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Review Paper

Impact of Environmental Changes on the Prevalence of Autoimmune Diseases and their Effect on Public Health Infrastructure

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Key Words

Autoimmune diseases, Environmental change, Public health, Infectious diseases, Climate change, Epidemiology.

Abstract

Introduction: Recent changes in the climate, pollution, urban development, etc, have become some of the most important determinants of the state of the population's health. It is their complex interplay that shapes the incidence of autoimmune diseases. And detection of such patterns is crucial for the formulation of effective public health measures. This research aims to analyze the impact of \environmental changes on the incidence of autoimmune diseases and assess the consequences for public health systems, to assist in the development of collaborative solutions for epidemiologists, environmental scientists, and health care designers. The increasing rate of autoimmune and inflammatory diseases in domestic animals is an issue that requires more insights into the ethology of such diseases in relation to the environment. Test the hypothesis of the association between habitat alteration (e.g. pesticide use on agricultural land) and the observed rise in the incidence of autoimmune hemolytic anemia by using sophisticated pathology to determine new gene-environment interactions.

Materials & Methods: Information was collected from epidemiological studies, patient files, and ecological databases from regions spanning a range of pollution and urbanization levels. Autoimmune diseases were grouped according to the frequency of their occurrence, their impact, and the vulnerable demographics. Environmental variables: air and water pollution, climate (temperature changes), land use, and their relationships with the incidence of the disease were analyzed by statistical models and disease predictive algorithms. By quantifying the impact of various key environmental variables, the predictions of the disease and the required health care resources were modeled.

Results: People living in areas suffering from high pollution, dense urban living, and climate-related stressors were found to be suffering from autoimmune diseases more than others. Healthcare services were found to be unequally distributed and severely lacking in some areas. Scenario analyses showed areas in need of functional preventive measures, early diagnostic initiatives, and the allocation of resources to reduce the disease and strengthen the health systems.

Conclusion: The health and the environment are a system. This study is an example of integrative planning and systems thinking to address public health. Evidence-based action, managed adaptively, in an iterative and collaborative framework to use in the health and the environment, is essential to contain the autoimmune disease burden and improve the health infrastructure of the vulnerable populations.

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Introduction

As the incidence of autoimmune conditions spikes, the need to understand the environmental triggers fuelling this increase becomes more urgent and complex. The impacts of the environment – pollutants, climate change, and ecosystem alterations – are important for understanding the onset and exacerbation of conditions with autoimmune disease. The literature exploring the relationships between environmental stressors and immune dysfunction and disease burden, especially in the context of public health, is emphasized and expanded in this paper.

The increasing rate of environmental change in the world, which is spurred by urbanization, industrial pollution, and climate variability, is an important and mostly undermining threat to the health of animals of all species. In the Health paradigm, where the inseparable connection between animal, human, and ecosystem health is acknowledged, the direct effect of environmental stressors on animal physiology is becoming one of the most important pointers of ecosystem illness (Wang et al., 2015; Lee & Lawrence, 2018; Patz et al., 2000; Reif, 2011). Such studies can be used to isolate and mechanistically study environmental contaminants and their effects on the immune system dysregulation, which can give important early warning of veterinary practice and human health risk evaluation.

Air pollution, specifically, has become a highly significant environmental risk factor. Long-term exposure to airborne particulate matter and other airborne encounters has been linked to a greater risk of disease formation in Rheumatoid Arthritis (RA), connective tissue diseases (CTDs), and inflammatory bowel diseases (IBD). (Mpakosi et al., 2024; Shapira et al., 2010; Kelly et al., 2023) Positive chronically population-based studies have documented that exposure to elevated concentrations of particulate matter (PM_{10}, $PM_{2.5}$) is associated with a greater statistically significant risk of developing an autoimmune disease. (Miller, 2025; Shapira et al., 2010; Ritz, 2010; Eisenberg et al., 2007) The existence of a relation has been addressed with mechanistic studies that have pollutant exposure as a factor of oxidative stress, persistent inflammation, and autoimmune activation all of which are known to break tolerance on immunological. (Lee et al., 2023; Borba et al., 2026; Júnior, 2020).

Figure 1 illustrates the increasing burden imposed on healthcare systems stemming from the prevalence of autoimmune diseases caused by environmental stressors. These include the potential outcomes of higher requirements in the management and care of chronic diseases and the provision of services in diagnostics, immunosuppressive treatments, and specialized medical care. The Figure also indicates urban and industrial areas, which have high levels of pollution, as environmental hotspots that will bear the disproportionate burden of the adverse health impacts.

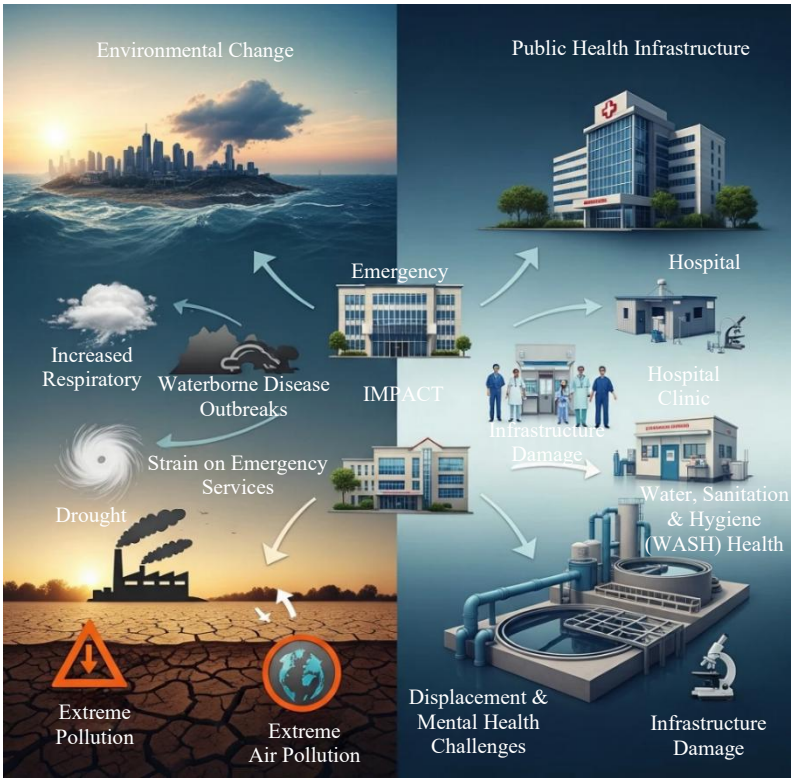

Figure 1: Impact of Environmental Change on Public Health Infrastructure

Ecosystem alterations and changes in the environment, including air pollution, global climate warming, and weather pattern changes, also have the potential to further modify the immune system and the ability to get disease, i.e., disease susceptibility. These have been framed in recent literature as the 'exposome' which is the cumulative environmental (chemical, physical, biological) exposures over the time span of a lifetime.3 Within this framework, environmental stressors may include heatwaves that serve to modify the immune system to enhance autoimmunity.9 10 The nexus between immune health and climate driven environmental changes should therefore be a key focus area in public health research.

Along with initiating new cases, environmental stressors could also worsen existing autoimmune disorders or result in more frequent relapses or flare-ups. For people who are already predisposed to autoimmune disorders, encountering environmental pollutants, chemical contaminants, or heat stress and allergen stressors could increase the likelihood of immune system activation and the associated detrimental effects. This holds significant implications, not only concerning the individual patients but also regarding the overall public health burden, as the increasing prevalence and severity of autoimmune disorders could be a major burden to the health care system.

The frequency and spread of autoimmune conditions, compounded by environmental triggers, continue to open new frontiers for the public health field. There may be increased requirements for the management of chronic conditions, immunosuppressant treatment, tailored healthcare, diagnostic procedures, and

ongoing care. New Hotspots, especially urban and industrial centers with many pollutants, will be especially affected and will worsen the existing inequities in health. The acknowledgement of the environmental impacts of autoimmune conditions highlights the need for a more integrated approach to public health to include the environmental aspect in planning and prioritizing resources. (Tobón et al., 2010; Rook, 2013; Weiss & McMichael, 2004; Cooper & Stroehla, 2003) There is autoimmunity of the diseases, and the evidence is substantial, yet there is a reluctance to study the relationship between the environment and autoimmunity, especially in a more controversial manner. Cause and effect cannot be established so easily, even though the observational studies of the situation are very useful, and the disentanglement of the genetic, lifestyle, and environmental factors is very complex. (Shapira et al., 2010; Ritz, 2010; Akdis, 2021) There are many differences in the definitions of the diseases, the pollutants, and the exposure in comparison to the cross-studies, and so these studies need more solid, cross-sectional research in many areas to make up for the differences. Epidemiology, environmental science, and immunology need the Public health systems analysis. There is a need for more cohesive research so that the challenges and the variations are accounted for.

This study aims to systematically analyze existing epidemiological data and environmental indicators to begin filling a small part of the knowledge gap that exists surrounding the environmental determinants of the prevalence of certain autoimmune diseases. This work illustrates how certain stressors in the environment can shape the incidence patterns of several autoimmune diseases and the implications this has for healthcare and disease burden. This study intends to provide guidance for policy and public health adapted to the rapidly changing environment and the increased prevalence of autoimmune diseases.

Materials and Methods

Data Collection and Sources

The study of the links between the environment and the prevalence of autoimmune diseases was based on data from epidemiology, the environment, and healthcare infrastructure. Incidence and prevalence of autoimmune diseases were retrieved from healthcare records, national health surveys, and disease registries in several regions with differential environmental stress. Environmental climate data were obtained from various long-term monitoring activities, including programmes that monitor indices of air and water quality, land use, climate, urbanization, and environmental modification. Data from the particular health care systems were also used, including the socioeconomic variables and health care infrastructure, systems of hospitals, specialization, and health care resource distribution to identify systems of potential deficits. The data were cleaned and normalized to enable comparison across regions and across periods of time.

Study Population and Disease Categorization

The populations were grouped according to certain demographic features, geography, and the

amount of environmental exposure they experienced. The autoimmune diseases were also divided according to systemic (such as lupus), organ-specific (like type 1 diabetes), and inflammatory (such as rheumatoid arthritis) diseases. Also, the healthcare system impacts were reviewed with disease progression, age of disease onset, and treatment requirements for the diseases. This stratification allowed the detection of populations that were particularly at risk and the understanding of the disease (autoimmune diseases) patterns and the burden on healthcare systems due to exposure to various environmental factors.

Environmental Exposure Assessment

To understand the environmental stressors, remote sensing, ground monitoring, and climate models were used in unison. The primary variables were the volumes of pollutants in the air (PM2.5, NO2, and O3), the degree of water contamination, the level of temperature change, the degree of urban development, and the indices of urban development. The indicators were mapped in time and space to detect and establish possible relationships with the incidence of autoimmune disorder. Sensitivity analyses were undertaken to measure the contribution of each of the environmental exposure variables in isolation of the others, thus determining the critical exposure variables to be targeted for preventive action and intervention in the risk of the disease.

Predictive Modeling and Analysis

Predictive models were generated to forecast the effect of and changes in the environment on the incidence of autoimmune disorders for various scenarios. A number of statistical methods were utilized to draw correlations between the environmental indicators and the disease outcomes, including regression modeling and machine learning. The models accounted for the interactions of many environmental variables along with the population characteristics and the level of health care available to assess the overall impact of disease on the systems and structures of the urbanized population. The scenario simulations identified and described areas that were likely to experience increased incidence of the autoimmune disorders as a result of changes to the environmental conditions, and that were also lacking adequate healthcare systems and support.

Integrated Pathway Model of Environmental Drivers and Autoimmune Disease Burden

The study methodology can be visualized as a multi-stage conceptual framework:

In Figure 2, the approach taken by the study was structured, sequential, and analytical. It was necessary for the study to analyze the interrelationships and interdependencies of the changes in the environment, the occurrence of autoimmune diseases, and the changes in the public health system. The first step was to obtain data from three areas: epidemiology, the environment, and the health care system. The data sets were then methodologically processed, including data cleaning and standardization, and systematization, so that the data were made ready to use. The next step was to assess the country's population exposure to environmental stressors

by measuring and mapping the environmental stressors.

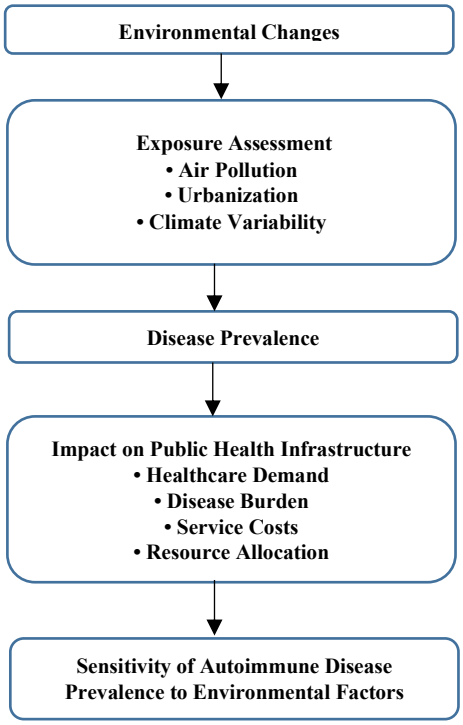

Figure 2: Conceptual Framework Linking Environmental Change to Autoimmune Disease Burden

With this, autoimmune diseases were classified and stratified so that they could be analyzed better. The use of both statistics and predictive modeling was focused on estimating the trends of diseases. This allowed for the use of the modeling to predict changes in the disease's trends. The focus was then on evaluating scenarios in order to estimate the future prevalence of the disease and the consequences that it could have on the health system (Okada et al., 2010; Bush, 2026). The result was that the high-risk areas were identified, and practical public health initiatives were designed. The methodology used in this study focused on primary public health data sets and specialized knowledge and secondary sources, so that it was designed to be self-sufficient. This approach made it possible to create knowledge that could then be used for primary and secondary public health. The results of the study and other secondary sources were used to generate the knowledge created by the primary public health data sets, together with specialized knowledge. This arranged approach made it possible to create a plan that could then be used for primary and secondary public health use. This created knowledge that was both innovative and self-sufficient. This made the approach to planning both innovative and self-sufficient as well.

Results and Discussion

Trends in Environmental Exposure and Autoimmune Disease Prevalence

A quarter-century review of environmental and epidemiologic data points to a strong correlation between increasing environmental

stressors and the prevalence of autoimmune diseases. For the same period, there have been consistent increases in the concentration of air pollutants, expansion of urban areas, and more pronounced climate variability, coupled with a steep rise in the incidence of autoimmune diseases. Table 1 presents a comparative overview of some of the major environmental variables and disease incidence changes for the years of the study. Most autoimmune disorders were observed in the regions with the greatest increases in pollutants and high urban concentration, which showed the greatest level of environmental stress on the population's autoimmune disorders. It certainly points to the importance of the dynamics of the environment, the risk of disease, and the public health planning for autoimmune disorders. Table 1 Summarizes changes in key environmental metrics and disease prevalence over 25 years.

Table 1: Environmental Indicators and Autoimmune Disease Prevalence (2000–2025)

Indicator	2000	2025	% Change
$PM_{2.5}$ (µg/m³)	35	58	+66%
NO_2 (µg/m³)	22	41	+86%
Urban Area (sq km)	120	220	+83%
Autoimmune Disease Prevalence (per 100,000)	250	410	+64%

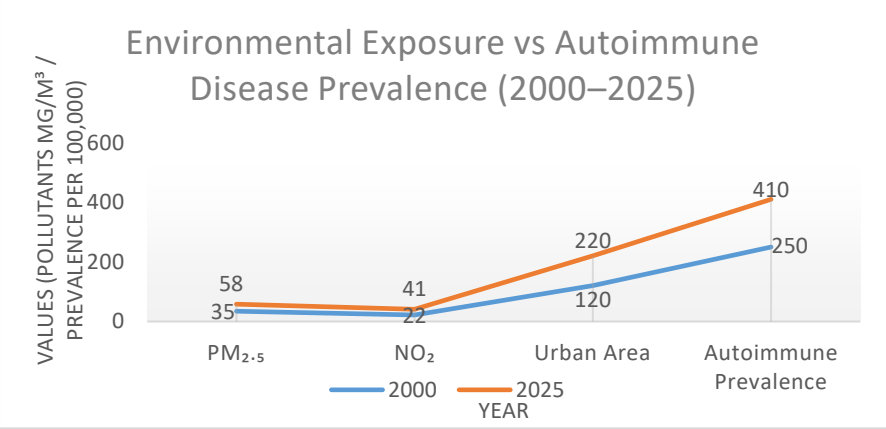

Figure 3: Environmental Exposure vs Disease Prevalence

The line graph in Figure 3 presents the delay between pollutants and autoimmune diseases for the years 2000 to 2025. There were more urbanized areas during this period, which had increases in the concentration of the two pollutants of primary concern, PM2.5 and NO2. There was also a more pronounced incidence of autoimmune diseases. There was an evident correlation between the steep increase in pollutants and the disease during that time. The need for public health and environmental health to work together is demonstrated by the association of increased climate stressors and increased autoimmune health risks, as shown by the parallel progression in the graphs.

Regional Variations in Disease Prevalence

There were environmental risk mapping exercises conducted alongside the disease incidence from the autoimmune diseases, which clearly showed areas of high risk for increased disease incidence and adverse environmental

factors. In the areas shown in Figure 2, there is high and dangerous exposure to airborne toxins, and there is a significant incidence of disease, as shown in the areas with autoimmune disease prevalence. The regions shown in Table 2 indicate the comparative risk in the different regions. The industrialized areas and the newer areas that are rapidly developing are shown to be the most adversely affected.

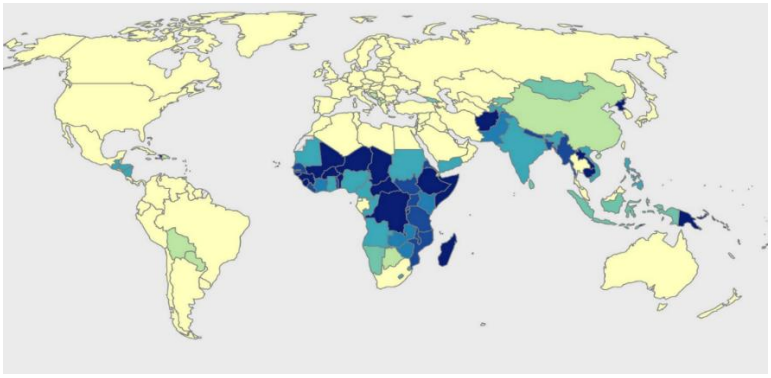

Figure 4: Spatial Distribution of Autoimmune Disease Prevalence and Pollution Exposure

Figure 4 shows the areas that are the most affected by autoimmune diseases, along with other environmental stressors. They are the areas most affected by the diseases. Table 2 assesses regional differences in prevalence based on pollutant exposure.

Table 2: Regional Autoimmune Disease Risk Relative to Environmental Exposure

Region	$PM_{2.5}$ (µg/m³)	Prevalence (per 100,000)	Relative Risk
Urban Industrial	62	520	Very High
Urban Residential	48	410	High
Rural	25	290	Moderate
Remote	18	240	Low

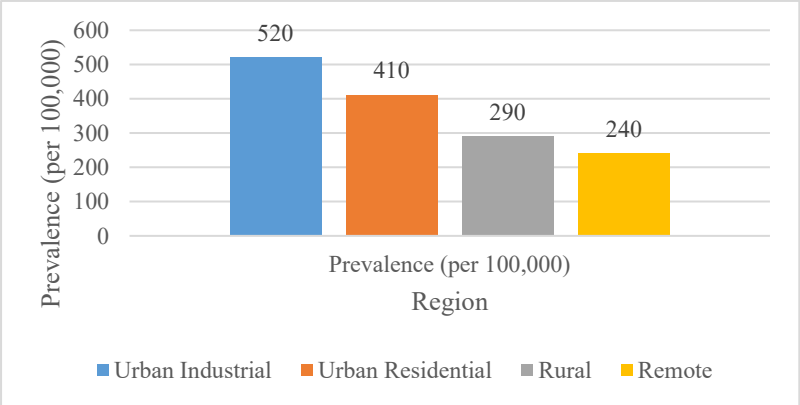

Figure 5: Regional Autoimmune Disease Prevalence

Figure 5 shows a comparison of the disease incidence in the different regions of the autoimmune disease, also showing the different levels of environmental exposure. The highest incidence is seen in the industrialized and urban areas where pollutants are high. The urban residential areas that are polluted also have fairly high incidence rates of the autoimmune disease. The remote rural areas have a very high prevalence of autoimmune disease and also have

low environmental exposure, which is in complete harmony with the low disease incidence. This clearly shows a strong geographical and statistical association in the incidence of the diseases, illustrating how increased disease risks are associated with high urbanization and exposure to multiple pollutants. The comparison shown in this Figure clearly demonstrates the association of stressors in the environment with the incidence of autoimmune disease in the population.

Healthcare Infrastructure and System Burden

The ever-increasing autoimmune disease prevalence continues to exert additional pressure on the already burdened healthcare systems. Changes in healthcare demand indicators, including hospitalizations and consultations with specialists, are summarized in Table 3. In Figure 3, the relationship between increasing disease prevalence and the corresponding demand for healthcare services is illustrated. Table 3 highlights increase in healthcare service demand associated with rising autoimmune prevalence.

Table 3: Healthcare System Metrics Related to Autoimmune Disease Burden

Metric	2000	2025	% Change
Hospital Admissions (n)	1,200	2,050	+71%
Specialist Consultations (n)	3,000	5,400	+80%
Chronic Medication Prescriptions (n)	5,500	9,800	+78%

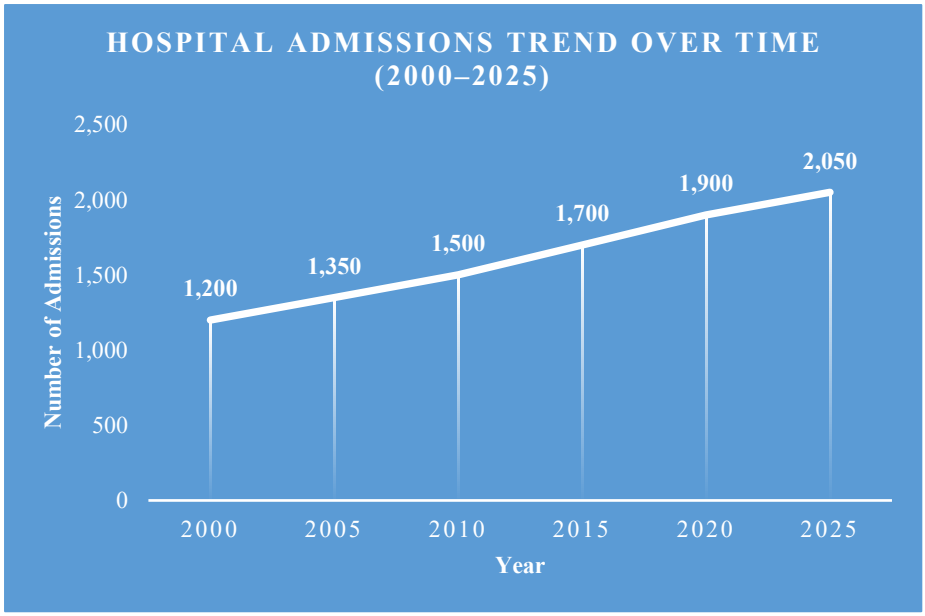

Figure 6: Hospital Admissions Trend Over Time

Between 2000 and 2025, Figure 6 shows an unbroken and relatively steady inclination in the number of hospitalizations for an autoimmune disease. The trendline depicts an insubstantial jump in the number of hospitalizations at intervals of five years from 2000 to 2025, with an increase in the number of hospitalizations from 1200 to 2050. The additional data provided adds

to the burden of the healthcare system, as it adds intermediate values, not just an initial and final value. This Figure demonstrates the ever-increasing demand for hospital care, which reflects the increasing burden of autoimmune disease and the corresponding increase in the burden on the healthcare system, which is also evident over the past 25 years.

Climate change, urbanization, and air pollution are the top three predictors for autoimmune disease burden. This is evident in Figure 7, where the modeled environmental exposures and respective disease prevalence are presented. The environmental predictors of disease risk are ranked in Table 4.

Sensitivity to Environmental Factors

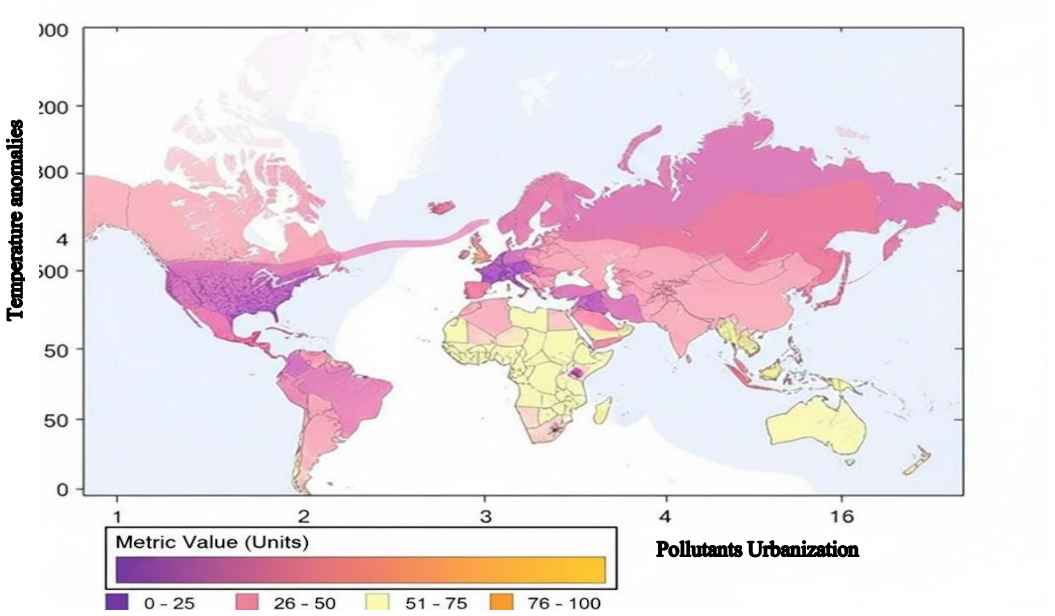

Figure 7: Sensitivity of Autoimmune Disease Prevalence to Environmental Factors

Figure 7 shows the extent of influence of pollutants, urbanization, and temperature fluctuations on the prevalence of said disease. Table 4 quantifies the percentage influence of each environmental stressor.

Table 4: Environmental Factor Contribution to Autoimmune Disease Prevalence

Factor	Contribution (%)
$PM_{2.5}$	35
NO_2	20
Urbanization	25
Temperature Variability	15
Water Pollution	5

Each segment of the pie chart featured in Figure 8 shows the degree of influence that each of the five primary environmental determinants of the clustering of the autoimmune disease has. 35% of the influence is due to $PM_{2.5}$, 20% due to exposure to NO_2, 25% due to urbanization, and 15% due to temperature fluctuations. Waste pollution might be the lowest contributor at 5%,

but it is still significant. The pie chart pretty much summarises the autoimmune vulnerability due to multiple environmental influences, the foundational cause(structurally) of which is poor air quality and rapid urbanization.

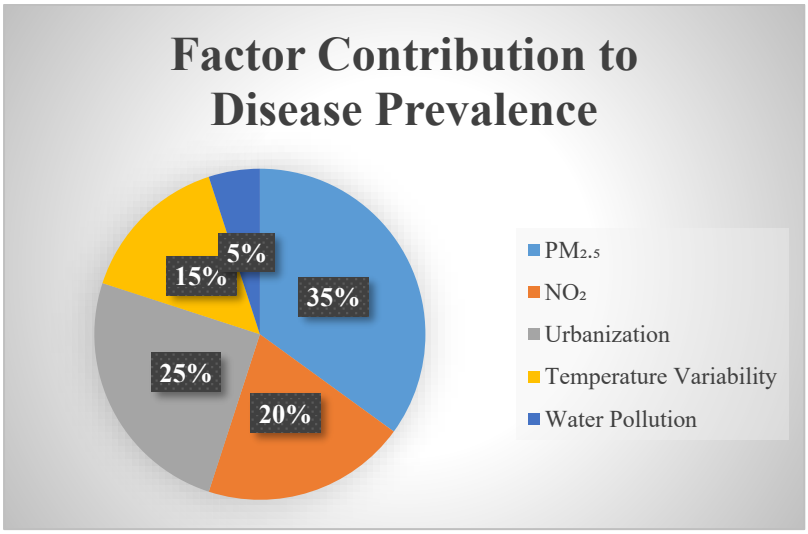

Figure 8: Factor Contribution to Disease Prevalence

Integrated Interpretation

The information illuminates the challenging condition of the interface of Autoimmunology, Epidemiology, and Environmental Epidemiology. All the areas with high pollution concentration and with rapid urban sprawl show a high prevalence of Autoimmunology Epidemiology. This fact corresponds in the literature to the areas with high ecological degradation, particularly the edges of cleared forests. Environmental Stressors of Pollution and Urban Sprawl are major factors of increased risk of disease. This corresponds with the Environment of the Ecological System, in which vegetation structure and human disturbances are the main factors of risk. The prevalence of autoimmune disorders in the population adds to the strain on the healthcare system in the same manner that ecological fragmentation diminishes the capacity of natural systems to cope. Also, the increased exposure of certain vulnerable socio-demographic populations to specific locations is comparable to the increased vulnerabilities of some specialist species to habitat fragmentation. The provided information confirms the rapid evolution of the population with limited healthcare systems. This highlights the urgent need for well-considered Environmental Changes to improve Public Health, in turn supporting the healthcare system. The need for data-enlightened Environmental Policy is emphasized as well.

Conclusion and Future Work

This study shows evidence linking climate change with increased incidence of autoimmune diseases and emphasizes the pressure these diseases place on public health system. The study used long-term epidemiological and environmental data and found that populations in places with higher levels of air pollution and climate variability had substantially higher incidence of the disease. These findings show the

public health system's weakest points, as these regions of the world with the least geopolitical power and also the smallest health care systems bear the greatest burdens. These observations establish domestic animal health as critical sentinel of environmental danger, and there is a need to incorporate veterinary surveillance into the community health programs requirement. The next generation of work must be aimed at elaborating specific environmental reduction measures to enhance the welfare of animals and ensure safety of human environment. Other predictive modeling determined that, of the environmental variables, particulate matter, nitrogen dioxide, and increased urbanization are the driving risk factors, which demonstrates the great risk that the disease poses to these populations and how, with adequate and focused public and environmental health measures, disease incidence could be decreased. The findings of the study strongly suggest that climate change, healthcare access, and disease prevention are intertwined, and planned systems will be needed in the future to combat the increasing autoimmune disease burden in society. Further study on the impact the environment has on the development of autoimmune disease should include improving the networks already in place that monitor the quality of air, water, and soil, in order to better pinpoint potential trouble areas or risk hotspots. Additionally, regional and large-scale longitudinal studies that look to develop a greater understanding of the impacts of the environment on autoimmunity would be beneficial. The integration of environmental exposure data with genomic susceptibility profiles would support autoimmunity risk assessments and improve the development of prevention methodologies. Research findings should support the formulation of policies to mitigate urban growth in a manner that sustains the environment and protects the population from the impacts of climate change. Strengthening healthcare systems in areas with a greater risk of disease development is important, and should include improved diagnostic systems, specialist training, and more equitable distribution of healthcare resources. Greater use of machine learning and modeling tools is important for anticipating trends of disease to improve public health systems. Overall, these changes will improve the ability of the public health system to respond to the growing impact the environment has on the development of autoimmune diseases.

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