original reports abstract

Authorship Patterns in Cancer Genomics Publications Across Africa

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PURPOSE Authorship is a proxy indicator of research capacity. Understanding the research capacity is imperative for developing population-specific cancer control strategies. This is particularly apropos for African nations, where mortality from cancer is projected to surpass that from infectious disease and the populations are critically under-represented in cancer and genomics studies. Here, we present an analysis and discussion of the patterns of authorship in Africa as they pertain to cancer genomics research across African countries.

METHODS PubMed metadata of relevant cancer genomics peer-reviewed publications on African populations, published between January 1, 1990, and December 31, 2019, were retrieved and analyzed for patterns of authorship affiliation using R packages, RISmed, and Pubmed.mineR.

RESULTS The data showed that only 0.016% (n = 375) of cancer publications globally were on cancer genomics of African people. More than 50% of the first and last authors of these publications originated from the North African countries of Tunisia, Morocco, Egypt, and Algeria. South Africa (13.6% and 12.7%) and Nigeria (2.2% and 1.9%) were the Sub-Saharan African countries most represented by first and last authorship positions, respectively. The United States contributed 12.6% of first and last authored papers, and nearly 50% of all African countries had no contributing author for the publications we reviewed.

CONCLUSION This study highlights and brings awareness to the paucity of cancer genomics research on African populations and by African authors and identifies a need for concerted efforts to encourage and enable more research in Africa, needed for achieving global equity in cancer outcomes.

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INTRODUCTION

Achieving global equity in health outcomes is determined by equitable representation and contribution to knowledge production. Hence, an understanding of the structural determinants of research inequalities is imperative in identifying national research capacity needs.[1] An important surrogate indicator of research capacity and productivity is the authorship of peer-reviewed publications.[2] Researches on the health needs of Africans have drawn interest globally, and African investigators have enjoyed research collaborations from high-income countries. However, factors like funding and research priorities have created power imbalances and structural inequalities between African researchers and their collaborators from high-income countries. These inhibit African scientists, including citizen scientists, from authorship recognition, publishing, or focusing the research on the health needs of African populations.[3,4]

One such critical area of need with huge inequality of outcomes in Africa is cancer. In Africa, cancer has gone from a quiet and hitherto unidentified disease[5-8] to a highly burdensome, devastating, and costly epidemic,[9-11] with more than 100% increase in the burden of some cancers between 1990 and 2017. Globocan 2018 projected a 100% increase in incidence and mortality by 2040.[10,12] The success of cancer control in Africa will require a more comprehensive understanding of the genomic landscape of cancer in Africans. The improved cancer survival in Europe and America resulted from the understanding of the risk factors identified through rigorous scientific studies on those populations.[13,14] It is, therefore, imperative to assess research capacity and identify areas in need of improvement to increase the likelihood for effective cancer control across the continent.

One measure of a country's research capacity is the number of scientific articles authored by researchers

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CONTEXT

Key Objective

With the increasing burden of cancer in Africa, it is important to identify factors that impede the application of genomics to cancer control on the continent. We used the authorship of cancer genomics publications to assess the extent to which the lack of knowledge production is hindering progress.

Knowledge Generated

Our findings showed that despite the increasing cancer burden, the number of publications on Cancer Genomics in Africa represents only 0.016% of all cancer genomics papers with more than half of the continent not represented in a single publication and where North African countries and South Africa are leading the knowledge production by a significant margin. In tandem, African scientists are also grossly under-represented in Cancer Genomics Research publications and are rarely positioned as either first or last authors with North Africa and South Africa being exceptions. These data indicate that not only is there a dearth of cancer genomics data but also the capacity to generate knowledge is lacking across most of the continent, especially in the Sub-Saharan regions.

Relevance

This study highlights the need to increase the capacity to generate cancer genomics knowledge across the continent, a feat that is critical for the fight against cancer among Africans and for attaining global health equity.

affiliated to homeland institutions.[15,16] There has been a doubling of publications by African researchers in the fields of science, technology, engineering, and math from 2003 to 2012.[17] However, cancer genomics remains nascent with limited resources available to African scientists to conduct costly genomics studies, stifling progress in the field.[18-20] To address this problem and study the potential research capacity across Africa, we conducted a metadata analysis of authorship for cancer genomics articles published on African populations.

METHODS

Data on genomics publications in any language were extracted from PubMed (covering the period of January 1, 1990, to December 31, 2019). The PubMed Medical Subject Headings (MeSH)[21,22] term {neoplasm} was used to retrieve all articles indexed by PubMed curators to be related to cancer. The search was restricted to publications on African countries alone by systematically including 54 African countries and combinations of study parameters (gene or protein or molecular biology or mutation or genetics or genomics) as key search terms. To avoid ambiguity, only publications with MeSH terms genetic or genomics or mutation were included as genomics papers. These publications were manually verified by two authors (S.O.R. and O.A.R.). Particular attention was paid to ensure that the included publications used biospecimens of African origin.

Thereafter, the publications' PubMed metadata was downloaded and analyzed using RISmed.[23] For the purpose of extracting the metadata on authorship, the article titles, abstracts, and authors' information were collected and subjected to text mining using the R package Pubmed.mineR.[24] For this study, we used the country of affiliation for each author listed in the 375 publications as the origin(s) of each publication.[25,26] However, where an author was affiliated to multiple countries, only the African country or the country where the biospecimen was sourced was considered.

To depict the pattern of authorship seniority, we generated a collaborative interactome between the countries of first authorship and co-authorship. To achieve this, we used Gephi[27] to generate a directed network in which the size of the nodes was proportional to the number of authors affiliated to each country and the positions of the nodes illustrating the geographical locations.[27] Furthermore, we proposed an estimate to assess each country's research capacity to address its cancer burden. This estimate, termed knowledge production index (KPI), was derived by normalizing the total (all) authorship in any position for each country with its GLOBOCAN estimated cancer incidence for 2018,[10] by using the following formula:

$$\mathrm{KPI} = \log_{10}\left(1 - \left(\frac{\text{Number of authors in any position}}{\text{2018 GLOBOCAN cancer incidence}}\right)\right),$$

where 1 is an arbitrary digit that was introduced to prevent the logarithmic error since some countries lack authorship, and cancer incidence was the estimated number of prevalent cases (5 year) as a proportion per 100,000 in 2018 for all cancers in both sexes between age 0 and 74.[10]

Finally, to assess the factors that influence the KPI of African countries, we correlated the KPI values with 2017 gross domestic product per capita[28], 2017 human development index,[29] and number of cancer-related foreign grants awarded to each country, herewith referred to as grant records,[30] using Tableau (2019.4.1). The grant records were retrieved from World RePORT.[31]

RESULTS

There Is a Knowledge Gap on the African Cancer Genome, Evidenced by Very Few Peer-Reviewed Publications

The total number of publications returned by our Pubmed MeSH terms (cancer, cancer molecular biology, and cancer genomics) on African populations between January 1, 1990, and December 31, 2019, is shown in Figure 1A. Of nearly 2.4 million publications, a meager 0.329% was related to cancer in Africa. Of these, 19% (n = 1,456) were related to molecular biology or genomics of cancer in Africa. Only 375 (0.16%) publications (353 in English and 22 in French) were focused on cancer genomics of African populations. This represents only about 5% of cancer research papers on African populations and is compared with about 173,000 overall cancer genomics publications. The number of cancer genomics publications grew steadily in Africa from an average of four per year between 1990 and 1995 to about 27 per year between 2016 and 2019 (Fig 1B), with the biggest spike occurring between 2005 and 2015.

African Scientists Are Under-Represented in African Cancer Research Publications

Next, we examined the geographical distribution of first, last, and an author in any position, as well as the collaborative interaction between authors, based on country of affiliation for the 375 genomics publications, and presented the top 10 publishing countries in Figures 2A-2C. South Africa (13.6% first author and 12.7% last author) and the North African countries of Tunisia (23.8% and 22.2%), Egypt (16.5% and 15.9%), Morocco (12.2% and 12.4%), and Algeria (3.0% and 2.4%) had more first and last authors than other African countries. Among non-African countries, the United States, France, Italy, and Australia had the most number of authors (Figs 2A and 2B) for any category (first, last, or any position), with the United States being represented up to four fold more than other non-African countries. Overall, the geographical distribution showed that there were more authors from North African countries than all the other parts of Africa combined (Fig 2C). We did not retrieve any publication with author affiliation from the following countries: Angola, Benin, Burundi, Cabo Verde, Central African Republic, Chad, Comoros, Republic of Congo, Djibouti, Equatorial Guinea, Eritrea, Eswatini, Réunion, Guinea-Bissau, Lesotho, Liberia, Libya, Madagascar, Mauritania, Mozambique, Namibia, Niger, Sao Tome and Principe, Sierra Leone, Somalia, South Sudan, and Zambia. Additional review of the 375 publications revealed that 24 publications using African biospecimens had no African author.

The collaborative interactome demonstrates the size of the collaborations between the affiliated countries (Fig 2D). The top five collaborative country pairs were Tunisia → France (n = 36), United States → Nigeria (n = 33), South Africa ↔ Egypt (n = 20), Tunisia → South Africa (n = 15), and South Africa ↔ Gambia (n = 15). Other noteworthy collaborations between African countries were Egypt → Tunisia (n = 12), Sudan → Tunisia (n = 10), and Egypt → Uganda (n = 9).

Africa Does Not Have the Research Capacity to Meet the Demands of Its Growing Cancer Burden, As Indicated by the Knowledge Production Index

Finally, we calculated each country's KPI to serve as a surrogate indicator of a country's capacity to conduct biomedical research, which is needed to help address its cancer burden as reported in GLOBOCAN 2018.[10] For this, the total number of authors in any position for a given country in the 375 publications was normalized to the cancer incidence of that country, and the resulting KPI is visualized in the geographical heatmap of Africa, as shown in Figure 3. Tunisia (0.65) had the highest KPI, followed by Morocco (0.37) and Egypt (0.32) (Fig 3). These data show that overall, there is a low KPI across the continent indicative of an ill-equipped research enterprise. Next, we found that overall, KPI was poorly to moderately correlated with the number of cancer-related foreign grants awarded

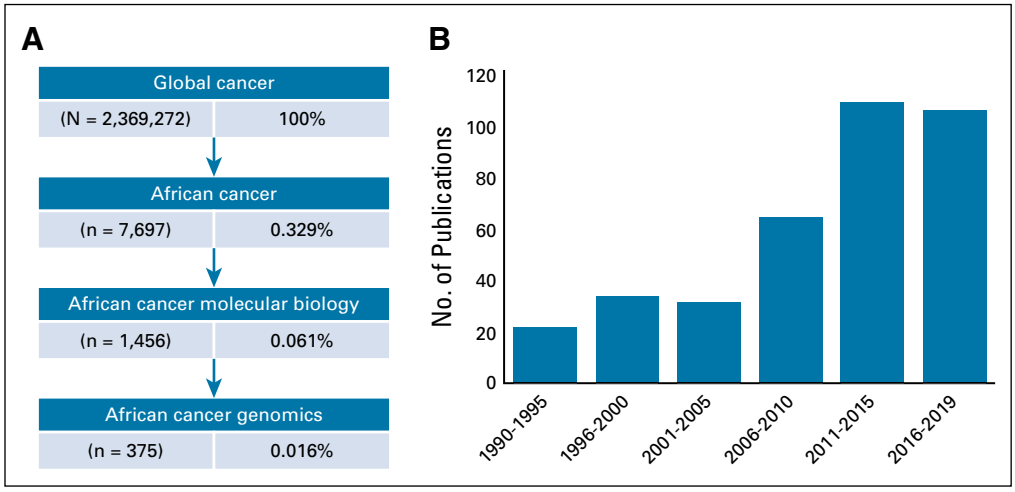

FIG 1. Number of peer-reviewed publications obtained from PubMed. (A) The relative proportion of publications for each Medical Subject Headings term was expressed as a percentage of total number of publications on cancer. (B) Yearly distribution of the number of peer-reviewed publications on cancer genomics on African populations.

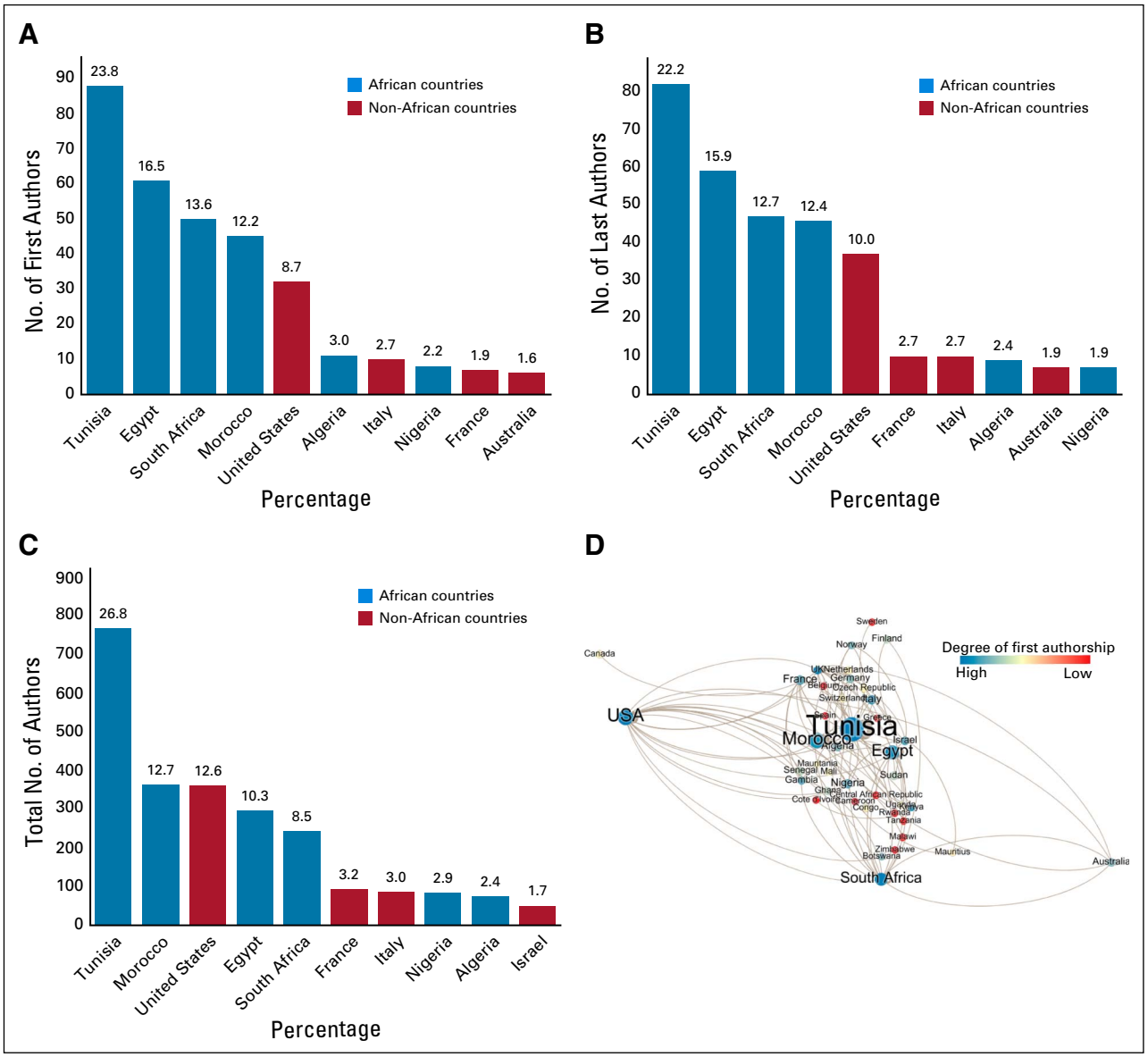

FIG 2. Authorship affiliation and collaboration pattern. (A) Histogram showing top 10 countries with first authors, (B) last authors, (C) or author in any position. (D) Authorship collaborative interactome, with the node size corresponding to the total number of authors in any position and node color representing the degree to which a country has contributed first authors.

to investigators in African countries depending on region (Fig 4). When graphed by region, South Africa ($P = .0002$ and $r^2 = 0.979$) had the strongest linear relationship of KPI to the number of grants, followed by West Africa ($P = .003$ and $r^2 = 0.477$) and Central Africa ($P = .060$ and $r^2 = 0.418$). Interestingly, KPI most poorly correlated with the number of grants received for North Africa ($P = .322$ and $r^2 = 0.242$), where KPI exceeded the number of foreign grants, and East Africa ($P = .0006$ and $r^2 = 0.558$), where the number of foreign grants did not improve KPI. The relationships between KPI and the number of grants in North Africa and Central Africa showed that KPI did not achieve statistical significance, suggesting the contribution of other factors. KPI was not associated with the gross domestic product per capita (Fig 4) and only slightly associated with the human development index within Africa (result not shown).

DISCUSSION

In the current study, we studied patterns in authorship for publications related to cancer genomics research in Africa. The purpose was to use these data as a surrogate for a country's internal research capacity and to bring awareness to the dearth of knowledge in a field essential for understanding the cancer epidemic riddling the continent. In terms of authorship numbers and lead authorship positions (first or last), the North African countries of Tunisia, Egypt, and Morocco contributed the highest number of authors for

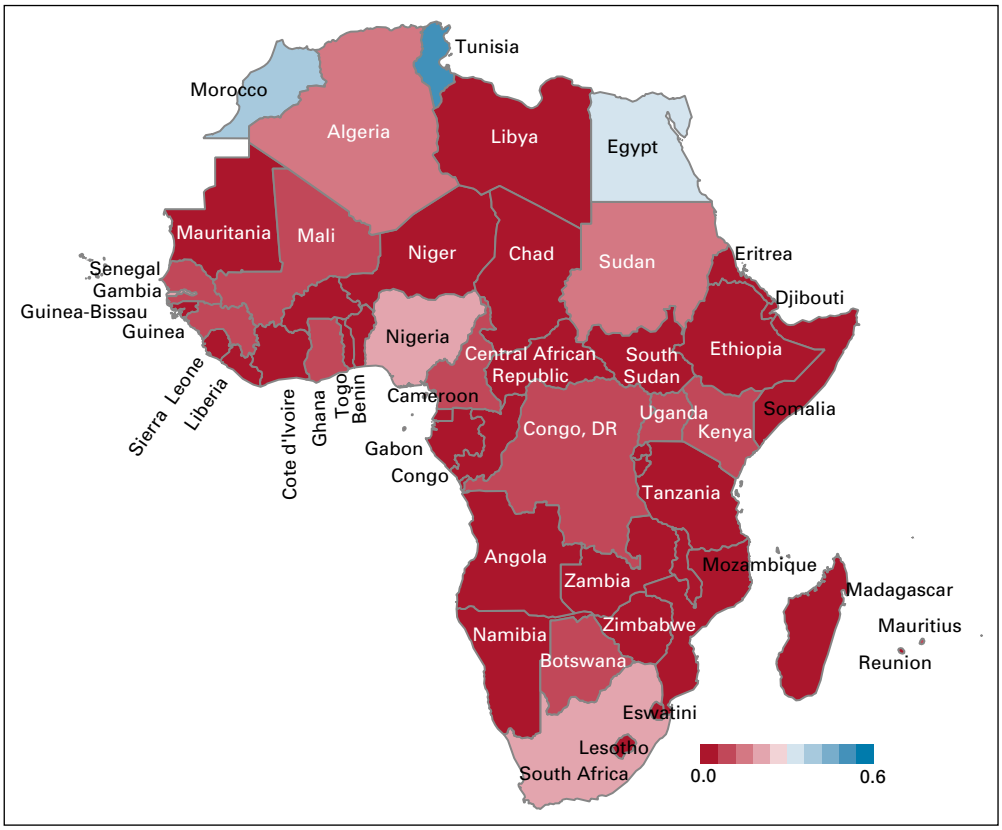

FIG 3. Relative knowledge production index map for cancer genomics publications in Africa. Congo, DR, Democratic Republic of the Congo.

the publications we reviewed. There were more authors from the United States, than France, Italy, Israel, or any other non-African country. Besides North Africa, South Africa is the only Sub-Saharan African country with more first and last authors than the United States. Up to 50% of African countries, mainly in the Sub-Saharan region, did not have any publications and/or affiliated authors studying their populations. This observation is consistent with the study by Mbaye et al,[32] who reported the underrepresentation of African authorship in research in the area of infectious diseases in Africa and attributed the authorship gap to lack of capacity and inequitable research partnership. This lack of authorship in many African countries could also be a reflection of the widespread lack of indigenous skilled oncology scientists and physicians in many African countries, as earlier reported by Boyle et al.[33] This 2017 report highlighted the dearth of pathologists in Sub-Saharan Africa, with only South Africa, Botswana,

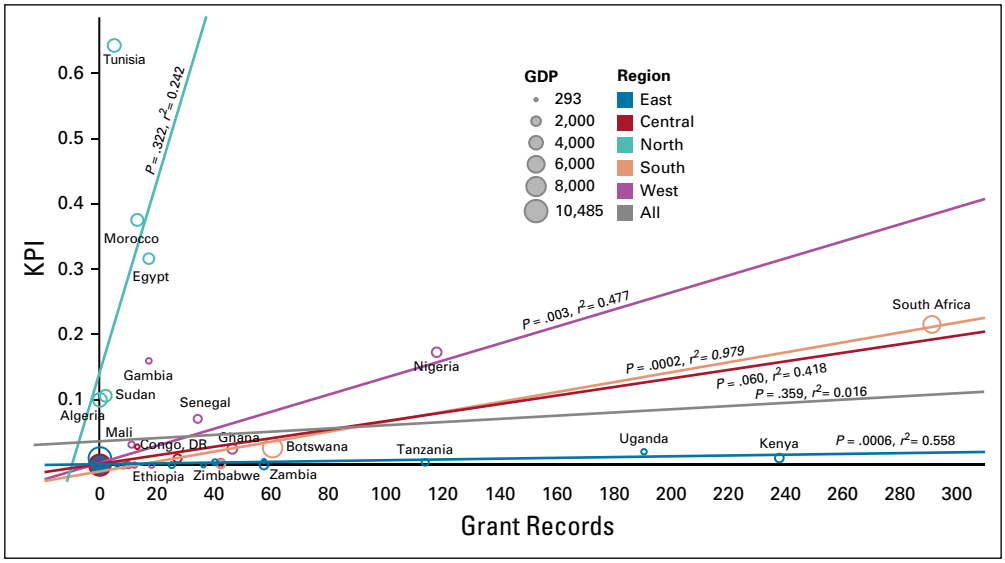

FIG 4. Correlation of KPI with GDP per capita and grant records of each African country. The size of the data points corresponds to the 2017 GDP per capita, whereas the color represents African region. Gray line is indicative of the overall correlation. Congo, DR, Democratic Republic of the Congo; GDP, gross domestic product; KPI, knowledge production index.

Namibia, Kenya, Gabon, Ghana, and Cameroon having more than one Pathologist per 1 million people. Hence, the lack of pathologists in these countries would grossly impede the diagnosis and treatment of cancer and likely, concomitantly, hampers cancer research. Furthermore, the lack of functional research ethics boards across the continent would add additional challenges for conducting translational genomics research.[34]

US-affiliated authors have the highest and most diverse research enterprise and funding supported in large part by the National Institute of Health.[30] Many of these National Institute of Health–supported investigations seek to understand the genetic etiology of cancer among African Americans, for whom the African populations provide the indispensable ancestral root for comparative studies,[35] underscoring the need to decipher the African cancer genome. These efforts are also helping to support US-led efforts in Africa, which is contributing to the high number of US-authored papers[32] and also to advancing cancer genomics research and training on the continent.

Despite these efforts, authoring papers remains quite low, and the impact of research funding to Africa varies by region, where funding from foreign grants did not necessarily correlate strongly with research productivity. We assessed return on investment by grants by correlating KPI with the number of grants received. North Africa had the highest conversion of grants to publications doing better than would be expected, whereas East Africa had the lowest productivity and fell behind expectations based on KPI. Although a caveat to this analysis is that of not knowing the dollar amounts funded, the data suggest that other factors, such as famine and war, affect research productivity independent of funding. North Africa clearly outperformed the Sub-Saharan regions for seemingly having the highest conversion of grants to publications. One could speculate that this is in part due to having more PhD-level science, technology, engineering, and math scientists than Sub-Saharan countries, with North Africa having more than 700% more researchers per million inhabitants than the Sub-Saharan region.[36] Aside from the infusion of grants, West Africa's productivity is strengthened by a high level of collaboration with US scientists.

Certainly, the barriers to progress and the reasons for differential progress across the continent are complex and multifactorial and cannot all be identified or discussed within the scope of our manuscript. Nevertheless, acknowledging a number of potential factors is highly prudent. For example, the reliance on English as a lingua franca for academic scholarly output could be a barrier for some African countries.[37] It is also important to note that our findings do not indicate that the lingua franca or history of colonialism has any influence on productivity in Africa. Level and access to education, however, could have profound effects. Data from the Times Higher Education World University Rankings 2021[38] only ranked 63 universities across Africa, with more than half of these in North Africa: North Africa (n = 42), Southern Africa (n = 12), Western Africa (n = 7), and Eastern Africa (n = 2). The ranking metrics used by Times Higher Education also rely on scholarly articles in peer-reviewed journals that are affiliated with a specific university. It is therefore not surprising that these University rankings mirror our observations for productivity for different African regions. Another major impedance to research breakthroughs in health genomics in Africa is the dearth of next-generation genome sequencing facilities,[39] with Africa having the least number of genome sequencing centers compared with other continents.

A low rate of publishing could be related to the idea of vampire or helicopter science—where foreign research groups working with African-based physicians and scientists acquire biospecimens and related data but without giving proper credit or providing an opportunity for further involvement.[40,41] About 7% (n = 24) of the publications we analyzed had no authors affiliated to African institutions[42-64] and three additional papers had African affiliations from another country.[65-67] Nigeria was the most affected nation without recognition in eight papers.[43,47,52,53,56-59] In the study by Akinloye et al,[66] the research participants were recruited from Ibadan, Nigeria, but no author from Nigeria was listed on the publication, but rather, South Africa was the affiliated country. Such practices have clinical, ethical, and academic implications[68] and need to be addressed. It is important to note that according to the *International Committee of Medical Journal*,[69,70] a major criterion for authorship is the substantial contribution to sample or data acquisition by an investigator. So although scientific vampirism may not directly explain the lack of correlation of funding with research productivity, it could sway others in Africa from taking part in research with foreign entities, limiting academic opportunities that could increase authorship and impede clinical breakthroughs.[71] The denial of authorship to African investigators is therefore of concern, and concerted efforts by funding bodies, editors, and the scientific community at large are needed to reduce scientific vampirism.[72,73] It is important that non-African–affiliated researchers involve African investigators in authorship-meriting aspects of the research and foster initiatives that will improve research infrastructure in Africa, which will equalize the partnership and promote team science.[74] Similarly, African researchers should have upfront discussions on the nature and scope of the collaboration[75] and institute agreements that guarantee them authorship and intellectual protections.

The African population now accounts for a quarter of the global population and is projected to experience an upsurge in cancer incidence. However, our estimation of the KPI showed a critical drought of human capital to engage in cancer genomics research on the continent. At present, African countries without authorship or representation in

cancer genomics amount to half of the continent. These understudied countries may hold the secret to solving global cancer burden because of the high-level genomic diversity and presence of the archaic genome within ancient African populations.[76] These populations are genetically similar to and/or represent the hunter-gatherers (southern San groups) and Iron Age farmers (Bantu-language speakers).[77,78] Therefore, to achieve global cancer equity, it is expedient for cancer genomics research to focus on understanding how the genome of these ancient populations influences their cancer burden and also to improve the capacity of African cancer investigators to conduct genomic research and use indigenous cancer genomics data.[79]

This study used only PubMed indexed publications because it is the most reputable index for biomedical peer-reviewed publications. Although our reliance on MeSH, as against free-text search, could have excluded some publications, MeSH has the advantage of involving synonym control and yielding precise search results.[22] The omitted publications, however, would not have changed the pattern of the results presented in this study or overall conclusions.

In summary, this study demonstrated and enumerated the degree to which there is a deficit in cancer genomics research studies across African countries. Although the need to increase cancer care facilities on the continent has been previously discussed[80] as a means to reduce the burden of cancer on the continent by improving detection and treatment strategies, increasing cancer genomic research infrastructure and capacity through training and studying the African population through biospecimen accrual will have a far-reaching impact. This will consequently expand the diversity in genome databases with concomitant improvement in global cancer care and prevention. It is, therefore, incumbent on African policymakers to implement national policies in science and health to achieve the much-needed growth and development of genome sciences across the continent.

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Data analysis and interpretation: All authors
Manuscript writing: All authors
Final approval of manuscript: All authors
Accountable for all aspects of the work: All authors

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

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Open Payments is a public database containing information reported by companies about payments made to US-licensed physicians (Open Payments).

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Uncompensated Relationships: CpG Diagnostics

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REFERENCES

1. Cash-Gibson L, Rojas-Gualdron DF, Pericas JM, et al: Inequalities in global health inequalities research: A 50-year bibliometric analysis (1966-2015). PLoS One 13:e0191901, 2018
2. Langhaug LF, Jack H, Hanlon C, et al: "We need more big trees as well as the grass roots": Going beyond research capacity building to develop sustainable careers in mental health research in African countries. Int J Ment Health Syst 14:66, 2020
3. Busse C, August E: Addressing power imbalances in global health: Pre-Publication Support Services (PREPSS) for authors in low-income and middle-income countries. BMJ Glob Health 5:e002323, 2020
4. Ward-Fear G, Pauly GB, Vendetti JE, et al: Authorship protocols must change to credit citizen scientists. Trends Ecol Evol 35:187-190, 2020
5. Gowshall M, Taylor-Robinson SD: The increasing prevalence of non-communicable diseases in low-middle income countries: The view from Malawi. Int J Gen Med 11:255-264, 2018
6. Higginson J: Malignant neoplastic disease in the South African Bantu. Cancer 4:1224-1231, 1951
7. Vint F: Malignant disease in the natives of Kenya. Lancet 2:628-630, 1935
8. Hollander B: Freedom of negro races from cancer. Br Med J 2:46, 1923
9. Gouda HN, Charlson F, Sorsdahl K, et al: Burden of non-communicable diseases in sub-Saharan Africa, 1990–2017: Results from the Global Burden of Disease Study 2017. Lancet Glob Health 7:e1375-e1387, 2019
10. Bray F, Ferlay J, Soerjomataram I, et al: Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 68:394-424, 2018

11. Graff S: Africa's neglected epidemic. J Natl Cancer Inst 109:djx169, 2017
12. Mattiuzzi C, Lippi G: Cancer statistics: A comparison between World Health Organization (WHO) and global burden of disease (GBD). Eur J Public Health 30:1026-1027, 2019
13. Heramb C, Wangensteen T, Grindedal EM, et al: BRCA1 and BRCA2 mutation spectrum—An update on mutation distribution in a large cancer genetics clinic in Norway. Hered Cancer Clin Pract 16:3, 2018
14. Silverman TB, Kuperman GJ, Vanegas A, et al: An applied framework in support of shared decision making about BRCA genetic testing. AMIA Annu Symp Proc 2018:961-969, 2018
15. Bowsher G, Papamichail A, El Achi N, et al: A narrative review of health research capacity strengthening in low and middle-income countries: Lessons for conflict-affected areas. Global Health 15:23, 2019
16. Gonzalez-Alcaide G, Park J, Huamani C, et al: Dominance and leadership in research activities: Collaboration between countries of differing human development is reflected through authorship order and designation as corresponding authors in scientific publications. PLoS One 12:e0182513, 2017
17. Blom A, Lan G, Adil M: Sub-Saharan African Science, Technology, Engineering, and Mathematics Research: A Decade of Development. Washington, DC, The World Bank, 2015
18. Hill S: Introducing genomics into cancer care. Br J Surg 105:e14-e15, 2018
19. Malats N, Katsila T, Patrinos GP: Cancer genomics and public health. Pub Health Gen 20:67-69, 2017
20. Mardis E: Cancer genomics. F1000Res 4:F1000 Faculty Rev-1162, 2015
21. Rogers FB: Medical subject headings. Bull Med Libr Assoc 51:114-116, 1963
22. Chang AA, Heskett KM, Davidson TM: Searching the literature using medical subject headings versus text word with PubMed. Laryngoscope 116:336-340, 2006
23. Kovalchik S: RISmed: Download content from NCBI databases. R Package, Version 2.1. 7. 2018
24. Rani J, Ramachandran S: pubmed. mineR: An R package with text-mining algorithms to analyse PubMed abstracts. J Biosci 40:671-682, 2015
25. Schmidt CM, Cox R, Fial AV, et al: Gaps in affiliation indexing in Scopus and PubMed. J Med Libr Assoc 104:138-142, 2016
26. Ibarra ME, Ferreira JP, Torrents M, et al: Changes in PubMed affiliation indexing improved publication identification by country. Scientometrics 115:1365-1370, 2018
27. Bastian M, Heymann S, Jacomy M: Gephi: An open source software for exploring and manipulating networks. Third International AAAI Conference on Weblogs and Social Media, San Jose, CA, May 17-20, 2009
28. World Bank. World Development Indicators. https://data.worldbank.org/indicator/NY.GDP.PCAP.CD
29. United Nations Development Programme. Human Development Report. http://hdr.undp.org/en/data
30. Adam T, Akuffo H, Carter JG, et al: World RePORT: A database for mapping biomedical research funding. Lancet Glob Health 8:e27-e29, 2020
31. National Institutes of Health. World Report: National Institutes of Health; 2019. https://worldreport.nih.gov/app/#!/
32. Mbaye R, Gebeyehu R, Hossmann S, et al: Who is telling the story? A systematic review of authorship for infectious disease research conducted in Africa, 1980–2016. BMJ Glob Health 4:e001855, 2019
33. Boyle P, Ngoma T, Sullivan R, et al: The State of Oncology in Africa, 2015, Volume 4. Lyon, France, iPRI Scientific Publication, 2016
34. Barchi F, Little MT: National ethics guidance in Sub-Saharan Africa on the collection and use of human biological specimens: A systematic review. BMC Med Ethics 17:64, 2016
35. Adewole I, Martin DN, Williams MJ, et al: Building capacity for sustainable research programmes for cancer in Africa. Nat Rev Clin Oncol 11:251-259, 2014
36. United Nations Educational, Scientific and Cultural Organization Institute for Statistics. 2017. http://data.uis.unesco.org
37. Suzina AC: English as lingua franca. Or the sterilisation of scientific work. Media Cult Soc 43:171-179, 2021
38. Times Higher Education: World University Rankings 2021. https://www.timeshighereducation.com/world-university-rankings/2021/world-ranking#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/stats 2021
39. Helmy M, Awad M, Mosa KA: Limited resources of genome sequencing in developing countries: Challenges and solutions. Appl Transl Genom 9:15-19, 2016
40. Rees CA, Lukolyo H, Keating EM, et al: Authorship in paediatric research conducted in low- and middle-income countries: Parity or parasitism? Trop Med Int Health 22:1362-1370, 2017
41. Bavdekar SB: Authorship issues. Lung India 29:76-80, 2012
42. Phelps HM, Pierce JM, Murphy AJ, et al: FXR1 expression domain in Wilms tumor. J Pediatr Surg 54:1198-1205, 2019
43. McWilliams RR, Wieben ED, Chaffee KG, et al: CDKN2A germline rare coding variants and risk of pancreatic cancer in minority populations. Cancer Epidemiol Biomarkers Prev 27:1364-1370, 2018
44. El-Amrani-Joutey M, Jimenez-Garcia R, Linares-Garcia-Valdecasas R, et al: Infection by Epstein-Barr virus in Fes (Morocco). Prevalence and predictors of positivity in nasopharyngeal cancer. J Infect Public Health 11:807-811, 2018
45. Wang Y, Freedman JA, Liu H, et al: Associations between RNA splicing regulatory variants of stemness-related genes and racial disparities in susceptibility to prostate cancer. Int J Cancer 141:731-743, 2017
46. McKay J, Tenet V, Franceschi S, et al: Immuno-related polymorphisms and cervical cancer risk: The IARC multicentric case-control study. PLoS One 12:e0177775, 2017
47. Catucci I, Casadei S, Ding YC, et al: Haplotype analyses of the c.1027C>T and c.2167_2168delAT recurrent truncating mutations in the breast cancer-predisposing gene PALB2. Breast Cancer Res Treat 160:121-129, 2016
48. Mathew S, Abdel-Hafiz H, Raza A, et al: Host nucleotide polymorphism in hepatitis B virus-associated hepatocellular carcinoma. World J Hepatol 8:485-498, 2016
49. Quiles F, Teule A, Martinussen Tandstad N, et al: Identification of a founder BRCA1 mutation in the Moroccan population. Clin Genet 90:361-365, 2016
50. Lovvorn HN III, Pierce J, Libes J, et al: Genetic and chromosomal alterations in Kenyan Wilms Tumor. Genes Chromosomes Cancer 54:702-715, 2015
51. Shan J, Al-Rumaihi K, Rabah D, et al: Genome scan study of prostate cancer in Arabs: Identification of three genomic regions with multiple prostate cancer susceptibility loci in Tunisians. J Transl Med 11:121, 2013
52. Zheng Y, Huo D, Zhang J, et al: Microsatellites in the estrogen receptor (ESR1, ESR2) and androgen receptor (AR) genes and breast cancer risk in African American and Nigerian women. PLoS One 7:e40494, 2012
53. Murphy AB, Ukoli F, Freeman V, et al: 8q24 risk alleles in West African and Caribbean men. Prostate 72:1366-1373, 2012
54. Ghaleb KI, Alkaladi A: Homozygous deletion of the FHIT gene, p21WAF1 protein expression and apoptosis in bilharzial bladder cancer. Pak J Biol Sci 14:212-218, 2011

55. Lei YJ, Makhaola K, Pittayakhajonwut D, et al: Human papillomavirus 16 variants from Zambian women with normal pap smears. J Med Virol 83:1230-1237, 2011
56. Zhang J, Fackenthal JD, Huo D, et al: Searching for large genomic rearrangements of the BRCA1 gene in a Nigerian population. Breast Cancer Res Treat 124:573-577, 2010
57. Panguluri RC, Long LO, Chen W, et al: COX-2 gene promoter haplotypes and prostate cancer risk. Carcinogenesis 25:961-966, 2004
58. Kittles RA, Young D, Weinrich S, et al: Extent of linkage disequilibrium between the androgen receptor gene CAG and GGC repeats in human populations: Implications for prostate cancer risk. Hum Genet 109:253-261, 2001
59. Kittles RA, Panguluri RK, Chen W, et al: Cyp17 promoter variant associated with prostate cancer aggressiveness in African Americans. Cancer Epidemiol Biomarkers Prev 10:943-947, 2001
60. Gao SJ, Zhang YJ, Deng JH, et al: Molecular polymorphism of Kaposi's sarcoma-associated herpesvirus (human herpesvirus 8) latent nuclear antigen: Evidence for a large repertoire of viral genotypes and dual infection with different viral genotypes. J Infect Dis 180:1466-1476, 1999
61. Stewart AC, Eriksson AM, Manos MM, et al: Intratype variation in 12 human papillomavirus types: A worldwide perspective. J Virol70:3127-3136, 1996
62. Bhatia KG, Gutierrez MI, Huppi K, et al: The pattern of p53 mutations in Burkitt's lymphoma differs from that of solid tumors. Cancer Res 52:4273-4276, 1992
63. Syrjanen S, Kallio P, Sainio P, et al: Epstein-Barr virus (EBV) genomes and c-myc oncogene in oral Burkitt's lymphomas. Scand J Dent Res 100:176-180, 1992
64. Harrison TJ, Lin Y, Stamps AC, et al: Hepatitis B virus-associated hepatocellular carcinoma in African patients. Cancer Detect Prev 14:457-460, 1990
65. Hesseling PB, Ankone K, Wessels G, et al: Neuroblastoma in southern Africa: Epidemiological features, prognostic factors and outcome. Ann Trop Paediatr 19:357-363, 1999
66. Akinloye O, Gromoll J, Simoni M: Variation in CAG and GGN repeat lengths and CAG/GGN haplotype in androgen receptor gene polymorphism and prostate carcinoma in Nigerians. Br J Biomed Sci 68:138-142, 2011
67. Unsal H, Yakicier C, Marcais C, et al: Genetic heterogeneity of hepatocellular carcinoma. Proc Natl Acad Sci USA 91:822-826, 1994
68. Kornhaber RA, McLean LM, Baber RJ: Ongoing ethical issues concerning authorship in biomedical journals: An integrative review. Int J Nanomedicine 10:4837-4846, 2015
69. Smith E, Hunt M, Master Z: Authorship ethics in global health research partnerships between researchers from low or middle income countries and high income countries. BMC Med Ethics 15:42, 2014
70. Huth EJ: Guidelines on authorship of medical papers. Ann Intern Med 104:269-274, 1986
71. Collaboration between academics and industry in clinical trials: Cross sectional study of publications and survey of lead academic authors. BMJ 363:k4298, 2018
72. Kelaher M, Ng L, Knight K, et al: Equity in global health research in the new millennium: Trends in first-authorship for randomized controlled trials among low- and middle-income country researchers 1990-2013. Int J Epidemiol 45:2174-2183, 2016
73. Sharma H, Verma S: Authorship in biomedical research: A sweet fruit of inspiration or a bitter fruit of trade. Trop Parasitol 8:62-69, 2018
74. Chu KM, Jayaraman S, Kyamanywa P, et al: Building research capacity in Africa: Equity and global health collaborations. PLoS Med 11:e1001612, 2014
75. Scientific Integrity Committee of Swiss Academies of Arts And Sciences, Hess CW, Bruckner C, et al: Authorship in scientific publications: Analysis and recommendations. Swiss Med Wkly 145:w14108, 2015
76. Hammer MF, Woerner AE, Mendez FL, et al: Genetic evidence for archaic admixture in Africa. Proc Natl Acad Sci USA 108:15123-15128, 2011
77. Quach H, Quintana-Murci L: Living in an adaptive world: Genomic dissection of the genus Homo and its immune response. J Exp Med214:877-894, 2017
78. Schlebusch CM, Malmstrom H, Gunther T, et al: Southern African ancient genomes estimate modern human divergence to 350,000 to 260,000 years ago. Science 358:652-655, 2017
79. Munung NS, Mayosi BM, de Vries J: Genomics research in Africa and its impact on global health: Insights from African researchers. Glob Health Epidemiol Genom 3:e12, 2018
80. Stefan DC: Cancer care in Africa: An overview of resources. J Glob Oncol 1:30-36, 2015