

Unveiling the gender gap in research: a bibliometric analysis of the 100 most-cited articles on food-borne pathogen outbreaks from 1990 to 2020

Das Gendergefälle in der Forschung: Eine bibliometrische Analyse der 100 meist zitierten Artikel über die Untersuchung lebensmittelbedingter Krankheitsausbrüchen im Zeitraum 1990–2020

Abstract

Introduction: Despite a recent increase in the representation of female authors in scientific literature, a significant gap persists concerning the inclusion of women in research. This necessitates the analysis of published literature from a gender perspective. This study aimed to provide gender distribution in authorship in the 100 most-cited articles on food-borne pathogen outbreaks from 1990 to 2020.

Methods: Bibliometric analysis was conducted using the Scopus database. Two reviewers were selected to search the database. We included the 100 most-cited articles on foodborne outbreak investigations. The analysis was conducted using Statistical Package for Social Sciences (SPSS) version 26 and Microsoft Excel version 2016. The citation data, including total citations, citations per year, and representation of women as first and senior authors, was analyzed in terms of frequencies, mean, median, and interquartile range. The correlation between journal impact factor and the representation of women in high-impact factor journals was determined. A p-value of <0.05 was considered significant.

Results: Most of the top-cited articles were published between 2001 and 2010 (n=47). The top 3 most-cited articles were from the USA. Of the total 100 articles, women were the first and last authors in 46% and 28% of the articles, respectively, reflecting a significant gender gap. However, the proportion of females as principal investigators gradually increased from 25% (n=10/30) to 52% (n=24/47) during the period 2001–2010 and to 92% (n=12/13) during 2011–2020. The USA had the highest number of included articles (n=48), and women were principal authors in 56% (n=27) of them. The lowest representation of women was observed in Austria, Denmark, Japan, Netherlands, New Zealand, Nigeria, Portugal, and the United Kingdom.

Conclusion: Women are under-represented in published literature on food-borne pathogen outbreaks. Although the representation of women as principal authors has recently increased, disparities still exist at the senior-author level, calling for women's advancement in academic science.

Keywords: women representation, food-borne diseases, outbreak investigations

Zusammenfassung

Einleitung: Obwohl der Anteil von Frauen in der wissenschaftlichen Literatur in letzter Zeit zugenommen hat, besteht nach wie vor eine erhebliche Lücke bei der Einbeziehung von Frauen in die Forschung. Das macht eine Analyse der Literatur aus der Geschlechterperspektive erforderlich. Ziel dieser Studie war es, die geschlechtsspezifische Verteilung

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lung der Autorenschaft in den 100 meist zitierten Artikeln zu lebensmittelbedingten Ausbrüchen im Zeitraum 1990–2020 zu ermitteln.

Methode: Die bibliometrische Analyse wurde mit Hilfe der Datenbank Scopus durchgeführt. Zwei Reviewer wurden mit der Suche in der Datenbank beauftragt. Es wurden die 100 am häufigsten zitierten Artikel zur Untersuchung lebensmittelbedingter Krankheitsausbrüche berücksichtigt. Die Analyse wurde mit SPSS, Version 26, und Microsoft Excel, Version 2016, durchgeführt. Die Zitationsdaten einschließlich der Gesamtzahl der Zitate, der Zitate pro Jahr und des Anteils von Frauen als Erst- und Seniorautorin, wurden in Form von Häufigkeiten, Mittelwert, Median und Interquartilsbereich analysiert. Die Korrelation zwischen dem Impact-Faktor der Zeitschrift und dem Anteil von Frauen in Zeitschriften mit hohem Impact-Faktor wurde ermittelt. Ein p-Wert von $<0,05$ wurde als signifikant angesehen.

Ergebnisse: Die meisten der am häufigsten zitierten Artikel wurden im Zeitraum 2001–2010 veröffentlicht ($n=47$). Die 3 am häufigsten zitierten Artikel stammten aus den USA. Von den 100 Artikeln waren Frauen in 46% der Artikel Erstautorin und in 28% der Artikel Letztautorin, was ein erhebliches Geschlechtergefälle widerspiegelt. Der Anteil von Frauen als Hauptautorin stieg jedoch allmählich von 25% ($n=10/30$) auf 52% ($n=24/47$) im Zeitraum 2001–2010 und auf 92% ($n=12/13$) im Zeitraum 2011–2020. Da die USA die höchste Anzahl an eingeschlossenen Artikeln ($n=48$) aufwies, waren Frauen in 56% ($n=27$) der Artikel Hauptautorin. Der geringste Frauenanteil wurde in Österreich, Dänemark, Japan, den Niederlanden, Neuseeland, Nigeria, Portugal und UK beobachtet.

Schlussfolgerung: Frauen sind in der veröffentlichten Literatur über die Untersuchung von lebensmittelbedingten Krankheitsausbrüchen unterrepräsentiert. Obwohl der Anteil von Frauen als Hauptautorin in letzter Zeit zugenommen hat, gibt es immer noch Ungleichheiten auf der Ebene der leitenden Autoren und Autorinnen, die eine Förderung von Frauen in der akademischen Wissenschaft erfordern.

Schlüsselwörter: Frauenanteil, Lebensmittel-übertragbare Erkrankungen, Ausbruchsanalysen

Introduction

The representation of women in the medical field has gradually increased over the past few decades [1]. However, there is still a wide gender gap concerning the inclusion of women in research [2]. The resultant under-representation of women as authors in medical literature adversely affects women's professional success [3]. It is therefore crucial to analyze the published literature from a gender perspective. Bibliometric analysis best serves this purpose.

Bibliometric analysis is a method used to evaluate the characteristics, frequency, and pattern of citations in the available literature. This is an important yet easy-to-use technique. By analyzing the characteristics and trends of publications, bibliometric analysis helps to focus on neglected areas and draw comprehensive conclusions based on the existing evidence.

Food-borne diseases pose a global public-health challenge. The scale of food-borne illnesses is so high, that one in every 10 individuals world-wide becomes ill due to consumption of contaminated food [4]. The published literature on food-borne pathogen outbreaks has not yet

been analyzed from the gender perspective. This study aims to provide gender distribution in authorship in the 100 most-cited articles on food-borne disease outbreaks.

Methods

The Scopus database was used to conduct this bibliometric analysis. Scopus has proven to be a wider database than PubMed and Web of Science when it comes to scientific literature [5], [6]. Two reviewers were selected to search the database during February 2023. The first list comprised original articles published between 1990 and 2020. The original articles were separated from the review articles using Scopus filters. We included all the articles on food-borne disease outbreaks involving field investigation and for which complete author information was available, including their names, gender, and country of origin. The review articles, guidelines, and those articles for which citation information was not available were excluded from the analysis.

The selected articles were related to food-borne disease outbreaks. The appropriateness and relevance were as-

essed by thoroughly examining the abstracts. In certain cases where abstracts were unavailable, we used other sources to obtain abstracts and determine their suitability based on our inclusion criteria. The “cited by” filter in Scopus was used to arrange the articles in order of citations. We finally compiled the list of the 100 most-cited original articles. Only those articles were included to which both the reviewers agreed.

The analysis of the final list of articles was conducted using Statistical Package for Social Sciences (SPSS) version 26 and Microsoft Excel version 2016. The citation data including total citations, citations per year, and representation of women as first and senior authors was analyzed in terms of frequencies, mean, median, and interquartile range. Microsoft Excel was used to visualize data through appropriate graphs and tables. The authors’ information was extracted to determine the nationality and gender of the first and senior authors. We used SPSS to determine the correlation between journal impact factor and the representation of women in high-impact-factor journals in the 100 most-cited articles. A p-value of <0.05 was considered significant.

Results

Table 1 shows the list of top-cited articles in descending order. The top 3 most-cited articles – namely, “An Outbreak of Diarrhea and Hemolytic Uremic Syndrome From *Escherichia coli* O157:H7 in Fresh-Pressed Apple Cider”, “An Outbreak of toxic encephalopathy caused by eating mussels contaminated with domoic acid”, and “A large community outbreak of salmonellosis caused by intentional contamination of restaurant salad bars” – were all from the USA.

Distribution of articles over time

Figure 1 shows the distribution of published articles over the three decades from 1990 to 2020. The articles were grouped according to their year of publication into three groups: 1990–2000, 2001–2010, and 2011–2020. Most of the top-cited articles were published from 2001 to 2010 ($n=47$).

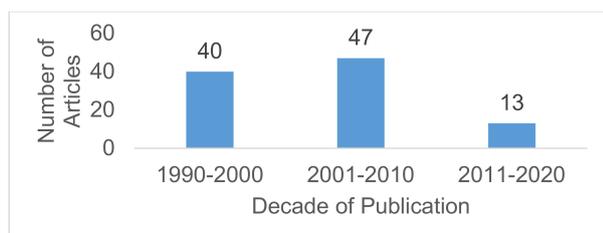


Figure 1: Distribution of published articles over the three decades

Country-wise distribution of the most-cited articles

Figure 2 shows the country-wise distribution of the most cited articles. Most of the articles were from USA ($n=48$) followed by the UK and Canada ($n=5$).

Gender distribution in authorship

Of the total 100 articles, women were first and last authors in 46% and 28% of the articles, respectively. In contrast, 54% and 71% of the first and last authors, respectively, were male. This reflects significant gender disparity, as women were less represented in most of the most-cited articles. However, we noted a temporal trend towards improvement in the representation of female first and last authors over the years. The proportion of females as principal investigators has gradually increased from 25% ($n=10/30$) to 52% ($n=24/47$) during 2001–2010 and to 92% ($n=12/13$) during 2011–2020.

Country-wise representation of women as principal author

Figure 3 shows a country-wise representation of women as principal authors. Israel, Scotland, South Africa, Tunisia, and Venezuela had the highest representation of women (100%) as principal authors. However, there was only one article from all these countries in the 100 top-cited articles. The USA had the highest number of included articles ($n=48$), and women were principal authors in 56% ($n=27$) of the articles. The lowest representation of women was observed in Austria, Denmark, Japan, Netherlands, New Zealand, Nigeria, Portugal, and UK where women authored none of the included articles as a principal investigator.

Discussion

We conducted the bibliometric analysis to evaluate authorship trends by gender for the most-cited articles on food-borne disease outbreaks over the last three decades. We showed that, despite a temporal trend towards improved female representation in the specialty of food-borne disease-outbreak investigations, female authors continue to be a minority among top-performing articles published on this subject over the years. This data corroborates previously conducted studies which demonstrated the under-representation of female authors in various medical specialties ranging from pathology to epidemiology to psychiatry to critical care to surgery.

According to UNESCO Institute for Statistics (UIS) data from 2016, less than 30% of STEM (science, technology, engineering and mathematics) researchers are female [7]. According to a study from the USA, female authors accounted for only 32.2% in the pathology clinical practice guidelines [8]. In 2018, the representation of female first

Table 1: Top-cited articles in descending order

	Top-cited articles in descending order	Citations
1	An outbreak of diarrhea and hemolytic uremic syndrome from Escherichia coli O157:H7 in fresh-pressed apple cider	803
2	An outbreak of toxic encephalopathy caused by eating mussels contaminated with domoic acid	611
3	A large community outbreak of salmonellosis caused by intentional contamination of restaurant salad bars	503
4	An outbreak of multidrug-resistant, quinolone-resistant Salmonella enterica serotype typhimurium DT104	406
5	Outbreak of Vibrio parahaemolyticus gastroenteritis associated with Alaskan oysters	379
6	An extensive outbreak of staphylococcal food poisoning due to low-fat milk in Japan: Estimation of enterotoxin A in the incriminated milk and powdered skim milk	353
7	An outbreak in 1996 of cyclosporiasis associated with imported raspberries	351
8	An outbreak of febrile gastroenteritis associated with corn contaminated by Listeria monocytogenes	340
9	Recurrent multistate outbreak of salmonella newport associated with tomatoes from contaminated fields, 2005	296
10	A national outbreak of Salmonella enteritidis infections from ice cream	294
11	An Outbreak of Cryptosporidiosis From Fresh-Pressed Apple Cider	283
12	An outbreak of hepatitis A associated with green onions	276
13	An international outbreak of Salmonella infections caused by Alfalfa sprouts grown from contaminated seeds	256
14	Clinical and pharmacological profile in a clenbuterol epidemic poisoning of contaminated beef meat in Italy	239
15	Large urban outbreak of orally acquired acute chagas disease at a school in Caracas, Venezuela	238
16	Hemolytic-uremic syndrome during an outbreak of Escherichia coli O157:H7 infections in institutions for mentally retarded persons: Clinical and epidemiologic observations	238
17	An international outbreak of salmonellosis associated with raw almonds contaminated with a rare phage type of Salmonella enteritidis	211
18	Emergence of Multidrug-Resistant Salmonella enterica Serotype Newport Infections Resistant to Expanded-Spectrum Cephalosporins in the United States	204
19	Postinfectious Irritable Bowel Syndrome After a Food-Borne Outbreak of Acute Gastroenteritis Attributed to a Viral Pathogen	197
20	An epidemic of food-borne listeriosis in western switzerland: Description of 57 cases involving adults	195
21	Multistate outbreak of hepatitis a associated with frozen strawberries	187
22	Nationwide outbreak of listeriosis due to contaminated meat	178
23	Nationwide outbreak of human salmonellosis in Germany due to contaminated paprika and paprika-powdered potato chips	178
24	A massive epidemic of multidrug-resistant typhoid fever in Tajikistan associated with consumption of municipal water	176
25	A case control study of infection with an epidemic strain of multiresistant Salmonella typhimurium DT104 in England and Wales.	172
26	Multistate outbreak of escherichia coli O157:H7 infection associated with consumption of packaged spinach, August–September 2006: The Wisconsin investigation	166
27	A foodborne outbreak of gastroenteritis associated with Norwalk-like viruses: First molecular traceback to deli sandwiches contaminated during preparation	163
28	Outbreak of listeriosis among Mexican immigrants as a result of consumption of illicitly produced Mexican-style cheese	161
29	Outbreak of Shigella sonnei infection traced to imported iceberg lettuce	161
30	An outbreak of hepatitis A associated with green onions	160
31	An outbreak of food-borne listeriosis due to cheese in Japan, during 2001	156
32	An outbreak of Salmonella serotype Thompson associated with fresh cilantro	154
33	Mass outbreak of food poisoning disease caused by small amounts of staphylococcal enterotoxins A and H	150
34	International outbreak of Salmonella Oranienburg due to German chocolate	149
35	Outbreak of life-threatening thiamine deficiency in infants in Israel caused by a defective soy-based formula	147
36	A Multistate Outbreak of Salmonella enterica Serotype Newport Infection Linked to Mango Consumption: Impact of Water-Dip Disinfestation Technology	145
37	Outbreak of Salmonella serotype Hartford infections associated with unpasteurized orange juice	144
38	Two outbreaks of multidrug-resistant Salmonella serotype typhimurium DT104 infections linked to raw-milk cheese in Northern California	142
39	Multinational outbreak of Salmonella enterica serotype newport infections due to contaminated alfalfa sprouts	138
40	A multistate outbreak of Salmonella enterica serotype Baildon associated with domestic raw tomatoes	134

(Continued)

Table 1: Top-cited articles in descending order

	Top-cited articles in descending order	Citations
41	An outbreak of <i>Salmonella saint-paul</i> infection associated with beansprouts	134
42	A large outbreak of acute gastroenteritis associated with astrovirus among students and teachers in Osaka, Japan	133
43	A national outbreak of multi-resistant <i>Salmonella enterica</i> serovar Typhimurium definitive phage type (DT) 104 associated with consumption of lettuce	132
44	Outbreak of <i>Salmonella</i> Thompson infections linked to imported rucola lettuce	131
45	A nosocomial outbreak of fluoroquinolone-resistant salmonella infection	131
46	2008 Outbreak of <i>Salmonella</i> Saintpaul infections associated with raw produce	129
47	Investigation of multidrug-resistant <i>Salmonella</i> serotype typhimurium DT104 infections linked to raw-milk cheese in Washington State	129
48	Outbreak of <i>Salmonella</i> typhimurium infection traced to contaminated chocolate and caused by a strain lacking the 60-megadalton virulence plasmid	123
49	Multistate outbreak of <i>Listeria monocytogenes</i> infections linked to whole apples used in commercially produced, prepackaged caramel apples: United States, 2014–2015	121
50	An outbreak of salmonellosis among children attending a reptile exhibit at a zoo	121
51	Listeriosis outbreak associated with the consumption of rillettes in France in 1993	120
52	An outbreak of <i>Escherichia coli</i> O157:H7 colitis associated with consumption of precooked meat patties	120
53	<i>Listeria monocytogenes</i> infection from foods prepared in a commercial establishment: A case-control study of potential sources of sporadic illness in the United States	117
54	Two consecutive nationwide outbreaks of listeriosis in France, October 1999–February 2000	114
55	Foodborne giardiasis in a corporate office setting	112
56	Outbreak of listeriosis in South Africa associated with processed meat	111
57	A novel vehicle for transmission of <i>Escherichia coli</i> O157:H7 to humans: Multistate outbreak of <i>E. coli</i> O157:H7 infections associated with consumption of ready-to-bake commercial prepackaged cookie dough – United States, 2009	110
58	Imported frozen raspberries cause a series of norovirus outbreaks in Denmark, 2005.	109
59	An outbreak due to peanuts in their shell caused by <i>Salmonella enterica</i> serotypes Stanley and Newport – Sharing molecular information to solve international outbreaks	107
60	Outbreak of staphylococcal food poisoning among children and staff at a Swiss boarding school due to soft cheese made from raw milk	103
61	An outbreak of foodborne botulism associated with contaminated hazelnut yoghurt	103
62	Multistate outbreak of <i>Listeria monocytogenes</i> associated with Mexican-style cheese made from pasteurized milk among pregnant, Hispanic women	102
63	Egg consumption is the principal risk factor for sporadic <i>Salmonella</i> serotype Heidelberg infections: A case-control study in FoodNet sites	102
64	Foodborne nosocomial outbreak of SHV1 and CTX-M-15-producing <i>Klebsiella pneumoniae</i> : Epidemiology and control	100
65	Epidemiologic study of an outbreak of clenbuterol poisoning in Catalonia, Spain	100
66	First confirmation of human diarrhoeic poisonings by okadaic acid esters after ingestion of razor clams (<i>Solen marginatus</i>) and green crabs (<i>Carcinus maenas</i>) in Aveiro lagoon, Portugal and detection of okadaic acid esters in phytoplankton	98
67	Multistate outbreak of norwalk-like virus gastroenteritis associated with a common caterer	97
68	Multistate outbreak of <i>Salmonella</i> serovar Muenchen infections associated with alfalfa sprouts grown from seeds pretreated with calcium hypochlorite	97
69	An outbreak of <i>Salmonella</i> serogroup Saphra due to cantaloupes from Mexico	97
70	Packed with <i>Salmonella</i> – Investigation of an international outbreak of <i>Salmonella</i> Senftenberg infection linked to contamination of prepacked Basil in 2007	94
71	Food poisoning associated with pumilacidin-producing <i>Bacillus pumilus</i> in rice	94
72	An epidemic of salmonellosis caused by <i>Salmonella</i> Typhimurium DT160 in wild birds and humans in New Zealand	94
73	Coliforms, <i>Escherichia coli</i> and <i>Salmonella</i> serovars associated with a citrus-processing facility implicated in a salmonellosis outbreak	93
74	An outbreak of acute intoxications from consumption of insufficiently processed cassava in Tanzania	93
75	First reported foodborne outbreak associated with microsporidia, Sweden, October 2009	92
76	International outbreak of severe botulism with prolonged toxemia caused by commercial carrot juice	92

(Continued)

Table 1: Top-cited articles in descending order

	Top-cited articles in descending order	Citations
77	An international outbreak of Shiga toxin-producing Escherichia coli O157 infection due to lettuce, September–October 2007.	91
78	A multistate outbreak of Shiga toxin-producing Escherichia coli O26:H11 infections in Germany, detected by molecular subtyping surveillance	91
79	Outbreak of salmonella newport infections linked to cucumbers — United States, 2014	90
80	Staphylococcus aureus food-poisoning outbreak associated with the consumption of ice-cream	90
81	Salmonella typhimurium infections associated with peanut products	89
82	Outbreak of verocytotoxin-producing E. coli O145 and O26 infections associated with the consumption of ice cream produced at a farm, Belgium, 2007.	88
83	Illness outbreak associated with Escherichia coli O157:H7 in Genoa salami	88
84	A Massive Outbreak of Type E Botulism Associated with Traditional Salted Fish in Cairo	88
85	Outbreak of multidrug-resistant Salmonella enterica serotype typhimurium definitive type 104 infection linked to commercial ground beef, Northeastern United States, 2003–2004	87
86	A large outbreak of botulism: The hazardous baked potato	87
87	Norovirus gastroenteritis general outbreak associated with raw shellfish consumption in South Italy	85
88	Multidrug-resistant Salmonella Typhimurium Infection from Milk Contaminated after Pasteurization	84
89	A national outbreak of salmonella serotype Tennessee infections from contaminated peanut butter: A new food vehicle for salmonellosis in the United States	82
90	Outbreak of diarrhoea due to Escherichia coli O111:B4 in schoolchildren and adults: association of Vi antigen-like reactivity	82
91	Detection of both hepatitis A virus and Norwalk-like virus in imported clams associated with food-borne illness	81
92	Exposure of Listeria monocytogenes within an epidemic caused by butter in Finland	81
93	An outbreak of type a botulism associated with a commercial cheese sauce	81
94	Reactive arthritis after Salmonella among medical doctors – study of an outbreak	81
95	Listeriosis outbreak caused by acid curd cheese 'Quargel', Austria and Germany 2009	79
96	Nosocomial outbreak caused by Salmonella enterica serotype livingstone producing CTX-M-27 extended-spectrum β-lactamase in a neonatal unit in Sousse, Tunisia	79
97	An outbreak of salmonellosis traced to watermelon	66
98	Outbreak of norovirus infection associated with the consumption of frozen raspberries, France, March 2005.	63
99	National outbreak of Salmonella serotype Saintpaul infections: Importance of Texas restaurant investigations in implicating Jalapeño peppers	60
100	Outbreak of Cryptosporidium linked to drinking unpasteurised milk.	48

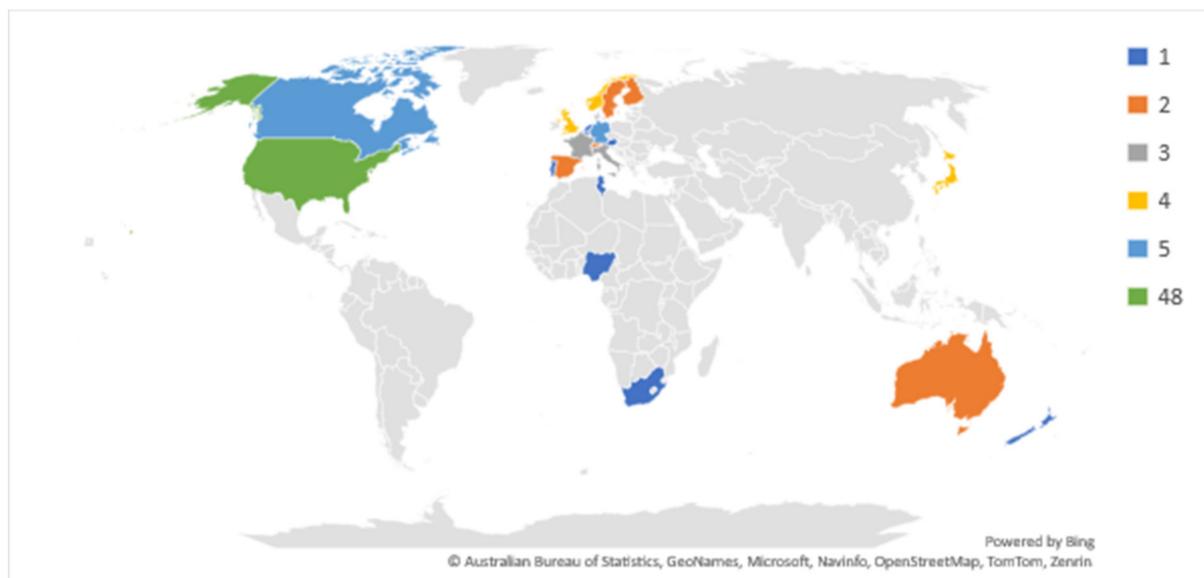


Figure 2: Country-wise distribution of the most cited articles

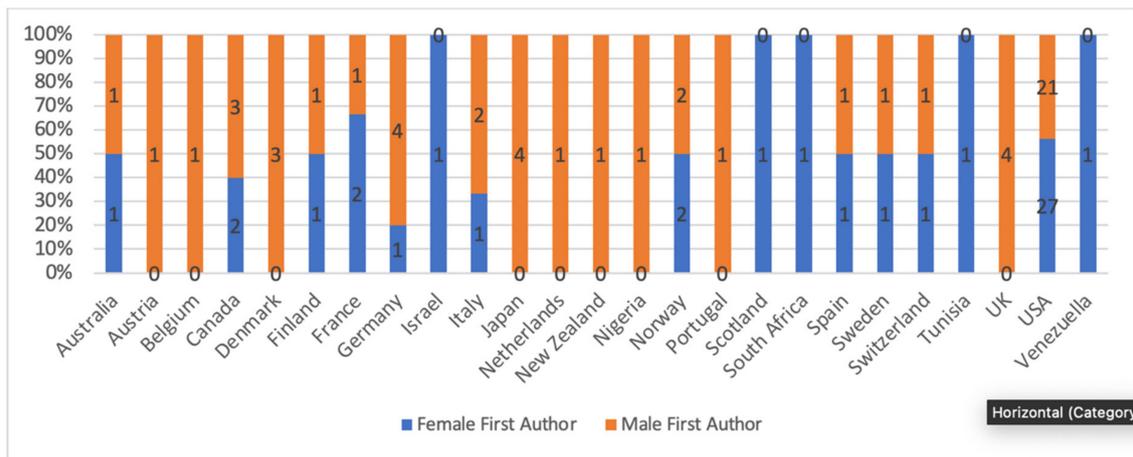


Figure 3: Country-wise representation of women as principal authors

authors in the field of emergency medicine was only 30% [9]. From 1987 to 2017, women orthopedic surgeons made up only 1.7% of senior writers and authors of orthopedic papers [10]. The same trend was apparent in the cardiology [11] and neurosurgery [12] literature, where female first authors made up only 20.8% and 10.5% of the total, respectively.

This gender disparity in the research output on food-borne disease outbreaks can be attributed to several factors. Firstly, females face implicit bias and social barriers during recruitment into a laboratory for graduate research, acceptance for postdoctoral positions, recruitment to fill tenure-track faculty positions, and evaluation for promotion in rank [13]. For instance, there are only 38% female pathologists and 37% female public health and preventive specialists in the US [14]. Although these constraints have been gradually lifting, the consequences are still evident in the under-representation of women in senior medical positions and as authors. Secondly, there are further gender differences in grant funding. Even when women's research is funded, their performance and research accomplishments as principal investigators are likely to be judged harsher than those of their male counterparts [15].

Thirdly, according to some studies, there may be a bias in the publication process that favors work by male authors. This can result in women's research being published less frequently or in journals with lower impact factors, reducing their visibility and career advancement [16]. Such bias could undermine women's greater research productivity by preventing publication of their submitted papers. Moreover, women may have difficulties in developing collaborative networks because of implicit biases or exclusion from informal networks that frequently lead to more publication opportunities. Finally, having effective mentors and role models can have a significant impact on an individual's career path. Female students and early-career professionals may lack the necessary assistance and direction in the medical field, where women are under-represented in leadership roles [13].

Our analysis shows that there is a trend toward increasing involvement of female authors in the field of outbreak

investigation, i.e., a 67% increase in 2020 from 1990, which seems promising. Nonetheless, despite significant progress, a gender disparity persists, notably among senior faculty and leadership, as there was no increase in the number of female senior authors from 1990. This raises a concern that even in fields where women's representation is increasing at lower ranks [17], they do not have equal representation at higher levels. Gendered divisions of labor within academia may be to blame for this imbalance. This disparity shows that the problem will not be solved just by more generations of women entering the academic pipeline, but that women's advancement in academic science must be fostered.

Limitations

There are some limitations to the current analysis. First, the gender of the authors was identified by inspecting first names and conducting internet searches, and hence there may have been some inaccuracy in gender assignment. Second, because this analysis included only the top 100 hundred referenced publications, the results may not truly represent the total food-borne disease-outbreak literature. Third, our data solely show the representation of female writers in published journal articles, without looking into whether there is any gender prejudice in the acceptance or rejection of female first- or second-authored manuscripts.

Notes

Competing interests

The authors declare that they have no competing interests.

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