Future Directions in Cancer Genomics Research and Capacity Building in East Africa

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ABSTRACT

Cancer genomics has transformed cancer diagnosis, treatment, and precision medicine globally, yet East Africa remains underrepresented in these advancements. This review examines the current landscape of cancer genomics research and capacity in East African countries, highlighting critical gaps in laboratory infrastructure, trained personnel, data systems, ethical and regulatory frameworks, and sustainable financing. Key challenges include fragmented research efforts, reliance on short-term donor funding, limited integration of genomics into national cancer control strategies, and inequitable access to innovations. The review proposes strategic directions for building a robust and sustainable genomics ecosystem, including networked sequencing hubs, human capital development through targeted training and career pathways, standardized cancer registries, ethical governance, blended financing models, and regional collaboration through consortia and Centers of Excellence. Addressing risks such as brain drain, donor dependence, and data privacy is emphasized to ensure equity and long-term sustainability. Implementing these strategies can enable precision oncology, generate locally relevant data, and improve cancer outcomes across East Africa.

Keywords: Cancer genomics, East Africa, precision medicine, capacity building, infrastructure, human resources.

INTRODUCTION

Cancer remains a growing public health concern worldwide, with a disproportionate burden increasingly falling on low- and middle-income countries (LMICs), including those in East Africa [1]. According to the World Health Organization (WHO), the global cancer burden is expected to rise to 28.4 million cases by 2040, with LMICs contributing the majority of this increase. East African countries such as Uganda, Kenya, Tanzania, Rwanda, and Ethiopia face unique challenges in addressing cancer due to limited healthcare infrastructure, low public awareness, and scarce specialized human resources [2]. Despite these challenges, advances in cancer genomics in high-income countries have revolutionized our understanding of cancer biology, enabling precision diagnostics, targeted therapies, and personalized treatment plans. Genomic technologies allow researchers to identify mutations, epigenetic changes, and gene expression patterns that drive tumor development and progression. Such insights facilitate early detection, risk stratification, and the development of individualized therapies, substantially improving patient outcomes [3].

However, the benefits of cancer genomics have largely bypassed East Africa. Genomic research in the region remains fragmented, underfunded, and concentrated in a few tertiary centers. This disparity is exacerbated by limited laboratory infrastructure, inadequate biobanking facilities, unreliable data systems, and a shortage of trained genomic scientists, bioinformaticians, and clinical researchers [4]. Furthermore, there is insufficient integration of genomics into national cancer control strategies, resulting in delayed adoption of precision medicine approaches that could improve diagnosis and treatment. These gaps highlight the urgent need for targeted investment in genomics capacity building that is contextually appropriate, ethically sound, and sustainable within the region [5].

Despite the promise of genomics to transform cancer care, East Africa continues to lag in research capacity and clinical implementation. The limited availability of genomic technologies constrains both research and clinical practice, creating a situation where patients often receive care guided by generalized protocols rather than

personalized genomic insights. Moreover, the lack of standardized cancer registries and genomic databases undermines the ability to conduct region-specific research, track disease trends, and identify populations at high risk [6]. Ethical and regulatory frameworks governing genomics research are underdeveloped, raising concerns about data privacy, informed consent, and equitable access to interventions. This combination of infrastructural, human resource, and governance gaps contributes to delayed diagnosis, suboptimal treatment outcomes, and widening inequities in cancer care between East Africa and higher-income regions. Without a coordinated strategy to build genomics research capacity, the region risks being left behind in the global shift toward precision oncology [7].

This study aims to advance cancer genomics research and capacity building in East Africa to improve clinical outcomes and public health impact. It seeks to assess the current landscape of genomics research and clinical integration, including infrastructure, human resources, and data systems, while identifying barriers to adopting genomics-enabled diagnostics and treatments. The study further explores opportunities for regional collaboration, knowledge sharing, and capacity strengthening, and proposes strategic interventions to enhance ethical, regulatory, and governance frameworks for genomics research. Additionally, it provides recommendations for sustainable investment in training, infrastructure, and research networks aligned with national and regional cancer control priorities. Guided by research questions on current capabilities, infrastructural and technological gaps, potential partnerships, governance challenges, and strategic interventions, the study underscores the importance of building a robust genomics ecosystem. Its significance lies in offering policymakers, researchers, and funders a comprehensive baseline to inform investments, improve cancer surveillance, early diagnosis, and treatment outcomes, and ensure equitable access to genomic innovations. By addressing capacity, governance, and collaboration, East African countries can generate locally relevant data, implement precision medicine approaches, and participate fully in the global genomics revolution, ultimately improving cancer care and reducing morbidity and mortality across the region.

Key Challenges Hindering Cancer Genomics Research and Capacity in East Africa

Cancer genomics research in East Africa faces multiple interrelated challenges that limit its development and clinical integration. First, laboratory and sequencing infrastructure remains inadequate, with many facilities lacking validated next-generation sequencing (NGS) platforms, reliable cold chains, consumables, and maintenance support [8]. Consequently, sequencing is often outsourced internationally, increasing costs, prolonging turnaround times, and reducing local control over data. Second, there is a pronounced shortage of trained personnel, including molecular pathologists, clinical geneticists, laboratory scientists, and bioinformaticians capable of managing and interpreting genomic data. Existing training programs are few and frequently misaligned with local research and clinical needs. Third, data systems and cancer registries are fragmented, with incomplete, non-standardized records that limit the power of genomic studies. Fourth, governance, ethical, and legal frameworks for genomic research are underdeveloped, leaving uncertainties around data sharing, consent, biobanking, and cross-border transfers, which undermines trust and collaboration [9]. Fifth, research funding is often project-based and short-term, creating unsustainable models that hinder equipment maintenance and staff retention. Finally, regional collaboration is limited, with research efforts siloed in select institutions, reducing opportunities for shared expertise, standardized protocols, and population-relevant discoveries. Addressing these challenges is critical to building a robust, equitable, and sustainable cancer genomics ecosystem in East Africa [10].

Strategic directions and practical recommendations

Advancing cancer genomics research and capacity in East Africa requires a multi-pronged, phased strategy that integrates laboratory infrastructure, human capital, data systems, governance, financing, and regional collaboration. Building resilient, networked laboratory infrastructure is a priority, beginning with mapping existing capacities and investing in modular, scalable equipment to reduce costs, followed by establishing regional sequencing hubs with quality-controlled service agreements, and ultimately developing national reference laboratories accredited to international standards [11]. Hybrid models combining local sequencing and cloud-based bioinformatics can optimize resources while building local expertise. Strengthening human capital is equally critical, starting with intensive practical training and "train-the-trainer" initiatives, integrating genomics into academic curricula, establishing targeted MSc and PhD fellowships, and supporting career pathways for bioinformaticians and molecular pathologists through competitive salaries, research time, and mentorship networks [12]. Modernizing cancer surveillance involves standardizing data collection, digitizing pathology and clinical records with unique identifiers, piloting registry-biobank linkages, and building interoperable national and regional analytic platforms guided by FAIR data principles. Governance and ethics require locally relevant frameworks for informed consent, robust research ethics committees, community engagement to build trust, and legal protections against genetic discrimination. Sustainable financing and local ownership can be achieved through dedicated governmental funding, blended finance, cost-recovery models, and domestic grant programs. Finally, fostering regional networks, consortia, and south-south collaborations, including a regional cancer genomics consortium and a Center of Excellence, ensures harmonized protocols, shared training, multi-site studies, and equitable partnerships.

Collectively, these measures provide a practical roadmap for developing a robust, sustainable, and locally led cancer genomics ecosystem in East Africa [13].

Metrics for success

Measuring progress in advancing cancer genomics research and capacity in East Africa requires a comprehensive set of metrics that capture infrastructure development, human resource capacity, research output, clinical integration, and governance. One key indicator is the establishment of accredited sequencing laboratories and regional genomic hubs, which reflects the expansion of local infrastructure capable of generating high-quality genomic data. Another critical metric is the increase in locally led genomics publications and competitive research grants, signaling enhanced research capacity, knowledge production, and regional scientific leadership [14]. Equally important is the training and retention of molecular technologists, bioinformaticians, and clinical geneticists, which ensures that skilled personnel can support sustainable genomics initiatives and clinical translation. The proportion of cancer cases captured in national and regional registries with linked pathology and genomic data provides insight into the integration of genomics into routine cancer surveillance and care [15]. Clinical performance indicators, such as the turnaround time for actionable genomic tests, reflect the efficiency and responsiveness of genomics-enabled healthcare. Finally, the presence of national genomic data governance policies, coupled with functional ethics review capacity, indicates adherence to ethical standards, protection of patient rights, and robust regulatory frameworks. Collectively, these metrics provide a multidimensional framework to evaluate progress, guide strategic interventions, and ensure that investments in cancer genomics translate into meaningful research and improved clinical outcomes across East Africa [16].

Risks and mitigation

Advancing cancer genomics research in East Africa entails several significant risks that must be proactively addressed to ensure sustainable and equitable outcomes. One major risk is brain drain, where skilled researchers and clinicians leave the region for better opportunities abroad, undermining local capacity. This can be mitigated by improving career incentives, providing protected time for research, creating clear pathways to leadership, and recognizing scientific contributions through competitive compensation and professional development [17]. Another critical risk is unsustainable donor dependence, as heavy reliance on external funding can create vulnerabilities to shifting priorities or funding cuts. Early implementation of blended financing models that combine public sector investment with cost-recovery mechanisms can enhance financial resilience and program continuity [18]. Privacy breaches and misuse of sensitive genomic data represent additional challenges, requiring robust legal protections, secure information technology infrastructure, and strict governance over data access and sharing. Finally, equity concerns must be addressed to prevent disparities in research benefits. Efforts should ensure that advances in diagnostics, treatment, and capacity building reach both urban and rural populations, promoting inclusive access. By proactively addressing these risks, East African cancer genomics initiatives can achieve long-term sustainability, ethical integrity, and broad societal impact [19].

CONCLUSION

Advancing cancer genomics research and capacity building in East Africa represents a critical pathway for improving cancer care, public health outcomes, and regional scientific leadership. While the region faces substantial challenges, including limited laboratory infrastructure, scarce trained personnel, fragmented data systems, underdeveloped governance frameworks, and dependence on short-term external funding, strategic, coordinated interventions can overcome these barriers. Establishing networked sequencing hubs, strengthening human capital through targeted training and career development, integrating genomics into national cancer registries, and fostering robust ethical and regulatory frameworks are essential. Sustainable financing, blending domestic investment with strategic external support, and promoting regional collaboration and knowledge sharing can enhance long-term resilience. Addressing risks such as brain drain, donor dependence, privacy breaches, and inequitable access is also crucial to ensure that genomics advances benefit all populations. By implementing these strategies, East African countries can develop a locally led, ethically sound, and sustainable cancer genomics ecosystem, enabling precision medicine approaches, generating population-relevant data, and ultimately improving cancer diagnosis, treatment, and survival outcomes across the region.

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