillain, B., Charles, M., Chevrier, C., Hulin, M., Sirot, V., Merlo, M., & Nougadère, A. (2016). Chronic dietary exposure to pesticide residues and associated risk in the French ELFE cohort of pregnant women.. *Environment international*, 92-93, 533-42. <https://doi.org/10.1016/j.envint.2016.04.007>.
- Gerage, J., Meira, A., & Silva, M. (2017). Food and nutrition security: pesticide residues

- in food. *Nutrire*, 42, 1-9. <https://doi.org/10.1186/s41110-016-0028-4>.
- Gomes, H., Menezes, J., Costa, J., Coutinho, H., Teixeira, R., & Nascimento, R. (2020). A socio-environmental perspective on pesticide use and food production.. *Ecotoxicology and environmental safety*, 197, 110627 . <https://doi.org/10.1016/j.ecoenv.2020.110627>.
- Government of Pakistan, (2023). Population statistics of Pakistan. Economic Survey of Pakistan.
- Grandjean, P., Harari, R., Barr, D., & Debes, F. (2006). Pesticide Exposure and Stunting as Independent Predictors of Neurobehavioral Deficits in Ecuadorian School Children. *Pediatrics*, 117, e546 - e556. <https://doi.org/10.1542/peds.2005-1781>.
- Kaushal, J., Khatri, M., & Arya, S. (2020). A treatise on Organophosphate pesticide pollution: Current strategies and advancements in their environmental degradation and elimination.. *Ecotoxicology and environmental safety*, 207, 111483 . <https://doi.org/10.1016/j.ecoenv.2020.111483>.
- Kiger, M., & Varpio, L. (2020). Thematic analysis of qualitative data: AMEE Guide No. 131. *Medical Teacher*, 42, 846 - 854. <https://doi.org/10.1080/0142159X.2020.1755030>.
- Kim, K., Kabir, E., & Jahan, S. (2017). Exposure to pesticides and the associated human health effects.. *The Science of the total environment*, 575, 525-535 . <https://doi.org/10.1016/j.scitotenv.2016.09.009>.
- Lebelo, K., Malebo, N., Mochane, M., & Masinde, M. (2021). Chemical Contamination Pathways and the Food Safety Implications along the Various Stages of Food Production: A Review. *International Journal of Environmental Research and Public Health*, 18. <https://doi.org/10.3390/ijerph18115795>.
- Mostafalou, S., & Abdollahi, M. (2017). Pesticides: an update of human exposure and toxicity. *Archives of Toxicology*, 91, 549-599. <https://doi.org/10.1007/s00204-016-1849-x>.
- Pathak, M., Fareed, M., Srivastava, A., Pangtey, B., Bihari, V., Kuddus, M., & Kesavachandran, C. (2013). Seasonal variations in cholinesterase activity, nerve conduction velocity and lung function among sprayers exposed to mixture of pesticides. *Environmental Science and Pollution Research*, 20, 7296-7300. <https://doi.org/10.1007/s11356-013-1743-5>.
- Rani, L., Thapa, K., Kanojia, N., Sharma, N., Singh, S., Grewal, A., Srivastav, A., & Kaushal, J. (2020). An extensive review on the consequences of chemical pesticides on human health and environment. *Journal of Cleaner Production*, 124657. <https://doi.org/10.1016/j.jclepro.2020.124657>.
- Roberts, J., & Karr, C. (2012). Pesticide Exposure in Children. *Pediatrics*, 130, e1765 - e1788. <https://doi.org/10.1542/peds.2012-2758>.
- Rupa, D., Reddy, P., & Reddi, O. (1989). Chromosomal aberrations in peripheral lymphocytes of cotton field workers exposed to pesticides.. *Environmental*

- research*, 49 1, 1-6 .
[https://doi.org/10.1016/S0013-9351\(89\)80017-9](https://doi.org/10.1016/S0013-9351(89)80017-9).
- Sălceanu, C., Paraschivu, M., Cotuna, O., Sărățeanu, V., Prioteasa, M. A., & Flondor, I. S. (2022). Global Pesticide Market: Size, Trends, Forecasts. "Annals of the University of Craiova-Agriculture Montanology Cadastre Series", 52(2), 146-157.
- Terziev, V., & Petkova-Georgieva, S. (2020). The Health and Safety Problems According to the Pesticides Usage in the Ecosystem. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3472055>.
- Tudi, M., Ruan, H., Wang, L., Lyu, J., Sadler, R., Connell, D., Chu, C., & Phung, D. (2021). Agriculture Development, Pesticide Application and Its Impact on the Environment. *International Journal of Environmental Research and Public Health*, 18. <https://doi.org/10.3390/ijerph18031112>.
- Tudi, M., Ruan, H., Wang, L., Lyu, J., Sadler, R., Connell, D., Chu, C., & Phung, D. (2021). Agriculture Development, Pesticide Application and Its Impact on the Environment. *International Journal of Environmental Research and Public Health*, 18. <https://doi.org/10.3390/ijerph18031112>.