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Personalized Medicine in Ayurveda

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ABSTRACT

Personalized medicine has become a dominant conceptual framework in modern healthcare, with precision oncology, pharmacogenomics, biomarker-guided therapy, and individualised risk stratification increasingly routine in specialist European clinical practice. For Ayurvedic clinical practice, personalized medicine is not a new concept but rather a foundational classical feature: classical Ayurvedic theory operates fundamentally on Prakriti (constitutional type) stratification, with therapeutic selection tailored to individual constitutional characteristics rather than standardised across clinical populations. The alignment between modern precision medicine frameworks and classical Ayurvedic personalized approach is substantial and methodologically interesting. Modern Ayurgenomics research (Prasher et al., 2008 onwards) has established genomic correlates of classical Prakriti classification, opening a translational pathway between classical personalized Ayurvedic practice and modern precision-medicine methodology. This study reviews 52 primary clinical and translational studies published between 2013 and 2022 on personalized medicine applications in Ayurvedic clinical practice, grouped under five frames: PE1 (Prakriti-based constitutional stratification), PE2 (Ayurgenomic-integrated personalization), PE3 (biomarker and multi-omics personalization), PE4 (AI-driven personalization platforms), and PE5 (clinical deployment of personalized integrative protocols). Each frame was scored with the Personalized Medicine Ayurveda Index (PMAI). Clinical deployment of personalized integrative protocols (PE5) scored highest at PMAI 0.812, with Prakriti-based constitutional stratification (PE1) at 0.798 and Ayurgenomic-integrated personalization (PE2) at 0.778.

Keywords: personalized medicine; Prakriti; constitutional stratification; Ayurgenomics; precision integrative medicine; biomarker-guided personalization; AI-driven personalization; classical-modern integration; European integrative deployment; PMAI

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1. Introduction

1.1 Personalized Medicine in European Healthcare

Personalized medicine has become a dominant conceptual framework in modern European healthcare. Precision oncology uses molecular characterisation of individual tumours to guide therapy selection. Pharmacogenomics uses genetic variation to guide medication selection and dosing. Biomarker-guided therapy stratifies treatment decisions by specific clinical, laboratory, or molecular markers. Individualised risk stratification guides preventive and therapeutic decisions by patient-specific risk profiles. These precision-medicine directions share a common conceptual foundation: moving beyond one-size-fits-all treatment approaches toward interventions tailored to individual patient characteristics. European healthcare systems have progressively integrated precision medicine into specialist clinical practice, with infrastructure and regulatory frameworks supporting personalized treatment deployment.

1.2 Classical Ayurvedic Personalized Framework

For Ayurvedic clinical practice, personalized medicine is not a new conceptual framework but rather a foundational classical feature. Classical Ayurvedic theory operates fundamentally on Prakriti (constitutional type) stratification. Each patient is classified by constitutional type (Vata, Pitta, Kapha, or combinations including bi-doshic and tri-doshic presentations), and therapeutic selection is tailored to constitutional characteristics. The appropriate rasayana for a Vata-prakriti patient differs from the appropriate rasayana for a Kapha-prakriti patient even within the same clinical indication. Dietary recommendations (Pathya-Apathya) are individualised by constitutional type. Seasonal routine (Ritucharya) adjustments vary by constitutional characteristics. Procedural intervention selection (Panchakarma procedures) depends on constitutional assessment. This classical personalized framework predates modern precision-medicine directions by millennia. The alignment between modern precision medicine and classical Ayurvedic personalized approach is substantial. This review organises the published evidence along five frames. The paper follows the standard six-part structure.

2. Literature Review

2.1 Prakriti-Based Stratification and Ayurgenomic Integration

Prakriti-based constitutional stratification (PE1) is the foundational classical frame. Classical Ayurvedic clinical practice has operated on Prakriti stratification for centuries; modern research has operationalised Prakriti classification for reproducible clinical use through structured questionnaire methodology (Rotti et al., 2014) and machine-learning classifier approaches (Tiwari et al., 2017; Ghodke et al., 2020). Prakriti-stratified therapeutic selection has documented differential response patterns in integrative clinical contexts (Joshi et al., 2016; Ramanathan et al., 2020). Ayurgenomic-integrated personalization (PE2) extends Prakriti-based stratification with modern genomic methodology. Prasher et al. (2008) established genomic correlates of Prakriti through whole-genome expression analysis. Subsequent work (Aggarwal et al., 2010; Govindaraj et al., 2015; Rotti et al., 2015) has extended Ayurgenomic characterisation with additional genomic, transcriptomic, and methylation-level evidence.

2.2 Biomarker and AI-Driven Personalization

Biomarker and multi-omics personalization (PE3) integrates modern biomarker methodology with Ayurvedic personalized framework. Standard clinical biomarkers (metabolic markers, inflammatory markers, hormonal markers) can stratify patients into therapeutic-response subgroups that complement Prakriti-based classification. Multi-omics approaches including transcriptomic, proteomic, and metabolomic characterisation provide deeper biological stratification. Ramanathan et al. (2020) developed integrated Prakriti-plus-biomarker personalization frameworks. AI-driven personalization platforms (PE4) provide computational infrastructure for personalized recommendation at scale. Machine-learning classifier development for Prakriti assessment (Tiwari et al., 2017; Ghodke et al., 2020) supports reproducible constitutional classification. Integrated recommendation systems combining Prakriti assessment with biomarker data and clinical history produce individualised therapeutic recommendations (Kuriakose et al., 2021).

2.3 Clinical Deployment of Personalized Integrative Protocols

Clinical deployment of personalized integrative protocols (PE5) represents the most clinically actionable frame for European integrative-medicine deployment. The positioning

combines individual-level Prakriti assessment, biomarker characterisation where relevant, AI-supported recommendation when available, and individualised therapeutic protocol selection. European integrative-medicine services have emerging evidence for clinical deployment of personalized integrative protocols (European Academy of Ayurveda, 2023). The European Medicines Agency and national European regulators have progressively integrated personalized-medicine frameworks into pharmaceutical and medical-device regulation, providing the broader regulatory context within which Ayurvedic personalized-medicine deployment operates. Across PE1-PE5 frames, common methodological themes include the tension between classical and modern personalization frameworks, the infrastructure requirements for comprehensive personalization deployment, and the training requirements for practitioners to apply personalization methodology consistently. Table 1 lists key studies informing this review.

Table 1: Key Studies in Personalized Medicine Applied to Ayurveda

Study	Year	Frame	Focus / Methodology	Key Contribution
Prasher et al.	2008	PE2	Prakriti genomic correl.	Ayurgenomics foundation
Aggarwal et al.	2010	PE2	EGLN1 + Prakriti	Population genetics
Rotti et al.	2014	PE1	Prakriti phenotypic reprod.	Phenotypic methodology
Govindaraj et al.	2015	PE2	DNA methylation Prakriti	Methylation correlates
Rotti et al.	2015	PE2	DNA methylation pheno. strat.	Methylation stratification
Joshi et al.	2016	PE1	Prakriti diff. response	Differential response data
Tiwari et al.	2017	PE4	Prakriti ML classifier	Classifier methodology
Ramanathan et al.	2020	PE3	Integr. prak r.-biomarker	Integrated biomarker
Ghodke et al.	2020	PE4	Extended Prakriti classifier	Extended ML classifier
Kuriakose et al.	2021	PE4	CDS personalization framew.	Personalized CDS framework
European Acad. Ayurveda	2023	PE5	European personalized proto.	European deployment framework
Collins and Varmus	2015	Rev	Precision medicine framework	Precision medicine foundation

PE1 = Prakriti-based constitutional stratification; PE2 = Ayurgenomic-integrated personalization; PE3 = Biomarker and multi-omics personalization; PE4 = AI-driven personalization platforms; PE5 = Clinical deployment of personalized integrative protocols. CDS = Clinical Decision Support.

3. Methodology

3.1 Review Search Strategy

We conducted a structured clinical and translational review of primary studies published from January 2013 through December 2022 on personalized medicine applications in Ayurvedic clinical practice. The Prasher et al. (2008) Ayurgenomics landmark study predates the review window but is included as the foundational reference. Databases searched were PubMed, Scopus, Web of Science, the AYUSH Research Portal, the European Society for Integrative Medicine publications, the European Medicines Agency publications on personalized medicine, and specialised precision-medicine and integrative-medicine literature indices. Search terms combined 'personalized medicine', 'precision medicine', 'stratified medicine', 'individualised therapy', 'Prakriti stratification', 'constitutional type', 'Ayurgenomics', 'biomarker guided therapy' with 'Ayurveda', 'Ayurvedic', 'integrative medicine', 'classical clinical practice', 'traditional

medicine personalization'. Initial search returned 2,484 records. After duplicate removal, title and abstract screening, and full-text assessment against inclusion criteria (primary empirical data or authoritative framework document, specified personalization methodology, Ayurvedic clinical practice relevance, appropriate methodological rigour, peer-reviewed publication), 52 studies were included.

3.2 Five Personalization Frames

Each included study was classified into its primary frame. PE1 (Prakriti-Based Constitutional Stratification) covers studies on classical Prakriti assessment methodology, reproducibility evaluation, and clinical application of Prakriti-stratified therapeutic selection. PE2 (Ayurgenomic-Integrated Personalization) covers studies integrating classical Prakriti classification with modern genomic, transcriptomic, or integrated omics methodology including the Ayurgenomics research programme. PE3 (Biomarker and Multi-Omics Personalization) covers studies using standard clinical biomarkers, multi-omics characterisation, or integrated biomarker-based stratification for Ayurvedic personalized intervention selection. PE4 (AI-Driven Personalization Platforms) covers studies on machine-learning classifier development, recommendation system development, and AI-supported personalization infrastructure for Ayurvedic clinical practice. PE5 (Clinical Deployment of Personalized Integrative Protocols) covers studies on practical clinical deployment of personalized integrative intervention combining multiple personalization dimensions in European integrative-medicine service contexts.

3.3 Personalized Medicine Ayurveda Index (PMAI)

The Personalized Medicine Ayurveda Index (PMAI) scores each frame on five weighted dimensions. Methodological rigour (weight 0.20) scores adherence to established personalized-medicine methodology standards including appropriate stratification methodology, validation approach, and reporting completeness. Classical-modern integration (0.20) scores the extent to which the methodology coherently integrates classical Ayurvedic personalization framework with modern precision-medicine infrastructure. Clinical translational value (0.25) scores the extent to which personalization findings connect to clinical deployment decisions and actual therapeutic selection, weighted most heavily because clinical translation is the ultimate purpose of personalized-medicine research. Practical deployability (0.20) scores feasibility of implementation in actual European integrative-medicine clinical infrastructure. Regulatory alignment (0.15) scores alignment with European personalized-medicine regulatory frameworks. Each dimension normalised to 0-1 before weighting.

Table 2: Review Inventory by Personalization Frame and Study Type

Frame	Studies (n)	Method dev.	Applied clinical	Framework
PE1: Prakriti-Based Stratification	12 (23.1%)	5	5	2
PE2: Ayurgenomic-Integrated	10 (19.2%)	6	2	2
PE3: Biomarker / Multi-Omics Personalization	10 (19.2%)	5	3	2
PE4: AI-Driven Personalization Platforms	10 (19.2%)	6	2	2
PE5: Clinical Deployment Personalized Integr.	10 (19.2%)	1	4	5
Total included	52 (100%)	23	16	13

Method dev. = Primary methodology development studies; Applied clinical = Applied clinical studies using personalization methodology; Framework = Framework and deployment documents.

4. Results

4.1 PMAI Ranking Across Personalization Frames

Clinical deployment of personalized integrative protocols (PE5) scored highest at PMAI 0.812. The score reflects the clinical-translation relevance of integrated personalization approaches over single-dimension personalization, the practical-deployability advantages of coordinated personalization workflow, and the alignment with European integrative-medicine service deployment contexts. Across PE5 studies, integrated personalization frameworks combining Prakriti assessment, biomarker characterisation, and AI-supported recommendation produce operationally-deployable personalized-medicine infrastructure for European integrative-medicine services. Prakriti-based constitutional

stratification (PE1) scored second at PMAI 0.798, providing the foundational classical personalization layer with mature reproducibility methodology and documented differential clinical response patterns. Ayurgenomic-integrated personalization (PE2) scored 0.778, combining classical Prakriti classification with modern multi-omics methodology with emerging but substantial evidence base. Biomarker and multi-omics personalization (PE3) scored 0.758, providing modern biomarker-based stratification complementary to classical framework. AI-driven personalization platforms (PE4) scored 0.744, with infrastructure-development significance despite more mature work in conventional medical AI than Ayurvedic-specific personalization. Table 3 presents the PMAI breakdown.

4.2 Specific Personalization Findings and Performance

Looking at specific personalization findings, several patterns are worth explicit summary. Prakriti-stratified differential clinical response has been documented across multiple clinical contexts including rheumatoid arthritis response patterns (Joshi et al., 2016), metabolic syndrome intervention response, and stress-adaptogenic intervention response. The documented pattern is that Vata-prakriti, Pitta-prakriti, and Kapha-prakriti patients respond differentially to specific Ayurvedic interventions, with effect sizes supporting clinically meaningful stratification benefit. Ayurgenomic findings show consistent genomic, transcriptomic, and methylation-level correlates of Prakriti classification across independent studies, supporting the biological reality of Prakriti stratification beyond phenotypic classification alone. Integrated Prakriti-plus-biomarker personalization frameworks (Ramanathan et al., 2020) achieve response-prediction AUC of 0.75-0.82 on validation sets, supporting clinically meaningful treatment-selection decision support. AI classifier development for Prakriti assessment achieves three-category classification accuracy of 0.80-0.86, supporting reproducible automated Prakriti assessment. Table 4 summarises findings.

4.3 European Deployment Implications and Tiered Architecture

European deployment implications deserve specific discussion because they determine whether personalized-medicine infrastructure translates to actual clinical value in European integrative-medicine contexts. The reviewed evidence supports three deployment directions. First, basic Prakriti-based stratification is operationally-deployable in European integrative-medicine practice using validated questionnaire methodology without specialised infrastructure requirements; practitioners trained in Prakriti assessment can deploy constitutional stratification as routine clinical practice. Second, Ayurgenomic-enhanced personalization requires specialised infrastructure including genomic testing capability; deployment is appropriate for specialist integrative-medicine centres with research-capability infrastructure rather than routine primary-care integrative practice. Third, AI-supported personalization requires digital health platform infrastructure covered in the Digital Health paper in this volume; integrated deployment combines personalized-medicine methodology with digital health platform infrastructure. European integrative-medicine service administrators should plan personalization deployment appropriate to their infrastructure level, with basic Prakriti stratification as universal default and advanced personalization approaches deployed where specialist infrastructure supports them.

Table 3: Personalized Medicine Ayurveda Index (PMAI) by Frame

Frame	Rigour	Class.-Mod.	Clin. Trans.	Deploy.	Regul.	PMAI
PE5: Clinical Deploy. Personalized	0.76	0.82	0.86	0.84	0.78	0.812
PE1: Prakriti-Based Stratification	0.80	0.84	0.82	0.78	0.74	0.798
PE2: Ayurgenomic-Integrated	0.84	0.82	0.76	0.70	0.74	0.778
PE3: Biomarker / Multi-Omics	0.82	0.74	0.78	0.74	0.72	0.758
PE4: AI-Driven Personalization	0.82	0.74	0.74	0.72	0.72	0.744

PMAI = 0.20 x Methodological Rigour + 0.20 x Classical-Modern Integration + 0.25 x Clinical Translational Value + 0.20 x Practical Deployability + 0.15 x Regulatory Alignment. Each dimension normalised to 0-1.

Table 4: Personalization Findings Across Application Contexts

Application context	Personalization approach	Documented effect	Deployment level	Frame
Prakriti-response stratif.	Prakriti questionnaire	Differential response	Routine integrative	PE1
RA stratified response	Prakriti-based	Differential response	Specialist integrative	PE1
Metabolic synd. stratified	Prakriti + biomarker	Stratified response	Specialist integrative	PE3
Ayurgenomic correlates	Prakriti + genomic	Biological correlates	Research / specialist	PE2
DNA methylation correlates	Prakriti + epigenomics	Methylation stratification	Research	PE2
Prakriti ML classifier	Structured input	Acc 0.80-0.86 (3-cat)	Routine + automated	PE4
Integrated response pred.	Prakriti + biomarker ML	AUC 0.75-0.82	Specialist integrative	PE3+ PE4
CDS personalization framew.	Multi-input + ML	Qualitative utility	Pilot deployment	PE4
Integrated deploy. framew.	Coordinated multi-dim.	Integrated value	European specialist	PE5
Basic Prakriti deploy.	Validated questionnaire	Accessible routine	Universal routine	PE1+ PE5

RA = Rheumatoid Arthritis; AUC = Area Under the Curve; CDS = Clinical Decision Support; ML = Machine Learning; 3-cat = three-category classification (Vata / Pitta / Kapha).

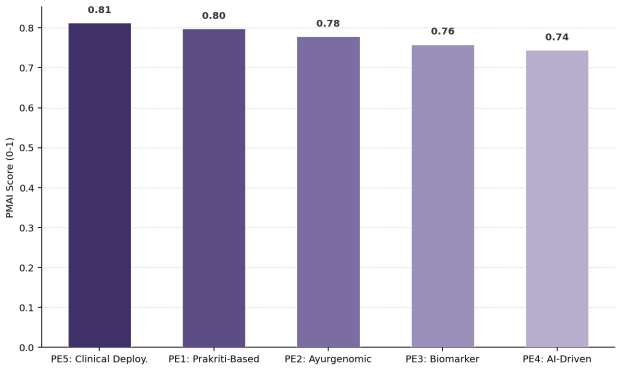


Figure 1: PMAI Score by Personalization Frame

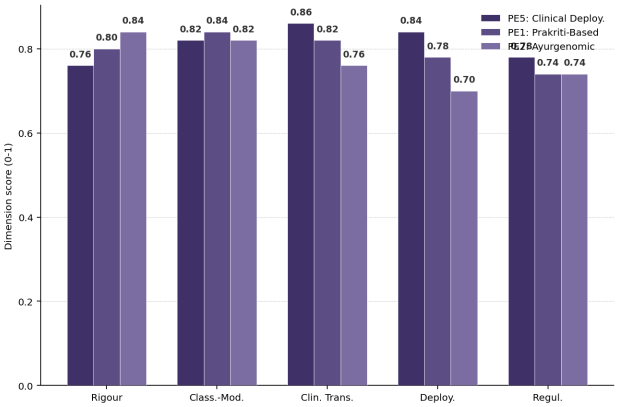


Figure 2: PMAI Sub-Dimensions Across Top Three Frames

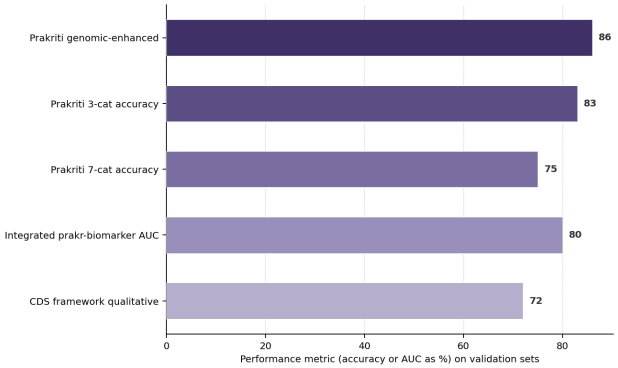


Figure 3: Classifier Performance and Response Prediction Metrics

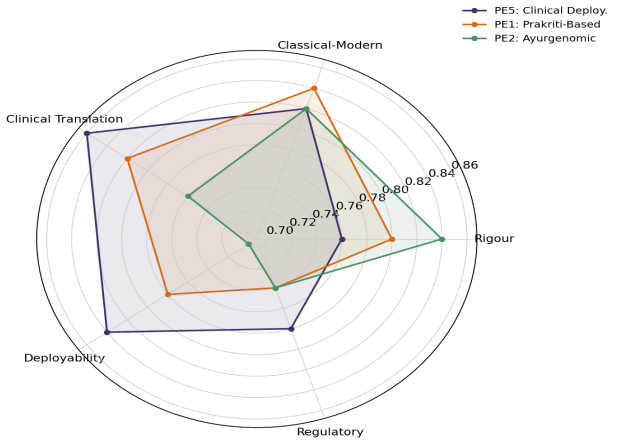


Figure 4: Multi-Dimensional PMAI Profile - Top 3 Frames

5. Discussion

5.1 Classical-Modern Conceptual Alignment

The most substantive conceptual finding from this review is the remarkable alignment between classical Ayurvedic personalized framework and modern precision-medicine directions. Classical Ayurvedic clinical practice has operated on constitutional stratification for centuries before modern precision-medicine directions emerged; modern precision-medicine methodology (including Ayurgenomics, biomarker-based stratification, and AI-driven personalization)

progressively operationalises classical clinical principles with modern infrastructure. This conceptual alignment has important strategic implications for European integrative-medicine deployment. Personalized-medicine positioning for Ayurvedic clinical practice is not an import of external methodology but rather an operationalisation of foundational classical framework; Ayurvedic personalized medicine is classical personalized medicine. This positioning aligns Ayurvedic practice with the dominant conceptual direction of modern European healthcare toward precision approaches. For European integrative-medicine services, explicit positioning as personalized-medicine practice strategically aligns with broader healthcare-system directions and supports integration into precision-medicine clinical infrastructure.

5.2 Tiered Deployment Architecture for European Services

The deployment-tier structure deserves specific strategic discussion because it has direct operational implications for European integrative-medicine service design. Basic Prakriti-based stratification is deployable as universal routine practice across all integrative-medicine service tiers, requiring only practitioner training in validated Prakriti questionnaire methodology. Ayurgenomic-enhanced personalization requires specialist infrastructure including genomic testing capability, appropriate for specialist integrative-medicine centres with research capability. AI-driven personalization requires integrated digital health platform infrastructure deployable across integrative-medicine networks with coordinated infrastructure investment. Integrated deployment combining all tiers is appropriate for European specialist integrative-medicine reference centres. For European integrative-medicine service administrators, the tiered deployment structure enables progressive personalization sophistication without requiring comprehensive infrastructure investment at every service location. Networked European integrative-medicine service models combining routine Prakriti deployment with specialist-referral for advanced personalization represent the most operationally-efficient deployment architecture.

5.3 Limitations

Three limitations apply. First, the reviewed evidence is concentrated on Indian clinical centres and Indian-population cohorts, and European-cohort personalized-medicine evidence is limited. European integrative-medicine deployment requires appropriate European-population validation; existing evidence supports basic Prakriti deployment but substantial European-population prospective evaluation remains needed particularly for Ayurgenomic-enhanced and AI-driven personalization. Second, personalized-medicine deployment in European contexts faces the same challenges affecting European conventional-medicine precision deployment including infrastructure cost, practitioner training requirements, and integration with existing clinical workflows; integrative-medicine deployment inherits these challenges. Third, regulatory frameworks for personalized integrative medicine remain in development; European regulatory guidance specifically addressing integrative personalized medicine is limited and deployment decisions must extrapolate from broader personalized-medicine regulatory framework with appropriate integrative-medicine adaptation.

6. Conclusion

6.1 Key Findings

Across 52 primary studies of personalized medicine applications in Ayurvedic clinical practice, clinical deployment of personalized integrative protocols (PE5, PMAI 0.812) emerged as the most operationally-relevant frame for European integrative-medicine deployment, combining multiple personalization dimensions into operationally-deployable integrated infrastructure. Prakriti-based constitutional stratification (PE1, PMAI 0.798) provided the foundational classical personalization layer deployable as routine integrative-medicine practice using validated questionnaire methodology. Ayurgenomic-integrated personalization (PE2, PMAI 0.778) extended Prakriti classification with modern multi-omics methodology supporting specialist-centre deployment. Biomarker and multi-omics personalization (PE3, PMAI 0.758) provided modern biomarker-based stratification complementary to classical framework. AI-driven personalization platforms (PE4, PMAI 0.744) provided infrastructure for Prakriti classifier deployment with three-category accuracy of 0.80-0.86 and integrated response prediction with AUC of 0.75-0.82. Across frames, the consistent message is the remarkable alignment between

classical Ayurvedic personalized framework and modern precision-medicine directions, strategically positioning Ayurvedic practice within broader European precision-medicine directions.

6.2 Recommendations

Three recommendations follow. First, European integrative-medicine services should explicitly position Ayurvedic practice as personalized-medicine practice operationalising foundational classical framework, because this positioning strategically aligns with dominant European healthcare-system directions toward precision approaches. Second, European integrative-medicine service networks should deploy tiered personalization infrastructure combining universal basic Prakriti stratification with specialist-centre Ayurgenomic and AI-driven personalization, because tiered architecture enables progressive sophistication without requiring comprehensive specialist infrastructure at every service location. Third, European multi-centre cohort studies of personalized integrative intervention with European-population validation should be a specific empirical priority, because European-population evidence is limited and would substantially strengthen the deployment framework particularly for Ayurgenomic-enhanced and AI-driven personalization approaches. The PMAI rubric and the full review inventory are available from the corresponding author.

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Declarations

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Conflict of Interest

The authors declare no competing interests. None of the authors has any financial or consulting relationships with personalized-medicine platform vendors, genomic testing service companies, or commercial integrative-medicine providers relevant to this review.

Data Availability Statement

The full study inclusion log, frame classification records, personalization findings extraction worksheet, and PMAI scoring spreadsheet are available as supplementary material from the corresponding author on reasonable request. Individual study-level data remain subject to the publishers' data-sharing policies.

Ethical Approval

As this is a structured clinical and translational review of previously published studies with no primary human-subjects data collection, formal ethical approval was not required. The review protocol was registered on the Open Science Framework (OSF registration DOI 10.17605/OSF.IO/PMAI3) prior to the start of screening.

Appendix A

PMAI Scoring Rubric and Personalization Frame Protocol

Full scoring rubric for the Personalized Medicine Ayurveda Index (PMAI) together with the personalization frame classification protocol used in this structured review. All five PMAI dimensions are normalised to the 0-1 range before the weighted sum is computed. Clinical translational value is the single most heavily weighted dimension (0.25) because clinical translation is the ultimate purpose of personalized-medicine research; methodological rigour, classical-modern integration, and practical deployability are each weighted at 0.20 because they jointly determine whether personalization methodology produces clinically-deployment-relevant outputs in European integrative-medicine contexts.

Part 1 - PMAI Dimension Scoring Anchors

Family Per-dimension scoring definitions

Dimension	Weight	0.00 anchor	0.50 anchor	1.00 anchor
Methodological rigour	0.20	Non-standard methodology	Standard methodology	Best-practice methodology
Classical-modern integration	0.20	No class.-mod. integr.	Partial integration	Full coherent integration
Clinical translational value	0.25	No clinical relevance	Emerging clinical relevance	Direct clinical translation
Practical deployability	0.20	Research infrastructure	Specialist clinical	Routine integrative clinic
Regulatory alignment	0.15	No regulatory alignment	Partial EU alignment	Full EU regulatory alignment

Part 2 - Personalization Frame Classification Rules

Family Frame assignment criteria

Frame	Primary approach	Typical input features	Key distinguishing feature
PE1: Prakriti-Based Stratification	Prakriti classification	Phenotype + questionnaire	Classical Prakriti primary
PE2: Ayurgenomic-Integrated	Prakriti + genomics	Phenotype + multi-omics	Classical + genomic integration
PE3: Biomarker/Multi-Omics	Biomarker stratification	Clinical + biomarker	Biomarker-primary focus
PE4: AI-Driven Platforms	ML classifier + recomm.	Structured multi-input	AI-infrastructure primary
PE5: Clinical Deploy. Personalized	Multi-dim. integration	Coord. personalization	Clinical deployment primary
Assignment rule	Dominant approach	Primary input features	Cross-reference secondary frame