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The emerging role of climate modeling in understanding rheumatic disease burden

Romatizmal hastalık yükünün anlaşılmasında iklim modellemesinin ortaya çıkan rolü

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Dear Editor,

Rheumatic diseases such as rheumatoid arthritis (RA), osteoarthritis (OA), systemic lupus erythematosus, and ankylosing spondylitis are lifelong conditions characterized by pain, inflammation, and fluctuating disease activity.[1] Genetics, immune dysfunction, and lifestyle factors are the cornerstones of our understanding of these diseases. However, environmental conditions, particularly climate-related variables, are often underappreciated despite their substantial effects on symptom severity.[1] Many patients report that changes in weather, humidity, and air pollution exacerbate pain and stiffness.[1] Nevertheless, clinical practice has not yet systematically incorporated these environmental triggers into disease management.

Nvidia recently introduced its advanced artificial intelligence-based climate modeling platform, "Climate in a Bottle", which is capable of predicting environmental changes with remarkable precision.[1] Although designed primarily for global climate simulations, this technology holds significant potential in healthcare, particularly rheumatology. By forecasting temperature fluctuations, humidity levels, barometric pressure shifts, and air quality patterns, such models could help anticipate periods when patients with rheumatic diseases are likely to experience symptom flare-ups.

The existing literature has already established associations between climate factors and rheumatic disease activity.[2] Sudden temperature drops, increased humidity, and decreased barometric pressure are frequently associated with heightened joint pain and swelling, especially in patients with RA and OA.[2] Moreover, air pollution, particularly fine particulate matter, has been shown to increase systemic inflammation, thereby aggravating autoimmune processes.[3] To date, clinicians have lacked the tools to provide patients with advance warnings of these environmental changes. Climate modeling may enable the anticipation of such triggers, allowing clinicians to counsel patients before symptoms intensify.

It is clear that weather conditions influence patient behaviour. During periods of extreme cold or hot weather, outdoor activity typically declines, resulting in reduced physical exercise.[3] For patients with rheumatic diseases, maintaining an active lifestyle is essential to preserving joint mobility and reducing stiffness. Anticipating adverse weather

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could therefore allow clinicians to recommend indoor exercise regimens and make timely treatment adjustments to maintain disease control.

In addition to physical factors, psychosocial variables influence how patients perceive and respond to climate-related risks. Recent machine learning studies have demonstrated that beliefs about climate change –and by extension, health behaviours– are shaped by both individual characteristics and broader cultural contexts. Integrating environmental forecasts with patient-specific disease patterns, activity levels, and psychosocial factors is essential for delivering truly personalized care plans.[3]

While existing literature has described associations between climate factors and rheumatic disease activity, much of this evidence remains observational or anecdotal, with limited validation from controlled trials or meta-analyses. Advancing the scientific foundation will require identifying specific, testable biological mechanisms such as inflammatory cytokine responses, immune cell activation, or epigenetic modifications- that can directly link environmental exposures to disease pathology.

It is also important to acknowledge limitations of large-scale climate models, which were originally designed for global or regional applications. These models cannot yet account for patient-specific factors such as genetics, comorbidities, lifestyle, and treatment regimens, all of which are crucial for personalized disease forecasting. Consequently, their most immediate utility in rheumatology may lie in identifying population-level risk periods (e.g., seasonal flare-up trends) rather than providing precise individual forecasts. To advance toward clinical integration, initial pilot studies should be conducted, followed by the resolution of implementation challenges, and ultimately the development of a structured framework for clinical adoption. Future progress will rely on combining climate modeling with personalized health data and rigorous clinical validation, paving the way for precision-based patient care.

In conclusion, rheumatologists must seize the opportunity to incorporate advanced climate modeling into patient care, shifting from a reactive to a preventive approach.[4] Tools such as those exemplified by "Climate in a Bottle" could allow prediction of environmentally driven disease flare-ups and enable proactive treatment planning. Collaboration among rheumatologists, climate scientists, and public health experts will be essential to refine and validate these models for clinical use. This forward-looking approach has the potential to substantially improve the quality of life for millions of individuals living with rheumatic diseases worldwide.

Footnotes

Authorship Contributions

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