The health endpoint due to exposure organophosphorus toxicant

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ABSTRACT

Background/objectives: Organophosphorus compounds are extremely predominant in terms of agricultural and commercial activities. The aim of this review study was to assess the health endpoint due to organophosphorus toxicant.

Methods: This study was conducted based on databases including Web of Science, Science Direct, PubMed, Springer, and Google Scholar.

Results: The result of this study showed that the severity of the symptoms, which include acute cholinergic syndrome and intermediate syndrome, depends on the dose received, the exposure duration, and the patient’s health status.

Conclusion: Long-term or short-term exposure to organophosphorus toxins will cause symptoms of poisoning and disruption of the nervous system sites.

1. Introduction

Organophosphorus chemicals are an important category of compounds that have economic significance due to their many different uses, such as pesticides, industrial liquids, flame-resistant drugs, plastic production, and solvents. Organophosphates are widely used in global agriculture for many different reasons, including pesticides, herbicides, and insecticides. These chemicals compound were the main factor for pesticide poisoning.2

Serious problems occur over potential for delayed effects after high-level exposure, in addition to the long-term effects of low-level exposure during a person’s life. Exposure to organic phosphorus toxic substances, whether it is during just a few minutes or for an extended time, may cause poisoning as an outcome of the ingestion of stimulants.3 The effects of organic phosphorus toxins may vary in intensity based on the mode of exposure, the dosage, the period of exposure, and the severity of a poison. Exposure to organophosphorous toxicants can lead to a range of significant health effects.4

These consist of sweating, seizure disorders, increased urine output, increased production of saliva, difficulty inhaling and exhaling, limited pupils, fatigue, cramps, vomiting and nausea, tremors of the muscles, shrinking of the pupil, changes in heartbeat, and other cardiovascular symptoms. Other symptoms could involve headaches, delusion, changes in emotions, diseases of both the central and peripheral nervous systems, confusion, loss of memory, nervousness, neuropathy, pancreatitis, harmful effects on various parts of the nervous system, schizophrenia, hypertension, and change of cholinesterase activity in synapses.5 This significant mechanism is thought to be responsible for the neurotoxic of these toxic substances. The impact of organic phosphorus toxins on the human body is extensive and complicated; thus, specific processes remain poorly elucidated. These chemicals inhibit the activity of numerous enzymes in the human body, with one of the most important being esterase, which has medicinal properties.

The enzyme acetate breaks down the acetylcholine neurotransmitter at the synapse of the autonomous nervous system as well as the neuromuscular junctions of the peripheral nervous systems.6 The inhibition of

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enzymes restricts the dehydration of the neurotransmitter, leading to its accumulation in cholinergic sites and causing alterations in the normal operation of the brain. When a cholinergic molecule is continuously hindered, the only way to restore its function is by creating a new enzyme during synthesis. The reduced activity of acetylcholinesterase initiates in an increased buildup of cholinergic at acetylcholine synapses, causing a prolonged response of its receptor. The following causes excessive stimulation of both nicotinic and muscarinic receptors, which is followed by eventual receptor downregulation. In recent decades, methods of therapy for poisoning resulting from exposure to organic phosphorus poisons have achieved significant improvements compared to past times. Thus, this study aimed to investigate the adverse health consequences caused by exposure to organic phosphorus poisons.

2. Materials and methods

2.1. Eligibility criteria and search strategy

A comprehensive review of the English language epidemiology research was done. Keywords and queries were used to do comprehensive searches through several databases, such as Google Scholar, Web of Science, Springer, PubMed, and Sciences Direct. The search was restricted to objects published in the English language and presented from 2007 to 2022. Search terms and query results showed in Table 1. A total of 436 documents have been obtained from the databases (Table 1). The citation system EndNote downloaded references. The search keywords that were chosen by the search phrase strategy included: Organic phosphorus poisons, acetylcholinesterase, Acute cholinergic Disorder, Subacute neuromuscular, organophosphorus delayed neuropathy caused by organophosphorus, and Chronic neuropsychiatric disease.

2.2. Study selection

A two-step investigation of the literature was carried out. First, the approach used search phrases derived from keywords. ‘organic phosphorus poisons’, ‘health endpoint due to exposure to organophosphorus’, ‘pesticides’, ‘Subacute neuromuscular’, ‘effects of organophosphorus toxins on human’ and ‘Chronic neuropsychiatric disease’. Review time efficiency of studies was limited in the range of 2007–2022. Using an extensive review of the published literature, such as articles from foreign journals and databases like PubMed, Science Direct (Scopus), Springer, Web of Sciences, and Google Scholar, a total of 436 articles were evaluated (Table 1). These research studies focused on the impact of organic phosphorus poisons on the activity of the cholinesterase enzyme and the development of disorders of the nervous system. 101 articles were found and selected based on records identified through database searching. In the next stage, 60 studies were screened after review and 33 full-text articles entered into the analysis process. Finally, 21 articles were selected in this study. The how to prepare studies and the selection process articles based on PRISMA flow diagram showed in Fig. 1.

The research involved in this review had to comply with rules.

- initially they had to be disclosed in the English language between 2007 and 2022

2.3. Extracting the data

The data obtained from all studies included research aims, study setting, statistical evaluation, primary results, and limitations. The method of extraction involved retrieving information on research design, study population, health requirements, and evaluations of outcomes for the research studies containing health data.

3. Result and discussion

3.1. Source of organophosphorus compounds

Pesticides are toxic and custom-made compounds intended to lethally affect specific groups of insects. Although the harmful effect of these substances is particular to certain species of organisms, it generally induces minor toxicity in other species. From the beginning of the Second World War, a significant quantity of insecticide has been developed and utilized extensively. Currently, more than 400 compounds have been discovered to have insect-repellent abilities, with about ninety percent of these being natural substances. Organic phosphorus poisons are of concern to toxicology researchers not only because of their mechanism of action but also because of their potential to cause both long-term and short-term toxicity. Because of the widespread utilization of insecticides, unintentional exposure to these chemicals has resulted in the poisoning and even mortality of humans at a single contact. Many of these issues arise from the inadvertent introduction of insecticides into foods or their improper application. While advanced analytical techniques are being evolved to aid sedimentation, the detection of chronic damage caused by insecticides in the environment remains complicated. Regardless of a decrease in their use, insecticides continue to play an essential role in the community, especially in the economy of agriculture. Nevertheless, according to examinations of both the advantages and disadvantages of these products, it is unlikely that the use of them will be completely ceased.

Organophosphate exposure can be via food products such as wheat, flour, and cooking oil. In addition, ant and roach sprays might also be a potential source of exposure. The exposure routes include inhalation, direct contact, or ingestion. Fig. 2 express source of organophosphorus toxins.

Table 1

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3.2. Human health due to exposure to organophosphorus toxins (acute cholinergic poisoning, intermediate syndrome and delayed neuropathy)

Organic phosphoric toxins act by bonding to acetylcholine enzymes, thus decreasing the activity of and neutralizing their role within the human body. Evaluation of the function of acetylcholinesterase (AChE) and butyrylcholinesterase (BuChE) in entirety blood as well as plasma is a quick and easy method for evaluating poisoning from organophosphorus substances. Nevertheless, this approach doesn’t have a high degree of specificity and sensitivity. On the other hand, assessing the byproducts of degradation of these chemicals in plasma and urine is possible but costly and can only be done in specialized labs. Fortunately, the toxicity caused by this compound is typically irreversible. With appropriate interventions, chemical and toxic substances can be separated from enzymes, enabling them to regain their capacity for carrying out their natural functions. Cholinesterase proteins that perform numerous roles, such as deactivating acetylcholine, may be categorized into two major types: tissue cholinesterase (current in the brain, spinal cord, and blood cells) and blood cholinesterase (also known as secondary cholinesterase).

The onset of organic phosphorus toxin poisoning can be affected by multiple components, including the particular kind of poison, how much consumed, the duration of exposure, and the route of exposure. These symptoms include an extensive range of mild to serious negative effects ranging from flu-like conditions to dangerous indicators. Whereas breathing of organic phosphorus toxins usually leads to a greater immediate symptom of poisoning, whereas contact with the skin occurs over an extended period. This can be attributed in part to the appearance of skin role as the body’s main defense barrier and its capacity to resist the penetration of foreign substances. Cholinergic syndrome, which occurs during acute poisoning with organophosphorus compounds, is directly associated with the level of activity of acetylcholinesterase enzyme. In general, this disorder is initially associated with mucarinc symptoms, followed by this mechanism, the involvement of the nervous system and nicotine manifestations will be observed. Muscarinic sites increase secretions (saliva, tears and sweating), meiosis leads to blurred vision, bronchial contraction (chest tightness and wheezing), bradycardia, increased motility of the digestive system (abdominal stiffness, muscle cramps and diarrhea) and vomiting.

The intermediate phase of the syndrome appears around 24–48 h after the cholinergic syndrome (acute poisoning) and is defined by the appearance of decreased strength in the closest muscles of the legs, neck flexors, the stomach, breathing muscles, and motor nerves in the brain. In this case, the patient suffers from shortness of breath due to the decrease in the normal function of the respiratory muscles and needs ventilation care. Recovery will be achieved in about four days or three weeks after taking the necessary care and treatment, otherwise the difficulty in breathing may turn into respiratory failure through the
paralysis of the diaphragm and other respiratory muscles, a situation that leads to the patient’s death. Although the exact working mechanism of this syndrome is not clearly investigated, studies in this field have shown that this abnormality is the result of a malfunction in the proper functioning of the neuromuscular synapse. This complication results in changing the proper functioning of many nicotinic receptors in the

Fig. 2. Source of organophosphorus toxins.

Fig. 3. The effects of organophosphorus toxins on human.
neuromuscular junction, and for this reason, they lose their previous efficiency. In contrast, some specialists in this field attribute the occurrence of these illnesses to the effect of insufficient or delayed administration of phenoxy treatment to patient. Delay peripheral neuropathy, which is an illness developed among people between the weeks of two and five after exposure to organic phosphorus substances, is defined by sensory deviations, muscle pain, vulnerability, and weakness, mostly affecting the legs. Since many organophosphorus compounds are neurotoxic and strong or weak inhibitors of the acetylcholinesterase enzyme, this complication may occur after exposure to appropriate amounts of organophosphorus agents. The most obvious symptom of this disorder is muscle cramp in the leg area, followed by drooping and weakness of the fingers. These symptoms can have an upward course like Guillain-Barre syndrome. This complication occurs when an organophosphorus poison or its metabolites, which have neurotoxic properties, bind to the neurotoxic esterase enzyme and cause the degeneration of the long axons of peripheral and central nerves system and then their demyelination. This enzyme, which is responsible for maintaining neuronal functions, is released after aging with a charged group due to hydrolysis by agents related to organophosphorus toxins and causes axonal degeneration. This event leads to symmetrical weakness of the peripheral muscles in hands and feet with a variable degree of sensory disturbance. The illness can progress during a period of 4–12 weeks, maybe subjecting the patient to additional serious conditions. However, people who have visual deviations can expect quicker recovery times, those who have serious problems at times might not fully recover in a number of cases. Fig. 3 showed the effects of organophosphorus toxins on human.

An organic phosphorus poison is utilized in agricultural goods, specifically herbicides, and also in the production of liquids and polymers as well. Exposure may cause a harmful outcome. The strength of the effect is dependent on the qualities of the goods and also the length and extent of the exposure. Emergency healthcare is essential for anybody who exhibits signs upon exposure to an organic phosphorus poison. Utilizing appropriate safety equipment when working these compounds may safeguard users from these harmful effects.

4. Conclusion

The current research aims at evaluating the effect of organic phosphorus toxin on the function of the enzyme known as cholinesterase and its relationship with disorders of the nervous system. Furthermore, the research emphasized on the neurotoxic conditions observed in people who had been subjected to organic phosphorus toxins, and on the fundamental mechanisms that were identified. Organism phosphates are widely employed as pesticides and insecticides worldwide. Exposure to these hazardous substances, whether intentionally or unintentionally, causes a substantial number of poisoning and deaths yearly. On the other hand, the entry of those compounds into the body causes various adverse effects in the peripheral and central nervous system, which may be irreversible. In this study, neurotoxic disorders associated with acute and chronic exposure to organic organophosphorus toxins were considered with emphasis on the inhibition of acetylcholinesterase enzyme activity and clinical manifestations. The results of this study showed that the absorption of organophosphorus poisons into human body via various inhalation, skin and digestive routes results in inhibition of acetylcholinesterase enzyme and excessive accumulation of acetylcholine in synaptic nerve terminals.

The results of this study also showed that exposure to organophosphorus compounds causes four main neurological effects including cholinergic syndrome, intermediate syndrome, organophosphorus-induced delayed neuropathy and chronic neuropsychiatric disorder caused by organophosphorus in humans. However, following to protective indications and regulations regarding organophosphorus toxins and even carrying out methods that reduce exposure to these dangerous substances, particularly among specific groups like farmers and those who manufacture these compounds, may successfully avoid poisoning incidents and reduce the serious risks caused by them.

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Authors contributions

YN, MF, MT, PA, FK and M-JM were principal investigators of the study and drafted the manuscript. YN, MF, and M-JM were advisors of the study. SI YN, MF, MT, PA, FK and M-JM performed the statistical analysis. All authors contributed to the design and data analysis and assisted in the preparation of the final version of the manuscript. All authors read and approved the final version of the manuscript.

Informed consent

Not applicable.

Ethical approval

The conducted research is not related to either human or animal use.

Consent to participate

‘Not applicable’ for that specific section.

Declaration of competing interest

No potential conflict of interest was reported by the authors.

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