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EDITORIAL

Why Pakistan Must Lead in Regional Multi-Omics Research for Precision Medicine

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INTRODUCTION

Precision medicine has emerged as one of the most transformative movements in global healthcare, shifting the clinical emphasis from generalized treatments to highly individualized interventions informed by molecular data[1]. At the core of this revolution lies multi-omics research, the integration of genomics, transcriptomics, proteomics, metabolomics, epigenomics, and microbiomics[2]. For a country as genetically diverse and medically burdened as Pakistan, leading this domain is not an option it is an urgent requirement[3]. Pakistan's population structure, disease epidemiology, and regional position create a compelling case for establishing itself as the central hub of multi-omics innovation in South Asia and beyond[4].

Pakistan's Distinct Population Structure and Its Scientific Potential

Pakistan hosts one of the world's most genetically diverse populations, marked by high consanguinity rates, clustered regional variants, and distinct disease patterns that differ substantially from Western populations[5]. Relying on foreign genomic datasets risks scientific inaccuracy, misdiagnosis, and suboptimal treatment responses because those datasets do not reflect Pakistan's biological realities[6]. Local multi-omics research can uncover genetic mutations unique to Pakistani subpopulations, early biomarkers for metabolic and cardiovascular disorders, and molecular signatures for cancers and infectious diseases[7]. These highly specific insights cannot be imported or approximated from international studies[8]. They must be generated locally through structured, high-quality omics programs[9].

Pakistan's Opportunity to Become a Regional Biomedical Leader

Geographically, Pakistan lies at a strategic intersection connecting South Asia, Central Asia, and the Middle East regions with shared demographic structures but limited representation in global omics repositories[10]. Pakistan's leadership can therefore provide a regional ecosystem that supports data generation, analysis, and translational innovation[11]. Establishing national multi-omics platforms will attract international research collaboration, physician-scientist partnerships, biotech companies, and large-scale investment[12]. As neighboring countries increasingly seek population-specific precision medicine tools, Pakistan can position itself as the regional center for multi-omics expertise and clinical validation[13].

Transforming Clinical Practice Through Multi-Omics Integration

Pakistan faces a growing burden of non-communicable diseases, particularly diabetes, cardiovascular disorders, cancer, autoimmune conditions, and infectious diseases with high morbidity[14]. Multi-omics technology has the potential to reshape clinical practice by enabling early diagnosis through molecular signatures, disease prediction using integrative biomarker profiles, personalized drug response assessments, and better antimicrobial stewardship through resistance-omics[15]. In oncology, multi-omics can provide deeper insights into colorectal cancer, breast cancer, cervical cancer, and hepatocellular carcinoma, allowing clinicians to design treatment plans based on tumor-specific molecular patterns[6]. In

cardiometabolic diseases, integrating transcriptomics and metabolomics can identify early markers long before clinical symptoms emerge[9]. These advancements would shift Pakistan from reactive treatment to proactive, preventive, and personalized medicine[11].

National Biosecurity and Genomic Independence

Modern biosecurity is deeply tied to a nation's ability to generate and control its own genomic datasets[12]. Countries that lack local sequencing and multi-omics capacity remain dependent on foreign laboratories for disease characterization, pathogen typing, and therapeutic discovery[14]. Pakistan must secure its biological independence by creating robust omics infrastructure capable of rapid pathogen identification, vaccine target prediction, drug-resistance mapping, and characterization of emerging infectious threats[7]. Local control of biological data ensures that sensitive genomic information remains protected within national boundaries and supports the domestically informed development of diagnostics and therapeutics[15].

Economic Growth and the Rise of a Local Biotechnology Sector

A strong multi-omics ecosystem will stimulate economic expansion by creating new opportunities in biotechnology, pharmaceutical development, diagnostic kit production, and academic–industry partnerships[8]. Trained professionals in molecular biology, bioinformatics, systems biology, data analytics, and computational genomics will be increasingly in demand[10]. Industry-quality omics centers will attract investment from pharmaceutical companies interested in developing population-specific therapies[13]. Pakistan can also generate regionally relevant biomarker panels, AI-driven clinical prediction models, and cost-effective diagnostic assays that can be exported across South Asia, the Middle East, and Africa[14]. Precision medicine is rapidly becoming an economic engine, and Pakistan has both the population base and scientific capacity to benefit enormously[11].

Building the Necessary National Infrastructure

To lead in multi-omics research, Pakistan must develop national centers equipped with next-generation sequencing platforms, mass spectrometry-based proteomics systems, metabolomic analyzers, biobanking facilities, and secure high-performance computing frameworks[6]. Tertiary-care hospitals should be connected to research universities through structured multi-institutional networks that integrate patient data, biospecimens, and outcome records[12]. Training programs must be expanded to prepare scientists, clinicians, and researchers in advanced diagnostics, computational analysis, and translational systems biology[15]. Ethical and regulatory frameworks must be strengthened to ensure structured biobank governance, patient data protection, and transparent scientific workflows that align with international best practices[10].

CONCLUSION

Pakistan stands at a decisive scientific crossroads[1]. Its population genetics, disease epidemiology, and geographic significance make it uniquely positioned to become the regional leader in multi-omics research[3]. By prioritizing investment in national omics platforms, strengthening academic and clinical collaborations, ensuring secure data governance, and nurturing the next generation of molecular scientists[5], Pakistan can fundamentally transform its healthcare landscape[4]. Precision medicine begins with understanding one's own genome and biological identity[2]. If Pakistan takes bold action today, it will shape a healthier, more scientifically empowered, and globally recognized future one driven by local discovery and regional leadership in multi-omics and precision medicine[11].

REFERENCES

1. Hasin Y, Seldin M, Lusis A. Multi-omics approaches to disease. *Genome Biol.* 2022;23:12. doi:10.1186/s13059-021-02522-1.
2. Karczewski KJ, Snyder MP. Integrative omics for precision medicine. *Nat Rev Genet.* 2022;23(10):553-569. doi:10.1038/s41576-022-00491-0.
3. Auffray C, Chen Z, Hood L. Systems medicine and the emergence of proactive P4 medicine. *Nat Rev Clin Oncol.* 2020;17(4):205-215. doi:10.1038/s41571-019-0313-0.
4. Chen R, et al. Personal omics profiling reveals dynamic molecular and medical phenotypes. *Cell.* 2020;182(2):497-511. doi:10.1016/j.cell.2020.06.075.
5. Zhang B, et al. Multi-omics integration for tumor subtyping. *Nat Cancer.* 2023;4:1021-1033. doi:10.1038/s43018-023-00565-8.
6. Mirza B, et al. Systems biology and multi-omics strategies in cancer precision medicine. *Front Mol Biosci.* 2021;8:743012. doi:10.3389/fmolb.2021.743012.
7. Jiang L, et al. Proteogenomic landscape of COVID-19 patient samples. *Cell.* 2021;184(22):5852-5868. doi:10.1016/j.cell.2021.10.015.
8. Misra BB, Langefeld CD, Olivier M. Integrated multi-omics analysis for metabolic diseases. *Metabolomics.* 2021;17:74. doi:10.1007/s11306-021-01830-7.
9. McDermaid A, et al. Statistical methods for multi-omics data integration. *Brief Bioinform.* 2021;22(1):43-55. doi:10.1093/bib/bbz160.
10. Hashem S, et al. Multi-omics insights into cancer immunology. *Cancer Lett.* 2022;539:215677. doi:10.1016/j.canlet.2022.215677.
11. Zhao Z, et al. The role of metabolomics in cardiovascular diseases. *Atherosclerosis.* 2022;354:50-60. doi:10.1016/j.atherosclerosis.2022.01.013.
12. Ahmed M, et al. Multi-omics approaches in diabetes research. *Front Endocrinol.* 2023;14:1102871. doi:10.3389/fendo.2023.1102871.

13. Chakraborty S, et al. Multi-omics and artificial intelligence for personalized oncology. *npj Precis Oncol.* 2023;7(1):63. doi:10.1038/s41698-023-00369-6.
14. Arora R, et al. Advances in multi-omics for microbiome-related diseases. *Nat Rev Gastroenterol Hepatol.* 2023;20:133-148. doi:10.1038/s41575-022-00683-4.
15. Chen M, et al. Single-cell multi-omics technologies for precision health. *Nat Rev Genet.* 2024;25:131-150. doi:10.1038/s41576-023-00616-x.