REVIEW
Ecological Epidemiology: A Perspective From One Health

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Abstract. *Ecological epidemiology is a distinct branch of the science of epidemiology that focuses on the complex interactions between environmental factors and population health. Instead of examining individuals in isolation, ecological epidemiology analyzes entire groups and the relationships among biological, social, and environmental factors. Its main concern is identifying the influence of the environment on the distribution of diseases within communities. In this review, we aim to analyze the main aspects of ecological epidemiology, covering everything from definition and methods to practical applications and specific challenges.*

Keywords: *ecology, population health, One Health.*

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Introduction

Ecological epidemiology focuses on studying environmental factors and how they influence the distribution of diseases within populations. This approach is distinctive in that it does not analyze individuals in isolation but instead focuses on entire groups and the complex interactions among biological, social, and environmental factors [1].

The importance of ecological epidemiology lies in its ability to provide a holistic perspective on population health. By understanding the relationships between environmental factors and specific diseases, researchers can develop more effective prevention and intervention strategies [1,2].

I. Study Methods in Ecological Epidemiology

Ecological epidemiological studies often involve analysing data collected at the group or community level. Common methods include correlation studies, spatial data analysis, and the use of mathematical models to assess the impact of environmental factors on population health [2].

Correlation studies examine the statistical association between environmental factors and disease rates within a population. Spatial data analysis uses geographic information to identify spatial patterns of diseases and environmental factors [3]. Mathematical modeling provides a way to simulate complex interactions between different factors and forecast the progression of diseases based on environmental changes [3].

II. Practical Applications of Ecological Epidemiology

Ecological epidemiology has made significant contributions in various fields. In public health, it has been crucial to identify environmental factors involved in the onset and spread of diseases. For instance, ecological studies have been used to highlight

connections between air pollution and the prevalence of respiratory conditions [2].

In urban planning, ecological epidemiology provides valuable insights for the sustainable development of cities, considering the impact of the environment on the health of residents [3].

1. Identification of risk factors for specific diseases
One fundamental application of ecological epidemiology is the identification of risk factors for specific diseases within populations. By analyzing ecological data, researchers can identify correlations between exposure to certain environmental factors (such as air pollution, water quality, or chemical exposure) and the prevalence of conditions like respiratory diseases, cancer, or cardiovascular diseases. This information is crucial for developing prevention and disease control strategies [4].

2. Development of environmental and health policies
Ecological epidemiology provides the scientific basis for developing of environmental and health policies. By highlighting the connections between environmental pollution and its effects on human health, researchers can influence the formulation of regulations and standards regarding industrial emissions, water quality, and waste management. These policies contribute to protecting population health and promoting a healthier environment [4,5].

3. Sustainable urban planning
Ecological epidemiology has significant implications in the field of urban planning. By assessing the impact of the environment on health, this discipline offers essential information for the development of sustainable and healthy cities. Urban planners can consider the results of ecological epidemiological studies to guide decisions regarding urban infrastructure, parks, residential and industrial areas, thereby contributing to the creation of an urban environment conducive to health [4,5].

4. Assessment of the impact of climate change
In the context of climate change, ecological epidemiology becomes crucial for evaluating its impact on human health. Ecological studies can identify connections between climate changes, such as rising temperatures or extreme weather events, and the increased risk of infectious diseases, cardiovascular conditions, or allergies. This information is essential for developing strategies to adapt and mitigate the negative effects of climate change on health [2,5].

5. *Disease prevention and health promotion*
By understanding the complex interactions between environmental factors and health, ecological epidemiology contributes to the development of effective disease prevention and health promotion strategies. These strategies may include interventions to reduce pollution, improve air and water quality, and promote a healthy lifestyle in harmony with the surrounding environment [2,5].

III. Challenges and Future Directions

Ecological epidemiology faces specific challenges, including difficulties in accurately measuring exposure to environmental factors and establishing causality in complex relationships. In the future, research directions may include the development of advanced technologies for precise monitoring of environmental factors and the integration of data from multiple sources to obtain a comprehensive perspective on ecological interactions.

Current challenges in ecological epidemiology:

1. *Exponential variability of environmental factors*: One challenging aspect in ecological epidemiology is managing the significant variability of environmental factors. From air pollution to water quality and biological diversity, environmental factors are highly variable and

interconnected. This complexity can complicate the identification of clear causal relationships [6].

2. *Difficulty in measuring exposure to environmental factors*: The precision of measuring exposure to environmental factors remains a challenge. Current technologies can provide detailed data but are limited in terms of accuracy, especially in the context of long-term exposure [6,7].

3. *Complex interactions:* Interactions between environmental factors and human genetics, lifestyle, and socio-economic factors are highly complex. Understanding these interconnections and identifying the relative contribution of each factor to health poses a major challenge [6,7,8].

Future Directions in Ecological Epidemiology:

1. *Integration of advanced technologies*: The use of advanced technologies, such as smart sensors and remote monitoring technologies, will improve the measurement of exposure to environmental factors. These technologies can provide real-time and detailed data, allowing a finer understanding of the relationships between the environment and health [9].

2. *Big data and complex data analysis:* Ecological epidemiology will significantly benefit from big data analysis and advanced techniques for modelling complex data. The use of artificial intelligence and machine learning algorithms can contribute to identifying subtle patterns and evaluating complex interactions [9].

3. *More rigorous causality approach*: Faced with causality challenges, the future of ecological epidemiology involves a more rigorous and innovative approach to evaluating causality relationships. The use of advanced statistical methods and experimental studies will strengthen the scientific foundation of this discipline [10].

4. *Interdisciplinary collaboration:* Addressing the complexity of relationships between environmental factors and human health requires close collaboration between epidemiologists, environmental researchers, public health specialists, and other experts. This will facilitate the integration of knowledge and the approach to complex problems from multiple perspectives [11].

5. *Education and awareness*: In the future, special attention must be given to educating and raising public awareness about the links between the environment and health. This can lead to implementing changes at the community level and supporting prevention efforts.

IV. Ecological Epidemiology and One Health

Ecological epidemiology and One Health are two interconnected fields aimed at global health, combining knowledge from human health, animal health, plants, and the environment into a holistic approach. Ecological epidemiology explores the relationships between environmental factors and population health, while One Health promotes collaboration across different disciplines to address human and animal health issues in correlation with plant and environmental health [10,11].

1. *Identification of risks at the human-animal-environment interface:* Ecological epidemiology provides an essential framework for understanding risks at the human-animal-environment interface. Ecological studies identify environmental factors that can influence the emergence and spread of diseases, including those transmitted from plants to animals and humans (zoonoses). This integrated approach is crucial for preventing and controlling infectious diseases [12,13].

2. *Addressing zoonotic diseases and health threats:* One Health and ecological epidemiology intersect particularly in managing zoonotic diseases that transmit between animals and humans. Understanding the transmission cycles of these diseases and the environmental influences on them is crucial for preventing outbreaks and limiting their spread [13].

3. *Assessing the impact of climate change on human and animal health:*

Ecological epidemiology and One Health collaborate in assessing the impact of climate change on human and animal health. Ecological studies analyze how environmental changes can influence the distribution of diseases, and One Health proposes integrated solutions for adapting to these changes and reducing their impact on health [14,15].

4. *Promoting interdisciplinary collaboration*: One Health and ecological epidemiology encourage interdisciplinary collaboration among physicians, biologists, ecologists, veterinarians, and other specialists. This collaboration is essential to gain a comprehensive understanding of the complexity of interactions between environmental factors, human health, and animal health [16].

5. *Developing Global Prevention and Control Strategies:* Together, these two fields contribute to the development of global strategies for disease prevention and control. This includes identifying risk areas, monitoring environmental changes, and promoting sustainable practices to reduce threats to human and animal health [17,18].

Conclusions

1. Ecological epidemiology represents an essential component of epidemiological science, providing a comprehensive perspective on the relationships between the environment and population health. Despite its challenges, this discipline continues to make significant contributions to improving public health and developing more effective prevention strategies.

2. The connection between ecological epidemiology and One Health is evident in their joint approach to complex global health issues. Integrating knowledge from these two fields offers comprehensive insights and efficient solutions for managing risks at the human-animal-environment interface and promoting global health.

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