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Environmental Toxins and Their Impact on Neurological Health

Maria Allesandra Elsasser
University of San Francisco, magutierrez10@dons.usfca.edu

Environmental Toxins and Their Impact on Neurological Health: A Public Health Evaluation

Maria Allesandra Elsasser
University of San Francisco
Master of Public Health – Community and Public Health Practice
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Abstract

This paper evaluates the impact of environmental toxins on neurological health from a public health perspective. Employing a comprehensive review of literature across various databases, the study sheds light on the mechanisms through which environmental neurotoxicity influences health, highlighting key correlations between toxin exposure and the onset of neurodegenerative disorders. The research identifies significant gaps in current approaches to managing these risks, particularly concerning policy regulations and public awareness. Based on these findings, strategic recommendations are proposed to address and mitigate the identified challenges, with implications emphasizing the broader benefits for public health.

Keywords: *environmental toxins, neurological health, neurodegenerative diseases, occupational exposure, neurotoxicity, pesticides, mitochondrial activity, neuroinflammation, heavy metals, Parkinson's disease, Alzheimer's disease, public health, environmental health, environmental policies, corporate accountability, longitudinal studies, neurocognitive potential, oxidative stress, environmental regulations, sustainable practices, environment*

Introduction

The rising tide of neurological disorders around the world cannot be understood fully without exploring the role of environmental factors. Of particular concern is the ubiquity of environmental toxins, substances harmful to biological organisms that pervade our surroundings due to both natural processes and human activities. Despite the diverse spectrum of these toxins, they share a common trait - the potential to trigger or exacerbate neurological disorders, thereby posing a significant public health concern (Aggarwal, V., 2022). This paper seeks to dissect this complex interplay between environmental toxins and neurological health, thereby casting light on a less explored but increasingly important dimension of neurological disorders.

From heavy metals like lead and mercury to organic pollutants such as pesticides, environmental toxins can be insidious, often exerting their harmful effects unbeknownst to those exposed. The neurological impacts of these toxins are wide-ranging and encompass cognitive impairment, developmental delays in children, and heightened risk of neurodegenerative diseases like Parkinson's and Alzheimer's (Aggarwal, V., 2022).

The purpose of this paper is to thoroughly define this public health issue using empirical data, scrutinize the current literature on programmatic and policy interventions designed to mitigate this problem, and, drawing from these analyses, devise recommendations to improve the neurological health of populations exposed to environmental toxins. This endeavor is crucial as it not only has direct implications for disease prevention and health promotion, but it also underlines the need for an environmentally conscious approach in public health, given our inherent interconnectedness with the environment we inhabit.

Background/Literature Review

Scale and Scope of the Problem

Environmental toxins and their impact on neurological health present an intricate and far-reaching problem, posing significant and complex challenges that cut across individual and community health as well as and global healthcare systems (Nabi, M., & Tabassum, N., 2022). Environmental toxins are pervasive in our contemporary environment, a reality spawned both from natural processes and human activities (Nabi, M., & Tabassum, N., 2022). Such ubiquity has led to a wide spectrum of adverse health effects, including neurological disorders that have an impact on millions of individuals around the globe (Nabi, M., & Tabassum, N.,2022).

The global impact of environmental toxins and their impact on neurological health is staggering. The World Health Organization (WHO) has consistently stressed environmental health as a key component of overall human health (WHO, 2016). According to the WHO, environmental factors contribute to about 25% of all global deaths - approximately 12.6 million people each year (WHO, 2016), painting a grim picture of the sheer scale of the problem.

Furthermore, children, due to their developmental status and higher vulnerability, suffer disproportionately from environmental factors (Wright R. J. ,2009). Around 26% of deaths in children under five years of age are attributed to environmental causes, with the majority of these deaths occurring in low- to middle-income countries (WHO, 2018). This troubling statistic underscores the severity of the issue and its specific implications for the most vulnerable of populations.

Not only does it occur in childhood, but the detrimental impact of environmental toxins continues to persist and is further magnified into adulthood, leaving an indelible imprint on a multitude of neurological conditions. In the realms of industry and occupation, chronic exposure to toxins has been insidiously tied to a substantial proportion of neurodegenerative diseases like Alzheimer's and

Parkinson's (Hanke, W., & Jurewicz, J., 2004). This nexus of toxins and neurological disorders has been supported by the work of Barnham, Masters, and Bush (2004), who estimated that 20% of all neurodegenerative diseases could potentially stem from enduring exposure to environmental toxins prevalent in workplace settings.

Why is it a Problem?

The importance of environmental toxins and their impact on neurological health is further emphasized when one examines the temporal trends of both neurological disorders and the production and disposal of environmental toxins. Over the last few decades there's been a striking increase in the prevalence of neurological diseases (Evans, D. A., 1990). According to the U.S. Census Bureau, middle series projections yield an estimated total of 10.3 million persons with neurodegenerative diseases by the year 2050; in the 1980s, those numbers where 2.88 million. (Evans, D. A., 1990). Concurrently, there's also been an uptick in the production and release of environmental toxins. The US Environmental Protection Agency's (EPA) annual report on Toxic Release Inventory shows an 8% increase in releases of toxic chemicals to the air, water, and soil between the years 2020 and 2021 (EPA TRI, 2021). This correlation suggests a possible relationship between the two, a fact supported by research indicating that environmental toxins could play a role in the onset or progression of neurological diseases (Chen, H., et al., 2012).

Toxin-induced neurological disorders pose huge financial costs to global healthcare systems. Neurological disorders, given their chronic nature and the extensive care they require, rank among the costliest health conditions to manage. Dementia serves as a potent example, with costs projected to reach $1 trillion worldwide in 2018, and expectations for this figure to double by 2030 (Wimo, A., et al., 2017). Such forecasts highlight the economic implications of the issue, providing another perspective on the extensive ramifications of environmental toxins. Environmental risk factors for dementia are categories in air quality, toxic heavy metals, other metal and trace elements and occupational

exposures; just to name a few (Killin, L. et. al. 2016). For example, levels of aluminum consumption most often found in drinking water in excess of 0.1 mg per day were associated with a doubling of dementia risk and threefold increase in the risk of Alzheimer's dementia (Killin, L. et. al. 2016).

Risk Factors and Affected Populations

The potential for exposure to environmental toxins is punctuated by an array of risk factors, encompassing both individual - attributes such as sociodemographic characteristics, occupation, and lifestyle, as well as broader societal dynamics including geographical distribution and the robustness of local environmental regulatory frameworks (WHO, 2016). For instance, inhabitants of regions burdened by intense industrial activities or those grappling with inadequate environmental safeguards stand on the frontline of toxin exposure risk. This precarious balance between industrial growth and environmental preservation is particularly striking in developing nations. Here, the whirlwind pace of industrialization often gallops ahead of the implementation of effective environmental protections, leaving populations vulnerable to the unseen dangers of environmental toxins (UNEP, 2019). Furthermore, these developing regions are often characterized by limited resources and capabilities to monitor and control environmental pollution, thereby exacerbating the already heightened risk of toxin exposure, and in turn, the potential for subsequent health complications (Vaccari, M. et. al., 2019).

Socioeconomic factors contribute to risk, highlighting the social inequities presented by toxin-exposure. Lower-income individuals and communities frequently experience higher levels of exposure due to their proximity to pollutant sources, such as industrial factories or waste disposal sites (Anetor G. O., 2016). This increased risk is further exacerbated by limited access to resources and services that could help mitigate the effects of exposure in relatively poorer communities (Evans, G.W., & Kantrowitz, E., 2002).

Current Interventions

Efforts to mitigate the impacts of environmental toxins on neurological health span various levels. At the policy level, numerous global, federal, and state-level policies are in place to control the production, disposal, and exposure to environmental toxins Riva, S. (2019). The effectiveness of these policies can greatly vary, however, due to disparities in enforcement and compliance Riva, S. (2019). Developing countries, where monitoring mechanisms might be less stringent, particularly face challenges in policy effectiveness (Arshad, M. U., et. al., 2021).

Community-level interventions often revolve around public education campaigns and mobilization efforts to reduce exposure to environmental toxins (Freudenberg, N. 2004). For instance, such initiatives could involve educating farmers about safe pesticide usage and promoting alternative pest control methods. The successful scaling up of these initiatives and measuring their impact at a population level, however, remains a significant challenge (Damalas, C.A., & Eleftherohorinos, I.G., 2011).

At an individual level, interventions tend to focus on promoting behaviors that reduce exposure to toxins and increase resilience to their effects (Allen, R. W., & Barn, P., 2020).Such interventions may include promoting the use of personal protective equipment among workers in high-risk industries, advocating for a healthy diet and lifestyle to reduce the overall risk of disease, and raising awareness about the risks of exposure to environmental toxins (WHO, 2019).

Background Conclusion

Despite the progress made in understanding and addressing the effects of environmental toxins on neurological health, there are still significant gaps that need to be addressed. These gaps encompass areas such as policy enforcement, the reach and effectiveness of community interventions, and barriers to individual behavior change. As the burden of neurological disorders continues to grow, and the cost of managing these disorders escalates, addressing these gaps becomes an urgent priority. This literature

review seeks to inform subsequent sections of the paper, which will offer recommendations for more effective strategies to tackle this complex public health issue.

Methods

This public health evaluation employed a systematic approach, utilizing a comprehensive literature review methodology, to investigate the impact of environmental toxins on neurological health. The study design chosen for this evaluation was a literature review, which allowed for the synthesis and analysis of existing research on the topic. The PICO (Population, Intervention, Comparison, and Outcome) framework was used to guide the formulation of search questions and the selection of relevant literature (Linares-Espinós, E. et. al, 2018). The search questions derived from the PICO framework provided a structured approach to identify relevant literature related to environmental toxins and neurological health (Appendix A: Table 1). The search terms and keywords used in the literature search were adapted based on the specific PICO components and the research objectives.

Population

The evaluation encompassed studies conducted in various settings, including both high-income and low- to middle-income countries as well as geographical regions with varying levels of industrialization, pollution, and environmental regulatory frameworks. This broad scope aims to capture the potential global impact of environmental toxins on neurological health.

Databases and Search Terms

The primary data sources for this evaluation were existing literature available, including published research articles, systematic reviews, as well as any relevant reports. To ensure comprehensiveness, databases such as PubMed, Scopus, and Web of Science were searched using a combination of keywords. The search terms included variations and synonyms related to the PICO

components, such as "environmental toxins," "neurological health," "lead exposure," "mercury exposure," "pesticide exposure," "children," "workers," and "neurodegenerative diseases."

Inclusion and Exclusion Criteria

Inclusion and exclusion criteria were applied to select studies or data sources based on their relevance, quality, and applicability to the research objectives. Articles published in English were considered, with no restrictions on the publication year to encompass a wide range of relevant literature.

Timeframe

In terms of timeframe, articles were selected from the early establishment of the previously mentioned databases (PubMed, Scopus and Web of Science) up until the present times were all considered. This was for the purpose of ensuring a breadth of both historical perspectives and contemporary findings on the topic. Having this unrestricted approach to the publication year aimed to encompass a wide range of relevant literature which helped provide insight into how understanding and research on the topic of environmental toxins on neurological health has evolved over time.

Analytical Process

The analysis process involved systematically reviewing and synthesizing the selected literature. Data extraction was performed to gather information on study characteristics, exposure measures, outcome measures, and relevant findings. A thematic analysis approach was employed to identify patterns, trends, and key findings across the included studies. This approach facilitated the exploration of various aspects of the association between environmental toxins and neurological health outcomes.

Additionally, the analysis focused on examining the association between environmental toxins and neurological health outcomes, considering potential confounding factors as well as variability in

study designs. Limitations of the individual studies and overall evidence base were critically assessed and discussed. This evaluation also took into account the limitations of policy enforcement (if present), community interventions, and individual behavior change in addressing the impact of environmental toxins on neurological health.

Recommendations

Based on the synthesis and interpretation of the evidence reviewed in the previous sections covered, this section provides comprehensive recommendations to address the complex issue of environmental toxins and their impact on neurological health. These recommendations are evidence-based, grounded in theory, and backed by substantial evidence that is available. Further, this section provides a clear and persuasive justification for pursuing these guidelines, compared to alternatives approaches. To help support these recommendations, Table 2 in Appendix B highlights key pieces of evidence from the literatures.

Recommendation 1: Strengthen Environmental Policies and Regulations.

The literature consistently demonstrates the association between toxin exposure and neurological disorders, highlighting the need for preventive measures (Nabi, M., & Tabassum, N. 2022). By implementing stringent standards for environmental toxin limits, monitoring, and enforcement, this recommendation aims to mitigate exposure and protect public health. Collaboration with relevant stakeholders, including government agencies, environmental organizations, and industry representatives, is essential for effective implementation. Regular monitoring and evaluation mechanisms should be established to assess compliance and the effectiveness of the policies. In terms of funding, resources can be allocated from governmental budgets and environmental impact fees (Phipatanakul, W., & Wylie, B. J. 2020). Additionally, the establishment of a dedicated fund, supported

by industry contributions, can provide sustained financing for the implementation and monitoring of environmental policies.

Recommendation 2: Public Awareness and Education Campaign.

The literature supports the potential of such campaigns in influencing behaviors and reducing exposure to environmental toxins. By creating awareness about the risks of toxins and promoting behavior change, this recommendation aims to empower individuals and communities to act. The campaign should target diverse populations, including parents, workers in high-risk industries, and community members. Utilizing various channels such as mass media, social media platforms, community engagement, and school programs can effectively disseminate accurate information and provide practical guidance (Fitzpatrick-Lewis, D. et. al. 2010). Collaborations with health professionals, community leaders, and educational institutions will enhance the reach and impact of the campaign. In terms of funding, partnerships with public health agencies, philanthropic organizations, and corporate social responsibility initiatives can provide financial support. Additionally, exploring collaborations with educational institutions to incorporate the campaign into existing curricula or extracurricular activities can leverage available resources.

Recommendation 3: Access to Quality Data.

Additional research with access to longitudinal data will be helpful in understanding the cumulative impact of exposures to environmental toxins on neurological health. Longitudinal studies track individuals' exposures to toxins throughout their lifespan, providing valuable insights into the actual long-term effects on neurological health outcomes and helping better establish whether a causal relationship exists. In addition, prospective cohort studies can be designed to follow individuals from different age groups, assessing toxin exposures through biomonitoring and conducting comprehensive neurological evaluations. The collected data can be analyzed to identify associations between

cumulative exposures and neurological health outcomes. Overall, longitudinal studies can provide robust evidence on the long-term impact of cumulative environmental toxin exposures on the wellbeing of the population, informing targeted interventions and prevention strategies (Lytras, T. 2021).

Recommendation 4: Strengthening Corporate Accountability for Toxin Reduction.

Addressing corporate contributions to environmental toxins is essential to safeguard neurological health. Although many might not be aware, but corporations significantly impact the environment through their production and waste disposal practices (Abubakar, I. R. et. al., 2022). By strengthening corporate accountability, it will serve as a powerful incentive for many companies to adopt a more sustainable organization with environmentally safe and ethical practices (Nureen, N. et. al., 2023). By doing so, this will lead to reduced toxin emissions and minimize exposure risks for many communities and individuals. Collaborating with local governments, environmental organizations and industry stakeholders is vital to develop effective corporate accountability frameworks (Nureen, N. et. al., 2023). With the implementation of regular monitoring and evaluation of corporate practices and emission reporting, we can continue to measure progress towards toxin reduction goals and assess the overall impact on neurological health outcomes effectively.

Implementation and Evaluation Strategy

To ensure successful implementation of these recommendations, an implementation and evaluation strategy should be developed. This includes setting clear objectives, identifying key stakeholders, establishing timelines, and assigning responsibilities. Regular monitoring and evaluation of the progress and impact of the recommendations are essential to assess their effectiveness and make necessary adjustments. Evaluation methods may include data collection on toxin levels, changes in behaviors and attitudes, and tracking neurological health outcomes (Benavides, J. et. al. 2022).

Funding options, including governmental budgets, industry contributions, philanthropic organizations, and collaborations with educational institutions, are considered. By following these recommendations and implementing appropriate strategies, it is possible to reduce toxin exposure, protect neurological health, and promote overall well-being in affected populations.

Summary

In summary, the recommended strategies of strengthening environmental policy and regulation, along with a public awareness and education campaign, provide robust approaches to address the issue of environmental toxins and neurological health. These recommendations are justified by the evidence reviewed in the literature, and their implementation and evaluation strategies are outlined (Zhang, J., Tang, H., & Bao, M. 2023).

Implications and Discussions

In this section, I discuss the public health impact and implications of the recommendations provided earlier. These recommendations aim to address the complex issue of environmental toxins and their impact on neurological health, with the broader goal of advancing public health outcomes and promoting a healthier environment. I analyze the desired public health impacts, consider potential pitfalls and limitations, and examine how these recommendations contribute to alleviating the public health issue.

Summary of Recommendations

The four recommendations put forth in this paper seek to target different aspects of the environmental toxins and neurological health issue, collectively contributing to a comprehensive approach. Strengthening environmental policy and regulation, implementing public awareness campaigns, conducting longitudinal studies, and strengthening corporate accountability have the

potential to achieve significant public health impacts. By regulating and monitoring toxin levels, the first recommendation aims to reduce exposure risks across populations, leading to a decline in toxin-related neurological disorders (Phipatanakul, W., & Wylie, B. J. 2020). The second recommendation on public awareness campaigns aims to empower individuals and communities to adopt safer practices, fostering behavior changes that contribute to toxin reduction (Fitzpatrick-Lewis, D. et. al. 2010). The third recommendation on longitudinal studies will provide robust evidence on the long-term impact of cumulative exposures, informing targeted interventions and prevention strategies to protect neurological health (Lytras, T. et. al. 2021). The fourth recommendation on strengthening corporate accountability can incentivize companies to adopt more sustainable practices, ultimately leading to reduced toxin emissions and minimizing exposure risks for communities and workers (Nureen, N., et. al 2023).

Limitations

While the recommendations hold promise for public health improvement, several limitations and pitfalls should be considered. The effectiveness of environmental policy and regulation depends on the commitment of stakeholders to enforce and comply with the standards. Inadequate resources or lack of political could hinder successful implementation (Zalmanovitch, Y., & Cohen, N. 2015). Public awareness campaigns face challenges in reaching vulnerable populations, particularly in resource-constrained settings (Gómez-Marí, I. 2021), Longitudinal studies require significant time and resources, and attrition rates may affect the validity of long-term data (Wu, W., & Jia, F. 2021). Additionally, enforcing corporate accountability may require overcoming resistance from industries and addressing potential loopholes in regulations (Utting, P., 2002). Addressing these limitations will be crucial for maximizing the impact of the recommendations.

Addressing the Public Health Issue

The recommended strategies collectively contribute to addressing the public health issue of environmental toxins and neurological health. Strengthening environmental policy will create a more robust protective framework against toxins, reducing exposure risks and improving neurological health outcomes (Zalmanovitch, Y., & Cohen, N. 2015). Additionally, public awareness campaigns will empower individuals and communities to make informed choices, leading to behavioral changes that promote toxin reduction and better neurological health (Gómez-Marí, I. 2021). Longitudinal studies will enhance our understanding of the long-term impact of cumulative exposures, guiding targeted interventions and preventive measures to protect vulnerable populations (Wu, W., & Jia, F. 2021). Lastly, strengthening corporate accountability will address the role of corporations in toxin generation, fostering sustainable practices that contribute to overall toxin reduction (Abubakar, I. R. et. al., 2022).

Next Steps

The impacts of these recommendations set the stage for further research, policy, and programmatic advancements. The evidence generated from the longitudinal studies will inform future research on environmental toxins and neurological health, facilitating the development of evidence-based interventions. Furthermore, successful policy implementation will pave the way for the expansion of environmental regulations to other toxins and sectors. Public awareness campaigns will also provide valuable insights into effective health communication strategies, benefiting future health promotion efforts. And lastly, enforcing corporate accountability will contribute to a culture of responsibility among industries, potentially leading to broader environmental initiatives. Ultimately, these impacts will lay the foundation for a more comprehensive and environmentally conscious approach to public health, with potential cascading benefits across diverse health issues related to environmental factors.

Conclusion

The recommendations outlined in this paper have the potential to yield significant public health impacts by addressing the intricate relationship between environmental toxins and neurological health. While there are limitations to be addressed, the suggested strategies can contribute to alleviating the public health issue, guiding future research and policy decisions, and promoting a more sustainable and health-oriented approach to environmental management.

Appendix A

Table 1. PICO Components and Example Search Questions:

PICO Component	Example Search Questions
Population	- What are the neurological health outcomes associated with environmental toxin exposure in children?
	- What is the relationship between occupational toxin exposure and neurological health in workers?
Intervention	- How does lead exposure affect neurological health outcomes?
	- What are the neurological effects of chronic mercury exposure?
Comparison	- What are the differences in neurological health outcomes between exposed and unexposed populations?
	- How do neurological health outcomes vary across regions with different levels of environmental toxins?
Outcome	- What is the impact of environmental toxins on cognitive function?
	- How does exposure to environmental toxins affect child development?
	- What is the association between environmental toxins and the risk of developing neurodegenerative diseases?

Appendix B

Table 2. Key Evidence from Literature:

Key Evidence from Literature
- Environmental toxins have been linked to cognitive impairment and neurodegenerative diseases such as Parkinson's and Alzheimer's.
- Children are particularly vulnerable to the detrimental effects of environmental toxins on neurological development.
- Occupational exposure to toxins in workplaces contributes to neurodegenerative diseases.
- Strengthening environmental policies and regulations can lead to significant reductions in toxin exposure.
- Public awareness campaigns have shown positive effects in increasing knowledge and promoting behavior change related to environmental toxin reduction.
- Longitudinal studies assessing cumulative exposures can provide insights into the long-term impact of environmental toxins on neurological health outcomes.
-Corporations should prioritize transparency and adopt sustainable toxin management practices to mitigate environmental harm.

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