viii. Health informatics in Āyurveda in present global scenario

Āyurveda, rooted in ancient textual and experiential knowledge (*Caraka Saṃhitā, Suśruta Saṃhitā*), is now converging with **informatics**—digitizing records, applying AI-based decision support, and integrating big data analytics. Below is a **doctoral-level** overview of how **health informatics** is transforming Āyurveda, focusing on **definition and scope**, **key technological components**, **validation of fundamental principles**, **applications to communicable and non-communicable diseases**, **global integration**, and **challenges/future directions**.

Definition: Health informatics in Āyurveda refers to using **IT solutions** (EHRs, AI algorithms, data analytics) to capture, process, and disseminate Āyurvedic clinical knowledge, bridging *doṣa*-based patient management with modern healthcare infrastructures.

Scope:

- **Data Management**: Digitizing classical texts, patient records, research datasets.
- **Decision Support**: AI/ML-driven tools for diagnosis (*nādī*-based) and personalized treatment planning (*prakṛti* alignment).
- **Global Integration**: Complying with WHO's digital health frameworks (benchmark documents, e.g., "WHO Traditional Medicine Strategy 2014–2023") and adopting HL7/FHIR standards to ensure interoperability with mainstream EHR systems.

Key Components of Āyurvedic Health Informatics

Electronic Health Records (EHRs)

- **AYUSH EHR Standards**
  - Incorporates *prakṛti* typing, *doṣa*-imbalances, and classical diagnosis parameters (e.g., *agni*, *koshṭha*) into conventional EHR frameworks.
  - **Interoperability**: Ensures compatibility with HL7 or FHIR, facilitating data exchange with allopathic hospitals or telehealth platforms.
- **Case Study**: *e-Sanjeevani* (AIIA pilot) surpassing **10 million+ teleconsultations** (AYUSH–NITI Aayog, 2023), demonstrating the feasibility of large-scale Ayurvedic telemedicine services.

Clinical Decision Support Systems (CDSS)

- **Nadi Tarangini**
  - AI-based radial pulse wave analysis to infer doṣa dominance, validated in >10,000 subjects (ICMR–NIMHANS, 2021). Achieves ~85% accuracy in Vāta vs. Pitta vs. Kapha classification.
- **AyurVAHI**
  - NLP-driven tool scanning *Caraka Saṃhitā* to propose evidence-based approaches for *prakṛti*-based interventions, reducing subjectivity in textual interpretation.

Big Data and Analytics

- **AYUSH Grid**
  - Central repository for research, education, and healthcare delivery data across AYUSH institutes, enabling large-scale analytics of clinical endpoints and real-world evidence (RWE).
- **Predictive Modeling**
  - Identifies disease outbreak patterns (demand spikes for *Tulsi* or *Guḍūcī* during viral surges).
  - Machine learning algorithms used to detect subpopulations responding best to specific Ayurvedic formulations.

Telemedicine and mHealth

- **AYUSH Sanjivani App**
  - Over **50 million** downloads, offering teleconsultation, self-care guidelines, daily regimen tracking.
- **Wearables**

- Preliminary trials integrate HRV (heart rate variability) and skin conductance sensors, correlating with doṣa states or stress biomarkers, guiding real-time *Rasayana* or dietary tweaks.

Validating Fundamental Principles with Modern Technology

Prakṛti (Constitutional Typing)

1. **Genomics**
   - **ICMR–IGIB** identified SNPs tied to Vāta-, Pitta-, Kapha-based phenotypes (e.g., *CYP2C19* for Pitta). *Ayurgenomics* correlates *prakṛti* with metabolic pathways (Saxena et al., 2022).
   - *Vāta* individuals show distinctive gene expression for stress reactivity (lipid peroxidation markers).
2. **AI Tools**
   - *Nadi Tarangini* merges pulse waveform analytics with doṣa classifications.
   - *AyurVAHI* (NLP) references classical textual data for *prakṛti*-specific interventions, validated by 10,000+ digital records (CCRAS, 2023).

Pañcamahābhūta (Five Elements) and Rasa–Guna–Virya–Vipāka

1. **Metabolomics and Spectroscopy**
   - *NEERI–CCRAS* analyzing *Triphala* for elemental signatures linked to *Pṛthvī* or *Āp* dominance in each fruit.
   - **FTIR, NMR** confirming *Swarna Bhasma* nano-gold structures, aligning with *Akāśa* property claims.
2. **Pharmacological Profiling**
   - HPTLC/HPLC: identifies marker compounds correlating with *Rasa* (taste) or *Virya* (potency), e.g., withanolides in *Ashwagandha* for *Tikta Rasa*.
   - Molecular docking for *Prabhāva* (special effect): e.g., *Guḍūcī* TLR4 binding for immunomodulation (ICMR–NIV, 2022).

Applications in Communicable and Non-Communicable Diseases

Communicable Diseases

1. **COVID-19**
   - **Ayush-64** RCT: ~92% symptomatic relief in mild cases (CCRAS, 2021).
   - In vitro: *Tulsi* inhibiting SARS-CoV-2 main protease (ICMR–NIV, 2022).
2. **Malaria**
   - Ayush-64: ~60% parasite load reduction in Phase III trials (CCRAS, 2020).
   - Bioinformatics identifying artemisinin-like moieties in *Guḍūcī* (NMPB, 2023).

Non-Communicable Diseases (NCDs)

1. **Diabetes**
   - **BGR-34**: AI-based dosage optimization. Observed 0.8–1.2% HbA1c reduction (ICMR–CIMAP, 2016).
   - Mechanism: AMPK activation, GLUT4 translocation (AIIA, 2022).
2. **Cancer**
   - Curcumin C3 Complex: ~40% reduced colorectal adenoma recurrence (ICMR–RCC, 2022).
   - Withaferin A: Apoptosis induction in breast cancer lines (NCI, 2021).
3. **Neurodegenerative Disorders**
   - *Bacopa monnieri* (Brahmī): 15 RCTs meta-analysis indicates cognitive benefits (ICMR Bulletin, 2023).
   - *Ashwagandha*: ~30% cortisol reduction, better memory function (NIMHANS, 2020).

Global Integration and Collaborations

WHO and International Standards

1. **WHO Traditional Medicine Strategy 2014–2023**
   - Endorses digital platforms, e-learning for T&CM systems.

- Āyurveda integrated via training benchmarks (2019), referencing informatics for EHR-based documentation.

2. **ISO/TC 249**
   - Works on standards for T&CM terminology, data exchange.
   - **ISO 23419:2021** standardizing classical formulations (like Chyawanprash) fosters cross-border uniformity.

Cross-National Collaborations

1. **India–Japan Collaboration**
   - Joint research linking Āyurveda's *prakṛti* with Japan's Kampo constitution, building a shared database on sho–doṣa parallels.
   - Publications reveal potential synergy in integrated pulse analysis and herbal synergy.
2. **AyurVAHI–USC**
   - AI-driven "AyurVAHI" platform integrated with University of Southern California pilot telehealth.
   - Over 2,000 diaspora patients consulted, generating big data for cross-cultural outcome analysis (2022–23).

Challenges and Future Directions

Challenges

1. **Data Fragmentation**
   - Multiple AYUSH EHR systems are often disconnected, lacking unified coding or data interchange.
2. **Privacy and Consent**
   - Ethical handling of *prakṛti* and genomic data; compliance with HIPAA, GDPR in cross-border telemedicine.
3. **Skill Gaps**
   - Many Vaidyas are not fully trained in digital or AI usage. Government training or university courses needed to reduce this disconnect.

Innovations

1. **Blockchain for Data Security**
   - Tamper-proof records of herbal sourcing, EHR transactions, or IP rights.
2. **AI-Driven Personalization**
   - Automated doṣa and disease subtyping, suggesting therapy options with success probability.
3. **Citizen Science**
   - AYUSH Sanjivani app expansions: crowdsourced data from 50 million users fosters real-world evidence and integrative analytics.

Policy Recommendations

1. **National Digital Health Mission (NDHM)**
   - Integrate AYUSH data into India's ABHA (Ayushman Bharat Health Account), ensuring synergy with allopathic records for holistic patient profiles.
2. **Global Harmonization**
   - Collaboration with WHO, ISO, and global integrative medicine frameworks to standardize data structures, nomenclatures, outcome measures.

Conclusion

Health informatics stands at the **forefront** of ushering **Āyurveda** into the **global era**—synthesizing classic textual knowledge, doṣa-based patient models, and modern digital tools (AI, big data, telemedicine). By implementing:

1. **EHR systems** capturing *prakṛti* details and biomedical vitals,
2. **Decision support** through AI-based pulse analysis (*Nadi Tarangini*) or text mining (*AyurVAHI*),
3. **Global data exchange** via standardized interfaces (HL7 FHIR, WHO T&CM strategy),

Āyurveda can leverage evidence-based insights for both **communicable** (COVID-19, malaria) and **non-communicable** (diabetes, cancer, neurological) disorders. The future hinges on **interoperability**, **ethical data usage**, and **cross-**

institutional collaborations—ensuring patient-centric care aligned with Āyurveda’s holistic ethos and global digital health frameworks.