Review Paper

A Decade of Managing Organophosphate Poisoning: A Systematic Review

Odochi O. Chukwu[1, 2*], Raphael C. Anakwue[1], Cordilia O. Iyare[2], Abdullateef I. Alagbonsi[3]

1. Department of Pharmacology and Therapeutics, Faculty of Basic Clinical Medicine, University of Nigeria, Enugu, Nigeria.
2. Department of Physiology, Faculty of Basic Medical Sciences, College of Medical Sciences, David Umahi Federal University of Health Sciences, Uburu, Nigeria.
3. Department of Physiology, School of Medicine and Pharmacy, College of Medicine and Health Sciences, University of Rwanda, Huye, Rwanda.

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ABSTRACT

Background: Organophosphate (OP) poisoning remains a significant public health concern. This systematic review aimed to assess the current state of knowledge on the management of OP poisoning.

Methods: A comprehensive search of PubMed, Scopus, Web of Science, and Google Scholar was conducted using relevant keywords, such as 'organophosphate poisoning', 'pesticide exposure', and 'agricultural workers. Search was restricted to studies published between 2014 and 2024. Filters were applied to include only articles in English, focusing on human and animal studies, clinical trials, and observational research. Studies were included if they examined OP poisoning, particularly in rural populations or agricultural workers, and excluded if they were not written in English, were non-peer-reviewed, or lacked relevant biomarkers or outcomes. Data from each study were extracted using a standardized form and analyzed thematically, focusing on key outcomes, like exposure risks, treatment methods, and poisoning-related mortality.

Results: Of the 152 studies initially identified, 25 were included in the final analysis. The majority of included studies focused on the clinical management of OP poisoning, including the use of antidotes and supportive care. However, there is a paucity of research on long-term health outcomes and the effectiveness of preventive interventions in rural settings. Key findings from the included studies highlight the importance of early diagnosis and prompt treatment.

Conclusion: While the review did not find significant treatment advances, it emphasized the continued relevance of promoting safe pesticide use, education, and awareness in preventing OP poisoning in agricultural communities. Rural populations, who are disproportionately affected due to higher exposure to agricultural chemicals and limited access to healthcare and education, require targeted public health interventions. Future studies should focus on more effective prevention strategies and therapeutic interventions to address the unique vulnerabilities of rural communities, including community-based interventions and digital health technologies.

Keywords: Organophosphate (OP) poisoning, Pesticide exposure, Agricultural workers, Rural populations, Farm

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*** Corresponding Author:**
Odochi O. Chukwu, PhD.
Address: *Department of Physiology, Faculty of Basic Medical Sciences, College of Medical Sciences, David Umahi Federal University of Health Sciences, Uburu, Nigeria.*
Phone: *+23 (48) 109224709*
E-mail: *chukwuoo46@gmail.com*

Introduction

Organophosphate (OP) poisoning remains a significant public health concern worldwide, particularly in rural communities, especially in developing countries where agriculture is a primary economic activity. Studies have consistently reported high rates of OP poisoning among agricultural workers, particularly those involved in pesticide application, mixing, and storage [1, 2]. South and Southeast Asia have recorded some of the highest rates of OP poisoning, with India and Bangladesh experiencing significant burdens [3]. Sub-Saharan Africa has also seen a considerable number of cases, particularly in agriculture-dependent countries [4]. While data may be limited in some regions, Latin American countries have also reported instances of OP poisoning in rural communities [5].

Younger individuals, particularly those under 18, and men working in agricultural settings are at a heightened risk of OP poisoning [6]. These groups often have higher levels of exposure due to direct contact with pesticides during spraying or planting activities, and in many cases, there are limited protective measures in place [7]. Lower education levels are also associated with higher rates of poisoning, as individuals may have limited knowledge about pesticide safety [8]. Poverty and lack of access to healthcare further contribute to higher poisoning rates due to limited preventive measures and delayed medical care [9].

Recent statistics indicate that OP poisoning remains a significant public health concern, with an estimated 3 million cases of pesticide poisoning reported annually globally. In rural agricultural areas, the mortality rate due to OP poisoning is particularly high, with a recent study showing an increase in pesticide-related fatalities over the past decade [2]. Rural communities often face limited access to healthcare facilities, specialized medical expertise, and timely treatment for OP poisoning, and organophosphorus toxins continue to be a leading cause of poisoning worldwide, especially in agricultural communities [2, 4]. Despite advances in medical treatment, gaps remain in the availability of effective antidotes and long-term management strategies, particularly in rural areas where healthcare access is limited. Preventive measures, such as promoting the safe use, storage, and disposal of pesticides, as well as using personal protective equipment (PPE), are crucial in reducing the incidence of OP poisoning [5]. Educational campaigns to raise awareness about pesticide risks, proper handling techniques, and the importance of medical checkups for those in high-risk occupations can further mitigate exposure.

The development of evidence-based guidelines for the management of OP poisoning in rural communities is crucial to improve outcomes and reduce the burden of this health problem. Ongoing research is exploring new treatment options and strategies for OP poisoning. Moreover, OP poisoning can have significant social and economic consequences for individuals, families, and communities. While treatment is crucial, preventive measures are equally important in reducing the burden of OP poisoning. By synthesizing the existing literature, this systematic review will provide a comprehensive overview of the current state of knowledge regarding the management of OP poisoning, particularly in rural communities. The findings may inform the development of guidelines, recommendations, and future research directions.

Method

The PRISMA guidelines were followed in the selection, inclusion, and analysis of studies for this review. This ensured a rigorous and transparent review process, focusing on high-quality studies that met the inclusion criteria.

Search strategy

The search strategy utilized Boolean operators (AND, OR) to combine keywords. For example, ‘OP poisoning’ AND ‘agriculture workers’ OR ‘pesticide exposure’ was used to narrow the search results to the most relevant studies. To identify relevant studies, a comprehensive search was conducted using the following databases: PubMed, Scopus, Web of Science, and Google Scholar. The search terms used included “organophosphate poisoning”, “organophosphate treatment”, “organophosphate management”, “organophosphate prevention”, and “organophosphate outcomes”. Additional relevant keywords were also considered, such as “pesticide poisoning,” “agricultural communities,” and “healthcare access”.

Inclusion and exclusion criteria

All studies in which OP poisoning was reported between 2014 and 2024 were included. The selection of studies from 2014 to 2024 was made to ensure the review reflects the most current research on OP poisoning, including advances in treatment options, new findings on exposure risks, and the evolving epidemiology of pesticide poisoning. The included original articles reported on some or all of the following: studies on humans (including randomized controlled trials, observational studies, case-control studies, and cohort studies). Studies that provided quantitative data on outcomes related to the

treatment, management, or prevention of OP poisoning were also included. Studies using the Newcastle-Ottawa scale (NOS) for observational studies with a score of 7 or higher were included. Conference abstracts and duplicate publications were identified through a combination of manual checking and using reference management EndNote software, version X9. Any duplicate studies were excluded from the final analysis to ensure the accuracy and integrity of the review process.

Data extraction and synthesis

Data were extracted independently by two reviewers using a standardized data extraction form. Discrepancies were resolved through discussion and consensus. The following information was extracted from each study: Study title, the name of authors, year of publication, study design, and findings. The extracted data were synthesized using a narrative approach. Findings were categorized based on the subtopics addressed in the studies, such as treatment, prevention, and outcomes.

Results

Characteristics of the studies

A total of 152 articles were retrieved through the literature search (Figure 1). Of these, 80 articles were retained after removing duplicates; 51 were excluded due to irrelevance based on their titles and abstracts, and 29 were retained for full-text evaluation. Finally, after a detailed full-text evaluation, 25 articles published between 2019 and 2024 were included.

Studies included after full-text evaluation

Table 1 shows the distribution of studies included after full-text evaluation. In terms of study design, of the 25 articles, 10 were retrospective studies, 5 were case-control studies/reports, 5 were cross-sectional studies, and 2 were observational studies. There was 1 randomized controlled trial, 1 experimental study, and 1 cohort stud. The studies included in this review were conducted in various countries, including Asia (India, Pakistan, Bangladesh, Sri Lanka, China, and Nepal), Africa (Ethiopia and South Africa), Europe (Turkey), and potentially North America (US or Canada). Data on the consequences of OP poisoning from this study range from muscarinic effects (salivation, lacrimation, urination, defecation, miosis, and bradycardia), nicotinic effects (muscle weakness, fasciculations, and paralysis), and central nervous system effects (confusion, seizures, and coma). In severe cases, respiratory failure and death were reported. The pooled study reported India as the country with the highest mortality rate from OP poisoning (11.5%). The management of OP poisoning in this review involves a combination of antidotal therapy and supportive care. Antidotal therapy includes the administration of atropine to block muscarinic effects and pralidoxime to reactivate inhibited acetylcholinesterase. Supportive care measures, such as mechanical ventilation and fluid and electrolyte management, were also reported.

Sociodemographic attributes of participating populations in the studies

Three studies specifically focused on pediatric populations, while 7 studies specifically highlighted the risks faced by agricultural workers. Eight studies highlighted the impact of rural residence on OP poisoning (Table 2).

Thematic overview of OP poisoning: Epidemiology, Clinical manifestations, treatment strategies, and barriers to management based on recent studies

Table 3 presents a synthesis of key studies on OP poisoning, summarizing the epidemiological trends, clinical manifestations, and treatment modalities across diverse geographical regions. The table consolidates findings from verified research, offering insights into the global scope of OP poisoning, highlighting regional variations, and emphasizing gaps in clinical management and intervention strategies.

Discussion

This systematic review highlights significant research on the management of OP poisoning in rural communities. While notable progress has been made, challenges persist, particularly in low-resource areas. Key findings underscore the need for improved healthcare infrastructure, preventive measures, and better access to treatment in agricultural regions, where OP exposure is most prevalent.

Geographical distribution and sociodemographic vulnerabilities

OP poisoning is most common in developing countries, particularly across Asia and Africa, where agriculture is central to the economy. The vulnerability of rural populations is compounded by limited healthcare access and insufficient awareness about the risks of pesticide exposure. Although many studies emphasize the importance of infrastructure improvements and education campaigns, it is clear that these interventions are not uniformly implemented, and their impact remains inconsistent.

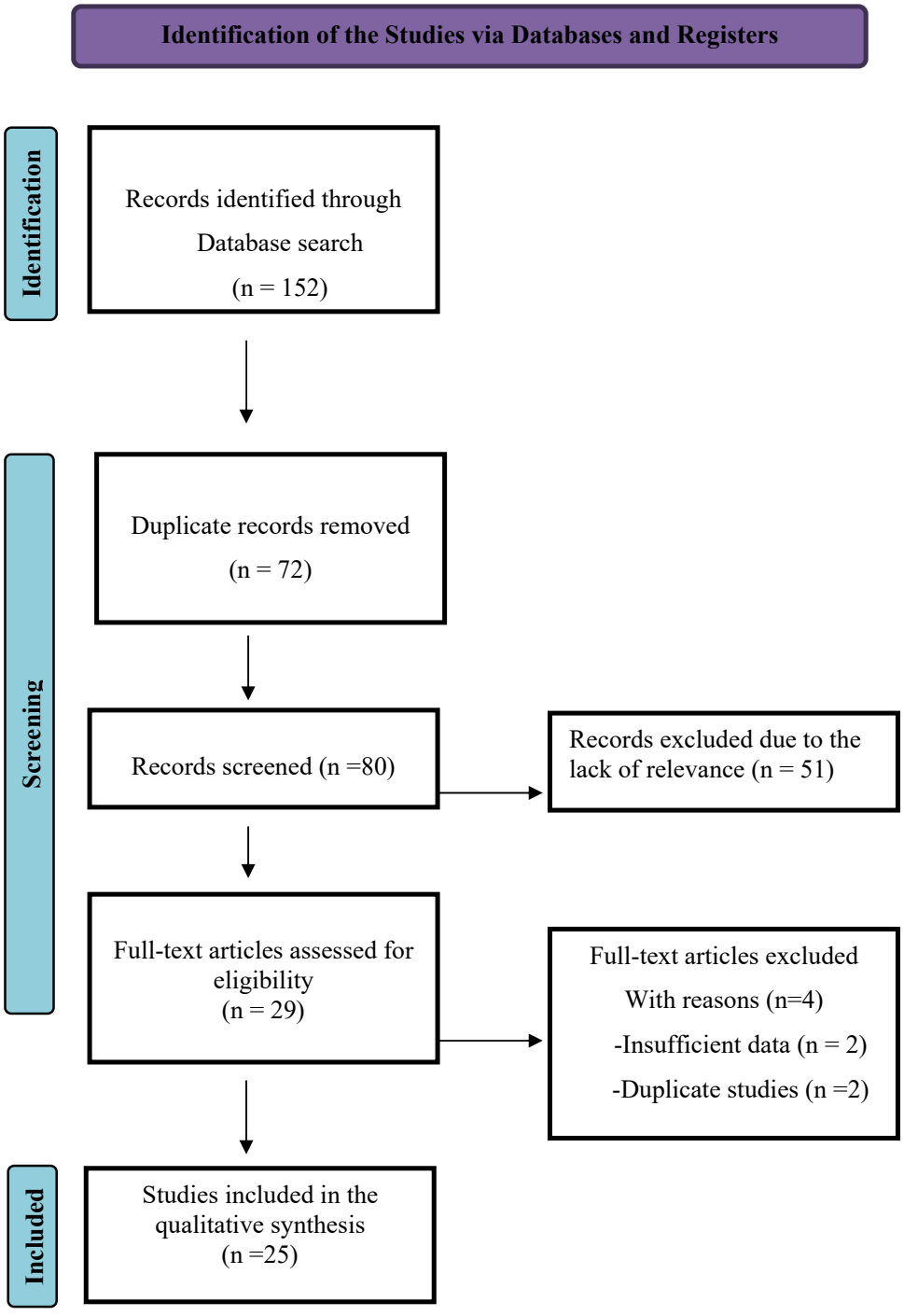

Figure 1. Flowchart of the study selection process

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Particular attention should be paid to younger individuals, especially children and men working in agricultural settings, as these groups are at the highest risk. Children's higher metabolic rates and increased hand-to-mouth contact make them especially vulnerable to pesticide exposure [17, 23, 24]. Agricultural workers, predominantly males, face the greatest occupational risks, with direct exposure to pesticides during spraying, mixing, and storage. Gender-related disparities also persist, although some studies highlight increased risks for women in domestic settings, particularly those involved in cleaning or gardening activities [16]. Studies also point to the critical role of education and income in the risk of OP poisoning. Low educational levels and poverty often correlate with

Table 1. Studies included after full-text evaluation

Study	Author(s)	Study Design	Types of OP Reported	Consequence of OP	Management of OP	Key Findings
Mortality from and incidence of pesticide poisoning in South Korea: Findings from national death and health utilization data between 2006 and 2010	Cha et al. 2014 [1]	Retrospective analysis of national data	Not reported	Mortality and incidence	Not applicable	High mortality rate from OP poisoning.
A retrospective review of intensive care management of OP insecticide poisoning: Single-center experience	Coskun et al. 2015 [10]	Retrospective study	Not reported	Not reported	Mechanical ventilation, anticholinergics, pralidoxime	ICU management can improve outcomes.
Pattern of acute organophosphorus poisoning at the University of Gondar Teaching Hospital, Northwest Ethiopia	Adinew et al. 2017 [11]	Retrospective study	OPs and Carbamates	Muscarinic and nicotinic signs and respiratory failure	Atropine, pralidoxime, and mechanical ventilation	Younger age and lower Glasgow Coma scale score are associated with mortality.
Factors affecting mortality in patients with OP poisoning	Gündüz et al. 2015 [12]	Retrospective study	Not reported	Mortality	Atropine, pralidoxime, and mechanical ventilation	Higher APACHE II score and the presence of coma are associated with mortality.
Survival pattern in patients with acute OP poisoning on mechanical ventilation: A retrospective intensive care unit-based study in a tertiary care teaching hospital3	Ahmed et al. 2014 [13]	Retrospective study	Not reported	Not reported	Mechanical ventilation, Anticholinergics, and pralidoxime	Survival pattern in mechanically ventilated patients.
Organophosphorus compound poisoning and its outcome: experience from a teaching hospital of Bangladesh	Islam et al. 2017 [14]	Retrospective study	Not reported	Respiratory failure and Neuromuscular weakness	Atropine, Pralidoxime, and Mechanical ventilation	Mortality rate of 18.2%.
To identify morbidity and mortality predictors in acute OP poisoning	Muley et al. 2014 [15]	Retrospective study	Not reported	Mortality	Atropine, pralidoxime, and mechanical ventilation	Higher initial pulse rate and lower Glasgow Coma Scale score are associated with mortality.
Effectiveness of household lockable pesticide storage to reduce pesticide self-poisoning in rural Asia: a community-based, cluster-randomised controlled trial4	Pearson et al. 2017 [16]	Randomized controlled trial	Not applicable	Self-poisoning	Lockable pesticide storage	Lockable storage reduced self-poisoning rates.
Epidemiology of OP Poisoning in the Tshwane District of South Africa	Razwiedani and Rautenbach 2017 [4]	Retrospective analysis of hospital data	Not reported	Not reported	Not reported	High incidence of OP poisoning in rural areas.
Neuropsychiatric disorders in farmers associated with organophosphorus pesticide exposure in a rural Village of Northwest México	Serrano-Medina et al. 2019 [5]	Cross-sectional study	Not reported	Neuropsychiatric disorders	Not applicable	Association between OP exposure and neuropsychiatric disorders.
Patterns and outcome of acute poisoning among children in rural Sri Lanka	Dayasiri et al. 2018 [17]	Retrospective study	Not reported	Not reported	Not reported	OP poisoning is a common cause of childhood poisoning.
Acute Poisonings Admitted to a Tertiary Level Intensive Care Unit in Northern India: Patient Profile and Outcomes	Ahuja et al. 2015 [9]	Retrospective study	Not reported	Not reported	Mechanical ventilation, Anticholinergics, and Pralidoxime	High mortality rate in ICU patients with OP poisoning.
Epidemiology of acute poisoning in children presenting to the poisoning treatment center at Ain Shams University in Cairo, Egypt, 2009-20137	Azab et al. 2016 [18]	Retrospective study	Not reported	Not reported	Not reported	OP poisoning is a common cause of childhood poisoning.
Prolonged paralysis in a child with OP pesticide poisoning	Balme et al. 2018 [19]	Case report	Not reported	Prolonged paralysis	Not reported	Case report of prolonged paralysis in a child.

Study	Author(s)	Study Design	Types of OP Reported	Consequence of OP	Management of OP	Key Findings
Poisoning cases reported to poison information centre, Ahmedabad, India: A three-year observational study	Pagdhune et al. 2020 [20]	Observational Study	Pesticides	Poisoning cases	Not applicable	Pesticides as the major cause of poisoning.
Different patterns of ECG in OP poisoning and their effect on mortality	Javed et al. 2016 [21]	Not specified	Not reported	Not reported	Not reported	ECG changes in OP poisoning.
Prognostic significance of various biochemical parameters in acute organophosphorus poisoning	Sumathi et al. 2014 [22]	Not specified	Not reported	Not reported	Not reported	Prognostic significance of biochemical parameters.
Clinicoepidemiological Pattern and Outcome of Poisoning in Children in a Tertiary Care Hospital of Western Nepal	Chaudhary et al. 2022 [23]	Cross-sectional study	Not reported	Not reported	Not reported	Children as the majority of poisoning cases.
Acute poisoning in children in Ethiopia: A cross-sectional study	Molla et al. 2022 [24]	Cross-sectional study	Not reported	Not reported	Not reported	Children as the majority of poisoning cases.
Detoxification of OP poisoning using nanoparticle bioscavengers	Pang et al. 2015 [25]	Experimental study	Not applicable	Not applicable	Not applicable	Development of nanoparticle bioscavengers for OP poisoning.
Pattern of acute poisoning admissions in the medical intensive care unit of a tertiary care hospital	Aravind and Rai 2014 [26]	Retrospective study	Not reported	Not reported	Not reported	OP poisoning is a common cause of ICU admission.
Patterns of pesticide usage in agriculture in rural Tanzania call for integrating agricultural and public health practices in managing insecticide resistance in malaria vectors	Matowo et al. 2020 [6]	Cross-sectional study	Not applicable	Not applicable	Not applicable	Study on pesticide usage patterns, not on management.
Pesticide poisoning and neurobehavioral function among farm workers in Jiangsu, People's Republic of China	Zhang et al. 2016 [7]	Cross-sectional study	Not applicable	Neurobehavioral dysfunction	Not applicable	Association between OP exposure and neurobehavioral dysfunction.
Organophosphorus-induced extrapyramidal intermediate syndrome in an adolescent suicide attempt survivor	Sarkar et al. 2014 [27]	Case report	Not applicable	Extrapyramidal intermediate syndrome	Not applicable	Case report, not on management in rural communities.
Unintended Inhalational OP poisoning presenting as angioedema: a rare case report	Hepat et al. 2021 [28]	Case report	Not applicable	Angioedema	Not applicable	Case report, not on management in rural communities.

Table 2. Sociodemographic attributes of participating populations in the studies

Study	Location	Age	Gender	Occupation	Residence
Cha et al. (2014) [1]	South Korea	Not reported	Not reported	Not reported	Not reported
Coskun et al. 2015 [10]	Turkey	Not reported	Not reported	Not reported	Not reported
Adinew et al. 2017 [11]	Ethiopia	Adults	Not reported	Farmers	Rural
Gündüz et al. 2015 [12]	Pakistan	Adults	Not reported	Farmers	Rural
Ahmed et al. 2014 [13]	India	Adults	Not reported	Not reported	Not reported
Islam et al. 2017 [14]	Bangladesh	Adults	Not reported	Farmers	Rural
Muley et al. 2014 [15]	India	Adults	Not reported	Not reported	Not reported
Pearson et al. 2017 [16]	Sri Lanka	Adults	Not reported	Farmers	Rural
Razwiedani & Rautenbach 2017 [4]	South Africa	Not reported	Not reported	Farmers	Rural
Serrano-Medina et al. 2019 [5]	Mexico	Adults	Not reported	Farmers	Rural
Dayasiri et al. 2018 [17]	Sri Lanka	Children	Not reported	Not reported	Rural
Ahuja et al. 2015 [9]	India	Adults	Not reported	Not reported	Not reported
Azab et al. 2016 [18]	Egypt	Children	Not reported	Not reported	Not reported
Balme et al. 2018 [19]	South Africa	Child	Not reported	Not reported	Not reported
Pagdhune et al. 2020 [20]	India	All ages	Not reported	Not reported	Not reported
Javed et al. 2016 [21]	Pakistan	Adults	Not reported	Not reported	Not reported
Sumathi et al. 2014 [22]	India	Adults	Not reported	Not reported	Not reported
Chaudhary et al. 2022 [23]	Nepal	Children	Not reported	Not reported	Not reported
Molla et al. 2022 [24]	Ethiopia	Children	Not reported	Not reported	Not reported
Pang et al. 2015 [25]	Review	Not applicable	Not applicable	Farmers	Rural
Aravind & Rai 2014 [26]	India	Adults	Not reported	Not reported	Not reported
Matowo et al. 2020 [6]	Tanzania	Not reported	Not reported	Farmers	Rural
Zhang et al. 2016 [7]	China	Adults	Not reported	Farmers	Rural
Sarkar et al. 2014 [27]	India	Adolescent	Not reported	Not reported	Not reported
Hepat et al. 2021 [28]	India	Adult	Not reported	Not reported	Not reported

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increased exposure due to limited knowledge of safety practices and reduced access to healthcare [9]. A strong regulatory framework is essential to manage pesticide use effectively, but its enforcement varies widely across countries, further exacerbating risks in regions with weak oversight.

Types of OPs and health consequences

The diverse range of OPs used in agriculture, from less toxic variants, like malathion, to highly toxic compounds, like parathion, contributes to a broad spectrum of health effects. Acute toxicity can result in muscarinic, nicotinic, and central nervous system symptoms, while chronic exposure is linked to neurological, reproductive,

Table 3. Thematic overview of organophosphate poisoning: Epidemiology, clinical manifestations, treatment strategies, and barriers to management based on recent studies

Theme	Sub-theme	Summary of Evidence	Key Studies
1. Epidemiology and risk factors	Geographic prevalence	High incidence in rural South & South-east Asia, Sub-Saharan Africa, and Latin America. India reports the highest mortality rates (~11.5%).	Cha et al. 2014 [1], Kumar et al. 2016 [3]
	At-risk populations	Agricultural workers, children, young adults (15-34), and individuals with low education are at the highest risk.	Razwiedani & Rautenbach 2017 [4], Zhang et al. 2016 [7]
	Gender & socioeconomic risk factors	Men are predominantly affected due to agricultural work. Poverty and lack of education are linked to higher exposure rates.	Razwiedani & Rautenbach 2017 [4], Ahuja et al. 2015 [9]
2. Clinical manifestations	Muscarinic effects	Symptoms include salivation, miosis, bradycardia, and respiratory failure.	Gündüz et al. 2015 [12], Dayasiri et al. 2018 [17]
	Nicotinic effects	Muscle weakness, fasciculations, and paralysis are observed in severe cases.	Sumathi et al. 2014 [22], Chaudhary et al. 2022 [23]
	Central nervous system effects	Seizures, confusion, and coma are common in severe OP poisoning.	Islam et al. 2017 [14], Gündüz et al. 2015 [12]
	Mortality	Mortality varies from 7-18% in ICU settings, with India showing the highest rates of fatality (~11.5%).	Cha et al. 2014 [1], Ahuja et al. 2015 [9]
3. Treatment strategies	Antidotal therapy	Atropine and Pralidoxime are primary antidotes. Survival rate improves with early administration.	Coskun et al. 2015 [10], Adinew et al. 2017 [11]
	Supportive care	Mechanical ventilation, fluid management, and electrolyte management are crucial for severe cases.	Ahmed et al. 2014 [13], Islam et al. 2017 [14]
	Innovative therapies	Nanoparticle bioscavengers are under investigation for more effective detoxification.	Pang et al. 2015 [25]
4. Barriers to Effective Management	Healthcare access in rural areas	Limited healthcare resources in rural regions contribute to delays in diagnosis and treatment.	Pearson et al. 2017 [16], Chaudhary et al. 2022 [23]
	Challenges in treatment	Delays in specialized care, lack of access to ICU facilities, and timely antidote administration are significant issues.	Ahuja et al. 2015 [9], Chaudhary et al. 2022 [23]
5. Prevention and future directions	Preventive interventions	Lockable pesticide storage and community education programs are recommended.	Pearson et al. 2017 [16], Chaudhary et al. 2022 [23]
	Research gaps	Further studies are needed on long-term health outcomes and preventive measures in rural areas.	Cha et al. 2014 [1], Zhang et al. 2016 [7]

and potentially carcinogenic health problems [11]. The severity of poisoning depends on several factors, including the type of OP, the dose, and the route of exposure, with children and individuals with preexisting health conditions being at greater risk.

Management of OP poisoning

The treatment of OP poisoning remains a challenge, with atropine and pralidoxime being the primary interventions. However, their effectiveness can vary depending on the type of OP and the timing of administration. While atropine continues to be crucial in neutralizing the toxic effects of acetylcholine, the role of pralidoxime remains debated, with mixed findings regarding its effectiveness in improving outcomes [31]. Severe cases require intensive care, including mechanical ventilation and hemodialysis, to support vital functions [9]. Further research into alternative therapies, such as enzymes to detoxify OPs, may provide more targeted and effective treatments in the future [29]. Although many studies provide valuable insights into the prevalence, risk factors, and management of OP poisoning, there are notable limitations in the existing literature. The majority of studies have focused on short-term clinical outcomes, with limited attention given to long-term health consequences. Additionally, while many studies are concentrated on rural agricultural populations, their findings often lack generalizability to other settings due to variability in healthcare infrastructure and pesticide use practices. There is also a need for more robust, randomized clinical trials to assess the effectiveness of treatment protocols, particularly for pralidoxime and other emerging therapies.

Conclusions

OP poisoning remains a critical public health issue with significant morbidity and mortality, especially in rural settings. The systematic review of 25 studies highlights the effectiveness of early diagnosis and timely intervention, particularly with the use of antidotes, such as atropine and pralidoxime. While acute management strategies are well-documented, there is a conspicuous gap in research regarding the long-term health outcomes and preventive strategies in rural and underserved populations. Additionally, while clinical management is relatively well-established, the accessibility of care in rural regions continues to pose significant barriers to optimal treatment. The review underscores the need for innovative approaches in both the prevention and management of OP poisoning, with a particular focus on leveraging technology and community-based interventions in rural areas.

Limitations of the study

The main limitation of this review was the potential for publication bias, which may have led to an over-representation of studies with positive findings. Many studies did not report detailed information on sociodemographic characteristics, particularly education and income levels. This lack of data hinders a comprehensive understanding of the factors influencing vulnerability to OP poisoning. Additionally, the quality of some studies may have been limited, which could affect the overall reliability of the findings.

Recommendations

It is recommended to improve access to care by enhancing healthcare infrastructure in rural areas, including mobile clinics and telemedicine, to ensure timely treatment. Additionally, research should focus on the long-term outcomes of OP poisoning, particularly neurological and psychological effects. Preventive interventions should be developed and evaluated, with an emphasis on educational programs and safer pesticide handling in rural communities. The integration of digital health tools and telemedicine should be prioritized to improve access to diagnosis and care in underserved areas. Finally, community-based interventions should be implemented to empower local communities with the training and resources needed to prevent and manage OP poisoning effectively.

Implications for policymakers

Policymakers should prioritize investments in rural healthcare access, including mobile healthcare units, telemedicine, and local training programs to ensure timely care in underserved regions. Funding should be allocated for research into the long-term effects of OP poisoning, the development of new antidotes, and preventive strategies tailored to rural populations. Policies should strengthen the regulation of pesticide use, emphasizing safe handling and disposal to minimize exposure risks. Additionally, efforts should be made to support the integration of digital health tools and telemedicine into rural healthcare systems to improve care accessibility.

Implications for the public

The public should be educated about the risks of OP poisoning and the importance of seeking immediate medical treatment upon exposure. Awareness campaigns promoting the safe handling, storage, and disposal of OP pesticides should be encouraged to reduce accidental exposure. Communities should be empowered to take proactive steps in recognizing the symptoms of OP poisoning and accessing care, thereby reducing mortality. Furthermore, the public should advocate for improvements in healthcare infrastructure, including support for telemedicine and digital health solutions, to ensure timely care in rural areas.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

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Authors' contributions

Conceptualization: Odochi O. Chukwu and Raphael C. Anakwue; Methodology, writing, review, and editing: Odochi O. Chukwu, Raphael C. Anakwue and Abdullateef I. Alagbonsi; Supervision: Raphael C. Anakwue and Abdullateef I. Alagbonsi; Data collection and data analysis: Odochi O. Chukwu and Cordilia O. Iyare; Final approval: All authors.

Conflict of interest

The authors declared no conflicts of interest.

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