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Sex and authorship in global cancer research

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ABSTRACT

Introduction Research is an essential pillar of cancer control and key in shaping regional cancer control agendas. Imbalances in science and technology in terms of lack of female participation have been well documented. However, there is little evidence about country-level female participation in cancer research.

Methodology Through a complex filter, cancer research papers were identified and grouped by countries and sex of the first and last authors of each paper and analysed by the percentage of females in these positions alongside other parameters.

Results Our analysis of 56 countries' outputs, in 2009, revealed that females were the first authors in 37.2% and last authors in 23.3% of papers. In 2019, females were the first author in 41.6% and last author in 29.4% of papers. Females increased as first authors by 26%, and as last authors by 12% between these two time periods. The top performing countries in terms female/male parity for first or last authorship were in Eastern and Southern Europe as well as Latin American countries.

From 2009 to 2019, the highest proportion of females as first and last authors were from low-income and middle-income countries in Latin America and Eastern Europe. Females were more likely to publish in lower impact journals and were less likely to be cited compared to males.

Conclusions Globally, progress in female's authorship in oncology research has been uneven. More research is needed to understand the reasons behind this. Advancing diversity and equity in research leadership and authorship will be essential to address the complex challenges of cancer globally.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Diversity—sex, gender, ethnicity, etc—is one of the key attributes to both high-quality research and the shaping of research agendas that reflect national priorities. Female authorship may also serve as a surrogate marker for gender equity in global oncology and is closely linked to professional advancement and promotion in many settings. However, little exists on the contribution of female authors in global oncology research.

WHAT THIS STUDY ADDS

⇒ This study provides a snapshot for performance in terms of female contributions in global oncology across different countries and regions and a means to benchmark progress in different regions.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study builds on recent work by the Lancet commission on women, power and cancer that calls for increased female representation in oncology leadership and authorship by providing a situational analysis of the cancer research landscape. This will form the basis for further research around the heterogeneity in authorship that exists in different countries and settings. This may help to inform, develop and optimise institutional, regional and global policy that enhances diversity in global oncology research.

INTRODUCTION

Research is an essential component of cancer control and is a key factor informing and shaping regional and national cancer prevention and control strategies and agendas.[1] The composition of authors in a region may potentially have an impact on the nature of research output and focus of efforts in cancer control. It is essential to have diverse research teams and collaborators to advance cancer research along the entire cancer research spectrum.[2] Traditionally, women are more active in social science research and qualitative research methods than men.[3] In terms of career advancement, as first and last authorship on research publications is closely linked to promotion in many settings, representation of women in these roles can serve as a surrogate marker for gender equity in global cancer research. Recent evidence of publications from a global oncology journal between 2012 and 2020 suggested an increase in research output for women in oncology, though regional variations persisted.[4 5]

Despite a steady increase in the number of female authors on research publications, there is still a paucity in the representation of female in positions of leadership.[6 7] Some surrogate markers, such as representation on boards, invited speakers, may help to provide an indication of overall advancement in

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academic medicine.[8] However, research output remains key in academic currency and is fundamental in career advancement.[9] Despite this, women's research output has traditionally been less than that of men, and has been featured in less prestigious journals and topics.[10–12] This inequity has been exacerbated by the COVID-19 pandemic that showed a sharp decline in research output and production for women due to increased social responsibilities and workloads.[13] These data though not specific to women in oncology suggest a similar decline in output particularly given the decrease in funding and collaborative opportunities for cancer research post-pandemic, more so in low-income and middle-income countries (LMICs).[14]

As we move towards a more connected global oncology community and increasing awareness of the importance of sex parity, we sought to examine whether there had been an overall improvement in sex parity for global cancer research.

METHODOLOGY

A cross-sectional review of the global research output at two points over a 10-year period was performed. Global oncology output in two time periods—2009 and 2019—was identified and categorised by sex for subsequent analysis. These two periods were chosen to cover the contemporary global cancer research, that is, from the emergence of molecular targeted therapies era in the 2000s. Patients and the public were not involved in the development of this study.

Determining the sex of authors

There are important differences between biological sex and gender, which is a social construct. Our analysis was aimed at identifying authorship attributed to sex using the following methods.

The determination of the sex of a researcher is generally performed with reference to their names. Onomastic analyses, which look at the history of names, tend to link specific names with a biological sex 'clustering', that is, some names may be mostly 'female' or 'male'. In addition, a few countries, such as Iceland and Russia, many people's family names have gendered endings and so reveal their sex. For example, in Iceland, patronymics are widely used, such as Eiriksdottir (female) or Jonasson (male)) (Lewison, 2001).[15] In Russia, names such as Alekseeva and Anisimova are attributed to female and Alekseev and Antonov to male (Lewison and Markusova, 2011).[16] There are also sex-specific endings for some family names in the Czech Republic and Poland (Webster,2001).[17] Alternatively, for some, it is possible to inspect their web-based biographies, which may include a photograph, or a sentence such as 'she graduated from the university of X'. However, the latter is a very labour-intensive process, and only possible for the minority of researchers who have posted the necessary information on their institutional websites.

We were, therefore, effectively restricted to the use of given names as an indicator of sex. In this study, three sources of data were used. The first was a list of UK medical practitioners maintained by the General Medical Council. The version for 2015 contains over 320 000 names, with their surname, given name, place of qualification and sex. This was used to generate a list of 9445 given names with at least 3 entries, and a ratio of 1 sex over the other of at least 3–1. Of these, 5265 of the names are attributed as male and 3820 as female. Although most of the names are of British origin, there were also many that stemmed from South Asia, continental Europe and from other countries. These provided a template for cross-reference.

Our second source was a commercial website, Gender API, based in Germany (https://gender-api.com). It takes account of the country of the person with the selected given name and also gives the degree of certitude that any given name is of a particular sex. Names for which this is only 50% are classified as 'unknown'. As an example, Gender API was able to ascertain sex for 85% of 3337 Japanese researchers' given names from 2009. Some of these names had been misprinted, or the Optical Character Recognition system used by the WoS for scanning text erred. For example, the name, Akemi, generally a female name, was rendered as Akerni which looks very similar. However, many of the missing names were probably not in the Gender-API database.

We also used a third, smaller and more informal, source of the sex of given names in the form of personal contacts in several different countries. We provided contacts with a list of names where sex could not be determined via any of the three databases described. They were usually able to recognise typos, and names where an accent or umlaut was missing, and so fill in many of the gaps. For example, our Japanese contact was able to assign sex to an additional 486 Japanese names (11%), which increased our sex identification rate to 96% from 85%.

The cancer research databases

We identified cancer research papers (limited to articles and reviews) in the Web of Science (WoS, Clarivate Analytics) by means of a complex filter based primarily on 384 title words (and a few phrases), and 396 specialist cancer journals. It was calibrated and determined to have a precision, p, of 0.95 and a recall, r, of 0.98, so it slightly overestimated cancer research outputs by 3%. It is notable that the title words alone were able to identify 96% of the papers, but the journals alone only 36%, showing that the majority of cancer research papers were published in general rather than specialist journals.[18] We downloaded all papers from the 2 years, 2009 and 2019 to a series of text files, and converted these to MS Excel spreadsheets by means of a special macro developed to capture, with high precision, all relevant cancer research papers. This macro has much greater sensitivity and specificity compared with commercially available tools.

In 2019, there were 188 countries that contributed to the total of 144 318 cancer research papers in that year,

but many of them published so few, that the sex ratio of their authors would have been unrepresentative. We decided to limit our analysis to those 56 countries with at least 200 entries in the 2 years. This rendered a diverse geographical spread, with 16 countries in 'western' Europe, 10 in 'Eastern Europe', including Russia, 9 in the Levant (Middle East) and Maghreb (North Africa) 8 in East Asia and the Pacific, 5 in Latin America and 2 each in North America, Oceania, south Asia and sub-Saharan Africa (see online supplemental material).

The analysis of persons and contributions

For each country and each year, we carried out subanalyses of the numbers of male, female and 'sex unknown' which were performed to reflect first and last authors and middle and sole authors. All the authors were listed in alphabetical order, with duplications identified and eliminated. Contributions were the total fractional counts of papers by sexed authors.

Impact factor, authorship and sex

In order to further evaluate the potential impact of sex inequality on cancer research careers, we undertook a subanalysis, by journal impact factor (JIF), number of downloads and citations. The original files of cancer research papers also contained data on the numbers of citations received, and the number of attempted downloads of the full text of the papers since 2013. The latter was appropriate for the 2019 cohort because most of the attempted downloads of the 2009 papers would have occurred prior to 2013. A third indicator of likely impact is the JIF, determined by Clarivate Analytics for nearly all the journals covered in its database. We were able to determine this for 95% of the papers in 2009 but only 90% of those in 2019, possibly because there were so many new journals with just a few papers in each.

We developed multifactorial equations to incorporate all the parameters as independent variables, which might have an effect, positive or negative, on the dependent variables of impact factor, downloads and number of citations. 59 independent variables were compared.

These parameters included ones associated with the paper such as number of authors (A), number of addresses (D) and number of funders acknowledged (F), and their squares; also the paper research level and its research domain and cancer anatomical site. They also included the country income level (IL) of the first and last authors and the female percentage presence in the country of these authors. (Only those parameters with a highly statistically significant (p<0.01%) effect on these dependent variables have been listed in online supplemental e-Table 3a and b).

Cancer research funding and sex

Projects supporting investigators were extracted from the International Cancer research Partnership (ICRP) database as previously described.[19] The full names of the principal investigators for each project were extracted and analysed for the sex and country according to previously described filters.

We hypothesised that several other indicators associated with human development and/or gender inequality might be associated with the sex of last (senior) authorship namely the Gender Inequality Index (GII; https://hdr.undp.org/data-center/thematic-composite-indices/gender-inequality-index#/indicies/GII),[20] determined by the United Nations Development Programme (UNDP) and based on three dimensions—reproductive health, empowerment and the labour market); and the Gini coefficient, a measure of income inequality https://ourworldindata.org/grapher/economic-inequality-gini-index[21]

The GII deals with women's empowerment and it was hypothesised that increased empowerment may translate to more women in academia and by extension more academic output. The Gini coefficient, which is a measure of the inequality among incomes, has reflected differences in earning for women. It was hypothesised that this index might also correlate with women in academia and their output.

RESULTS

Key findings

Our final dataset of published cancer research papers comprised of 66802 publications in 2009, and 144318 in 2019. In 2009, females were the first authors in 37% and last authors in 23% of all cancer research papers. In 2019, we identified female first authors in 42% and last author in 29% of all cancer papers. Female authors increased their participation as first authors by 26%, and as last authors by 12% between these two years. (table 1).

There were significant variations between countries in the proportion of female first and last authors (table 2). Countries are listed in order of highest to lowest proportion of female last authors in 2019. The top 10 countries for female last author position included (1) Argentina, (2) Portugal, (3) Serbia, (4) Romania, (5) Slovenia, (6) Croatia, (7) Brazil,

Table 1 Total number of global cancer research papers in 2009 compared with 2019 sexed by males (M) and females (F), and authors of unknown sex (U), in first and last author positions

	First author position					Last author position				
Year	M	F	U	% Sexed	F %	M	F	U	% Sexed	F%
2009	36963	21941	7898	88.2	37.2	45980	13992	6830	89.8	23.3
2019	73831	52601	17886	87.6	41.6	90917	37836	15565	89.2	29.4

F% is percentage of females among sexed authors.

Table 2 The proportion of females (F) in first (f) and last (L) author positions of cancer research papers in 2009 compared with 2019

	2009		2019			2009		2019	
Country	F (f) first	F (L) last	F (f) first	F (L) last	Country	F (f) first	F (L) last	F (f) first	F (L) last
Argentina	56.1	50.0	60.3	54.8	France	42.2	26.4	49.6	33.8
Portugal	62.6	37.8	71.5	51.5	Spain	41.8	23.8	53.0	33.7
Serbia	60.1	50.7	64.8	51.4	Canada	43.7	27.5	47.8	33.6
Romania	55.1	47.9	59.6	50.7	Hungary	48.5	25.7	48.3	32.8
Slovenia	53.8	32.6	66.9	50.4	UK	40.5	23.2	47.1	32.6
Croatia	56.1	41.1	53.9	48.7	USA	38.8	25.3	43.3	31.5
Brazil	53.5	40.4	58.9	47.3	Israel	44.6	23.7	45.2	31.4
Poland	52.8	28.2	63.3	43.7	Belgium	46.4	22.7	54.7	30.8
Colombia	36.7	57.1	52.5	42.5	Chile	31.4	23.2	40.4	30.7
Sweden	54.5	31.5	52.1	42.5	**Bulgaria**	55.0	46.4	48.2	30.6
Egypt	32.3	35.2	47.7	41.9	Taiwan	31.6	27.8	32.0	29.6
Norway	50.3	28.5	56.9	41.3	**World**	**37.2**	**23.3**	**41.6**	29.4
Ireland	45.3	30.8	51.7	40.5	**Lebanon**	32.1	12.5	44.4	29.3
Thailand	50.4	36.1	57.8	40.4	**Jordan**	4.0	21.4	27.1	28.6
South Africa	38.3	42.4	49.5	40.0	**Iran**	37.0	23.7	48.9	28.1
Finland	61.5	34.9	57.4	40.0	**China**	31.9	28.9	34.5	27.5
Mexico	45.4	37.6	50.3	39.5	**India**	32.5	28.9	40.6	27.3
Malaysia	42.2	30.1	48.9	39.3	Singapore	36.1	21.8	43.2	26.4
Denmark	52.9	24.7	62.1	39.1	**Nigeria**	26.7	26.1	24.3	26.1
New Zealand	39.1	27.7	48.5	38.6	Switzerland	34.2	16.7	47.1	24.8
Morocco	40.6	15.6	42.9	38.4	**Tunisia**	61.3	26.1	69.3	24.7
Australia	44.9	28.5	51.7	36.8	Germany	30.7	15.7	41.8	24.4
Indonesia	50.0	16.7	43.4	36.8	Czech Rep.	43.1	28.2	48.0	23.3
Netherlands	51.7	22.8	57.0	36.5	Greece	33.7	14.9	40.7	22.9
Slovakia	67.2	39.3	66.9	35.7	Austria	34.5	15.2	41.1	22.1
Russia	44.9	30.0	54.5	34.9	Saudi Arabia	9.6	20.6	29.1	20.9
Turkey	36.3	25.7	45.2	34.4	South Korea	24.7	15.4	28.9	19.1
Pakistan	31.3	31.8	48.3	34.2	Japan	15.0	5.3	17.3	5.0
Italy	43.0	22.5	50.8	34.2					

Percentages in last author position >50% tinted green, >40% tinted pale green.
For the 56 most research-active countries, ranked by percentage in last position in 2019.
<30% tinted pale yellow, <20% tinted pink. Countries in bold=low/middle income.

(8) Poland, (9) Colombia and (10) Sweden. The bottom 10 countries in terms of authorship were, in descending order Nigeria, Switzerland, Tunisia, Germany, Czech Republic, Greece, Austria, Saudi Arabia, South Korea and Japan. There was no clear income association with the position of countries. No associations were found with the two social and economic indexes.

As most papers had three or more authors, it was also possible to determine the sex ratio both in terms of persons and overall contributions (online supplemental e-Table 1). We analysed the numbers of cancer researchers and the numbers of papers to which they contributed in the two years. Male contributors were more numerous than female contributors in both 2009 and 2019. For all authors on all global cancer papers, female contributions rose marginally from 33% in 2009 to 36% in 2019.

Variations by region

An analysis of all cancer research authors by country again revealed significant differences between countries and regions (table 3). Broadly, countries in Latin America (except Chile), Central and Eastern Europe (except Hungary and Czech Republic) and Nordic countries had the highest overall presence and contribution of female authors to their cancer research over the last decade. Notably, the countries in the Far East, Middle East (except North Africa), Western Europe

Table 3 Combined percentages of females in cancer research, all author positions

Country	Persons 2009	Persons 2019	Contributions 2009	Contributions 2019	Country	Persons 2009	Persons 2019	Contributions 2009	Contributions 2019
Portugal	51.6	61.1	52.7	59.7	**Ukraine**	29.1	41.4	26.7	40.4
Argentina	50.4	58.8	49.6	58.2	Canada	37.5	43.4	34.2	40.4
Serbia	49.4	56.3	49.6	58.1	**Turkey**	34.5	42.1	33.1	40.2
Romania	47.6	55.6	48.3	55.5	Australia	38.4	44.5	35.9	40.2
Slovenia	48.2	55.1	45.5	55.1	Israel	38.4	43.0	37.6	41.0
Slovakia	52.9	59.2	50.5	55.0	Belgium	37.7	43.8	34.0	40.0
Croatia	45.7	53.9	46.1	52.3	UK	36.2	42.6	34.2	40.0
Poland	44.9	55.1	42.8	52.2	**Morocco**	30.9	38.8	29.4	39.7
Brazil	43.4	52.9	42.9	51.7	Czech Rep.	44.9	44.0	41.6	39.7
Tunisia	37.2	52.0	34.7	51.3	Hungary	38.0	41.3	37.9	39.3
Thailand	40.3	51.2	39.1	50.7	**Lebanon**	33.9	41.7	31.5	38.5
Bulgaria	44.9	53.2	47.0	49.7	USA	36.4	41.0	34.1	38.3
Lithuania	43.0	53.2	43.3	49.6	**Pakistan**	32.1	40.3	33.6	37.2
Spain	40.9	50.6	39.4	48.7	**Iran**	28.9	41.4	29.7	37.0
Finland	44.6	51.4	41.3	48.0	Greece	34.2	40.0	32.4	37.0
Russia	42.5	47.9	43.1	47.4	Chile	35.5	38.8	33.2	36.3
South Africa	33.6	48.1	31.9	47.3	Austria	33.2	39.5	28.6	34.9
Italy	42.8	51.8	39.0	47.2	Switzerland	31.2	39.0	28.3	34.6
Norway	38.9	48.4	36.4	46.5	**Jordan**	23.0	35.1	22.0	33.8
New Zealand	35.3	46.7	32.8	46.5	**China**	31.8	31.0	32.6	32.7
Denmark	37.6	49.0	37.1	45.5	Germany	30.7	37.1	27.2	32.4
Egypt	37.9	46.4	36.6	45.4	Singapore	30.9	34.1	28.7	32.2
Mexico	38.9	44.9	37.7	45.0	**India**	30.4	33.2	29.4	31.8
France	39.8	47.3	36.6	43.5	Qatar	47.1	34.4	36.0	31.4
Malaysia	38.4	43.5	37.5	43.4	Taiwan	30.0	30.7	29.9	30.5
Ireland	39.7	45.7	37.4	43.1	**Nigeria**	29.7	25.0	32.2	25.2
Indonesia	32.6	43.1	31.0	42.9	Saudi Arabia	17.9	27.2	18.6	25.0
Netherlands	36.9	45.2	33.1	42.9	South Korea	22.6	25.0	21.9	24.2
Colombia	41.8	44.9	35.8	42.8	**Viet Nam**	28.0	23.2	28.0	23.0
Sweden	40.3	46.0	36.8	41.9	Japan	21.0	17.8	18.8	13.4

Values >50% tinted green, >40% tinted pale green, <30% tinted pale yellow, <20% tinted pink. Bold countries=LMIC.
2009 compared with 2019. Countries ranked by percentage of female contributions in 2019.
LMIC, low-income and middle-income country.

(UK, Germany, etc), as well as North America performed poorly. Some regions, for example, Southeast Asia were split, with some countries performing well in terms of overall female contribution (Thailand, Malaysia and Indonesia) and others poorly (India, Vietnam and Singapore).

Sex and journal impact

To determine whether the sex of authors was associated with a publication's impact, we analysed three different types of indicators to triangulate this data: JIF, paper downloads and citations (online supplemental e-Table 2). There are three main observations from this table. First, it appears that female authors' performance relative to that of male authors remained stable between 2009 and 2019. And second, except for the count of downloads in 2009 papers, female authors performed better when in first position than when in last position. (This measure is only partial, as most downloads are likely to occur in the first 4 years following the paper's publication, and these were only counted from 2013). The third finding is that, apart from when female authors were in last position in 2019, the sex differences between the indicators are quite small.

These results are based on simple averages and take no account of the many other factors that could influence these three indicators. For example, in 2009, female authors

wrote fewer reviews (which obtained a mean of 70 citations compared with 42 for original articles), and in 2019, they wrote relatively more papers in languages other than English, which are much less cited than ones in English. We, therefore, carried out a detailed examination of the dependence of these impact indicators on the sex of first and last authors (online supplemental e-Table 3)), using a multiple linear regression analysis (SPSS 25). The main result is repeated, namely that although males score more highly than female authors in both first and last positions the difference for first author and downloads is small and not statistically significant.

Female principal investigators on grants

Only seven countries have complete public (national and philanthropic) grants filed in the public database ICRP (online supplemental e-Table 4) that are amenable to ascertaining the sex of the grant lead (principal investigator). However, these high-income countries (HICs) are responsible for a major proportion of global cancer research (around 42%). The percentage of female principal investigators leading all research projects between 2009 and 2019 varied from a low of 33% (UK) to 48% (Italy), with an overall average of 39% for the 25 705 grants awarded by research funding organisations in these countries over the decade.

DISCUSSION

Our global analysis of cancer research papers revealed a consistent sex imbalance, despite a modest increase in the proportion of female authorship on cancer research outputs over this 10-year period. The proportion of women as first authors increased by 26%, and as last author by 12%. However, this average hides great heterogeneity across different regions and countries. The top performing countries in terms of female presence for first and last authorship were in Eastern and Southern Europe and Latin America. Female authors were more likely to publish in lower-impact journals and were less likely to be cited. There was no correlation between female-led research output by country and any composite index for example, GII or Gini coefficient. This suggests a more complex relationship between sex and research participation with different factors—sociological, cultural, economic, etc—operating differently depending on the country or region.

For example, cancer research in Argentina, Colombia, Portugal, Serbia and Romania each included greater than 50% female first and last authors. These countries have little commonality across most gender domains. Moreover, Switzerland, Germany and Austria had among the lowest representations of female authors in both first and last positions, while Japan and South Korea had among the lowest representation of female authors in both key/high status authorship positions. Similar to findings of a recent bibliometric analysis of cancer research in Africa, Egypt and South Africa had a high research output and female representation was about 32% and 26.6%, respectively.[22] Over the two time points, some countries showed a decline or stagnation in the number of female last authors.

While the reasons behind this are not possible to tease out from a single cross-sectional view, it is consistent with the general inadequacy of effective and sustained efforts to support women's academic advancement. Women frequently bear the majority of social caregiving and support for families,[23] and recent data suggest many women are more likely to leave academia due to a hostile workplace climate and more so than due to social factors.[24]

Some of the findings regarding Eastern Europe might, however, not be entirely unexpected, given the complex medical and often paradoxical history of feminisation of medicine and science since the Soviet era.[25 26] In the EU, the availability of affordable childcare might at least partly explain the greater representation of female first/last authors compared with countries with less enabling environments for female to pursue successful cancer research careers.[27] However, more research is needed to better understand such success factors.[28 29]

A further finding from our analysis relates to the inherent value of female contributions to cancer research and implicit bias to this. (These are the summed fractional counts of their publications.) The 'Matilda' effect in scientific literature has been described where women are more likely to be undervalued and under-recognised due an intersectionality of disparities around under-representation, less favourable peer review and fewer first and last authorship positions.[30] Our

Table 4 Suggestions to improve female representation in global cancer research output

Gender-based concerns	Suggested efforts to improve female representation in global oncology output
Less pay and research opportunities	1. More research to better understand the reasons for persistent gender inequality in research/authorship in different regions.
Less grants and leadership opportunities	2. Invest in empowering female researchers in methodology, grant writing and management skills.
Less women in global oncology research	3. Increase mentorship and authorship opportunities in global research for females by creating a global database of research skills.
Less recognition of women in research	4. Value contributions of females in research along the cancer continuum through efforts that support publications of a range of research designs and topics in regional journals.
Less academic progression	5. Develop new matrices for assessment of academic prowess beyond research impact factor such as community impact, capacity building and mentorship.

findings showed that female authors were less likely to publish in higher-impact journals and to be cited. This is in keeping with pre-existing literature showing disparities in both the volume and impact of female contributions as measured by authorship positions and citations.[31] Female authors more often publish in domains such as palliative/supportive care that tend to have lower citation rates.[32] There is also a hierarchy in clinical cancer research, with randomised clinical (especially therapeutic) trials valued above other types of research.[33] However, even in these studies, female contributions are frequently undervalued.[32] For instance, the vital role that cancer nurses (a largely female profession) play in clinical trials, in patient education, support, advocacy and care is under recognised[34 35] and they are rarely part of the authorship of publications. Part of the solution to addressing wider sex parity in cancer research may thus rest with expanding research domains beyond the increasingly narrow focus on discovery science and biopharmaceutical research.[36]

Though data suggest that female researchers are more collaborative across domains,[37–39] our results also speak to power imbalances due to the intrinsic nature of collaborative research. There is a widespread authorship sexhomophily effect in most scientific disciplines. This refers to the tendency of researchers to copublish with colleagues of the same gender more often.[40 41] While this can amplify female contributions, it can also disadvantage women, as female collaborative networks generally have less access to resources, are at increased risk of ghettoisation (clustering in 'lower ranking' research areas) and lack of recognition. To counter these disadvantages, female collaborative networks in research should be strengthened though increased funding, increased recognition of the value of their research areas, knowledge perspectives and facilitating diversity and inclusion of research teams in all disciplines.[2] The question remains whether, for example, in the awarding of research grants sufficient attention is given to sex. Previous research has indicated that female authors tended to publish less in research areas that require extensive resources.[42] Even in HICs with complete funding data, females received on average less than 40% of all total funding. An exception is in Italy with female researchers holding an average of 48% of all public funding/grants held. This disparity in academic research funding by sex is consistent with other studies.[43 44]

CONCLUSIONS

There is a need to develop frameworks to increase female participation and leadership in cancer research, globally (table 4). Developing and implementing 'evidence-informed' policies that encourage and support early career researchers in general, and female researchers in particular, requires more deliberate efforts. These can include policies and related investments to advance women's leadership development and to assure sex parity in female representation in research leadership positions (eg, in academia, research institutes and research funding bodies). Greater investments in historically female-dominated and undervalued methodologies, such as qualitative, health systems and implementation research is needed generally to improve cancer control and reduce cancer health disparities globally and nationally, and can be considered as another potential opportunity to advance sex equity in cancer research. Metrics that reflect impact beyond journal citations should also be considered as relevant to academic advancement, such as community impact and capacity building. It will be necessary to acknowledge and address implicit bias and the misogyny that frequently exists in academic institutions in order to provide an enabling environment for all health professionals. More research into (global and national) barriers and facilitators to achieving sex parity in cancer research leadership including authorship is needed. Allyship will be key to successfully advance these proposed efforts.

STUDY LIMITATIONS

This study provides an overview of the publishing landscape in global oncology by sex. However, it was not possible to ascertain author sex for all the publications, which may result in an under-representation of certain groups especially in the East Asian region notably China. Our study was not able to delve into funding sources other than for HICs which may not necessarily reflect trends in LMICs. In addition, much of the work done in LMICs frequently appears in grey literature in the form of unpublished dissertations, etc, which was beyond the scope of this study as the Web of Science is predominantly focused on the serial literature.

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