

# Precision Medicine: Global landscape and its Strategic Imperative for Bangladesh

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## Abstract:

Precision medicine (PM) is a fundamental transformation in healthcare, moving from a reactive, "one-size-fits-all" model to a proactive approach based on individual variability in genes, environment, and lifestyle. This review summarizes the global landscape of PM on its technological drivers, clinical applications, and associated ethical challenges. It then critically analyzes the nascent state of PM in Bangladesh on the existing infrastructure, formidable barriers, and potential opportunities. The article concludes with a strategic roadmap, emphasizing that for Bangladesh to employ PM's potential for its dual disease burden, a coordinated national strategy focusing on infrastructure, workforce development, and ethical governance is not just beneficial but essential.

**Keywords:** Precision medicine, Global, Bangladesh

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## Introduction:

Traditional medical practice, which is based on population averages, often fails to account for individual patient differences. Precision medicine (PM) is a paradigm shift that leverages multi-scale genomic, transcriptomic, proteomic, and clinical data to deliver the right intervention to the right patient at the right time.<sup>1</sup> Driven by declining sequencing costs and advances in bioinformatics, PM is becoming a clinical reality globally. However, there are significant disparities on implementation of PM between developed and developing nations. This review explores the global PM landscape and provides a critical analysis of its prospects within socio-economic context of Bangladesh, outlining a path forward to ensure equitable health benefits.

## Global Landscape of Precision Medicine:

### Foundational Initiatives and Technological Pillars:

PM adoption has been propelled by large-scale national initiatives worldwide. The US "All of Us"

Research Program aims to build a diverse cohort of one million participants,<sup>2</sup> while the UK Biobank provides extensive genetic and health data for half a million individuals.<sup>3</sup> Similar large-scale efforts are underway in China, Japan, and the European Union.

### The feasibility of PM rests on key technological pillars:

**1. Next-Generation Sequencing (NGS):** The cost of whole-genome sequencing has declined from \$100 million to under \$1,000, making large-scale genomic profiling practical.<sup>4</sup>

**2. Bioinformatics and Artificial Intelligence (AI):** AI and machine learning algorithms are crucial for analyzing the massive datasets generated by PM technologies, identifying patterns of predicting disease risk and treatment response.<sup>5</sup>

**3. Multi-Omics Integration:** PM is evolving beyond genomics to integrate data from the transcriptome, proteome, and metabolome, providing a holistic view of health and disease.<sup>6</sup>

### **Clinical Applications and Impact:**

PM has found its strongest base in oncology. Molecular profiling of tumors enables targeted therapies (e.g., trastuzumab for HER2+ breast cancer, imatinib for CML) that improve survival and reduce toxicity compared to conventional chemotherapy.<sup>7</sup> In pharmacogenomics, testing for genetic variants in genes like CYP2C19 guides the dosing of drugs like clopidogrel and antidepressants, preventing adverse reactions and optimizing efficacy.<sup>8</sup> Exome and genome sequencing have dramatically shortened the diagnostic odyssey for patients for rare genetic diseases.

### **Ethical, Legal, and Social Implications:**

The promise of PM is hardened by significant challenges:

**1. Data privacy and security:** The sensitive nature of genetic information essentially needs robust protection.

**2. Genetic discrimination:** Legal protections are needed to prevent discrimination by employers or insurers.

**3. The Genomic divide:** There is a real danger that PM will exacerbate health disparities, primarily benefiting wealthy populations while neglecting underrepresented groups, as most genomic databases are of European ancestry.<sup>9</sup>

### **Precision Medicine in Bangladesh: An Emerging Frontier**

#### **Burden of Disease and it's Potential:**

Bangladesh faces a complex double burden of communicable diseases (e.g., dengue, drug-resistant TB) and a rapidly rising incidence of non-communicable diseases (NCDs) like cancer, diabetes, and cardiovascular conditions.<sup>10</sup> PM offers transformative potential for both. Pathogen genomics can track outbreaks of communicable diseases and identify drug resistance markers of infective diseases, informing public health responses. It also enables risk stratification, early diagnosis, and personalized treatment of non-communicable diseases, allowing for more efficient allocation of limited healthcare resources.

#### **Existing Infrastructure and Pioneering Efforts**

The foundation for PM in Bangladesh is being laid gradually. Bangladesh Medical University (BSMMU) has established a Molecular Medicine and Bioinformatics Department. The Child Health Research Foundation uses genomic sequencing to

track bacterial pathogens and antibiotic resistance, directly influencing national vaccine policy.<sup>11</sup> A specific national policy on genetic data is underdevelopment through the Bangladesh Medical Research Council (BMRC). Few private sectors offer limited genetic testing, but access is confined to affluent urban populations.

### **Challenges and Barriers:**

There are many hurdles in Integrating PM into mainstream healthcare, like

**1. Resource and budget constraints:** The high cost of NGS platforms and reagents is a major barrier for a resource-limited public health system.

**2. Scarcity of skilled human manpower:** There is a critical shortage of bioinformaticians, clinical geneticists, and genetic counselors.

**3. Underdeveloped Regulatory and Ethical Frameworks:** The absence of comprehensive guidelines for genetic data privacy, consent, and ownership creates a risky environment for research and clinical application.

**4. Limited Digital Health Infrastructure:** Fragmented and paper-based health records prevent the integration of genomic and clinical data.

**5. Lack of Population-Specific Data:** The unique genetic makeup of the Bangladeshi population is largely uncharacterized, meaning risk predictions based on foreign data which may be inaccurate.

#### **A strategic roadmap for Bangladesh:**

A deliberate, phased strategy is needed to navigate the path towards PM.

**1. Development of a national PM strategy:** The government must formulate a clear roadmap with defined priorities, ethical guidelines, and promotion of inter-institutional collaboration to enter the holistic approach to PM.

**2. Building capacity and workforce:** Invest in university programs to train genomic scientists and bioinformaticians and offer continuous professional development for clinicians.

**3. Initiation of pilot projects in priority areas:** Focus on areas with immediate public health impact like, National Infectious Disease Genomics surveillance for drug-resistant TB and outbreak tracing for dengue. Implement testing for CYP2C19 to guide clopidogrel use in cardiac patients. Establish molecular tumor boards at major cancer centers to guide treatment for common cancers.

**4. Investment in digital infrastructure:** Prioritize the development of secure, standardized Electronic Health Record (EHR) systems.

**5. Strengthening international partnerships:** Collaborate with global consortia to access technology and training, ensuring equitable data sharing that benefits the local population.

### Conclusion:

Precision medicine is an ongoing revolution in global healthcare. Bangladesh is just beginning of the journey. The challenges of resource limitations, infrastructure, and governance are significant, but the potential benefits—more effective, efficient, and personalized care for its population—are immense. By adopting a strategic, context-sensitive, and ethically grounded approach, Bangladesh can avoid a simple "copy-paste" model and instead leapfrog into the future of medicine. It must build its own evidence base, prioritize equitable access, and ensure that the promise of precision medicine becomes a transformative force for the entire nation, not a privilege for the few and take their health sector global standard.

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