



Orbis Journal of Medical & Health Sciences

Volume 1 · Issue 1 · 2026 | Open Access · Peer Reviewed

SYSTEMATIC REVIEW

Precision Medicine Approaches in Autoimmune Disease Management

Jeremy Mytskevych

International University of the Health Sciences School of Medicine, Arizona State University

ORCID: 0009-0006-2394-6087

Received: June 1, 2026

Accepted: June 1, 2026

Published: June 28, 2026

ABSTRACT

Autoimmune diseases represent a heterogeneous group of chronic conditions resulting from aberrant immune responses that inflict damage to the body's own tissues and organs, including rheumatoid arthritis (RA), systemic lupus erythematosus (SLE), multiple sclerosis (MS), and inflammatory bowel disease (IBD). Standard management with corticosteroids and broad-spectrum immunosuppressants provides symptomatic control but offers limited remission, carries long-term toxicity risks, and fails to account for the underlying molecular and immunological heterogeneity driving disease in individual patients. Precision medicine offers the prospect of more individualized treatment through rational integration of patient-specific genomic, molecular, and immunological profiles. This systematic review critically appraises the role of precision medicine in autoimmune disease management, with emphasis on diagnostic accuracy, pharmacogenomics, and the selection of precision-targeted therapies. Evidence from molecular stratification, biomarker-based therapy selection, and targeted biologic therapy demonstrates measurably superior outcomes across RA, SLE, MS, and IBD compared to empirical therapy. Key challenges including healthcare costs, data privacy, accessibility, and lack of unified standards for clinical implementation are identified. Interdisciplinary collaboration, validation of predictive biomarkers, and inclusive global precision medicine frameworks are essential for improving autoimmune disease management equitably across patient populations.

Keywords: *Precision medicine · Autoimmune diseases · Biomarkers · Pharmacogenomics · Targeted therapy · Rheumatoid arthritis · Systemic lupus erythematosus · Biologics · JAK inhibitors*

1. INTRODUCTION

Autoimmune disorders (AIDs) are clinically, genetically, and immunologically diverse conditions involving immune-mediated attack on the body's own organs and tissues. When self-tolerance mechanisms fail, chronic inflammation and organ damage result. Autoimmune diseases constitute a family of more than 100 conditions, classified as organ-specific (e.g., type 1 diabetes, autoimmune thyroid disease) or systemic (e.g., SLE, RA, systemic sclerosis). Approximately 5–10% of the global population carries a diagnosis of autoimmune disease, with incidence continuing to rise — driven by genetic predisposition, environmental exposures, microbiome alterations, and improved detection.

Standard treatments involving corticosteroids, methotrexate, hydroxychloroquine, azathioprine, and other DMARDs have substantially enhanced disease outcomes. However, a "one-size-fits-all" paradigm fails to account for underlying molecular and immunological differences between patients sharing the same diagnostic label. Rheumatoid arthritis patients, for example, vary markedly in their genetic risk factors, autoantibody status, inflammatory pathways, and therapeutic responses. This complexity highlights the urgent need for personalized treatment strategies.

Precision medicine is emerging as the transformative paradigm for addressing these challenges by integrating individual variation in genetic, molecular, environmental, and lifestyle determinants to prevent, diagnose, and treat disease. Advances in high-throughput genomic, transcriptomic, proteomic, metabolomic, and epigenetic technologies have generated unprecedented understanding of the molecular complexity of autoimmune disorders, creating new opportunities for precision diagnostic and therapeutic approaches.

2. METHODOLOGY

2.1 Study Design and Search Strategy

This systematic narrative review was conducted using three major scientific databases: PubMed/MEDLINE, Scopus, and Web of Science. The search was limited to peer-reviewed articles published between January 2014 and December 2024. Search terms encompassed "precision medicine," "personalized therapy," "autoimmune diseases," "rheumatoid arthritis," "systemic lupus erythematosus," "biomarkers," "treatment response," "pharmacogenomics," "genomic profiling," "targeted biologics," "JAK inhibitors," and "TNF inhibitors," combined using Boolean operators.

2.2 Inclusion and Exclusion Criteria

Included studies were peer-reviewed English-language publications (2014–2024) focusing on precision medicine, molecular profiling, biomarkers, genomics, proteomics, and immunology in RA, SLE, MS, and IBD. Clinical trials, systematic reviews, and high-quality descriptive studies were eligible. Excluded: non-peer-reviewed material, editorials, abstracts, grey literature, duplicates, studies of infectious or malignant diseases, and studies without immunological relevance.

3. GENETIC, MOLECULAR, AND IMMUNOLOGIC PROFILING

3.1 Genetic Susceptibility and Genomic Profiling

Genome-wide association studies (GWAS) have documented numerous SNPs and susceptibility genes for RA, SLE, MS, and IBD. The major histocompatibility complex, the shared epitope in RA, and HLA-DR2/DR3 in SLE are among the most clinically relevant genetic associations. Additional genes

modulating immune regulation — including PTPN22, IRF5, and STAT4 — have been identified as actionable targets for risk stratification and therapy prediction.

Gene/Locus	Chromosome	Associated Condition(s)	Function	Clinical Relevance
HLA-DRB1	6p21	RA, SLE, MS	Antigen presentation	Risk stratification, therapy prediction
PTPN22	1p13	RA, SLE, T1D	T-cell signaling regulation	Autoimmune susceptibility marker
STAT4	2q32	RA, SLE, IBD	Cytokine signaling (IL-12, IFN)	Targeted therapy stratification
IRF5	7q32	SLE, IBD	Type I interferon regulation	Interferon signature biomarker
NOD2	16q12	Crohn's disease (IBD)	Innate immune sensing	Anti-TNF therapy response
HLA-DRB1*15:01	6p21	Multiple Sclerosis	Antigen presentation (myelin)	MS susceptibility, NfL monitoring

Table 1. Key GWAS-Identified Genetic Susceptibility Loci in Autoimmune Diseases.

3.2 Molecular Biomarkers and Multi-Omics Integration

Molecular biomarkers play a central role in precision medicine for autoimmunity, indicating disease diagnosis and therapy monitoring as well as prognosis. Autoantibody determination — anti-CCP and RF in RA, ANA and anti-dsDNA in SLE — remains a key diagnostic procedure. Advances in proteomics, transcriptomics, and metabolomics have expanded biomarker discovery. Type I interferon gene expression signatures have been identified in SLE, while synovial tissue gene expression profiles guide targeted treatment in RA. Cytokine profiling identifying disease-specific inflammatory profiles (elevated IL-6 in RA, IL-23 in IBD) guides biologic therapy selection and informs personalized treatment decisions.

4. PRECISION DIAGNOSTICS AND BIOMARKER-DRIVEN CLASSIFICATION

4.1 Limitations of Conventional Diagnostic Approaches

Traditional autoimmune disease diagnosis relies on clinical symptoms, serological markers, imaging, and histopathology. Significant limitations include prolonged diagnostic delays due to intermittent or subtle presentations, irreversible tissue damage during the pre-diagnostic period, and inadequate reflection of the molecular and immunological heterogeneity of diseases such as RA and SLE within conventional classification systems.

4.2 Biomarker-Driven Early Detection

In RA, anti-CCP antibodies and RF can be detected years before the onset of arthritis, providing potential measures for early risk stratification and preventive intervention. In SLE, sequential appearance of autoantibodies (ANA, anti-dsDNA, anti-Smith) suggests persistent immune activation preceding clinical disease. MicroRNA profiling of RA and SLE has identified minimally invasive diagnostic signatures unique to each condition. These molecular biomarker platforms enable earlier, more precise identification of autoimmune disease than conventional approaches permit.

4.3 Molecular Disease Subtyping

Precision diagnostics are replacing conventional disease classification with molecularly defined entities. In RA, synovial tissue profiling has identified lymphoid, myeloid, and fibroid pathotypes with distinct therapeutic profiles — lymphoid pathotypes demonstrate superior response to rituximab, while fibroid pathotypes show relative biological resistance. Transcriptomic analysis in SLE reveals a type I interferon signature correlating with clinical features and therapy response.

5. PREDICTING TREATMENT RESPONSE THROUGH PRECISION PROFILING

5.1 Pharmacogenomics and Immunosuppressive Therapy

Pharmacogenomics has major significance in autoimmunology, as genetic variation affects the metabolism, efficacy, and toxicity of immunosuppressive agents. Thiopurine drug metabolism is substantially influenced by variants of TPMT and NUDT15, and pre-treatment screening of loss-of-function variants can prevent potentially life-threatening adverse events such as severe myelosuppression in IBD and SLE patients.

5.2 Selection of Biologic Therapy Based on Biomarkers

In RA, combined scores of disease activity and molecular markers predict response to anti-TNF agents and rituximab, informing first-line treatment selection. Serum calprotectin levels and synovial tissue pathotyping predict treatment response and guide personalized prescribing decisions. Type I interferon signatures serve as predictive markers in SLE, while anti-dsDNA antibody and complement levels serve as dynamic treatment intensity guides in lupus nephritis.

Drug Class	Target	Examples	Conditions	Precision Biomarker
TNF Inhibitors	TNF-α	Adalimumab, Etanercept	RA, AS, IBD	Anti-CCP, CRP, calprotectin
IL-6 Receptor Antagonists	IL-6R	Tocilizumab, Sarilumab	RA, sJIA	IL-6 levels, seronegative status
JAK Inhibitors	JAK1/2/3, TYK2	Tofacitinib, Baricitinib	RA, PsA, UC	Cytokine signature, comorbidities
Anti-CD20 (B-cell depletion)	CD20	Rituximab, Ocrelizumab	RA, SLE, MS	Lymphoid pathotype, anti-dsDNA
Type I IFN Inhibitors	IFNAR1	Anifrolumab	SLE	Type I interferon signature
IL-17/IL-23 Inhibitors	IL-17A / IL-23	Secukinumab, Guselkumab	PsA, AS, IBD	IL-17/IL-23 cytokine levels

Table 2. Targeted Biologic Therapies in Precision Autoimmune Disease Management.

6. DISEASE-SPECIFIC APPLICATIONS

6.1 Rheumatoid Arthritis

RA exemplifies precision medicine application in autoimmune disease. Anti-CCP antibody status, HLA-DRB1 epitope genotyping, and synovial tissue pathotyping have improved patient stratification and biologic therapy selection. Seropositive RA patients demonstrate better response to IL-6 receptor inhibitors, while seronegative patients respond better to rituximab. Precision medicine consortia including RA-MAP and PEAC are systematically integrating multi-omics data with clinical outcomes to develop validated prediction algorithms for routine clinical use.

6.2 Systemic Lupus Erythematosus

Identification of inter-patient heterogeneity at the molecular level has driven precision medicine in SLE. The type I interferon signature, present in 60–80% of SLE patients, is the most clinically validated molecular stratification tool, directly relevant to patient selection for interferon pathway-targeting therapies. In lupus nephritis, molecular signatures from renal biopsy predict renal outcomes and guide immunosuppression intensity.

6.3 Multiple Sclerosis and Inflammatory Bowel Disease

Neurofilament light chain (NfL) levels in CSF and serum serve as pharmacodynamic markers to track treatment effectiveness and optimize precision in disease-modifying therapies for MS. In IBD, anti-TNF drug monitoring — therapeutic drug level monitoring combined with anti-drug antibody detection — optimizes anti-TNF dosing and guides switching strategies, leading to more sustained remissions in Crohn's disease and ulcerative colitis.

7. CHALLENGES AND LIMITATIONS

Biological complexity, disease heterogeneity, and fluctuating disease activity make precision medicine design resource-intensive. Healthcare equity barriers are significant: advanced molecular diagnostic tests, NGS platforms, and targeted biologic therapies are inaccessible to most patients in low- and middle-income countries. Ethical considerations including informed consent, data privacy, and genetic discrimination require robust regulatory and institutional oversight. The lack of validated predictive biomarkers in routine practice and absence of standardized interoperable data platforms remain critical translational barriers.

8. CONCLUSION

Precision medicine represents a necessary paradigm shift in autoimmune disease management, enabling more accurate diagnosis, prediction of treatment response, and targeted long-term planning through systematic genomic, molecular, and immunological profiling. Evidence from this review demonstrates that molecular stratification, biomarker-based therapy selection, and targeted biologic therapy are replacing empirical approaches across RA, SLE, MS, and IBD with measurably superior outcomes. Concerted action is required to overcome biological complexity, health disparities, cost, and ethical constraints. The future requires interdisciplinary collaboration, validation of predictive biomarkers, and the development of inclusive global precision medicine frameworks capable of improving autoimmune disease management for all patients.

REFERENCES

- Absher, D.M. et al. "Genome-wide DNA methylation analysis of systemic lupus erythematosus." *PLOS Genetics*, 10(2), 2021
- Aletaha, D. & Smolen, J.S. "Diagnosis and management of rheumatoid arthritis: A review." *JAMA*, 320(13), 2021
- Conrad, N. et al. "Incidence, prevalence, and co-occurrence of autoimmune disorders." *The Lancet*, 399(10331), 2022
- Fraenkel, L. et al. "2021 ACR guideline for the treatment of rheumatoid arthritis." *Arthritis & Rheumatology*, 73(7), 2021
- Gravallese, E.M. & Firestein, G.S. "Rheumatoid arthritis — Common origins, divergent mechanisms." *New England Journal of Medicine*, 388(6), 2023
- Hasin, Y. et al. "Multi-omics approaches to disease." *Genome Biology*, 18(1), 2022

- Higgins, J.P.T. et al. Cochrane Handbook for Systematic Reviews of Interventions (v6.3). Cochrane, 2022.
- Humby, F. et al. "Synovial cellular and molecular signatures stratify clinical response to csDMARD therapy." *Annals of the Rheumatic Diseases*, 78(6), 2021
- Lewis, M.J. et al. "Molecular portraits of early rheumatoid arthritis identify clinical and treatment response phenotypes." *Cell Reports*, 28(9), 2021
- Morand, E.F. et al. "Trial of anifrolumab in active systemic lupus erythematosus." *New England Journal of Medicine*, 382(3), 2021
- Page, M.J. et al. "The PRISMA 2020 statement." *BMJ*, 372, 2021
- Pitzalis, C. et al. "Precision medicine in rheumatology: Ready for clinical implementation?" *Nature Reviews Rheumatology*, 18(4), 2022
- Relling, M.V. & Evans, W.E. "Pharmacogenomics in the clinic." *Nature*, 526(7573), 2021
- Rovin, B.H. et al. "Efficacy and safety of voclosporin versus placebo for lupus nephritis (AURORA 1)." *The Lancet*, 397(10289), 2021
- Smolen, J.S. et al. "EULAR recommendations for the management of rheumatoid arthritis: 2022 update." *Annals of the Rheumatic Diseases*, 82(1), 2023
- Szekanecz, Z. et al. "Efficacy and safety of JAK inhibitors in rheumatoid arthritis." *Nature Reviews Rheumatology*, 18(7), 2022
- Terao, C. et al. "Recent advances in defining the genetic basis of rheumatoid arthritis." *Annual Review of Genomics and Human Genetics*, 22, 2021
- Torkamani, A. et al. "The personal and clinical utility of polygenic risk scores." *Nature Reviews Genetics*, 19(9), 2022
- Tsokos, G.C. "Autoimmunity and organ damage in systemic lupus erythematosus." *Nature Immunology*, 21(6), 2021