

Independent Researchers: A Bibliometric Analysis

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ABSTRACT

Independent Researchers (IRs), namely unaffiliated or voluntary researchers, are a small yet important and distinct population of contributors to scholarly discourse. Due to their small number, IRs rarely receive attention in debates regarding scholarly publishing but the distinctiveness of the unaffiliated researchers warrants further examination. Documents were extracted from the Web of Science. Bibliometric parameters were as follows: main scientometric characteristics, citations analysis, publishing trends, geographical distributions, most productive countries, co-authorship network of countries, top funding sources, research areas, keyword co-occurrence network, top cited publications, top productive journals and gender of IRs. 3357 documents were retrieved that were individually or collaboratively authored by 3784 IRs from 1980-2021. There were 589 single-authored documents. More than 70% of documents were research articles, followed by meeting abstracts (8.66%). All documents received 52279 citations, with 19.45 average citations per document. Private Practice was the most affiliation format of IRs. Publications started to grow since 2000, with almost 40% of them published from 2017-2021. The United States published almost half of all IRs-related publications. Most of the research funding was primarily contributed by government agencies, with the United States being a major player in this regard. Also, many IRs are active in medical disciplines research, and are highly collaborative, often with multiple Co-authors. 33.5% of IRs authors were women and 66.5% were men. This understanding of IRs illustrates the importance of this group and encourages further research and support for this population of science contributors.

Keywords: Independent Researcher, Independent Scholar, Unaffiliated Researchers, Scholarly Publishing, Scientific Collaboration, Bibliometric.

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INTRODUCTION

Independent Researchers (IRs) are researchers who are not affiliated with academic (or other) institutions, or opt to conceal their affiliation.^[1] IRs typically refers to researchers who are knowledgeable in a specific domain and pursue questions within that domain but are not directly compensated for their work or affiliated with a research institution.^[2] Typically, they choose “independent researcher” affiliation deliberately in their researches,^[3] often due to their passion for the pursuit of pure research,^[1] and perhaps their job duties do not include research and scholarship.^[4] IRs present themselves under a variety of titles, including *Independent Consultant*, *Independent*

Scholar, *Independent Researcher*, *Independent Practice*, *Freelance Consultant*, and *Private Consultant*.

The scientific community of IRs is in the minority, and for this reason, only a handful bibliometric studies have been conducted on them. They are less commonly discerned and talked about than other researchers.^[3] An earlier study showed the growth of publications authored by IRs from 3 articles in 2008 to 50 articles in 2015.^[1] In another study, the published results of independent researchers from Polish institutions^[5] showed the growing participation of these researchers in projects related to geographical institutions.

Nonetheless, the recent growth in the population of IRs has made it an “interesting group” for study.^[5] There are still many gaps concerning the scientific activities of IRs. Given the limited number of studies on IRs, as well as the distinct situation faced by these researchers, their role and service to science is unknown. This community deserves to be researched and understood more comprehensively in order to identify and analyze the scientific



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activity of small yet important and distinct population of IRs from different aspects by presenting a general picture of the status of their scientific contribution, which can provide valuable guidance for policymakers, funding agencies, and researchers in the future, highlighting more detailed directions of future research areas.

However, no study has examined the publications associated with IRs over an extended period of time. The goal of the present study is to fill this gap by describing the proliferation of independently-authored publications over the past four decades with a focus on characteristics such as citations analysis, publishing trends, geographical distributions, most productive countries, co-authorship network of countries, top funding sources, research areas, keyword co-occurrence network, top cited publications and journals and gender of these researchers.

LITERATURE REVIEW

Few studies have examined the importance and contribution of IRs to advancing human knowledge. A study conducted by Elsabry analyzed the independent researchers' publication patterns and characteristics.^[1] The mentioned study used Scopus data to identify the set of papers authored by independent researchers, either individually or together with others. The author found 217 papers exclusively authored by unaffiliated/ independent researchers individually or with other collaborators. This study found that a large number of publications from independent authors came from USA and England. It was surprising that no authors had revealed the source of funding for their research. The results show the periodic growth of publications originating from independent researchers over the years. The study of Elsabry encourages authors to explore the uncharted field of independent researchers to deep-dive into how they receive financial support from research funding bodies and investigates the impact of Open Access (OA) publications on them. In another research, Bański examined the research output of independent researchers from Poland geographical institutions.^[5] The Web of Science Core Collection and Google Scholar citation databases were used for obtaining the data for the study. The results showed that Polish geographical researchers have published a large number of international papers in physical geography relative to other subdomains of geography and have worked collaboratively to publish their papers. It was found that because of greater scientific collaboration and high impact of research publications produced by young scientists of Poland's geographical institutions, their impact would be greater in the coming years.

Independent researchers face several problems such as access to literature and laboratories, budgets, lack of attention and fair reviews of their papers.^[2] In his article, Line deliberated on the difficulties of independent researchers in retrieving scholarly literature.^[6] The author argued that unlike researchers affiliated with universities, independent researchers face huge problems in accessing scholarly literature available in both public and

academic libraries. However, independent researchers have some advantages such as no teaching and administrative responsibilities, exploring out-of-the-way places for quality and productive life, and enough time to focus solely on their specific research interests.^[3]

Orlans has documented the general experience of independent scientists.^[4] They examined the benefit of independent scientists in pursuing ideas that are exciting rather than working within a defined subject boundary. He also discussed the difficulties that independent researchers or scientists face in receiving funds for their projects without any institutional affiliations, as well as their lack of access to libraries and laboratories for experimental projects. The role of independent scientists' associations has also been discussed and their role emphasized in providing institutional support for independent scientists.

In several related studies, researchers have stressed the importance of amateurs' role in bringing diversified voices to the existing body of knowledge.^[7] There is even an organization that works to promote the work of these individuals, namely National Coalition of Independent Scholars (NCIS: affiliated to the American Historical Association). NCIS provides professional support and camaraderie to all researchers outside of tenure-track/tenured academia. According to reports in 2019, NCIS members include more than 250 scholars from 26 countries in Europe, Asia, Australia, as well as Canada and the Americas.

Although distinct in terms of their training and expertise, independent researchers share many similarities to the more widely-known group of citizen scientists. Recently, citizen science has grown in prominence as members of the general public have shown interest in investigating the world around them and now have a platform (the Internet) to share their work.^[8] Prominent citizen scientists who are unaffiliated but publish in scholarly journals have gained particular notoriety since many figures in scholarly communications seek to encourage greater interest and participation in science among the public.^[9]

This literature review illustrates that independent researchers have rarely been considered in scholarly literature. Those studies that do examine this population have yet to provide a truly cohesive picture of the attributes of these researchers and their growth within scholarly communications. This gap invites further research to understand more about IRs and shed light on their publication pattern.

METHODOLOGY

Data Sources and Searches

For this study, Web of Science Core Collection (WoS) was selected and searched as the world's leading scientific citation search and analytical information platform.^[10] The purpose of this research is to update and expand upon the prior work in Elsabry's study,

which searched for publications where at least one author stated “Independent Researcher” or synonyms in address section.^[1] Thus, similar methods for literature retrieval were adopted. Previous experiences and knowledge in the literature guided the selection of appropriate keywords for the search strategy. The search strategy was as follows:

Search Strategy	AD= ((private* OR independent* OR freelance* OR amateur* OR volunteer OR unemployed) SAME (scholar* OR researcher* OR scientist OR writer OR consultant OR practice OR practitioner))
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AD=Address: Searches for institution and/or place names in the Address field within a paper.

SAME: In Address searches in Web of Science, using SAME restrict the search to terms that appear in the same address within a paper.

The timespan for this study was from 1980 to 2021. The indices used include SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI (1975-present). The search was performed on 17.1.2022. A total of 3,357 publications were retrieved from WoS. All searches and downloads of the data were extracted in a single day to avoid changes caused by daily updates to the database. All records (as full record) were exported to Excel file format.

Screening

The screening phase was performed independently by two authors (AGh, ASh). We used a narrow definition of IRs for whom the address mentioned in publications at least included any of the following keywords: Private, independent, freelance, amateur, volunteer, and unemployed. The basis of independent researchers' identification and documentation was examining the “Addresses” part mentioned in their publications. Information related to affiliations of authors in data imported from WoS appeared in the “Addresses” column of the dataset, which was saved in a Microsoft Excel file format. At this step, IRs with multiple affiliations were eliminated, along with authors who had a company (Co), institute (Inst), university (Univ), Department (Dept), clinic (Clin), association (Assoc), office, center as their affiliation. As some authors introduced themselves as both independent researchers and affiliated with a university or institute. An example is shown in Figure 1. Affiliations in which there was ambiguity were reviewed by the researchers to more accurately determine their situation. In this regard, a session was held by the authors to finalize some discrepancies and solve any potential conflicts between the two authors.

Data Analysis

We used Microsoft Excel (version 2013) for reports of description and citations analysis of results. Khartis (version 2.1.0), an open-source thematic map creator, was used to generate

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Effects of self-ligating brackets and other factors influencing orthodontic treatment outcomes: A prospective cohort study

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Affiliations – collapse

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Free PMC article

Figure 1: An example of an author who has identified themselves as both an independent researcher and affiliated with a university.^[11]

geographical distribution of IRs publications. To visualize the network of keywords co-occurrence and country co-authorship network, we used VOSViewer (Version 1.6.7, Leiden University, Leiden, The Netherlands), namely a network visualization application available freely on the web. In addition, a free Application Programming Interface (API) called Genderize.io was employed to determine the gender of authors' first names. Python programming language extracted the author's name of independent researchers exclusively among all the authors associated with publications. Among all the author names, those of IRs were identified through a Python programming language. For this purpose, we worked on RP (Reprint Address) field in the exported file of the database and then by searching in this field, IRs were identified and extracted for further processing. Then, the authors' first names were cleared – names that were single letter or abbreviated (e.g., B.L. Thomson), as well as items where it was not clear to which affiliation the author belonged. The authors' gender was then determined using Genderize.io online gender-sorting tool (available at: <https://genderize.io>). The genders that were identified with at least 60% accuracy were examined, following the threshold used in prior study.^[12] Genderize.io is an online tool that allows users to predict the gender of a given name. This online tool includes over 250,000 names and determines the probability of each name being male or female based on the distribution of these names in the database.^[13] The tool can be accessed through an API or used directly on their website.

RESULTS

Characteristics and citations analysis

A total of 3,357 publications were retrieved from WoS database, which were authored individually or collaboratively by 3,784 IRs over time (up to January 1, 2022). The first article authored by an IR was published in 1980. In this period of 41 years, out of 3,357 documents, research articles accounted for more than 70%, followed by meeting abstracts (291, 8.66%), conference proceeding papers (198, 5.89%), review articles (192, 5.71%),

etc. There were 589 (17.54%) single authored documents with 0.173 authors per document. A total of 3,357 documents received 52,279 citations with 19.45 average citations per documents. Table 1 shows the main characteristics and citations analysis of IRs publications.

Table 1: Characteristics and citations analysis on publications associated with IRs (1980–2021).

Description	Findings
Time Span	1980-2021
Sources (Journals, Books, etc.)	1,800
Number of Documents	3,357
Document Type*	
Article	2,356 (70.18%)
Meeting Abstracts	291 (8.66%)
Proceeding Papers	198 (5.89%)
Review Articles	192 (5.71%)
Editorial Materials	149 (4.43%)
Book Chapters	137 (4.08%)
Book Reviews	116 (3.45%)
Others (letters, early access, data papers, etc.)	133 (3.96%)
Authors	
Authors	19,426
Independent authors	3,784
Authors Collaboration	
Single-authored documents	589
Documents per Author	0.173
Authors per Document	5.79
Co-Authors per Documents	11.7
Collaboration Index	6.84
Citations	
Citations	65,294
Average citations per documents	19.45
Average citations per year per doc	2.287
Top 10 forms of affiliations used by IRs in documents	
Private Practice	608
Independent Consultant	259
Independent Scholar	94
Independent Researcher	86
Private Practice Limited in Endodontics	77
Private Dental Practice	68
Independent Practice	44
Freelance Consultant	42
Private Consultant	38
National Coalition of Independent Scholars	37

*Each document can be assigned to more than one document type.

The Private Practice affiliation form used by 608 authors in 608 documents ranked first, followed by Independent Consultant by 259 authors in 259 documents at second place, Independent Scholar used by 94 authors at 94 documents in third place, and Independent Researcher by 86 authors in 86 documents ranked fourth as the most popular forms of affiliations used on publications that were associated with IRs.

Publishing trends

Figure 2 indicates the growth of publishing trends of IRs from 1980-2021. From 1980 until 2000, for two decades, there was no considerable growth in terms of the number of publications associated with IRs. From 2000 onwards, however, there was a significant increase in terms of number of papers authored by IRs. There was a stagnating trend between 2008 to 2011 in the growth of IRs' publications. However, after 2012, there was once again a rapid increase in publications authored by IRs. Between 2000 and 2021, the number of articles produced increased from 13 to 326, with a growth rate of 48.57%. Moreover, the Compound Annual Growth Rate (CAGR) over this period was calculated at 18.19%, indicating a consistent growth rate. Almost 40% (1250) of publications from IRs appeared over the last five years (2017-21).

Global geographical distributions

Table 2 depicts the most productive countries of IRs. Publications associated with IRs originate from 166 countries. Among all the publications, the United States alone accounted for almost half of the total publications (1,525, 45.42%) associated with IRs. Germany with 494 publications accounted for 14.71% of total publications, followed by England with 417 (12.42%) publications.

Figure 3 shows the co-authorship network of countries associated with IRs' publications. The threshold for considering the co-authorship network of countries was set at 5 documents per country. Out of 149 countries, 85 met this threshold. The most significant countries were as follows: the United States (1477 documents, 27731 citations), United Kingdom (388 documents,

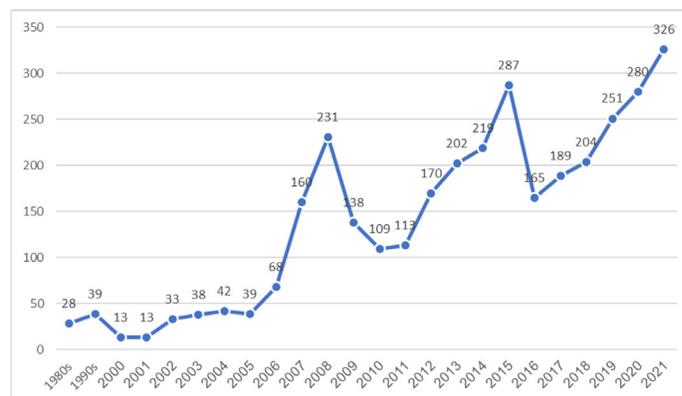


Figure 2: Trends of publications associated with IRs (1980–2021).

Table 2: Top 10 Countries with IRs (1980–2021).

Countries	Record Count	Percentage
USA	1525	45.427
Germany	494	14.716
England	417	12.422
Italy	315	9.383
Canada	236	7.030
Australia	204	6.077
Switzerland	199	5.928
France	165	4.915
Spain	158	4.707
Netherlands	142	4.230

Co-authorship network of countries.

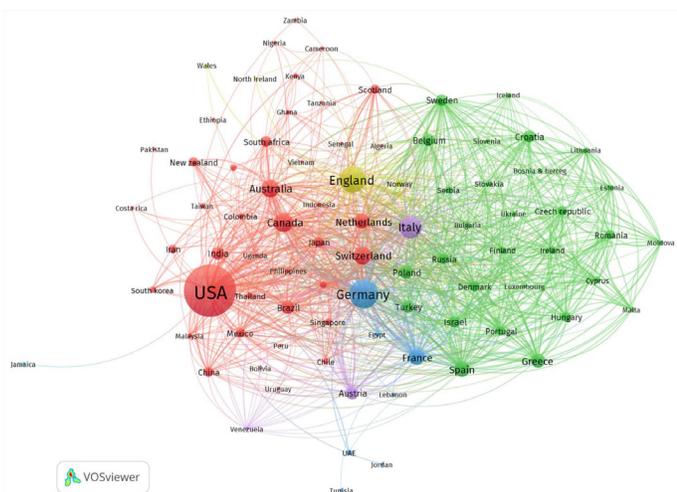


Figure 3: Visualization of a co-authorship network of countries with a minimum of five publications among publications associated with IRs (1980–2021).

8791 citations), Germany (469 documents, 9615 citations), Italy (292 documents, 6531 citations), and Canada (209 documents, 6661 citations).

Funding source

Table 2 shows the funding source of IRs' publications. The data revealed that only 25.48% of the documents acknowledged funding sources. As shown in Table 2, the majority of funding sources belonged to government research funding agencies. There were also many globally-known biopharmaceuticals companies such as Novartis (16, 0.47%), Abbvie (15, 0.44%), Bayer AG (13, 0.38%), Pfizer (13, 0.38%), Roche Holding (12, 0.35%), Bristol Myers Squibb (11, 0.32%) and Eli Lilly (11, 0.32%). Government research funding agencies from the United States such as Department of Health Human Services, National Institute of Health (NIH), National Science Foundation and others funded

the highest number of IRs' publications. As can be seen in Table 2, 9 out of 20 top funding sources for IRs were located within the United States.

Research areas

The research areas of publications as found in WoS database are presented in Table 3. Dentistry Oral Surgery Medicine (670, 19.95%), followed by General Internal Medicine (188, 5.92%), Psychology (195, 5.80%), and Engineering (153, 4.55%) were major areas of research in which the highest number of publications were produced by IRs. A majority of IRs publications are in a health and medical science related discipline.

Keyword co-occurrence network

Figure 4 shows the keyword co-occurrence network for publications associated with independent researchers. This analysis was based on 3,357 publications, which gave 198 keywords appearing in 10 or more publications. Five major clusters of keywords were identified. Cluster 1 (shown in red) contains 58 keywords ranging from augmentation, beam computing-tomography, bone generation, dental implants, osseointegration, regeneration, to tooth extraction etc. This cluster appears to be related to dental science, treatment and devices. Cluster 2 (shown in green) contains 46 keywords. The major keywords associated with cluster 2 are abuse, adolescents, alcohol, behavior, depression, gender, psychotherapy, students, and women. This cluster closely relates to the adolescent issues, gender, psychology and psychotherapy. Cluster 3 (shown in blue) includes 35 keywords related to Alzheimer disease, cardiovascular disease, epidemiology, prevention etc. COVID-19 infectious disease is also represented in this cluster. Cluster 4, depicted in yellow, contains 32 keywords. Some major keywords associated with this cluster are as follows: accuracy, chiropractic, dysfunction, pain, physical activity, quality of life, rehabilitation, etc. Cluster 5 (shown in purple) includes 27 keywords. These keywords are related to cancer, irradiation, pharmacokinetics, skin, safety, surgery and treatment.

Top 10 cited publications

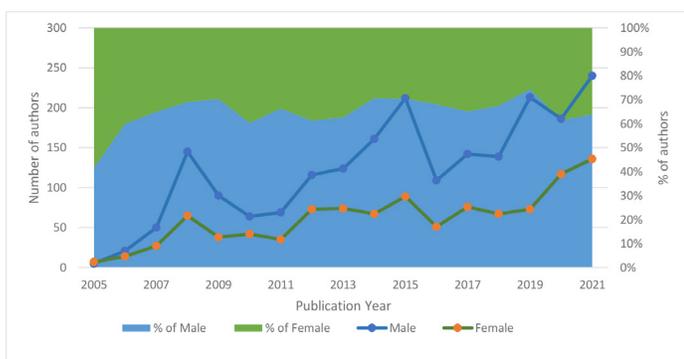
A total of 3,357 documents received 65,294 citations with an average of 19.45 citations per document. Table 4 provides a list of top 10 cited publications of independent researchers. The article titled "Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013" that was published in 2015 received the highest number of citations with 4,606 citations (average of 575.75 citations per year). Most of the top cited papers are review, multi-authored publications, and collaborative in nature.

Table 4: Top 10 cited publications from among documents associated with IRs (1980–2021).

Rank	Title	Authors	Type	Year	Total Citation	Avg. Citations Per Year
1	Global, regional, and national age–sex specific all-cause and cause-specific mortality for 240 causes of death, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013.	Naghavi, M. <i>et al</i>	Article	2015	4606	575.75
2	Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015.	Wang, Haidong <i>et al</i>	Article	2016	2993	427.5714
3	Global, Regional, and National Cancer Incidence, Mortality, Years of Life Lost, Years Lived with Disability, and Disability Adjusted Life-years for 32 Cancer Groups, 1990 to 2015 A Systematic Analysis for the Global Burden of Disease Study.	Fitzmaurice, C., <i>et al</i>	Article	2017	2398	399.6667
4	The enduring effects of abuse and related adverse experiences in childhood.	Anda R.F. <i>et al</i>	Review	2006	2182	128.3529
5	Global, regional, and national comparative risk assessment of 79 behavioral, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015.	Forouzanfar, M.H., <i>et al</i>	Article	2016	2063	294.7143
6	A comparison of direct vs. self-report measures for assessing height, weight and body mass index: a systematic review.	Gorber S.C., <i>et al</i>	Review	2007	1328	83
7	Alirocumab and Cardiovascular Outcomes after Acute Coronary Syndrome.	Schwartz G.G., <i>et al</i>	Article	2018	1177	235.4
8	Global, regional, and national Disability-Adjusted Life-Years (DALYs) for 315 diseases and injuries and Healthy Life Expectancy (HALE), 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015.	Kassebaum, N.J., <i>et al</i>	Article	2016	1136	162.2857
9	Smoking prevalence and attributable disease burden in 195 countries and territories, 1990–2015: a systematic analysis from the Global Burden of Disease Study 2015.	Reitsma, M.B., <i>et al</i>	Article	2017	830	138.3333
10	St John's wort for depression—an overview and meta-analysis of randomized clinical trials.	Linde, K. <i>et al</i>	Article	1996	746	27.6296

Table 5: Top 10 productive journals on publications associated with IRs (1980–2021).

Rank	Journal Titles	Total Publication	Total Citations	Avg. Citation per Publication	JIF ₂₀₂₀
1	<i>Journal of Endodontics</i>	39	1267	32.49	4.171
2	<i>International Journal of Oral Maxillofacial Implants</i>	28	834	29.79	2.804
3	<i>Journal of Sexual Medicine</i>	24	525	21.88	3.802
4	<i>International Journal of Esthetic Dentistry</i>	23	254	11.04	-
5	<i>Angle Orthodontist</i>	21	355	16.90	2.079
=5	<i>Clinical Oral Investigations</i>	21	99	4.71	3.573
6	<i>International Journal of Periodontics Restorative Dentistry</i>	20	582	29.10	1.84
7	<i>Clinical Oral Implants Research</i>	19	650	34.21	5.977
8	<i>Journal of Clinical Periodontology</i>	17	656	38.59	8.728
9	<i>Journal of Clinical Oncology</i>	16	219	13.69	44.544
=9	<i>Journal of Periodontology</i>	16	534	33.38	6.993
=9	<i>PLOS Biology</i>	16	4	0.25	8.029
=9	<i>PLOS One</i>	16	283	17.69	3.24
=9	<i>Value in Health</i>	16	32	2.00	5.728

**Figure 5:** Gender trends on publications associated with IRs.

Top 10 productive journals

Journal of Endodontics, published by American Association of Endodontics, has the credit of publishing the highest number of papers associated with IRs with 39 publications, followed by *International Journal of Oral Maxillofacial Implants* with 28 publications and *Journal of Sexual Medicine* with 24 publications. In Table 5, other highly productive journals have been listed along with number of publications, total citations they have received and the Impact Factor (JIF) of the Journal.

Gender trends

A total of 3,228 author names remained after cleaning the data to identify all IRs with full first names provided. The gender of 3137 names (97.2%) was successfully identified using the Genderize.io tool, of which 1,051 (33.5%) were female and 2,086 (66.5%) were male. The gender trend of authors by year is mapped in Figure 5. Notably, the ratio of female and male authors has remained fairly

consistent over the years, even as the total number of IRs has increased substantially in recent decades.

DISCUSSION

This study examines a relatively ignored population – that of independent or unaffiliated researchers. The impact of independent or unaffiliated researchers on scholarly discourse has not been thoroughly investigated in prior literature, but it is significant. This study identified 3357 indexed documents that were published with the participation of 3784 IRs. The growth rate of these publications has jumped exponentially in recent years, where the average number of articles published by IRs increased from 4 per year in 1990s to 78 per year in 2000s and 191 per year in 2010s. The results trend of publications by IRs indicate that the authors has experienced a significant growth in the number of articles produced over the past two decades. The growth rate of 48.57% highlights the substantial increase in the author's productivity. Moreover, the CAGR of 18.19% suggests that this growth has been consistent over the years. If a similar rate of growth is maintained in 2020s, we may expect to see an average of over 400 independently-authored publications per year. Factors like the introduction of Internet worldwide, Open Science, and Wiki data leading to easier availability of scientific information provided many datasets that facilitate the work of IRs and offer support for IRs, which may be responsible for the observed growth rates. Another reason could be COVID-19 epidemic and the need for research on this subject, which would provide the basis for further activity of this group, especially in recent years.

The growth of these independently-authored publications has not occurred equally across all countries and disciplines. Authors'

countries are heavily skewed towards those in Global North, especially the United States. However, the distribution is roughly equal to that of overall authorship across scholarly publishing, which also favors the Global North. Such a situation can be due to economic conditions because independent researchers do not receive financial support from institutions, so the existence of this community in countries with lower income may be logical.

Government and pharmaceutical companies based in the United States were the major funders for IRs; government and private companies based out of the United Kingdom, Germany and Switzerland were other major funders for IRs.

Currently, the scientific activity and participation of independent researchers is higher in health-related fields relative to other scientific disciplines such as humanities and social sciences. This is mainly because health research is crucial for improving community health, which is a fundamental factor for economic and social development. To achieve the greatest impact, health research needs researchers with adequate expertise and experience, and this group of researchers mainly works independently. Additionally, health research requires collaboration with governmental and non-governmental organizations, where independent researchers usually participate as collaborators. Therefore, the activity of independent researchers in the field of health is higher compared to other fields.

Those who lack tenure, research funding, and organizational membership have difficulty conducting and publishing research because they must invest by themselves.^[3] It looks like the government; private and pharmaceutical companies solve this problem and enable the presence of independent researchers in research. In general, independent researchers tend to receive financial support from independent funding agencies.

Based on Figure 3, IRs from the countries such as the United States, the United Kingdom, Germany, Italy, Canada and France have strong collaborative research networks. However, independent scholars have an institution called National Coalition of independent scholars (NCIS). After examining the requests of members, NCIS supports them in different ways by offering grants. In addition to NCIS, other platforms such as <https://www.zooniverse.org>, the project called <https://species.wikimedia.org> or European Association of Archaeologists and many others offer support for IRs and bring together them.

The results of our study showed that there is a significant relationship between geographical distribution, most productive countries, co-authorship network of countries, top funding sources. The distribution of disciplines, on the other hand, severely over-represents the medical disciplines. This is logical as many medical professionals conduct and publish research throughout their careers even while not being directly affiliated with an institution of higher education. This is more common in clinical fields because even while under the auspices of supportive

organizational conditions, some medical experts were more likely to participate in Interdisciplinary Research (IDR) teams than others did.^[14] Clinicians typically have professional practices, which are often related to the topics of their research. Evidence Based Medicine (EBM) is an approach in the field of health that seems to provide the environment for cooperation of independent researchers and the use of their experiences in research.

The skew toward medical disciplines is also evident in the keywords for articles, which favor medical terms, as well as funding sources, nearly all of which are health- and medicine-related agencies.

At present, the scientific function and participation of independent researchers in health and hygiene is more conspicuous than other scientific fields such as humanities and social sciences. Perhaps one of the reasons for this phenomenon is that funding agencies demand the knowledge and experience of this group of researchers. It appears that pharmaceutical companies with huge expenses in the field of health are the main sponsors of research in which independent researchers are active.

It is noteworthy that except for original and review articles, most publications by IRs are in the category of articles that do not require special funding. These articles are simpler for IRs as they do not require the same ethical review/oversight as with human subjects' research and are not as dependent on subscription-based databases. However, these researchers publish the bulk of their research in original articles, which appear to be under the financial support provided by other authors.

Among the top 10 highly cited publications, five were based on Institute for Health Metrics and Evaluation (IHME) (University of Washington's School of Medicine, Seattle, WA, USA) that published in different intervals or annually. These studies are crucial in health policymaking issues both globally and nationally, which is likely a factor in the top-cited status of these publications. The papers published by IHME provide a comprehensive picture of health status worldwide. Due to the high impact of IHME-affiliated papers, they attract many citations.^[15]

Journal of Endodontics, International Journal of Oral Maxillofacial Implants, Journal of Sexual Medicine, International Journal of Esthetic Dentistry, Angle Orthodontist, and Clinical Oral Investigations were major journals in which IRs contributions have often published. The analysis of journals in which independent researchers have published is also a proof of the claim that clinical and practical health related fields are important areas of activity for this group of researchers.

In addition, the gender distribution observed among IRs is consistent with previous research findings,^[16, 17] rejecting the claim that IRs are mainly women^[4] indicating a gender gap between this scientific community. The results of our study showed that about 17.5% of publications were single authored, which indicates the complete independence of many of these

types of authors. However, single-authored research can lead to author disappearance because multi-authored papers receive more citations than single-authored papers.^[18] On the other hand, average citations per documents by IRs are a considerable number and what does the author mean by considerable number, which seems to be due to active presence of IRs in the area of medicine because this subject area receives more citations than other domains.^[19]

CONCLUSION

By highlighting the publication trends among independent researchers, this study brings attention to this rapidly growing population. These researchers are often involved in medical and other natural science disciplines and participate in reviews of existing literature or data, such that they do not require the ethical approval that human subjects' research would necessitate. They tend to be highly collaborative, working in teams that may or may not include other independent researchers. Their work, in many instances, has created a substantial impact upon their disciplines, with several highly-cited review papers that have been published over the past decades. This population deserves greater recognition in the future for their contribution to scholarly discourse.

This study has a number of limitations. The publications analyzed in this study were retrieved only from WoS. However, future researchers can use the Scopus database or Google Scholar. Although we have used multiple tools to identify IRs in our search strategy, we may have missed some of them if, for instance, their information was not indexed properly by WoS. The output of WoS for some researchers and publications was incomplete. The limitations are related to the nature of publications indexed in WoS.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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