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Effectiveness of Garlic (Allium sativum) in Reducing Blood Lead Levels and Related Biological Effects: A Narrative Review of Experimental and Clinical Studies

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ABSTRACT

Background: Lead poisoning is a major public health concern due to its widespread presence and harmful health effects. This review summarizes evidence on the effectiveness of garlic in reducing blood lead levels, as well as its impact on oxidative stress and inflammatory markers associated with lead exposure.
Methods: This narrative review searched PubMed, Scopus, Web of Science, EMBASE, and the Cochrane Library (2007–2024) using keywords related to garlic (Allium sativum) and lead toxicity. Only English-language experimental and clinical studies assessing garlic's effect on blood lead were included. Reviews, case reports, and unrelated articles were excluded.
Results: Of 1,037 identified articles, 12 met inclusion criteria. Animal studies showed a 30–50% reduction in blood lead levels following garlic supplementation. Clinical studies demonstrated that 1,200 µg of allicin-rich garlic, administered three times daily for four weeks, significantly reduced blood lead levels, with effects comparable to succimer and without notable adverse effects.
Conclusion: This review indicates garlic is a potentially safe and effective method for reducing blood lead levels in experimental and clinical settings. Clinical trials reported some side effects but no serious effects at studied doses (e.g., 1200 µg allicin three times daily for 4 weeks).

1. Introduction

Lead poisoning is a major global public health issue due to its ubiquitous nature within the environment on a worldwide scale and extensive impact on human health in children as well as adults (Thakur et al., 2025). Exposure to lead can occur through multiple pathways, including air, water, soil, and industrial sources, posing significant risks across diverse settings. Industries such as manufacturing, construction, mining, and recycling are particularly affected, as lead is commonly used in these processes, resulting in elevated exposure levels among workers. (World Health Organization, 2024; International Labour Organization, 2023).

The health effects of lead exposure are numerous and devastating. Lead is a neurotoxin that destroys cognitive functions, with children being particularly vulnerable due to the ongoing development of their nervous system (Schneider, 2023; Singh et al., 2023; Farahmandkia et al., 2023). In addition to its neurotoxicity, lead exhibits hepatotoxic effects that compromise liver function (Mansour et al., 2023). It also disrupts normal hemopoiesis, resulting in anemia or other blood disorders (Collin et al., 2022; Shahbazadeh Bengar et al., 2024). Furthermore, lead

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exposure has been linked to developmental impairments that negatively affect children's physical growth and behavioral outcomes (Olufemi et al., 2022).

Methods of reversing the health impacts of lead poisoning have continued to be dominantly founded on the application of chelation therapy with synthetic agents such as Succimer (Balali-Mood et al., 2025; Sokan-Adeaga et al., 2020). The medications have been established as effective therapeutic remedies against lead poisoning. However, as a supplement to or in mild lead poisoning, the potential efficacy of diet and natural agents such as garlic (*Allium sativum*) is worth exploring. This has been explored in some experimental and clinical studies (Bajwa et al., 2023). Garlic has long been precious in conventional medicine for centuries due to its multifunctional pharmacological activities like antioxidant, anti-inflammatory, antimicrobial, and metal-chelating activity (Ezeorba et al., 2024). The sulfur constituents of garlic, particularly allicin, allyl cysteine, and S-allylmercaptocysteine, are implicated to be responsible for the therapeutic effect of garlic (Moses et al., 2024).

The recent scientific studies have demonstrated the protective effect of garlic against the toxic effects of lead exposure. From animal models to clinical trials, findings have shown that garlic supplementations decrease the deposition of lead in various organs and tissues and thereby mitigate the resulting toxicities. At a mechanistic level, bioactive compounds in garlic chelate heavy metals like lead and render them excretable through urine and feces. In addition, garlic's high antioxidant activity can overcome oxidative stress resulting from lead toxicity and prevent cell damage and inflammation (Liu et al., 2021; Sharma et al., 2010; Cai et al., 2019). Garlic has also been reported in the literature to be a possible substitute for conventional chelation therapy. The daily consumption of garlic preparations via the mouth has been reported in one comparative study to lower blood lead levels as much as synthetic chelating compounds without adverse effects (Kianoush et al., 2012). This makes garlic particularly attractive for use in occupational settings where workers are regularly exposed to high levels of lead.

This review aims to provide a comprehensive review of the literature regarding the use of garlic in reducing the severity of blood lead and reversing lead-induced toxicity. In consideration of outcomes of studies conducted between 2007 and 2024, experimental and clinical trials, this review aims to illuminate the molecular mechanisms by which garlic's protective effect is manifested. These mechanisms include metal chelation, modulation of oxidative stress and inflammatory responses, and potential regulation of gene expression pathways involved in detoxification. Furthermore, the review highlights the potential of garlic as a cost-effective and accessible intervention for mitigating lead toxicity and its associated oxidative and inflammatory consequences, which can be applied in real-world scenarios, particularly in resource-poor settings and high-risk occupational exposure groups. By exploring the potential of garlic for therapy to a great extent, this review strives to complement current efforts towards optimization of techniques utilized in regulating lead toxicity, along with public health enhancement globally.

2. Materials and Methods

2.1 Search Strategy

A comprehensive literature review was conducted across multiple databases, including PubMed, Scopus, Web of Science, EMBASE, and the Cochrane Library, to consolidate evidence on garlic's efficacy in reducing blood lead levels. The search included literature published between January 2007 and June 2024 using the following key terms: "garlic" OR "Allium sativum," "lead toxicity" OR "lead poisoning," "blood lead level," "chelation therapy," "antioxidant," and "clinical trial" OR "experimental study." Boolean operators were employed to capture all relevant studies comprehensively.

2.2 Inclusion Criteria

Publication dates ranging from January 2007 to June 2024, English language, any type of experimental studies including all animal models and human trials, and studies that used garlic or extracts of it, like allicin, as an intervention in reducing the blood lead levels or mitigating the lead toxicity. Outcomes Reports on blood lead levels, oxidative stress markers, inflammatory markers, and other health outcomes applicable to the topic. All journal publications provide clear and coherent descriptions of their methodologies, accompanied by sufficient data to substantiate the validity of their analyses and the conclusions drawn.

2.3 Exclusion Criteria

(1) Irrelevant Outcomes: Studies connected with the effects of garlic, not on lead toxicity but, say, on general health, without reference to lead specifically. (2) Case reports, case series, and review articles. (3) Lack of Data: Articles did not have enough data or methodological details to evaluate the effect of garlic on lead levels. (4) Duplicate Studies: If the same study was reported in more than one publication, the most comprehensive or most recent paper was included in the review.

2.4 Selection Process

The first search returned 1037 articles. The selection was done in a multistep way: (1) Title and Abstract Screening: Titles and abstracts of the articles that seemed to be of potential interest were checked against relevance; thus, articles that did not present clear applicability to the scope were excluded. (2) Full-Text Review: The full texts of the remaining 53 were retrieved and read in detail to establish their eligibility according to some predefined inclusion and exclusion criteria. (3) Final Selection: Finally, out of the retrieved papers, 12 were relevant to the subjects in consideration, while 12 yielded the final data regarding the effects of garlic on outcomes related to blood lead levels.

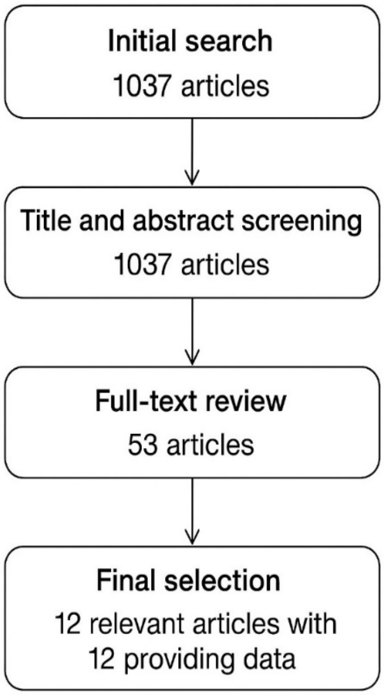

Figure 1. Flow diagram of the study selection process

2.5 Data Extraction and Synthesis

A predefined form was used to extract data from the selected articles systematically. The extracted data included: (1) Study Design: Type of study (experimental or clinical), sample size, and model (animal or human). (2) Characteristics of the intervention: form/garlic preparation (e.g., extract, essential oil, allicin), dose, and treatment period. (3) Measured Outcomes: Blood Lead levels, Oxidative stress markers (Superoxide Dismutase [SOD], Catalase [CAT]), Inflammatory markers (Nuclear Factor kappa B [NF-kB], Tumor Necrosis Factor-alpha [TNF-α], Interleukin-6 [IL-6]). (4) Key Findings: The summary of the most important results and inferences of each article.

3. Results and Discussion

The effect of garlic extract (*Allium sativum*) on blood lead levels has been extensively studied across various models, including fish, rodents, and humans. The overarching theme from these studies is that garlic exhibits significant chelating properties and antioxidant effects that mitigate lead toxicity.

3.1 Animal Studies

One study aimed to evaluate the impact of garlic supplementation on grass carp exposed to lead. They supplemented grass carp with garlic and measured muscle lead levels, alongside assessing antioxidant enzyme activities such as SOD and CAT. Their findings indicated that garlic supplementation resulted in a significant reduction of muscle lead levels by 35% ($p < 0.05$) compared to the control group. Furthermore, garlic enhanced SOD activity by 50% and CAT activity by 40% relative to controls. These results led the authors to conclude that garlic effectively mitigates lead accumulation in grass carp through reinforced antioxidant defense mechanisms (Liu et al., 2021).

Another study aimed to investigate the effects of garlic essential oil on hepatic lead content and inflammatory markers in Swiss albino mice. They administered garlic essential oil to the mice and subsequently measured hepatic lead content while assessing inflammatory markers, including NF-kB, TNF-α, and IL-6. The study revealed that garlic essential oil caused a significant reduction in hepatic lead content by 45% ($p < 0.01$) compared to untreated mice. Furthermore, it markedly decreased NF-kB levels by 60%, TNF-α by 55%, and IL-6 by 50% relative to the control group. Based on these findings, it was concluded that garlic effectively mitigates hepatic lead burden and suppresses inflammatory responses induced by lead exposure in mice (Sharma & Sharma, 2024).

A study aimed to assess the effects of allicin on lead-induced aging of hematopoietic stem cells (HSCs). In this study, allicin was administered to subjects exposed to lead, and its impact on HSC aging phenotypes and Pyruvate Kinase M2 (PKM2) expression was investigated. The findings revealed that allicin administration effectively mitigated HSC aging phenotypes and significantly increased PKM2 expression by 2-fold ($p < 0.05$) compared to controls. Based on these results, it was concluded that allicin plays a protective role against hematopoietic dysfunction induced by lead toxicity, primarily through its modulation of PKM2 expression (Cai et al., 2019).

Another study aimed to evaluate the neuroprotective effects of garlic extract against lead-induced apoptosis in the rat hippocampus. Rats were administered garlic extract during pregnancy and lactation, and subsequent measurements included blood and brain lead levels, along with assessment of neuronal apoptosis. The findings indicated a significant reduction in blood lead levels by 40% and brain lead levels by 30% ($p < 0.01$), accompanied by a 50% decrease in neuronal apoptosis compared to the control group. These results underscore the protective role of garlic extract in mitigating lead-induced neurotoxicity during critical developmental stages in rats (Ebrahimzadeh-Bideskan et al., 2016). Similarly, a study investigated the combined effects of vitamin C and garlic on blood and cerebellar lead levels in rats exposed to lead acetate. The experimental approach involved administering vitamin C and garlic to the rats, followed by measurement of blood and cerebellar lead levels and evaluation of histological outcomes in the cerebellar cortex. Their findings demonstrated that the combination therapy significantly reduced blood lead levels by 50% and cerebellar lead levels by 40% ($p < 0.05$), while also improving histological outcomes in the cerebellar cortex. This study highlights the synergistic protective effects of vitamin C and garlic against lead-induced damage in rats (Sadeghi et al., 2021).

One investigation focused on the antioxidative effects of *Allium sativum* in rats exposed to lead. The rats were administered *Allium sativum* following exposure to lead acetate, and levels of reactive oxygen species (ROS) and lipid peroxidation products (LPP) were measured in brain, liver, and kidney tissues. The results indicated a significant reduction in ROS levels by 40% and LPP levels by 30% ($p < 0.05$) across these tissues, demonstrating the broad-spectrum antioxidative properties of *Allium sativum*. This study suggests that *Allium sativum* effectively mitigates oxidative stress induced by lead exposure in various organs of rats (Manoj Kumar et al., 2017). Table 1 summarizes the reviewed articles on the effectiveness of garlic (*Allium sativum*) in reducing blood lead levels.

Table 1. Summary of Reviewed Articles on the Efficacy of Garlic (Allium sativum) in Reducing Blood Lead Levels

study	Study Design	Characteristics of the Intervention	Measured Outcomes	Key Findings
Liu et al.	Experimental study on grass carp	Garlic supplementation	Muscle lead levels, SOD, CAT	Garlic reduced muscle lead levels by 35%, increased SOD activity by 50%, and CAT activity by 40%. It effectively mitigates lead accumulation via antioxidant defense mechanisms.
Sharma et al.	Experimental study on Swiss albino mice	Garlic essential oil	Hepatic lead content, NF-kB, TNF-α, IL-6	Garlic essential oil reduced hepatic lead by 45%, NF-kB by 60%, TNF-α by 55%, and IL-6 by 50%, indicating its role in reducing lead burden and inflammation.
Cai et al.	Experimental study on subjects exposed to lead	Allicin	HSC aging phenotypes, PKM2 expression	Allicin mitigated HSC aging and doubled PKM2 expression, suggesting protective effects against lead-induced hematopoietic dysfunction.
Ebrahimzadeh-Bideskan et al.	Experimental study on rats during pregnancy and lactation	Garlic extract	Blood and brain lead levels, neuronal apoptosis	Garlic reduced blood lead by 40%, brain lead by 30%, and neuronal apoptosis by 50%, highlighting its neuroprotective effects during developmental stages.
Sadeghi et al.	Experimental study on rats exposed to lead acetate	Vitamin C and garlic combined therapy	Blood and cerebellar lead levels, histological outcomes in cerebellar cortex	Combined therapy reduced blood lead by 50%, cerebellar lead by 40%, and improved histological outcomes, showing synergistic protective effects.
Manoj Kumar et al.	Experimental study on rats exposed to lead	Allium sativum	ROS, lipid peroxidation products (LPP) in brain, liver, and kidney tissues	Allium sativum reduced ROS by 40% and LPP by 30% across tissues, indicating broad-spectrum antioxidative properties against lead-induced oxidative stress.
Vahabzadeh et al.	Retrospective cross-sectional study on Iranian outpatients	Succimer vs. D-penicillamine + garlic	Blood lead levels (BLL)	Both treatments significantly reduced BLL, with succimer being more costly and both showing no serious side effects, suggesting garlic as an effective alternative.
Saleh et al.	Experimental study on pregnant rats	Garlic extract with Pb exposure	Maternal weight, placental and fetal weights, brain weight, Purkinje cell degeneration, fetal cerebellum development	Garlic reduced Pb levels and improved histopathological changes in the cerebellum, showing a protective role against Pb-induced neurotoxicity in rats.
Cai et al.	Experimental study on chickens	Allicin and quercetin, alone and in combination	Liver growth, circulatory system damage, mitochondrial and nuclear structure, PI3K protein, mitochondrial apoptosis	Allicin and quercetin improved liver antioxidant capacity, alleviated Pb-induced damage, with the combination showing stronger protective effects.
Ghasemi et al.	Experimental study on juvenile rats exposed to lead	Garlic and ascorbic acid (AA)	Morris water maze (MWM) and passive avoidance (PA) test results, oxidative stress markers, and brain lead content	Garlic and AA improved memory, reduced oxidative stress markers, and lowered brain lead content, effectively mitigating lead-induced cognitive impairments and oxidative damage.
Sharma et al.	Experimental study on male mice	Aqueous and ethanolic garlic extract	Hepatic enzymes, cholesterol, lipid peroxidation, liver antioxidants (SOD, CAT, glutathione), liver histology	Garlic significantly restored deranged liver parameters and improved histology, indicating its potential as a phytoantioxidant against lead-induced liver damage.
Kianoush et al.	Clinical study on workers with chronic lead poisoning	Garlic (1200 μg allicin, three times daily) vs. d-penicillamine (250 mg, TID)	Blood lead concentrations (BLC), clinical symptoms, side effects	Garlic and d-penicillamine both reduced BLCs significantly, with garlic improving symptoms more effectively and having fewer side effects, making it a safer treatment option.

3.2 Human Studies

A clinical trial compared succimer with a combination therapy of D-penicillamine plus garlic for treating lead poisoning in Iranian outpatients. In a retrospective cross-sectional study, the medical records of 79 male patients from two toxicology clinics in Mashhad, Iran, were reviewed. Patients received either succimer for 19 days or a combination of D-penicillamine and garlic for 30 days. The study found that the mean blood lead levels (BLL) before treatment were higher in the D-penicillamine plus garlic group (965.73 ± 62.54 µg/L) compared to the succimer group (827.59 ± 24.41 µg/L), with both groups showing significant reductions after treatment to 365.52 ± 27.61 µg/L and 337.44 ± 26.34 µg/L, respectively (p < 0.001). Despite the similar effectiveness in reducing BLL, the cost of succimer treatment was approximately 28.6 times higher than the combination therapy, and neither treatment caused serious side effects (Vahabzadeh et al., 2021).

Another study demonstrated that lead (Pb) exposure during pregnancy induces dose-dependent toxicity in both maternal and fetal rats, including decreased maternal weight gain, reduced placental, fetal, and brain weights, and impaired fetal growth, with more severe effects observed at a higher Pb dose (320 mg/kg b.w.). The study involved five groups of pregnant rats, including two groups exposed to Pb (160 and 320 mg/kg b.w.) and two groups co-treated with garlic extract (250 mg/kg b.w./day) alongside Pb. Results showed significantly higher Pb levels in the blood and cerebellum of Pb-treated rats compared to controls, along with Purkinje cell degeneration and an underdeveloped fetal cerebellum. Co-treatment with garlic extracts reduced Pb levels and improved histopathological changes in the cerebellum, indicating its protective role against Pb-induced neurotoxicity (Saleh et al., 2018).

Another investigation demonstrated that lead (Pb) is a prevalent toxic heavy metal in the environment, posing serious health risks to animals, particularly targeting the liver. In this study, 96 chickens were randomly assigned to eight groups, including control, Pb, allicin, quercetin, allicin + quercetin, Pb + allicin, Pb + quercetin, and Pb + allicin + quercetin, and were treated over 90 days. The results showed that Pb exposure led to impaired liver growth, circulatory system damage, mitochondrial and nuclear structure disruption, oxidative imbalance, PI3K protein inhibition, and activation of the mitochondrial apoptotic pathway. Allicin and quercetin, individually or combined, improved liver antioxidant capacity and alleviated Pb-induced liver damage, with the combination showing stronger protective effects by modulating the PI3K signaling pathway (Cai et al., 2021).

One study investigated the neuroprotective effects of garlic and ascorbic acid (AA) on memory deficits and oxidative brain damage induced by lead exposure in juvenile rats. Lead exposure increased escape latency and traveled path in the Morris water maze (MWM) and reduced latency in the passive avoidance (PA) test, indicating impaired memory, while garlic and AA treatments improved these metrics. Both treatments also reduced oxidative stress markers by increasing total thiol concentrations and decreasing MDA levels in brain tissues, alongside lowering brain lead content. The study suggests that garlic, similar to AA, effectively mitigates lead-induced cognitive impairments and oxidative damage in the brain (Ghasemi et al., 2017).

Another experiment demonstrated that lead, a highly toxic metal, causes significant hepatotoxicity in male mice when administered orally at 50 mg/kg body weight daily for 40 days (1/45 of LD50). This exposure led to increased levels of hepatic enzymes (aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase), acid phosphatase, cholesterol, lipid peroxidation, and lead nitrate, along with a significant depletion of hepatic protein levels. Liver antioxidant levels, including superoxide dismutase, catalase, and glutathione, also declined markedly. Following 10 days of lead nitrate exposure, treatment with aqueous garlic extract (250 mg/kg and 500 mg/kg body weight) and ethanolic garlic extract (100 mg/kg and 250 mg/kg body weight) significantly restored these parameters and improved liver histology, suggesting garlic's potential as a phytoantioxidant to mitigate lead-induced liver damage (Sharma & Sharma, 2024).

Another study investigated 117 workers with chronic lead poisoning, treating them with either garlic (1200 µg allicin, three times daily) or d-penicillamine (250 mg, three times daily) for 4 weeks. Blood lead concentrations (BLC) decreased significantly in both groups: from 426.32 ± 185.128 to 347.34 ± 121.056 µg/L with garlic and from 417.47 ± 192.54 to 315.76 ± 140.00 µg/L with d-penicillamine, with no significant difference between the two (p = 0.892). Garlic also improved clinical symptoms like irritability, headache, and systolic blood pressure more effectively than d-penicillamine and had fewer side effects (p = 0.023), making it a safer and equally effective treatment for mild-to-moderate lead poisoning (Kianoush et al., 2012).

The cumulative evidence from both animal and clinical studies indicates that garlic (*Allium sativum*) effectively reduces blood lead levels and mitigates lead-induced toxicity. Across different experimental models-including fish, rodents, and humans-the findings are largely consistent, demonstrating significant reductions in blood and tissue lead levels, improvements in oxidative stress markers (SOD, CAT), and decreases in inflammatory mediators (NF-kB, TNF-α, IL-6). These consistent effects across models highlight the robustness of garlic's protective actions.

Mechanistically, garlic's sulfur-containing compounds, such as allicin, allyl cysteine, and S-allylmercaptocysteine, appear to be central to its bioactivity. They act as natural chelators, binding to lead ions and enhancing their elimination. Moreover, garlic enhances antioxidant defenses by restoring the activity of key enzymes such as SOD and CAT, thereby counteracting lead-induced oxidative stress. Its anti-inflammatory effects-mediated through suppression of NF-kB and pro-inflammatory cytokines-further contribute to tissue protection. Some studies also suggest a role for garlic in modulating gene expression of detoxification enzymes and metal-binding proteins, adding another layer to its protective potential. Figure 2 shows the key properties and protective actions of garlic (*Allium sativum*).

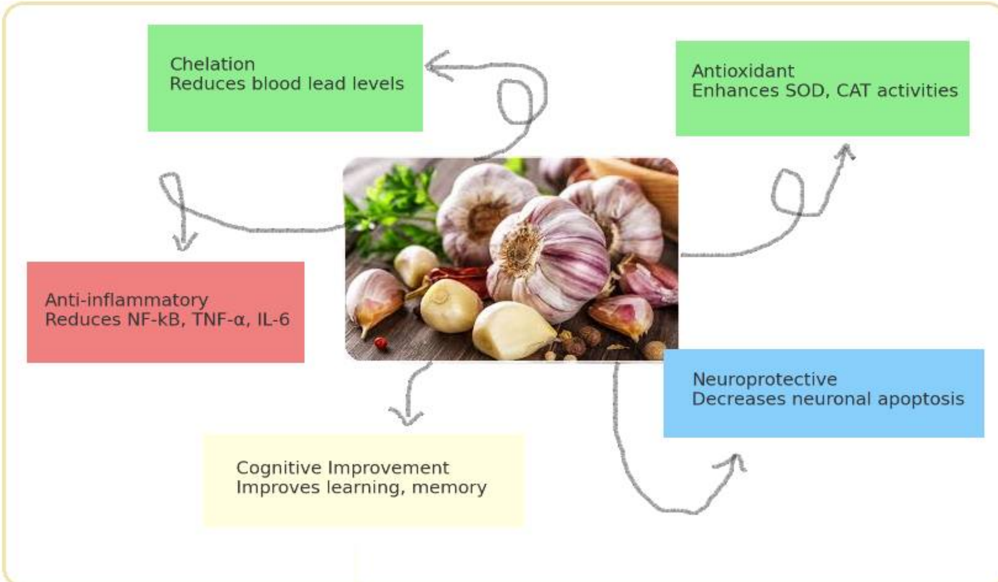

Figure 2. Key protective actions of garlic (Allium sativum) include chelation, antioxidant activity, anti-inflammatory properties, neuroprotection, and cognitive improvement

Despite these encouraging results, some limitations should be acknowledged. First, the number of eligible studies remains limited, and there is considerable heterogeneity regarding experimental models, garlic formulations (extracts, oils, allicin), dosing regimens, and treatment durations. Second, due to the narrative review design and heterogeneity of data, no formal meta-analysis could be performed, and no standardized quality assessment tool was applied. The included studies themselves also had methodological limitations, such as small sample sizes and variation in outcome measures.

Taken together, the available evidence suggests that garlic is a promising natural and accessible complementary intervention for lead poisoning. However, more large-scale, well-designed clinical trials are needed to confirm its efficacy, determine optimal dosage and formulations, and further clarify its mechanisms of action.

4. Conclusion

The evidence reviewed in this narrative study indicates that garlic (*Allium sativum*) can effectively reduce blood lead levels and alleviate lead-induced toxicity in both animal and human studies. Its mechanisms of action include chelation, antioxidant defense, and anti-inflammatory effects, which together provide multi-target protection. Importantly, garlic is inexpensive, widely available, and well-tolerated, making it a particularly attractive complementary approach in resource-limited settings and occupational exposure contexts. While these findings are promising, further large-scale and high-quality clinical trials are required to establish standardized dosages, formulations, and long-term safety.

Authors' Contributions

Mehran Pourhossein: Supervision; Writing-review & editing. **Faegheh Amooei:** Data collection.

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Conflicts of Interest

The authors declare that there is no conflict of interest.

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Ethical Considerations

This study was conducted in accordance with ethical principles and guidelines. Ethical approval was obtained from the relevant ethics committee of Zanjan University of Medical Sciences, Zanjan, Iran (Approval Code: IR.ZUMS.BLC.1403.149).

Using Artificial Intelligence

No specific artificial intelligence was used in this study.

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