Advancing genetic counselling in Southern Africa

Unveiling opportunities for inclusive healthcare and genomic education for Angola

Maria Chimpolo, *LLM, PhD,* ***Shahida Moosa,*** *MBBCh, PhD,* ***Catherine Lynn T. Silao,*** *MD, PhD,* ***Nasser Calumbuana,*** *MBBS, ABFM,* ***Elka Kay,*** *BSc,* ***Hashim Halim-Fikri,*** *BAppSc, MSc,* ***Dhavendra Kumar,*** *MD, DSc, PhD,* ***Bin Alwi Zilfalil,*** *MBBS, PhD.*

ABSTRACT

الأهداف: تقييم الوضع الراهن للاستشارات الوراثية في جنوب أفريقيا بشكل نقدي من خلال الكشف عن مواطن الضعف في دمجها ضمن أنظمة الرعاية الصحية الوطنية.

المنهجية: أجريت مراجعة منهجية، وفقًا لإرشادات PRISMA، حول الاستشارات الوراثية في جنوب أفريقيا من عام 2008م إلى عام 2023م. ركزت معايير الإدراج على النطاق الجغرافي، وأهمية المحتوى، وتصميم الدراسة، والفترة، واللغة. استخدمت عمليات البحث في قواعد البيانات مثل PubMed وScopus وWeb of Science كلمات رئيسية ومصطلحات MeSH. قمنا باختيار الدراسات من خلال عملية فحص ثنائية المستوى، وتنظيم البيانات المستخرجة في نظرة عامة شاملة. قيمت أداة Cochrane Collaboration التحيز في الدراسات الفردية.

النتائج: من بين 1،876 دراسة أولية، استوفت 42 دراسة معايير الإدراج، مع مناهج تشمل الوصفية (76%)، والعرضية (17%)، والتجارب العشوائية المضبوطة (5%)، ودراسات الاتراب (2%). تراوح المشاركون بين مستشارين وراثيين ومرضى وأطباء عامين. كشف تقييم مخاطر التحيز أن 21.4% من الدراسات كانت ذات مخاطر عالية للتحيز، وغالبًا ما يكون ذلك بسبب عدم كفاية التعمية والبيانات غير المكتملة، بينما أظهرت 29% مخاطر منخفضة للتحيز. حددت النتائج الرئيسية حواجز مثل الموارد المحدودة، والفجوات التعليمية بين المتخصصين في الرعاية الصحية، والتحديات الثقافية. وبالمثل، أظهر التحليل التأثير الكبير للاستشارة الوراثية على تحسين نتائج المرضى والحاجة إلى معالجة التنوع اللغوي الإقليمي والتفاوتات في الرعاية الصحية.

الخلاصة: تُظهر الاستشارة الوراثية إمكانية تعزيز معرفة المرضى واتخاذ قرارات مستنيرة في جنوب إفريقيا. إن معالجة التحديات من خلال البحث المستهدف والتعليم وإصلاحات السياسات أمر ضروري لدمج الرعاية الصحية الوراثية في النظم الإقليمية. وعلى الرغم من القيود، فإن هذه المراجعة تؤكد على الدور الأساسي للاستشارة الوراثية في تحسين استراتيجيات الرعاية الصحية ونتائج المرضى في جميع أنحاء أنغولا ودول جنوب إفريقيا الأخرى.

Objectives: To critically evaluate the current status quo of genetic counseling in Southern Africa by uncovering grey areas in their integration within national healthcare systems. It pinpoints the need for improved genetic education and healthcare inclusivity to advance genomic medicine and precision healthcare for underserved populations by analyzing policy frameworks, infrastructure, education, and initiatives.

Methods: A systematic review following PRISMA guidelines examined studies on genetic testing in Southern Africa from 2008 to 2023. Searches in databases such as PubMed, Scopus, and Web of Science employed keywords and MeSH terms. A 2-tiered screening process selected studies, and extracted data were organized into a comprehensive overview. The Cochrane Collaboration tool assessed bias in individual studies.

Results: Of 1,876 initial studies, 42 met inclusion criteria. Participants ranged from genetic counselors and patients to general practitioners. Risk of bias assessment revealed that 21.4% of studies had a high risk of bias, often due to inadequate blinding and incomplete data, while 29% showed a low risk of bias. Key findings identified barriers such as limited resources, education gaps among healthcare professionals, and cultural challenges.

Conclusion: Genetic counseling shows potential to advance patient knowledge and informed decision-making in Southern Africa. Addressing challenges through targeted research, education, and policy reforms is essential for integrating genetic healthcare into regional systems. Despite limitations, this review underscores genetic counseling's fundamental role in improving healthcare strategies and patient outcomes across Angola and other Southern African countries.
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Keywords: Genetic counseling, genomic education, Southern Africa, Angola, healthcare barriers, genetic disease management

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From the Department of Biochemistry, Clinical Pathology and Genetics (Chimpolo, Calumbuana, Kay), Faculty of Medicine, Universidade A. Neto, Hospital Américo Boavida, Luanda; from the Department of Medical Basic Sciences (Chimpolo), Faculty of Medicine, Universidade Katyavala Bwila, University Campus of Catumbela, Benguela;from Division of Molecular Biology and Human Genetics (Moosa), Stellenbosch University, Cape Town, South Africa; from the Institute of Human Genetics, National Institutes of Health and Department of Pediatrics (Silao), College of Medicine and Philippine General Hospital, University of the Philippines-Manila, Manila, Philippines; from Malaysian Node of the Human Variome Project (Halim-Fikri), School of Medical Sciences, Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia; from the Department of Cardiovascular Genomics (Kumar), William Harvey Research Institute, Bart's and The London School of Medicine and Dentistry, Queen Mary University of London, London, United Kingdom; from the Human Genome Centre (Zilfalil), School of Medical Sciences, Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia.

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Address correspondence and reprint request to: Prof. Bin Alwi Zilfalil, From the Human Genome Centre, School of Medical Sciences, Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia.
E-mail: zilfalil2@hotmail.com
ORCID: https://orcid.org/0000-0001-5055-7892

The field of genetic counseling has shown rapid progress over the past several decades. It is closely aligned with the accelerated advancements in genomics and precision medicine. Initially emerging as a support service for individuals at risk of genetic disorders, it has expanded significantly to address the needs of diverse populations affected by hereditary conditions, rare diseases, and complex genetic information. As genetic testing becomes more accessible and widely utilized, genetic counseling enables patients to better understand their genetic risks, empowering informed decision-making and personalized treatment strategies. This paradigm shift underscores genetic counseling's essential contribution to elucidating the genetic basis of diseases and enhancing patient care in the era of personalized medicine. However, the integration of genetic counseling into healthcare systems in regions such as Angola, in Southern Africa, remains embryonic, constrained by a number of challenges that include the health educational needs, infrastructural deficiencies, and sociocultural barriers.[1,2] For the present study, the Southern Africa region is herein covering Angola, Botswana, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Sao Tome, South Africa, Swaziland (Eswatini), Zambia, and Zimbabwe. Angola is the seventh-largest country in Africa, bordered by the Democratic Republic of Congo to the north, Namibia to the south, Zambia to the east, and the Atlantic Ocean to the west. It spans an area of 1,246,700 square kilometers (km) and supports a population exceeding 36 million.[3] Notably, the region is burdened with a high prevalence of genetically linked diseases such as sickle cell disease and hereditary cancers.[4,5] Specifically, one-quarter of the population in Angola carries the sickle cell trait, while the disease's prevalence is 3.3% unifying genetic variants such as those in the CD36, VCAM1, and NOS3 genes known to influence disease severity, levels of hemolysis, and hospitalization rates.[6] Although sickle cell disease is a critical health issue throughout the SADC region, Angola's high prevalence makes it as one focal point for public health interventions and thus underlining the importance of its indication in the title.[7] The region requires a complex understanding of its settings as reinforced by authors such as Wessels and Koole[8] who explore the concept of risk communication within genetic counseling sessions and argue that while the integration of genetic counseling is crucial, it remains underdeveloped. This stark contrast also highlights the pressing need for a systematic examination of the current state of genetic counseling and the need for advancing genetic counseling as a vital strategy for revolutionizing healthcare delivery and outcomes. Integrated genetic health strategies, such as those documented in South Africa with the "Implementation of a breast cancer genetic service" and tailored approaches to genetic counseling have shown to be a strategy to address the burden of these genetic disorders and the significant public health challenges it represents.[9] Furthermore, the integration of genetic counseling services represents a commitment to healthcare inclusivity, ensuring that genetic services are shaped to the diverse genetic makeup of the population, including traditionally marginalized communities.[9,10] These approaches not only address disparities but also democratize access to state-of-the-art healthcare innovations, as discussed by Biesecker et al.[11]

Therefore, the integration of genetic counseling in Southern African healthcare services is a blasting approach for strengthening regional genomic literacy and education. This initiative is particularly critical given the prominence of genetics as a major component in global healthcare evolution. However, acknowledging the transformative potential of genetic counseling requires a holistic and systematic review to identify what already exists, as well as identifying barriers, opportunities, and educational priorities.

This review aims to enumerate existing initiatives and critically evaluate barriers, opportunities, and educational priorities that determine the regional landscape. Further, a systematic review in this context proves useful for mapping the current policy landscapes, infrastructural readiness, and existing frameworks for genetic counseling as seen in reviews focused on Genomic Medicine in Africa (Table 1).[12]

In so doing, it shall prepare the way for solid frameworks and policies to appropriately fuse genetic counseling into Southern Africa healthcare systems. Such strategic integration aligns with the global health agenda aimed at reducing health disparities and enhancing healthcare quality by incorporating genetic insights into clinical practice.[13]

It is thus, through a systematic review that this study seeks to thoroughly analyze and synthesize the status quo of genetic counseling in Southern Africa to uncover grey areas within its integration at national levels and potentially highlight different pathways for its full incorporation into regional healthcare systems. Participating in the present academic pursuit contributes to strengthening genetic health and precision medicine

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Table 1 - Summary of included studies arranged by relevance. The study design, specific focus on genetic counseling, and outcomes measured are listed. The language used by all included studies is English.

Theme	References	Study Details	Focus and Outcomes	Quality; Language
Risk and Uncertainty in Genetic Counseling	Wessels TM., & Koole T. (2019); Scott M., Watermeyer J., & Wessels TM. (2011); Wessels TM. (2024);	Qualitative, observational; Descriptive; Self-reflective	Focus on patient decision-making in multicultural settings, addressing risk communication and uncertainty in family history information.	Moderate to High; English
Genetic Disorders and Counseling Challenges	Moore SW., & Zaahl M. G. (2008); Bruwer Z., Futter M., & Ramesar R. (2013); Urban MF. et al. (2011); Kinsley N (2012); Essajee F et al. (2022); Penn C et al. (2009); Mafisa L, Dlova AN, Moodley V (2022); Gardiner SA et al. (2019); Akinyemi RO et al. (2016)	Case-control, Qualitative observational, Retrospective analysis, Case report, Prospective cohort, Exploratory study, Interview, Review	Discusses genetic counseling for Hirschsprung's disease, Lynch syndrome, Down syndrome, Turner Syndrome, developmental epileptic encephalopathies, hemophilia A, and traditional beliefs.	Low to Moderate; English
Genomic Medicine and Education in Africa	Jongeneel CV. et al. (2022); Iwai Y. et al. (2023); Tindana P. et al. (2015); Moyo E et al. (2023); Adebamowo SN et al. (2017); Abacan M et al. (2019); Nembaware V (2019); Mlotshwa BC et al. (2017); Siwo GH, Williams SM, Moore JH (2015)	Descriptive, Cross-sectional, Scoping review, Review, Exploratory survey, Report	Explores the implementation of genomic education, the readiness of African scientists, and the challenges in genomic research across Africa. Emphasizes community engagement.	Moderate to High; English
Cancer genetic counseling and testing	Okunola AO et al. (2023); Van Wyk C et al. (2016); Rayne S et al. (2019); Morris M et al. (2015); Schoeman M et al. (2013); Kromberg JG., Sizer EB., Christianson AL. (2012); Mohamad HB. & Apffelstaedt JP. (2008)	Exploratory research, Retrospective analysis	Focuses on breast cancer genetic testing, knowledge among GPs, and mothers' experiences in Johannesburg. Discusses the effectiveness and patient understanding in cancer genetic counseling.	Moderate; English
Ethical, Cultural, and Community Engagement	Zingela Z. et al. (2023); Penn C et al. (2009); Mboowa G., Sserwadda I (2019); Kromberg JGR, Kerr R. (2022); Owolabi P., Adam Y., Adebiyi E. (2023)	Review, Exploratory study	Examines ethical challenges, cultural beliefs, and community engagement strategies in genetic counseling for schizophrenia, hemophilia, albinism, and personalized medicine.	Low to Moderate; English
Genetic Counseling Practice and Innovations	Wessels TM et al. (2021); Ormond KE et al. (2019; 2023); Van Der Merwe N, Ramesar R, De Vries J (2022); Greenberg J et al. (2012); Kromberg JG, Wessels TM, Krause A (2013); Wilson LA et al. (2023); Mitropoulos K et al. (2015)	Descriptive qualitative/ Action research, Cross-sectional, Exploratory study, Review, Cohort, Narrative review	Covers global variations in genetic counseling, telecounseling adaptations during COVID-19, genetic counseling roles in South Africa, neuromuscular disease genetics, and genomic success stories.	Moderate to High; English
Public Health Genomics and Policy Implications	Owolabi P, Adam Y, Adebiyi E (2023); Wilson LA et al. (2023); Ibidunni L et al. (2019); Essajee F et al. (2022); Oosthuizen J et al. (2021); Nembaware V (2019)	Review, Cohort, Cross-sectional, Prospective cohort, Cross-sectional, Report	Discusses personalizing medicine, neuromuscular disease genetics, sickle cell disease, developmental and epileptic encephalopathies, and genomics training in Africa.	Moderate to High; English

competencies of the region—an essential undertaking that could stimulate improved healthcare outcomes and equitable health across diverse populations.[10]

Hypothesis. Enhanced genetic and genomic education in Southern Africa can significantly improve healthcare inclusivity and outcomes, particularly for underserved populations like those in Angola, by addressing existing barriers and leveraging regional opportunities.

Methods. A systematic review was conducted according to the standards in PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Table 1) guidelines.[14] It included studies on various aspects of genetic testing in Southern Africa published in peer-reviewed journals between 2008 and 2023 and arranged by order of citation to facilitate resolving disagreements. A clear, delineated inclusion criterion was established to ensure this systematic review's methodological rigor and specificity.

Inclusion criteria:

i. Geographical scope: Studies and reports on Southern Africa, including Angola. This criterion aligns with our aims to synthesize data pertinent to the regional context, facilitating the generation of 12-region-specific insights.[15]

ii. Content relevance: Publications that explicitly discuss genetic counseling, its implementation challenges, opportunities, and educational aspects within the healthcare settings of the specified regions. This ensures the relevance and alignment of the data with our research objectives.[16]

iii. Study design: Empirical studies, policy analyses, and educational program evaluations. The inclusion of diverse study designs enriches the comprehensiveness of the review, allowing for a multifaceted understanding of the genetic landscape.[17]

ix. Publication period: Research published within the last 15 years (2008-2023). This timeframe ensures that the review encompasses contemporary developments in genetic counseling, reflecting current trends and future directions.[18]

x. Language: Studies published in English, Portuguese, or French with English abstracts. This criterion recognizes the region's linguistic diversity while maintaining accessibility for a broad scholarly audience.[19]

Information sources. The systematic review primarily sourced literature from an array of comprehensive databases, ensuring a robust and exhaustive exploration of relevant studies. The primary databases included PubMed, Scopus, and Web of Science, which are recognized for their extensive coverage of medical and health sciences literature.[20] The Africa-Wide Information and LILACS databases were also utilized, targeting regional studies pertinent to Southern Africa. This approach was complemented by manual searches in specialized journals and consultation with grey literature databases, such as OpenGrey, to encompass non-traditional yet academically valuable sources.[21]

Search strategy. A meticulous search strategy was employed, utilizing a combination of keywords and MeSH terms to capture the broad scope of genetic counseling. The search terms included variations of "Genetic Counseling," "Genomic Education," "Healthcare in Angola," "Southern Africa Health Systems," and "Inclusive Healthcare." Boolean operators and specific filters were applied to refine the search results, focusing on studies published within the last 15 years in English, Portuguese, and French. The search strings were adapted to the syntax and subject headings specific to each database to optimize the retrieval of pertinent literature.[22]

Study selection. The study selection followed a two-tiered screening process.[23] The first phase involved the screening of titles and abstracts, which was followed by the assessment of full-text articles based on the inclusion and exclusion criteria, including irrelevance to the review question, study design, or language restrictions, are explicitly stated, ensuring transparency and reproducibility of the review process. Two reviewers conducted the procedure independently to mitigate bias. Disagreements were resolved through discussion or consultation with a third reviewer, ensuring an objective and balanced assessment.

Data collection process. Data extraction was conducted using a standardized form designed to capture key study characteristics and findings.[24] Reviewers extracted data such as study design, sample size, geographical focus, main outcomes, and specific aspects of genetic practices. Inconsistencies in data extraction were resolved through discussion and consensus, ensuring the accuracy and completeness of the extracted data.

Data items. Data items extracted from the studies included the following variables: titles of the articles, year of publication, language (Portuguese, French, or English language), journal name and country of authors, geographic location of the study, study design (such as, cross-sectional, longitudinal, descriptive), participant characteristics (age, gender, socio-economic status), specific focus on genetic and genomic education (such as prenatal, cancer, pediatric), various aspects of genetic counseling, including its impact, challenges, and opportunities in Southern Africa, outcomes measured (such as effectiveness of counseling, patient understanding, decision-making, professional orientation), and educational approaches utilized in genetic and genomic implementation.[25]

This comprehensive data extraction facilitated a nuanced understanding of the current state of genetic and genomic education and its impact in Southern Africa.[26]

Risk of bias assessment. In evaluating the risk of bias in individual studies, we adhered to the Cochrane Collaboration's tool for assessing the risk of bias. This comprehensive approach involved a systematic examination of several domains, including selection bias, performance bias, detection bias, attrition bias, and reporting bias. Two reviewers independently assessed each study using a standardized form to ensure consistency in the evaluation process. This rigorous process allowed for identifying studies with high, moderate, low, or unclear risk of bias, thereby providing insights into the overall quality and reliability of the evidence base.[27,28]

Synthesis of results. Extracted data from each eligible study in this systematic review were meticulously organized and tabulated to provide a clear and

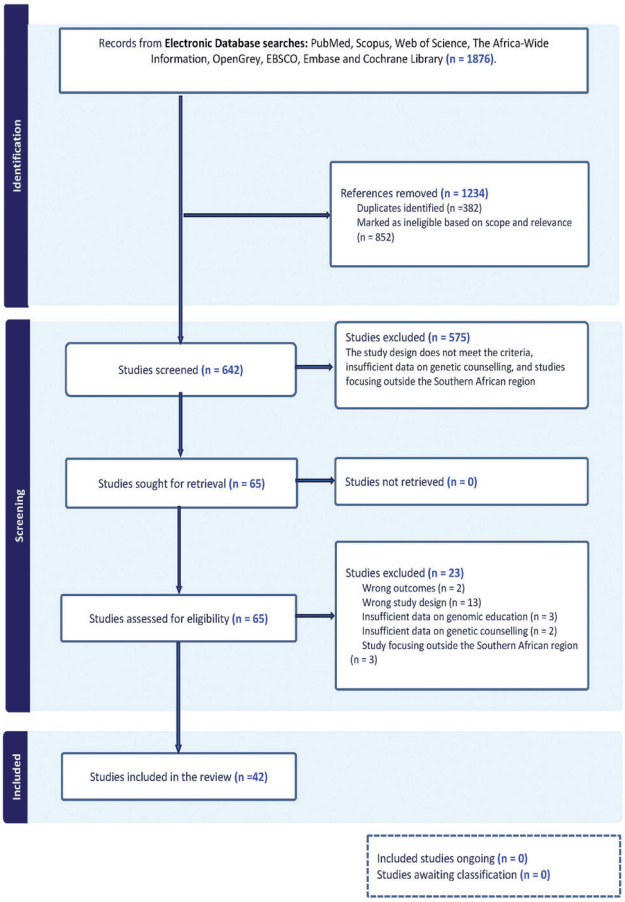

Figure 1 - PRISMA 2020 flow diagram illustrating the systematic review process, including identifying records through electronic database searches, the screening process for eligibility, and the final inclusion of studies.

comprehensive overview of the findings. It followed a structured approach and included key variables such as the titles of the articles, year of publication, language, journal name and author's country, syntax, study design, sample size, geographical setting, participant characteristics, specific focus on genetic counseling, and outcomes.

The data from the variables were also organized to provide a contextual interpretation and synthesis of the findings narratively, highlight patterns across studies, explore differences in methodologies and outcomes, and synthesize key insights within Southern Africa.

Results. The PRISMA flow diagram visually represents the systematic review process (Figure 1). This diagram clearly and concisely depicts the study selection process, starting from the initial number of records identified through database searching and other sources. The search and selection process initiated with the retrieval of 1,876 records. Upon the elimination of duplicates, 642 records were subjected to a screening of titles and abstracts. This screening led to the exclusion of 575 records due to their lack of relevance and alignment with the scope of our review. The resulting 65 full-text articles were further evaluated for eligibility. Of these, 42 studies satisfied the inclusion criteria and were incorporated into the final review. The predominant reasons for exclusion at the full-text assessment stage were non-compliance with the study design requirements, inadequate data regarding genetic counseling, and the focus of studies beyond the Southern African region, as also highlighted by authors

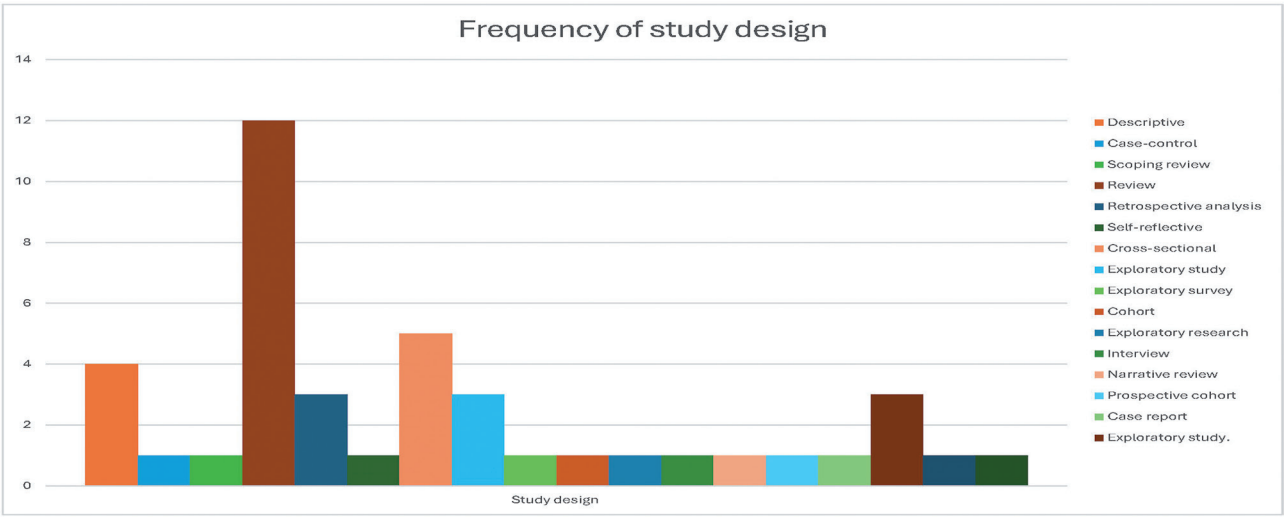

Figure 2 - Frequency of study design among the selected studies.

such as Kolaski et al.[24] Notably, no studies pertaining to genetic or genomic education within Angola were identified.

Table 1 details the summary of 42 included studies and some additional data was also distributed in Figure 2, Figure 3, and Figure 4. These studies covered a wide range of topics, including risk communication in genetic sessions, the uncertainty in gathering family history, genetic mutations in familial diseases, the impact of genetics on decision-making, and the challenges and recommendations for conducting genomics research in Africa.[8,29-31]

The research papers span from 2008 to 2024. In the first decade, they accounted for 45% of the included publications, while the remaining 7 years (from 2018 to 2024) accounted for 55%. The highest number of publications in one year was 7 (years 2019 and 2023), contrasting with 2010, 2014, and 2020, which had no relevant publications.

The studies were published in a wide range of reputable journals, such as the "European Journal of Medical Genetics," "Social Science and Medicine," and "Frontiers". The primary country of authorship was South Africa (83%), indicating a concentrated effort within South Africa to advance genetic counseling. Other studies also involve authors from multiple countries, addressing diverse genetic conditions and scenarios and indicating collaborative international research efforts while acknowledging the need for broader African insights. Most of the studies were set in South Africa, and its geographical settings varied widely, from urban settings, including tertiary hospitals, outpatient departments, and various healthcare clinics in Johannesburg, to multi-regional analyses across Southern Africa. Additionally, cultural and societal influences from different geographical regions were indicative of community variability and were crucial to understanding genetic counseling's challenges and opportunities in the region, as seen in studies exploring traditional beliefs about genetic disorders in South Africa.[32]

Unsurprisingly, all included studies used the English language as it reflects the author's first language, the international reach, and the academic standards of the journals involved.

The studies offered a rich spectrum of approaches, from descriptive studies (76%) to cross-sectional studies (17%), randomized controlled trials (5%), and a cohort study (2%), highlighting diverse research designs tailored to exploring the intricacies of genetic and genomic education.

Participants ranged from genetic counselors, patients with specific genetic conditions (such as Turner Syndrome, Hemophilia), mothers, and grandmothers to general practitioners, showcasing the wide range of stakeholders impacted by genetic counseling.[32-35] Consequently, a significant emphasis was placed on prenatal genetic counseling, decision-making processes, patient understanding, and the effectiveness of counseling, reflecting a broad spectrum of interests within the field of genetic counseling.

The sample sizes varied significantly across the studies, from as few as one case report to more extensive reviews involving up to 7,000 genetic counselors globally.[36,37] This variation reflected the breadth of research questions, from detailed case studies to broader exploratory and review studies.

With the rich environment across different medical conditions and cultural contexts, it was worth noting that the results also indicated that the focus areas varied and included prenatal genetic counseling, cancer risk communication, ethical considerations for schizophrenia, the impact of genetics on decision-making and patient understanding, and the integration of genetics within healthcare systems. However, only studies from the last 10 years demonstrate the integration of Next Generation Sequencing (NGS) and the exploration of point-of-care genetic testing models to illustrate the technological advancements influencing genetic practices in the region.[38,39] At the same time, ethical challenges, such as the return of incidental findings and navigating the complexities of genetics for conditions like schizophrenia are explored, highlighting the need for ethical guidelines and considerations in genetic research and counseling.[40]

The results in the column with the outcomes span a wide range of information, from the effectiveness of counseling and patient understanding to decision-making regarding prenatal screening and managing hereditary diseases to evaluating genetic testing technologies and exploring the emotional and ethical aspects of genetic counseling. Remarkably, these studies also emphasize the importance of culturally relevant approaches, the potential benefits of genetic testing for disease management and prevention, and the development of personalized medicine strategies.

Risk of bias assessment revealed that 21.4% of the studies had a high risk of bias, primarily due to inadequate blinding and incomplete outcome data. Approximately 29% exhibited a low risk of bias, and the remaining 50% were judged to have a moderate risk. This assessment underscored the need for cautious interpretation of the study findings, particularly those from studies with a high risk of bias.[41]

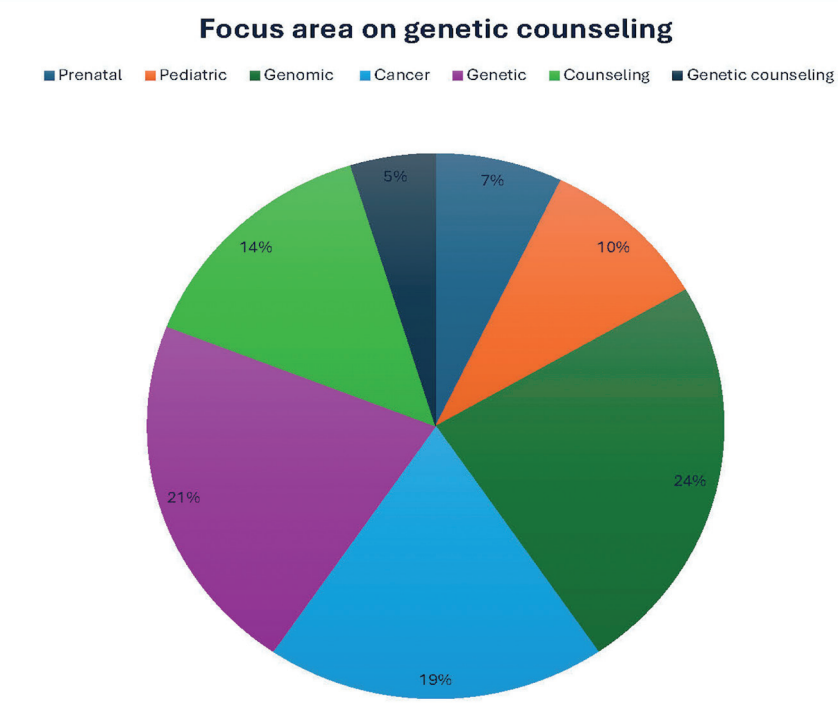

Figure 3 - Distribution of focus areas on genetic counseling among the selected published studies

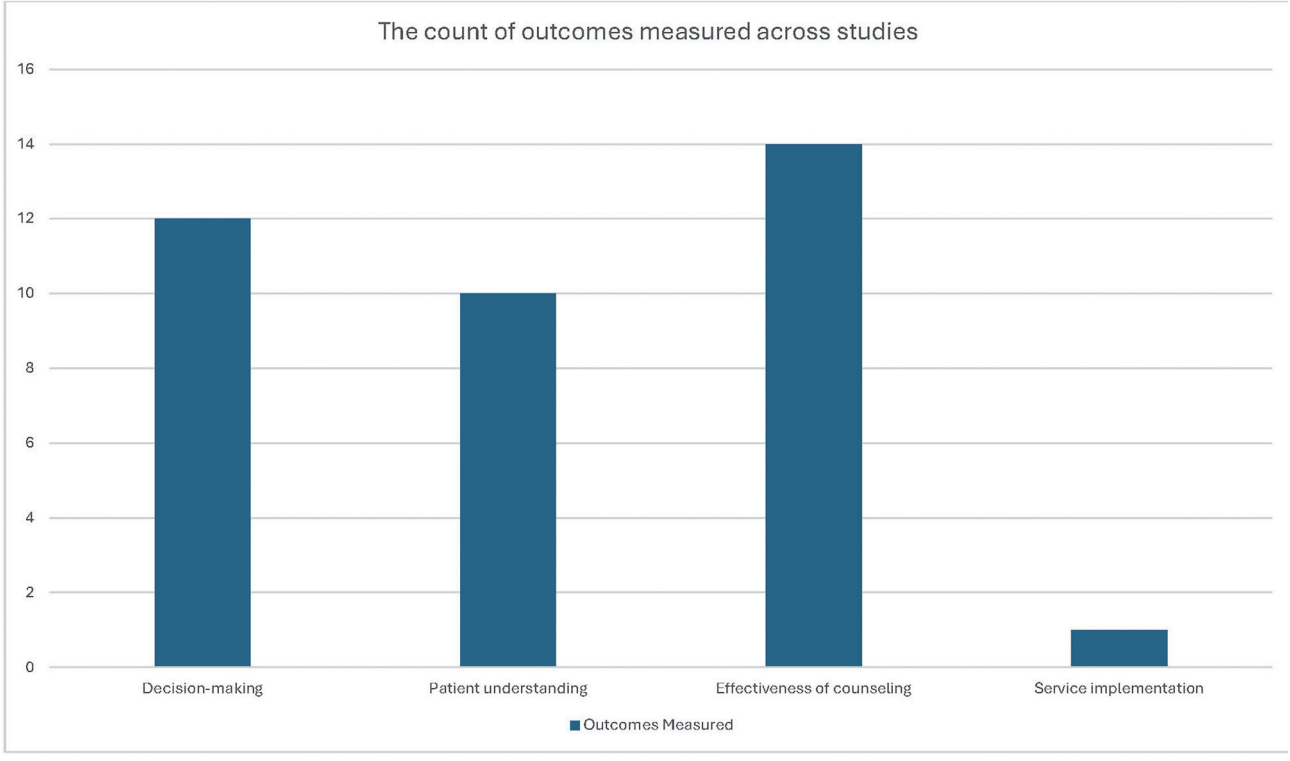

Figure 4 - Distribution of outcomes measured across the selected published studies.

Overall, the results gathered from the table show a considerable insight into the current state and future directions of genetic health and precision medicine in Southern Africa, aligning with the hypothesis that enhanced genetics can significantly benefit healthcare inclusivity and outcomes.

Discussion. This systematic review, encompassing 42 studies, provides a comprehensive panorama of the evolution of genetics in Angola and other countries in Southern Africa. The collated evidence reveals a multifaceted landscape where genetics is at an emerging stage but prepared for substantial growth.

This systematic review explored the realm of genetics in Southern Africa, including Angola, providing an insightful perspective on its current state and potential advancements. The evidence gathered through our research underscores the formative stages of genetics in this region. Despite the disparity in its development across countries or areas, as well as urban and rural settings, a foundational stage is set for further growth, with insights into existing practices offering a roadmap for future interventions. These findings are congruent with the hypothesis positing that advancements in genetic science are poised to substantially enhance healthcare inclusivity and outcomes across the region.

Central to our findings is the demonstrable role of genetics in enhancing patient understanding and facilitating informed decision-making in genetic health. This advance is particularly significant in a landscape where misconceptions about genetics and hereditary conditions are rampant and where the healthcare infrastructure often struggles with resource constraints. The positive impact of genetic counseling in these settings is a testament to its potential efficacy in diverse healthcare contexts. This positive trend, however, is set against a backdrop of substantial systemic challenges, including limited resources, insufficient genetic education among healthcare providers, and prevalent cultural misconceptions regarding genetics and hereditary diseases. In addressing these challenges, the review draws attention to innovative solutions emerging in the field. Pioneering studies like those by Haldane et al[42] and Zhong et al[43] underscore the efficacy of community-based approaches and culturally sensitive models. These models have shown promise in bridging the gap between advanced genetic practices and Southern African countries' unique cultural and socio-economic contexts. They offer a blueprint for crafting more inclusive and effective genetic services that resonate with the local community while addressing their specific needs and concerns.

A key finding of our review is the identification of barriers like infrastructural challenges, educational gaps, and cultural misunderstandings alongside facilitators such as community engagement and region-specific methods.[44] These challenges are compounded by inadequate policy support and strategic planning, as indicated by current policy and strategy documents pertaining to genomic medicine in Southern Africa. Such documentation highlights the urgent need for enhanced infrastructural and educational advancements in genomics, which are essential for translating genetic advancements into practical healthcare solutions.

These findings echo the sentiments of Haldane et al[42] and Zhong et al,[43] emphasizing the importance of understanding these regions' unique cultural and socio-economic backdrop in tailoring genetic strategies.

By addressing these foundational issues, Southern Africa can better harness the potential of precision medicine to meet the diverse health needs of its populations, thereby moving towards a more equitable healthcare system.

Our review substantiates the role of genetic counseling in enhancing patient understanding and decision-making, confirming its effectiveness across various healthcare settings in Southern Africa. Innovative, culturally congruent models, particularly those emphasizing community participation, have emerged as promising solutions to regional challenges, providing a template for future genetic strategies.[45]

The collective evidence gathered in our review supports the adoption of region-specific genetic frameworks, culturally competent healthcare practices, and improved infrastructure. Our findings lay the groundwork for future research, stressing the need for longitudinal studies to assess these interventions' enduring effects and sustainability. Such research will contribute significantly to developing a more robust, culturally sensitive, and efficient healthcare system in Southern Africa.

The synthesis of data extracted from the comprehensive table provides profound insights into the prevailing conditions and prospective trajectories of genetic health and precision medicine within Southern Africa. It is noteworthy, however, that these broad conclusions were drawn when the search strategy was specifically narrowed to focus on genetic counseling. This aspect underscores the necessity of interpreting these results within the context of the available data, which primarily centers on genetic counseling initiatives.

Study limitations. This systematic review encounters several constraints. A notable limitation is the propensity for publication bias, with a possible

underrepresentation of studies yielding negative or inconclusive outcomes. Moreover, the diversity in study methodologies, regional healthcare settings, and demographic variables complicate extracting universally applicable conclusions. The observed high risk of bias in the included studies (21%), as meticulously described by Fitz Gerald et al,[44] further needs a prudent interpretation of the aggregated data, acknowledging the possibility of skewed representations in some instances.

The lack of quantitative meta-analysis has also limited our systematic review due to the variability in study methodologies, outcomes, and contextual focus across the included studies, precluding the possibility of aggregating data for quantitative synthesis. Nevertheless, the data from our results show that genetics holds significant promise for improving healthcare outcomes in Angola and Southern Africa. Realizing this potential is contingent on systematically addressing the identified challenges, particularly the need for contextually adapted educational initiatives, infrastructure development, and building cultural competence among healthcare practitioners.[44] As noted by Cohen-Kfir et al[46] the region stands at a crucial juncture where targeted efforts in these areas can catalyze a transformative change in the landscape of genetic healthcare services.

Our results also indicate that the implications of our findings are manifold, and it is highly recommended that further and detailed studies of clinical practice be taken as a pressing need emerges for the development of region-specific genetic frameworks attuned to the unique cultural, economic, and infrastructural realities of the individual countries in Southern Africa. From a research perspective, there is a clear pathway for future investigations to focus on the effectiveness of such contextualized models, strategies to surmount existing barriers, and the exploration of longitudinal impacts of genetics on patient outcomes and healthcare system efficiencies. Furthermore, as Appiah et al[47] underscored, longitudinal studies investigating the long-term benefits and sustainability of integrated genetic services in these regions are imperative.

In conclusion, while challenges in genetic counseling in Southern Africa are evident, the potential for significant enhancements in healthcare inclusivity and effectiveness is undeniable. As countries like Angola in the Southern part of Africa go through the complexities of their unique healthcare challenges and the evolving field of genomic medicine, the insights from this review are crucial in shaping focused and effective strategies for fully managing genetic counseling. Further, this study acts as a call to action for longitudinal research efforts to further our understanding and application of these findings in creating a transformative healthcare landscape in Angola and other countries in Southern Africa.

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References

1. Quinonez SC, O'Connor BC, Jacobs MF, Tekleab AM, Marye A, Bekele D, et al. The introduction of genetic counseling in Ethiopia: Results of a training workshop and lessons learned. *PLoS One* 2021;16: e0255278.
2. Harding B, Webber C, Rühland L, Dalgarno N, Armour C, Birtwhistle R, et al. Bridging the gap in genetics: a progressive model for primary to specialist care. *BMC Med Educ* 2019; 19: 195.
3. Schmitt A. Município de Angola: Censo 2014 e estimativa de 2018. Rev Conexão Emancipacionista. Accessed 2024 September 9]. Available from: http://aurelioschmitt.blogspot.com/2018/02/municipios-de-angola-censo-2014-e.html
4. Greenberg J, Kromberg J, Loggenberg K, Wessels TM. Genetic Counselling in South Africa. In: Kumar D, editor. Genomics and Health in the Developing World. Oxford University Press; 2014. (2012; online edn, Oxford Academic, 1 Feb. 2014).
5. Gurdasani D, Carstensen T, Tekola-Ayele F, Pagani L, Tachmazidou I, Hatzikotoulas K, et al. The African Genome Variation Project shapes medical genetics in Africa. *Nature* 2015: 327-332.
6. Ibidunni L, Nunez KP, Jonassaint JC, De Castro L. Regional Differences in the Beliefs and practices among adults with sickle cell disease regarding reproductive health and family planning: A sub-analysis. *Blood* 2019; 134: 2114.
7. Adigwe OP, Onoja SO, Onavbavba G. A critical review of sickle cell disease burden and challenges in sub-saharan Africa. *J Blood Med* 2023; 14:367-376.
8. Wessels TM, Koole T. "There is a chance for me" – Risk communication in advanced maternal age genetic counseling sessions in South Africa. *Eur J Med Genet* 2019; 62: 390-396.
9. Schoeman M, Apffelstaedt JP, Baatjes K, Urban M. Implementation of a breast cancer genetic service in South Africa - lessons learned. *S Afr Med J* 2013; 103: 529-33.
10. Cragun D, Lewis C, Camperlengo L, Pal T. Hereditary Cancer: Example of a Public Health Approach to Ensure Population Health Benefits of Genetic Medicine. *Healthcare* 2016; 4: 6.
11. Biesecker BB, Peters KF, Resta R. Introduction to Genetic Counseling. In: Advanced Genetic Counseling: Theory and Practice. New York: Oxford Academic; 2019. Accessed March 16, 2024.
12. Jongeneel CV, Kotze MJ, Bhaw-Luximon A, Fadlelmola FM, Fakim YJ, Hamdi Y, et al. A view on genomic medicine activities in Africa: implications for policy. *Front Genet* 2022; 13: 769919.
13. Patch C, Middleton A. Genetic counselling in the era of genomic medicine. *Br Med Bull* 2018; 126: 27-36.

14. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. ***BMJ*** 2021; 372: n71.
15. Elliott JH, Turner T, Clavisi O, Thomas J, Higgins JPT, Mavergames C, et al. Living systematic reviews: an emerging opportunity to narrow the evidence-practice gap. ***PLoS Med*** 2014; 11: e1001603.
16. Jung A, Balzer J, Braun T, Luedtke K. Identification of tools used to assess the external validity of randomized controlled trials in reviews: a systematic review of measurement properties. ***BMC Med Res Methodol*** 2022; 22: 100.
17. Darling-Hammond L, Flook L, Cook-Harvey C, Barron B, Osher D. Implications for educational practice of the science of learning and development. ***Appl Dev Sci*** 2020; 24:97-140.
18. Wariri O, Okomo U, Kwarshak YK, Murray KA, Grundy C, Kampmann B. Timeliness of routine childhood vaccination in low- and middle-income countries, 1978–2021: Protocol for a scoping review to map methodologic gaps and determinants. ***PLoS One*** 2021; 16: e0253423.
19. Wilczewski M, Alon I. Language and communication in international students' adaptation: a bibliometric and content analysis review. ***High Educ (Dordr)*** 2023; 85: 1235-1256.
20. Desmedt M, Ulenaers D, Grosemans J, Hellings J, Bergs J. Clinical handover and handoff in healthcare: a systematic review of systematic reviews. ***Int J Qual Health Care***. 2021; 33: mzaa170.
21. Adams RJ, Smart P, Huff AS. Shades of grey: Guidelines for working with the grey literature in systematic reviews for management and organizational studies. ***Int J Manag Rev*** 2017; 19: 432-454.
22. Koffel JB. Use of recommended search strategies in systematic reviews and the impact of librarian involvement: a cross-sectional survey of recent authors. ***PLoS One*** 2015; 10: e0125931.
23. Kolaski K, Logan LR, Ioannidis JPA. Guidance to best tools and practices for systematic reviews. ***Syst Rev*** 2023; 12: 96.
24. Büchter RB, Weise A, Pieper D. Development, testing and use of data extraction forms in systematic reviews: a review of methodological guidance. ***BMC Med Res Methodol*** 2020; 20: 259.
25. Baine-Savanhu F, Macaulay S, Louw N, et al. Identifying the genetic causes of developmental disorders and intellectual disability in Africa: a systematic literature review. ***Front Genet*** 2023; 14: 1137922.
26. Bandara W, Furtmueller E, Gorbacheva E, Miskon S, Beekhuyzen J. Achieving rigor in literature reviews: Insights from qualitative data analysis and tool-support. ***Commun Assoc Inf Syst*** 2015; 37.
27. Higgins JPT, Altman DG, Gøtzsche PC, Jüni P, Moher D, Oxman AD, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. ***BMJ*** 2011; 343: d5928.
28. Haidich AB. Meta-analysis in medical research. ***Hippokratia*** 2010; 14: 29-37.
29. Scott M, Watermeyer J, Wessels TM. "We are just not sure what that means or if it's relevant": Uncertainty when gathering family history information in South African prenatal genetic counseling consultations. ***Soc Sci Med*** 2024; 342: 116555.
30. Moore SW, Zaahl MG. A review of genetic mutation in familial Hirschsprung's disease in South Africa: towards genetic counseling. ***J Pediatr Surg*** 2008; 43: 325-329.
31. Jongeneel CV, Kotze MJ, Bhaw-Luximon A, Fadlelmola FM, Fakim YJ, Hamdi Y, et al. A view on genomic medicine activities in Africa: implications for policy. ***Front Genet*** 2022; 13: 769919.
32. Penn C, Watermeyer J, MacDonald C, Moabelo C. Grandmothers as gems of genetic wisdom: exploring South African traditional beliefs about the causes of childhood genetic disorders. ***J Genet Couns*** 2010; 19: 9-21.
33. Van Wyk C, Wessels TM, Kromberg JG, Krause A. Knowledge regarding basic concepts of hereditary cancers, and the available genetic counselling and testing services: A survey of general practitioners in Johannesburg, South Africa. ***S Afr Med J*** 2016; 106: 268-271.
34. Morris M, Glass M, Wessels TM, Kromberg JG. Mothers' experiences of genetic counselling in Johannesburg, South Africa. ***J Genet Couns*** 2015; 24: 158-168.
35. Mafisa L, Dlova AN, Moodley V. The profile of patients with haemophilia managed at a haemophilia treatment centre in Pretoria, Gauteng. ***S Afr Fam Pract*** 2022; 64: e1-e7.
36. Abacan M, Alsubaie L, Barlow-Stewart K, et al. The global state of the genetic counseling profession. ***Eur J Hum Genet*** 2019; 27; 183-197.
37. Kinsley N. We Are 'Woman,' after all. ***J Genet Couns*** 2012; 21: 203-204.
38. Essajee F, Urban M, Smit L, et al. Utility of genetic testing in children with developmental and epileptic encephalopathy (DEE) at a tertiary hospital in South Africa: A prospective study. ***Seizure*** 2022; 101: 197-204.
39. Van Der Merwe N, Ramesar R, De Vries J. Whole exome sequencing in South Africa: Stakeholder views on return of individual research results and incidental findings. ***Front Genet*** 2022; 13: 864822.
40. Zingela Z, Sokudela F, Thungana Y, van Wyk S. Ethical principles, challenges and opportunities when conducting genetic counselling for schizophrenia. ***Front Psychiatry*** 2023; 14: 1040026.
41. Sterne JAC, Hernán MA, McAleenan A, Reeves BC, Higgins JPT. Chapter 25: Assessing risk of bias in a non-randomized study. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, editors. Cochrane Handbook for Systematic Reviews of Interventions version 6.4. Cochrane; 2023.
42. Haldane V, Chuah FLH, Srivastava A, Singh SR, Koh GCH, Seng CK, et al. Community participation in health services development, implementation, and evaluation: A systematic review of empowerment, health, community, and process outcomes. ***PLoS One*** 2019; 14: e0216112.
43. Zhong A, Darren B, Dimaras H. Ethical, social, and cultural issues related to clinical genetic testing and counseling in low- and middle-income countries: protocol for a systematic review. ***Syst Rev*** 2017; 6: 140.
44. FitzGerald C, Hurst S. Implicit bias in healthcare professionals: a systematic review. ***BMC Med Ethics*** 2017; 18: 19.
45. Tindana P, de Vries J, Campbell M, et al. Community engagement strategies for genomic studies in Africa: a review of the literature. ***BMC Med Ethics*** 2015; 16: 1-12.
46. Cohen-Kfir N, Bentwich ME, Kent A, Dickman N, Tanus M, Higazi B, et al. Challenges to effective and autonomous genetic testing and counseling for ethno-cultural minorities: a qualitative study. ***BMC Med Ethics*** 2020; 21: 98.
47. Appiah S, Korsah KA, AmpongAdjei C, Appiah OE. Genetic counseling in sickle cell disease: views of single young adults in Ghana. ***J Community Genet*** 2020; 11: 485-493.