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GENDER INEQUALITY IN SCIENTIFIC PRODUCTION AT UNICAMP: a scientometric analysis of female participation essential for equity (2019–2023)

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ABSTRACT

This study investigates gender representation in publications from the University of Campinas (UNICAMP) between 2019 and 2023, using data from the Scopus database API. Gender inference was performed using the OpenAI ChatGPT. The analysis includes an assessment of the success rate of proposals submitted to the São Paulo Research Foundation (FAPESP), one of Brazil's leading research funding foundations and the main one in the state of São Paulo. Male authorship predominates, especially in Physical and Social Sciences, while areas like Health Sciences and Life Sciences show greater gender balance. Female authorship declined post-2021, possibly due to the pandemic. Mann–Whitney tests revealed statistically significant differences in normalized impact (FWCI) between genders in most areas, with a lower FWCI for women, except in Physical Sciences, where it was slightly higher. The study also analyzes participation in projects related to the Sustainable Development Goals (SDGs), highlighting female participation in areas, such as peace and gender equality, but with less representation in clean energy and infrastructure. Despite progress, gender disparity persists in FAPESP's success rates as well. The study concludes that gender inequality in UNICAMP's scientific production demands actions to promote equity.

IMPACT STATEMENT

This study provides critical insights into gender disparities in scientific production at UNICAMP, revealing persistent inequalities in authorship, impact, and research funding success rates. By identifying trends in gender representation across disciplines and assessing the impact of research outputs, the findings contribute to ongoing discussions on academic equity. These findings can inform decision-makers at universities and funding agencies, fostering structural changes to reduce gender imbalances and enhance diversity in research environments.

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1. Introduction

The search for greater gender equity in universities and scientific production has been a global challenge, despite recent efforts to change this scenario (Choji et al., 2024). This issue, as highlighted by Oliveira-Ciabati et al. (2021), is intrinsically aligned with Goal 5 of the United Nation's (UN) 17 Sustainable Development Goals (SDGs): to achieve gender equality and empower all women and girls.

Recent studies have shown that women scientists tend to have a lower productivity and impact on their research compared to their male counterparts (Chen & Seto, 2022; Choji et al., 2024; Joanis & Patil, 2022; Kozlowski et al., 2022; Zhang et al., 2021). This underrepresentation of women in scientific production is more evident in some fields of knowledge, especially Science, Technology, Engineering and Mathematics (STEM). Such disparity is even more pronounced in specific subareas of STEM, such as Computer Science

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and Mathematics. In contrast, there seems to be greater gender equity in the areas of Humanities and Health (Choji et al., 2024; Joanis & Patil, 2022; Kozlowski et al., 2022; Larivière et al., 2013).

However, challenges and disparities persist and need to be addressed to promote more equitable gender representation across academic disciplines (Choji et al., 2024; Tonini & Araújo, 2019). In other words, gender inequality persists in many other aspects of the academic environment, from representation in leadership positions to disparity in the allocation of resources and research opportunities. Although there is a growing number of women entering higher education and pursuing academic careers (Tonini & Araújo, 2019), many of them still face significant obstacles in their professional progression. Understanding the dynamics of these inequalities requires an analysis that considers the multiple layers of sexism, from the formation of stereotypes in childhood (Signorella et al., 1993) to discriminatory practices present in higher education and research institutions (Leaper & Brown, 2018).

Institutional barriers faced by women in academia are not limited to career progression but also manifest in selection processes and scientific recognition. The study by Bao and Huang (2022) on scientific reforms and gender equality provides a striking example of how institutional structures can unequally impact men and women, regardless of their academic merit. The authors demonstrate that, in the election processes for scientific academies in China, women face a significantly lower approval rate than men, even when they have superior academic indicators. This pattern suggests that factors not directly related to scientific productivity, such as implicit biases and subjective evaluation criteria, influence decision-making.

Bao and Huang's (2022) analysis highlights the need for institutional reforms aimed at mitigating these inequalities, including greater transparency in selection criteria, external auditing of decision-making processes and strategies to encourage female participation in prestigious academic positions. These findings are particularly relevant for investigating treatment effects in academia, that is, the differentiated consequences that institutional policies may generate among different groups within the academic environment. They reveal how different groups respond asymmetrically to these policies, reinforcing the importance of interventions designed to correct these structural distortions.

The work of Bao, Huang, et al. (2024) introduces significant methodological innovations in the use of artificial intelligence (AI) for estimating treatment effects, demonstrating how these technologies can mitigate biases and improve the analysis of institutional interventions. In their study, the authors showed that interventions designed to minimize gender biases – such as replacing human professors with AI in a natural experiment – were effective in reducing performance disparities between men and women. This example underscores the relevance of evidence-based institutional reforms that consider treatment effects, meaning the differentiated responses of specific groups to interventions. In the academic context, the analysis of treatment effects helps identify how institutional policies impact men and women differently, emphasizing the need for strategies that combine quantitative indicators, such as scientific productivity, with qualitative aspects, such as researchers' lived experiences.

The persistence of these disparities, even in institutions of excellence, reinforces the need for studies investigating the mechanisms that perpetuate gender inequality in academia. The analysis of scientific output, combined with the investigation of institutional policies and their impacts, offers a powerful lens for understanding the complex interactions between individual, social and institutional factors that sustain gender inequalities. Reforms that address these interactions can transform academic institutions into more inclusive, diverse and equitable environments, fostering not only representation but also scientific excellence.

The University of Campinas (UNICAMP), the focus of this study, stands out as one of the leading universities in Latin America, ranking 2nd in the THE (Times Higher Education, 2025) rankings. Its significant scientific output, with 30,256 total publications indexed in the Scopus database between 2019 and 2023 (representing 16% of Brazilian scientific production during this period), and its impact indicators – a Field-Weighted Citation per Publication of 1.06 and an Output in Top 10% Citation of 11.4% during the same period – make it a relevant case for investigating female participation in science. This Output in Top 10% Citation performance significantly surpasses the average for Latin America (7.3%) and Brazil (7.7%). The comparative analysis will assess whether female representation at UNICAMP aligns with its high rates of scientific production and impact, considering its national and international influence. UNICAMP has implemented several policies to promote gender equality, including: extending the eligibility period for the New Faculty Incentive Program (Programa de Incentivo a Novos Docentes [PIND]) for mothers (two years per child); establishing a Human Rights Board Committee to combat harassment,

especially in graduate programs; and developing a good practices manual for selection processes, which aims for equity in evaluation committees and offers alternative schedules for breastfeeding mothers.

Although 49.4% of graduate students are women, only 37.6% of the faculty are female, highlighting the challenge of achieving gender equity at the University. In this sense, promoting gender equity enriches academic representativeness and diversity, leading to excellence and scientific innovation. This is a strategic measure for sustainable progress and a more just and equal society.

Research on gender identification of authors in academic works has been widely carried out, contributing to understanding and addressing the disparities that may arise between different groups of researchers (Abdalla et al., 2023; Zlakishvili & Horev, 2024; Becherucci et al., 2024). However, the absence of accurate information regarding the gender of the authors can represent a challenge in this type of research (Krstovski et al., 2023), leading researchers to resort to inference of gender from the names of the participants. This approach, although subject to ethical issues and uncertainties regarding accuracy, is a strategy used to obtain additional information considering the challenge of lacking accurate data on the gender of the authors.

This study mainly aims to identify the degree of gender equality in scientific publications of the UNICAMP, considering that scientific publication is the main means of disseminating scientific knowledge and that, in turn, it plays a fundamental role in the progression of academic career and the achievement of institutional leadership positions (Oliveira-Ciabati et al., 2021). As a specific objective, this study aims to investigate the success rate, by gender, of proposals submitted to the São Paulo Research Foundation (FAPESP), one of the main research funding foundations in Brazil and the main one in the state of São Paulo. Due to its relevance and influence, FAPESP plays a fundamental role in funding research at UNICAMP, supporting most of the scientific projects carried out at the institution. The findings of this research have the potential to offer valuable insights for the formulation of future strategies by the Pro-Rectory of Research (PRP) and the Pro-Rectory of Graduate Studies (PRPG) of UNICAMP, aiming to promote gender equity in research and scientific production of the University.

This study hypothesizes that UNICAMP's scientific production exhibits gender inequality in terms of authorship, author position and success in securing FAPESP-funded research projects. To investigate this hypothesis, the following questions will be addressed:

- What is the degree of female representation in UNICAMP's scientific output between 2019 and 2023?
- How is female participation distributed across different fields of knowledge?
- How is female participation distributed according to publications that address the SDGs?
- Are there differences in female participation regarding authorship positions (first, last and overall)?
- What is the success rate of research proposals submitted to FAPESP, considering the gender of the principal investigator?

Based on this information, PRP and PRPG may have concrete subsidies to develop specific strategies and policies toward promoting gender equity at UNICAMP. This could include measures such as implementing programs to encourage women's participation in traditionally male-dominated fields and strengthening support and mentoring networks for women academics. By leading this internal effort, UNICAMP would show its commitment to promoting gender equality and would contribute significantly to building a more inclusive, diverse and fair academic environment.

2. Materials and methods

2.1. Data sources and analysis period

This research employed a scientometric study using the Scopus database (Elsevier) due to its comprehensiveness, reputation, and the availability of an API for extracting detailed data. The SciVal platform (Elsevier) complements the analysis by providing additional metrics, such as the Field-Weighted Citation Impact (FWCI), the All Science Journal Classification (ASJC) and data related to the SDGs (2023). The analysis covers the period from 2019 to 2023, selected for its relevance in capturing recent trends in scientific production, including the impacts of the COVID-19 pandemic, which potentially affected researchers

of different genders disproportionately. This period is also relevant in light of the discussions by Martin and Ruble (2010) on the impacts of specific social contexts, such as social isolation during the pandemic, on gender socialization patterns and how institutions can inadvertently reproduce pre-existing gender biases in society.

Finally, information was requested from the São Paulo Research Foundation (FAPESP) regarding the success rates of proposals submitted by UNICAMP authors, stratified by gender. Analyzing proposal success rates allowed us to investigate whether women face additional obstacles in obtaining research funding, corroborating or refuting the evidence of female underrepresentation in scientific production.

2.2. Data collection

2.2.1. Bibliometric data from Scopus

The Scopus database was searched using 'Universidade Estadual de Campinas' in the 'Affiliation' field, filtered by document type (articles, reviews, conference papers and book chapters) and the period from 2019 to 2023. Data extraction utilized the Scopus API (Elsevier, 2024) and a Python script with the pybliometrics library (Rose & Kitchin, 2019) to ensure the accuracy of authorship data, particularly UNICAMP affiliation. A total of 233 publications were excluded due to affiliation errors, 890 due to missing Digital Object Identifiers (DOIs) and 2356 due to abbreviated author names, resulting in a final dataset of 25,138 publications (84.3% of the initial set). Figure 1 presents a flowchart of the selection process.

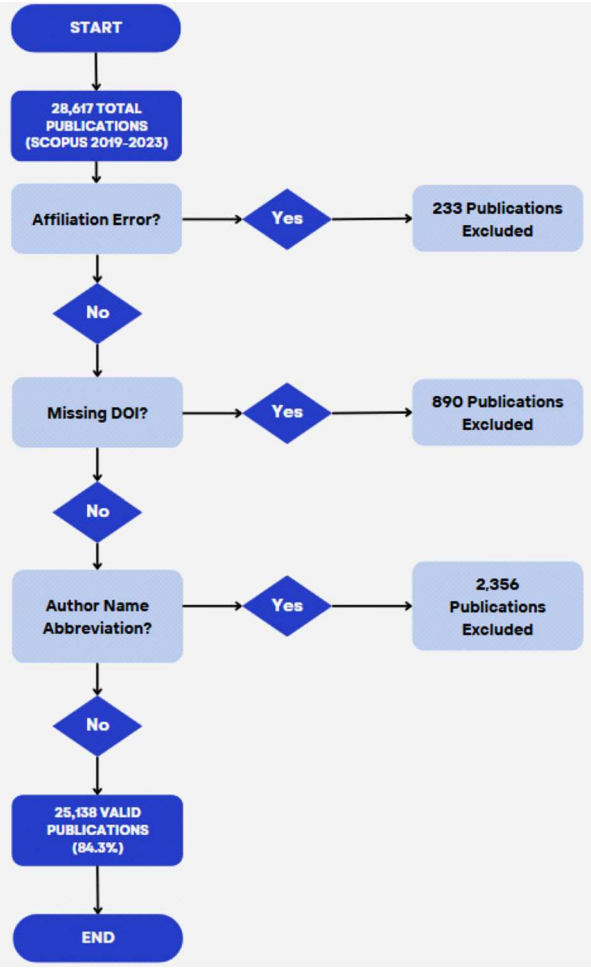

Figure 1. Publication selection and validation flowchart (Scopus 2019–2023). *Source:* Prepared by the authors.

2.3. Gender inference

2.3.1. Approach and limitations

Gender inference was performed using a binary classification ('Female' and 'Male') based on authors' full names. It is fundamental to acknowledge the inherent limitations of this approach. Binary classification simplifies the complexity of gender identities and can lead to the erasure of individuals who do not fit within these categories. While this methodology is common in scientometric studies (Bunker Whittington et al., 2024; Olechnicka et al., 2024; Sebo & Shamsi, 2023) due to the scarcity of gender information in bibliographic databases, its application can present limitations related to the accuracy of gender identification, potentially leading to misclassifications, especially for non-binary, gender-neutral or uncommon names.

Building on Signorella et al.'s (1993) emphasis on the distinction between knowledge of stereotypes and attitudes toward them, we aim to go beyond the simple measurement of female representation. Signorella et al. (1993), in their investigation of gender schemas in children, demonstrated the importance of considering different types of measures to capture nuances in understanding and attitudes toward stereotypes. Similarly, in this study, we recognize that simply counting authors by gender does not necessarily reflect individual attitudes or beliefs about gender. The inclusion of dimensions, such as research themes (SDGs) and publication impact (FWCI) broadens perspectives and allows for an investigation of potential biases in scientific production, moving beyond mere authorship quantification. Future research with gender data collected through self-identification will enable more precise and respectful analyses of diversity.

Furthermore, drawing on the contributions of Martin and Ruble (2010), we acknowledge that gender is not a binary and static variable but rather a complex, dynamic process influenced by various social factors. This complexity is not fully captured by methods that rely on name-based inference, underscoring the need for the development of more inclusive methods that respect gender diversity.

Methodological transparency allows us to situate this study within the context of existing challenges in gender research and to recognize that the results obtained are an approximation of reality. This highlights the existing information gap and the need for the development of more inclusive methods.

2.3.2. Inference procedure

The use of AI, specifically Large Language Models (LLMs), such as ChatGPT, for gender inference based on personal names presents a promising and innovative approach. These models can make inferences from the vast amounts of data on which they were trained. Zheng et al. (2023) demonstrated that LLMs, including ChatGPT 3.5 and 4, can function as effective assistants in various fields, facilitating tasks ranging from text mining to more complex data analysis.

ChatGPT (OpenAI) 3.5 was chosen for the initial inference due to its natural language processing capabilities and superior performance compared to other gender detection APIs (Goyanes et al., 2024; Wu et al., 2023). A Python script was used to query the ChatGPT API for each author name, with a prompt requesting classification as 'MASCULINO' (male), 'FEMININO' (female) or 'INCERTO' (uncertain).

To mitigate bias, the ChatGPT results underwent a two-step manual review process. First, the results were grouped by first name to identify potential inconsistencies in gender assignment. This step allowed for the identification of potential inconsistencies in gender assignment for identical names and streamlined the subsequent manual review. However, no inconsistencies were identified in the generated results. Then, the 71 authors classified as 'INCERTO' (uncertain) were manually checked on UNICAMP's faculty portal to confirm gender based on additional information. Following this process, the gender of only 9 authors remained undetermined due to insufficient information in the consulted profiles.

2.4. Ethical considerations

Inferring gender based on names and using AI, such as ChatGPT, raises important ethical concerns. AI can perpetuate biases present in training data, reinforcing gender stereotypes and leading to

misclassifications, especially for individuals with non-binary gender identities. Methodological transparency, validation of results, and contextualizing the limitations of AI-driven inference are crucial for mitigating these risks and ensuring the ethical conduct of research.

In this study, several measures were adopted to minimize ethical risks and protect individual privacy. The data used are publicly accessible and extracted from the Scopus database and the São Paulo Research Foundation (FAPESP). No sensitive personal data, such as contact information or any other information allowing direct identification of individuals beyond their names and institutional affiliations as provided by the Scopus database, were used. Gender inference was performed solely based on author names. Any additional information available in author profiles was not used in the analysis process.

The analysis focused on statistical aggregates, without requiring access to private information that could compromise author privacy. This approach aims to ensure compliance with relevant data protection regulations.

2.5. STEM and SHAPE field categorization

Publications were categorized into STEM and SHAPE (Social Sciences, Humanities, Arts and Economics) fields, following the classification of the British Academy (2021). The ASJC categories were used to classify these groupings, as shown in Table 1. Disciplines were grouped and mapped to STEM and SHAPE categories.

2.6. Scientometric and statistical analysis

Scientometric and statistical analysis were conducted using the Python programming language and the scipy library (Virtanen et al., 2020). Initially, a descriptive analysis of scientific production was performed, stratified by year, gender, field of knowledge and SDGs. This analysis included quantifying the number of publications and calculating statistics for the FWCI, such as mean, median, standard deviation and 95% confidence intervals. The normality of the FWCI data was assessed using the D'Agostino and Pearson omnibus normality test (D'Agostino, 1971; D'Agostino & Pearson, 1973), implemented in the scipy.stats.normaltest function. As the data did not follow a normal distribution (p value < 0.05), the non-parametric Mann–Whitney U test was chosen to compare FWCI between genders within each major field of knowledge. This choice is justified by the robustness of the Mann–Whitney test in situations where the normality assumption is not met (Hollander et al., 2013).

Table 1. Classification of ASJC areas in STEM and SHAPE.

SHAPE	STEM
Arts and Humanities	Agricultural and Biological Sciences
Business, Management, and Accounting	Biochemistry, Genetics, and Molecular Biology
Decision Sciences	Chemical Engineering
Economics, Econometrics, and Finance	Chemistry
Multidisciplinary Sciences	Computer Science
Psychology	Dentistry
Social Sciences	Earth and Planetary Sciences
	Energy
	Engineering
	Environmental Science
	Health Professions
	Immunology and Microbiology
	Materials Science
	Mathematics
	Medicine
	Neuroscience
	Nursing
	Pharmacology, Toxicology, and Pharmaceutics
	Physics and Astronomy
	Veterinary Medicine

Source: Prepared by the authors.

3. Results

3.1. Analysis of gender representation in UNICAMP publications

After completion of the methodological steps, the dataset consisted of 25,138 documents (20,234 articles; 2096 review articles; 1810 conference articles; and 998 book chapters), representing 87.8% of the 28,617 documents initially retrieved. These documents were authored by a group of 68,261 authors from UNICAMP, 42% of whom were women (28,843) and 58% men (39,418). In other words, the sample was performed by frequency of authorship input, and not by occurrence. For example, regarding the percentage mentioned above, for a publication with eight UNICAMP authors, if six were attributed to a certain gender, the other two were attributed to the other gender.

Although the period analyzed at UNICAMP (2019–2023) is slightly different from the national study by Elsevier and BORI (2024), which indicated 49% of female authors between 2018 and 2022, at UNICAMP this percentage was 42%, remaining stable (Figure 2). In contrast, the study by Oliveira-Ciabati et al. (2021) at University of São Paulo – USP, using Web of Science data from 1950 to 2019 and focusing exclusively on faculty members, reported a female participation rate of 38.28% among 3067 records. Although these numbers indicate a slight difference in female representation between the two institutions, it is essential to emphasize that a direct comparison of these percentages is problematic due to significant methodological differences. The database used (Scopus *vs.* Web of Science), the time period analyzed (2019–2023 *vs.* 1950–2019), and the target population (all authors *vs.* only faculty members) introduce biases that prevent a straightforward interpretation of the differences. However, the difference between Unicamp (42%), USP (38.28%), and the national average of 49% (Elsevier & BORI, 2024), although seemingly small, warrants further investigation to understand the nuances of this variation. The complex interaction between institutional, cultural and methodological factors requires a detailed analysis to determine whether these differences reflect structural gender disparities or are artifacts of distinct methodologies.

According to the data presented in Figure 3, one can verify that the representation of female authors exceeded that of men by only 2% in two major areas: Health Sciences and Life Sciences. According to Choji et al. (2024), there seems to be a more balanced trend in terms of gender equity in these areas of knowledge. Women's participation was also higher in the multidisciplinary area.

In the areas associated with Physical Sciences (33%) and Social Sciences (39%), a more marked female underrepresentation is observed, indicating that these areas need greater attention to promote the inclusion of women in UNICAMP's scientific production.

In the analyzed period, the participation of women in UNICAMP's scientific production was 43.6% in STEM areas. In SHAPE areas, this percentage reached 45%. The proportions of female participation at UNICAMP were similar between the STEM and SHAPE areas. This balance can be explained by the lower female participation in Social Sciences (39%), negatively impacting the SHAPE index, and by the higher participation in Health Sciences (51%), positively influencing the STEM index, as already presented in Figure 3.

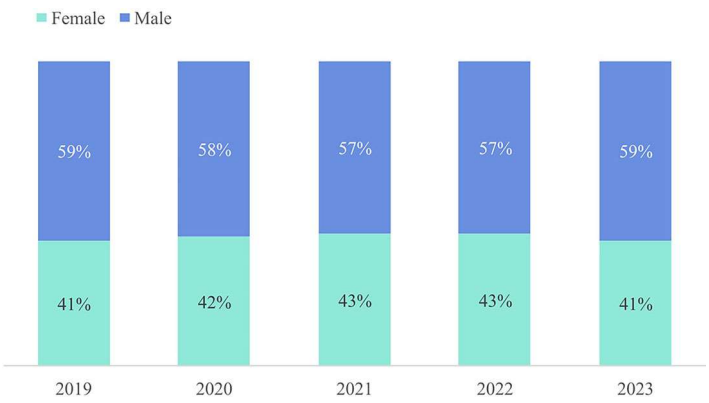

Figure 2. Evolution of the participation of authors, by gender and year, in UNICAMP publications (2019–2023). *Source:* Prepared by the authors.

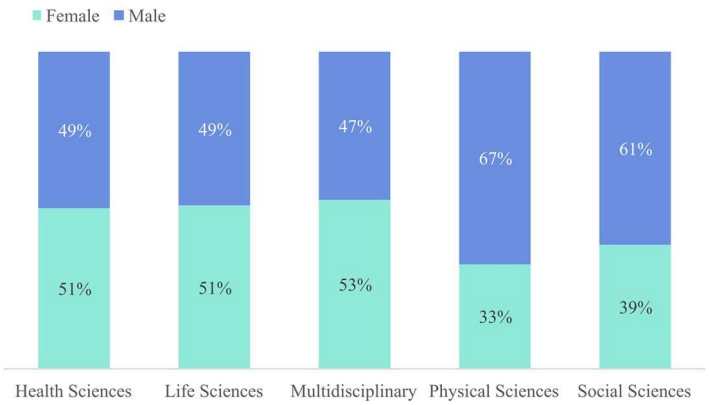

Figure 3. Participation of authors by gender and major areas of knowledge (ASJC), in UNICAMP publications (2019–2023). *Source:* Prepared by the authors.

Table 2. Number of publications, by year, gender and major areas of knowledge (ASJC) in UNICAMP Publications (2019–2023).

	2019		2020		2021		2022		2023	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Health Sciences	16,262	16,544	19,991	18,274	26,958	26,737	22,426	20,926	19,663	20,424
Life Sciences	16,485	17,293	21,143	21,357	27,809	22,896	21,029	19,233	22,524	23,183
Multidisciplinary Sciences	1926	1617	1614	1448	1324	1182	3755	3071	987	1125
Physical Sciences	15,100	35,419	18,185	38,243	21,798	38,941	19,804	38,631	20,040	41,676
Social Sciences	1455	2416	1801	2530	2128	3499	2239	3168	1957	3439

Source: Prepared by the authors.

Except for the multidisciplinary area, all other areas of knowledge showed growth in scientific production in 2023 when compared with 2019, for both men and women, as presented in Table 2. The period between 2019 and 2021 stands out for registering the highest growth in publications, especially those with female authorship.

After 2021, there was a drop in women's participation in UNICAMP's scientific production, a period marked by the intensification of the COVID-19 pandemic, which may be related to disproportionate impacts faced by women in their multiple social roles. This intensification of responsibilities, often disproportionately assigned to women, supports Leaper and Brown's (2018) perspective on contemporary manifestations of sexism. The authors argue that sexism, even in subtle forms, such as microaggressions and unconscious biases in evaluation and promotion processes, can significantly impact the development and trajectory of girls and women, limiting their opportunities and contributing to inequalities across various spheres, including academia.

Studies show that the pandemic has exacerbated gender inequality in academia, with women, especially mothers or caretakers of older adults and people with disabilities, taking on a greater burden of household responsibilities and child care (Staniscuaski et al., 2020; Staniscuaski, Reichert, et al., 2021; Staniscuaski, Kmetzsch, et al., 2021). Work overload, combined with lack of time for research and exhaustion, may have contributed to the reduction in female scientific production observed. The absence of social support networks, such as schools and families, during social isolation, also contributed to the intensification of the conflict between professional and personal life, especially for women (Machado et al., 2019; Staniscuaski, Reichert, et al., 2021).

In this context, the pandemic can be characterized as a true 'social lockdown,' as its restrictions on mobility and social interaction, including the closure of schools and daycare centers, exacerbated preexisting inequalities. The analysis of the pandemic's impact on female scientific productivity at Unicamp aligns with the findings of Bao, Cao, et al. (2024) regarding the effects of socioeconomic restrictions on individual behavior. Bao, Cao, et al. (2024) demonstrated that lockdowns affected creativity differently, leading to a sharper decline among men.

However, these findings highlight the asymmetry of the restrictions' effects: while the decline in creativity was more pronounced among men, the impact of the lockdown on women may have manifested

through increased domestic responsibilities and reduced access to support networks, factors that, in the analyzed context, likely contributed to the decline in female scientific production. The decrease in creativity observed in the study may have a relevant parallel with the decline in female scientific output at Unicamp during and after the pandemic. Just as lockdowns limited social interactions and restricted essential resources for academic development, the intensification of domestic and caregiving responsibilities, amplified by the absence of support networks, imposed additional barriers to women's scientific productivity.

The pandemic can be understood as a treatment variable, that is, an external factor that generated differentiated impacts on various social groups. In academia, this treatment effect was not homogeneous across genders, significantly altering the balance between professional and personal life, especially for female academics. This phenomenon suggests that gender inequalities in academia do not stem solely from historical structural factors but also from external events that deepen these disparities. The treatment effect concept discussed by Bao, Cao, et al. (2024) can, therefore, be applied to the analysis of the pandemic's consequences in academia: institutional restrictions and changes do not impact men and women uniformly but rather in differentiated ways, depending on each group's position within social and academic structures. For this reason, the 'social lockdown' may have intensified preexisting inequalities, disproportionately affecting female researchers. The increased domestic workload and reduced access to support networks, such as daycare centers and schools, help explain the decline in academic

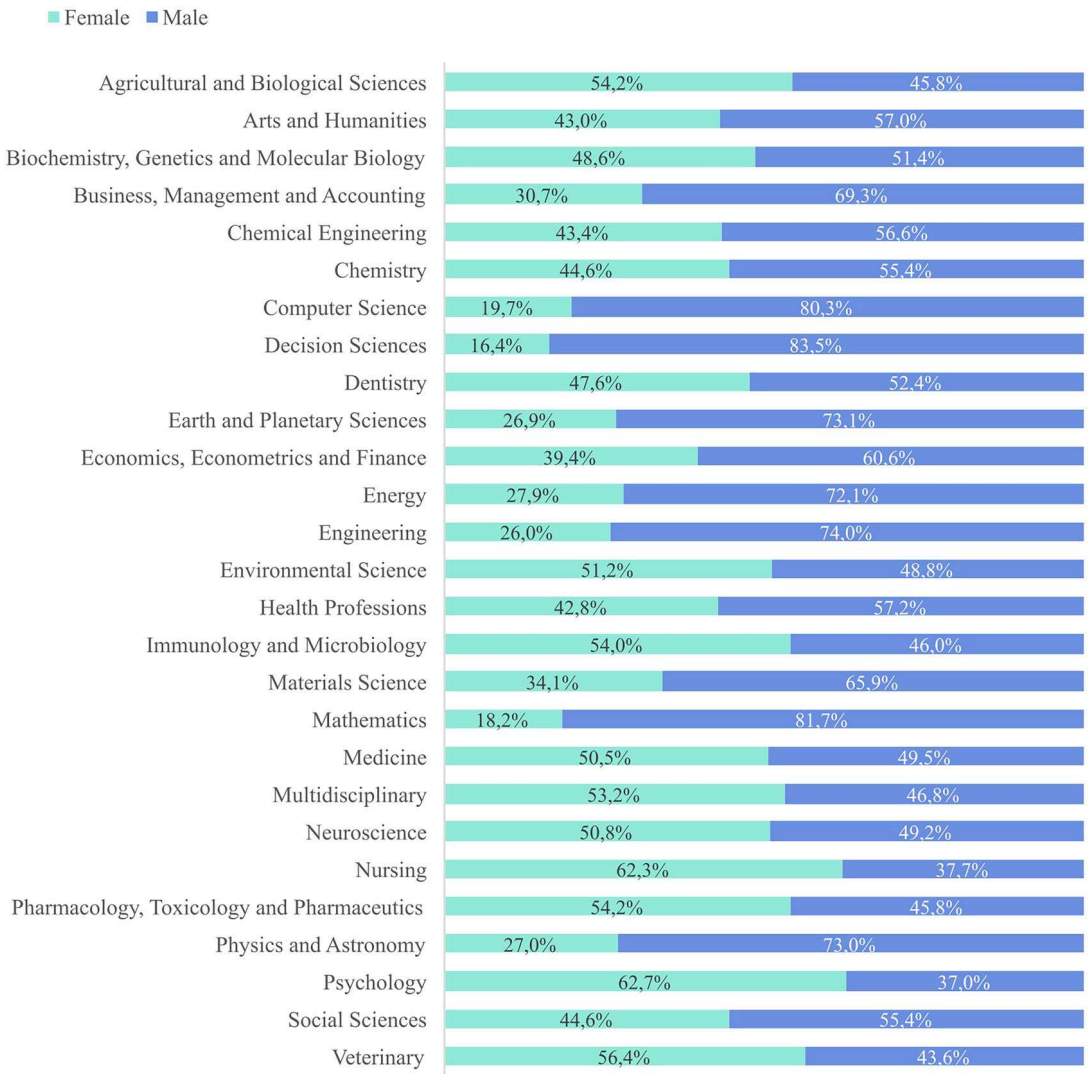

Figure 4. Participation of authors, by gender and areas of knowledge (ASJC), in UNICAMP publications (2019–2023). *Source:* Prepared by the authors.

productivity observed after 2021. This unequal impact constitutes a treatment effect, in which gender plays a determining role in individuals' responses to the restrictions imposed by the pandemic.

Figure 4 shows that the female presence stood out in several areas of knowledge, registering remarkable proportions in areas such as Psychology (63%); Nursing (62%); Veterinary Medicine (56%); Agriculture and Biological Sciences (54%); Pharmacology, Toxicology and Pharmacy (54%); Immunology and Microbiology (54%); Multidisciplinary Sciences (53%); Environmental Science (51%); and Neuroscience (51%). In the area of Medicine, both genders presented, curiously, an equitable participation, with 50% each. On the other hand, there is a significant disparity between male and female participation in various academic areas. Female representation is notably lower than that of males in the disciplines of Decision Sciences (16%), Mathematics (18%), Computer Science (20%), Engineering (26%), Earth and Planetary Sciences (27%), Physics and Astronomy (27%) and Energy (28%).

In addition to those areas where female production is significantly lower compared with male, there are others where this disparity also occurs, but on a smaller scale. For example, the areas of Social Sciences (45%), Chemistry (45%), Chemical Engineering (43%), Arts and Humanities (43%), and Economics, Econometrics and Finance (39%). On the other hand, there are areas in which the percentage difference is more subtle and equitable, such as in Biochemistry, Genetics and Molecular Energy (all with 49%) and Dentistry (48%).

This underrepresentation, however, manifests differently when comparing UNICAMP's data with the national landscape. The difference in distribution across fields of knowledge is even more striking. In Business, Management and Accounting, female participation at UNICAMP is 30.7%, while the national average between 2018 and 2022 reaches 37% (Elsevier & BORI, 2024). Conversely, in Nursing, female participation, although high (62.3% at UNICAMP), is considerably lower than the national average (80%). These disparities reinforce the importance of analyzing the specific context of each institution and field of knowledge to develop more effective gender equity promotion policies that consider local particularities.

When comparing the normalized impact (FWCI) between genders by area (Figure 5), one can observe considerable differences in this indicator in the areas of Social Sciences (41% points below the male gender), Multidisciplinary Sciences (36% points below the male gender) and Life Sciences (23% points below the male gender). In Health Sciences, the disparity is smaller, with only 6% points below the male gender. However, in the area of Physical Sciences, the scenario is reversed, with a female predominance, with 1% point above the male gender.

Analysis of the FWCI statistics by field of knowledge, as presented in Table 3, reveals statistically significant differences between genders in four out of the five major fields. Social Sciences, Life Sciences, Health Sciences and Multidisciplinary fields exhibit a significantly lower FWCI for women, corroborating the hypothesis of lower visibility for their research. This disparity is most pronounced in Social Sciences, where the mean FWCI for women (0.81) is substantially lower than that of men (1.22), with a p value of 0.00032, indicating a highly significant difference. The data dispersion, measured by the standard deviation, is considerably higher for men (2.86) than for women (1.3), suggesting greater heterogeneity in

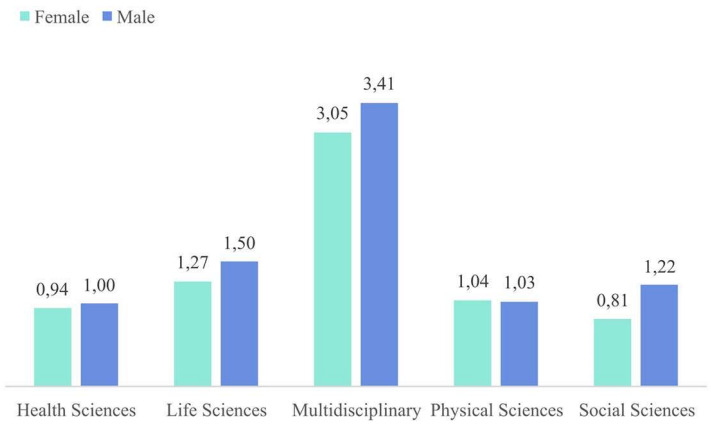

Figure 5. Impact normalized by area and gender of UNICAMP authors (2019–2023). *Source:* Prepared by the authors.

Table 3. Field-Weighted Citation Impact (FWCI) Statistics for UNICAMP Publications (2019–2023) by field of study and gender.

	Mean		Median		Standard deviation		95% Confidence interval of the mean		
Area	Female	Male	Female	Male	Female	Male	Female	Male	*p* Value (Mann–Whitney)
Social Sciences	0,81	1,22	0,38	0,43	1,3	2,86	0,78–0,84	1,16–1,27	0,00032
Life Sciences	1,27	1,5	0,62	0,65	2,85	3,75	1,25–1,29	1,47–1,53	$p < 0,0001$
Physical Sciences	1,04	1,03	0,63	0,57	1,51	1,74	1,03–1,06	1,01–1,04	$p < 0,0001$
Health Sciences	0,94	1	0,57	0,6	1,33	2,51	0,93–0,95	0,98–1,02	$p < 0,0001$
Multidisciplinary	3,05	3,41	0,84	0,9	4,91	5,2	2,96–3,15	3,30–3,52	0,01882

Source: Prepared by the authors.

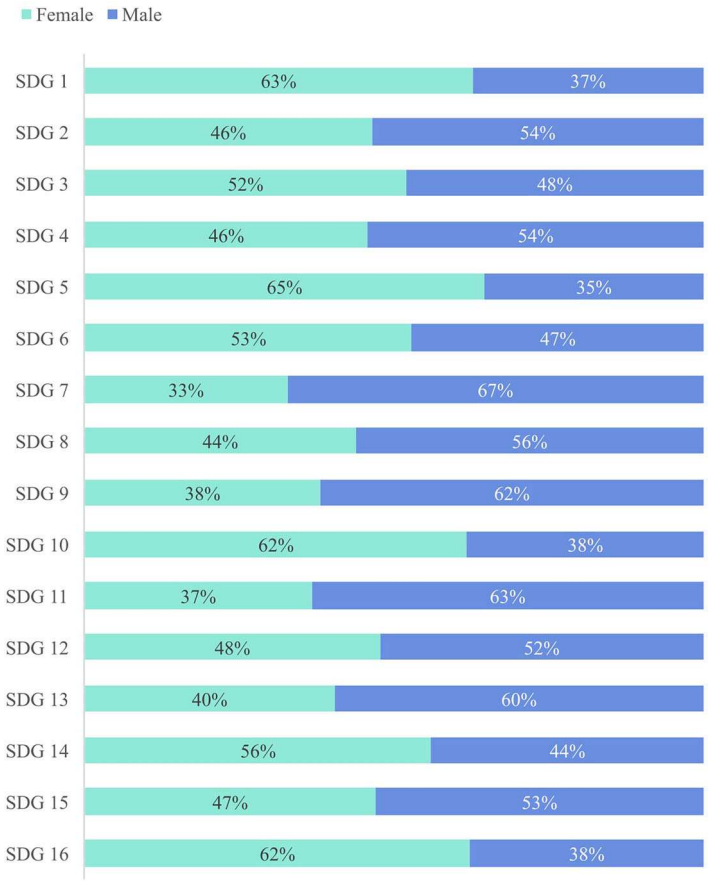

Figure 6. Participation of authors, by gender and SDG, in UNICAMP publications (2019–2023). *Source:* Prepared by the authors.

the impact of male-authored publications. This pattern of lower FWCI for women, albeit with smaller magnitudes and a caveat in Multidisciplinary research, is also observed in Life Sciences and Health Sciences, showing a statistically significant difference according to the Mann–Whitney test. In contrast, Physical Sciences presents a different scenario. While the difference in mean FWCI between women (1.04) and men (1.03) is numerically small, it is statistically significant ($p < 0.0001$). The overlap of the 95% confidence intervals for the mean FWCI of both genders suggests that, despite the lower volume of publications, women in this field achieve a comparable or even slightly higher, citation impact than men.

Regarding the participation of UNICAMP authors in publications related to the SDGs (Figure 6), they stand out mainly in six of the 17 objectives: SDG 1 – Eradication of Poverty (63%); SDG 3 – Good Health and Well-being (52%); SDG 5 – Gender Equality (65%); SDG 6 – Drinking Water and Sanitation (53%); SDG 10 – Reduction of Inequalities (62%); and SDG 16 – Peace, Justice and Effective Institutions (62%). Nevertheless, the female presence among UNICAMP authors is considerably less evident in other SDGs. In SDG 9 – Industry, Innovation and Infrastructure, 38% of publications have the contribution of female

authors. In SDG 11 – Sustainable Cities and Communities and SDG 7 – Clean and Affordable Energy, this representation is even lower, registering 37% and 33%, respectively.

The greater female representation in areas such as SDG 1 (No Poverty), SDG 3 (Good Health and Well-being), SDG 5 (Gender Equality), SDG 6 (Clean Water and Sanitation), SDG 10 (Reduced Inequalities) and SDG 16 (Peace, Justice and Strong Institutions) suggests a strong contribution by women at UNICAMP to themes related to social inclusion, public health and human rights. Conversely, the lower participation in SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation and Infrastructure), and SDG 11 (Sustainable Cities and Communities) indicates a need to encourage greater female involvement in fields traditionally dominated by men, such as engineering, technology and urban planning. This disparity reinforces the importance of promoting gender equality across all fields of knowledge, so that women can fully contribute to sustainable development in its various facets.

These figures highlight the progress achieved and the challenges to be faced in terms of gender inclusion in UNICAMP's scientific production. Thus, fostering and promoting greater female participation in these areas can not only contribute to a more comprehensive and equitable approach in the search for research and publications, but also boost innovation and progress in all areas of knowledge and SDGs.

The next sections aim to deepen the analysis of the representation of women authors in UNICAMP publications, specifically concerning the position of first and last author, considering that the position of first author is widely recognized as an indicator of leadership and substantial contribution in a study, while the last author is usually a mentor or leader of the research group, whose experience and expertise are fundamental to the success of the research. Therefore, both the first and the last author play essential and complementary roles, reflecting different aspects of leadership and contribution in the research process.

3.2. Analysis of gender representation in UNICAMP publications: highlighting the position of first and last authorship

The first author is usually the one who coordinates the work of the other authors and, often, is also responsible for the integral writing of the document, integrating the contributions of all those involved. On the other hand, the position of last author often reflects responsibility and supervision over the work done, usually occupied by the most established scientist in the group, project manager or publication advisor of the first author (Silva and Vanz, 2022). Therefore, examining the presence of women as first and last authors in UNICAMP publications is essential to understand their participation and their central role in conducting and developing research.

As highlighted by Silva and Vanz (2022), one should note that the practice of listing authors alphabetically to represent equal contributions is still common in areas such as Mathematics, Computer Science, Economics and High-Energy Physics. In Biomedical disciplines, it is common to find a note indicating that the first two or three authors contributed equally (equal first authors).

3.2.1. First authorship

Of the 25,138 publications analyzed, 14,667 (58.3%) had authors affiliated with UNICAMP as first author. Within this group, 8168 (56%) were contributions from male authors, whereas 6498 (44%) were from female authors.

The data in Figure 7 indicate predominance of female representation as first author in Health Sciences (57%) and Life Sciences (56%). However, regarding the disciplines associated with Physical Sciences and Social Sciences, the underrepresentation of women as first authors was notably lower, with a representation rate of only 34% and 40%, respectively, evidencing a similar challenge of female underrepresentation in these domains.

The analysis of the temporal evolution of gender participation in first authorship of scientific production reveals similarities only in Health Sciences, Life Sciences, and Social Sciences, despite fluctuations observed from 2021, as presented in Table 4. The drop in female participation in the total number of authors after 2021 is also repeated in the first authorship, especially in the Multidisciplinary area, in which the male proportion exceeds the female in 2022 and 2023.

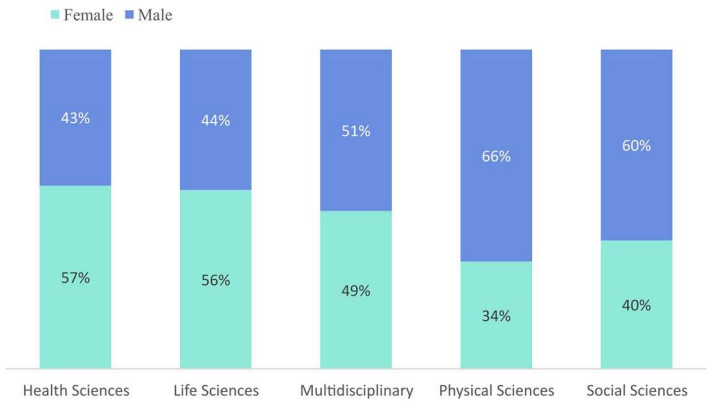

Figure 7. Participation of first authorship, by gender and major areas of knowledge (ASJC), in UNICAMP publications (2019–2023). *Source:* Prepared by the authors.

Table 4. Number of publications, by gender, major areas of knowledge (ASJC) and year in publications with first authorship of UNICAMP (2019–2023).

	2019		2020		2021		2022		2023	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Health Sciences	444	363	453	343	533	397	472	339	445	296
Life Sciences	427	341	498	414	585	391	463	396	388	318
Multidisciplinary Sciences	37	31	31	32	36	34	24	30	19	24
Physical Sciences	493	937	478	943	566	983	448	1008	423	904
Social Sciences	177	247	177	230	209	291	198	314	159	286

Source: Prepared by the authors.

According to Figure 8, the female presence as first author stood out in several areas, such as Nursing (77%); Pharmacology, Toxicology and Pharmacy (61%); Immunology and Microbiology (59%); Psychology (57%); Agriculture and Biological Sciences (57%); Dentistry (56%); Medicine (56%); Biochemistry, Genetics, and Molecular Energy (54%); Veterinary Medicine (54%); and Neuroscience (51%). On the other hand, there is a significant disparity between male and female participation as first author in various areas. In these areas, the participation of women as first author was significantly lower, such as in Arts and Humanities (37%); Business, Administration, and Accounting (32%); Computer Science (23%); Decision Sciences (23%); Economics, Econometrics and Finance (32%); Energy (30%); Engineering (30%); Materials Sciences (33%); Mathematics (20%); and Physics and Astronomy (25%).

When comparing the normalized Impact (FWCI) between the genders of the first authors by area (Figure 9) in the analyzed period, it is possible to observe significant differences in the areas of Multidisciplinary Sciences (48% points below the male gender), Social Sciences (30% points below the male gender) and Life Sciences (28% points below the male gender). In Health Sciences, the disparity is smaller, with only 4% points below the male gender. However, in the area of Physical Sciences, the scenario is reversed, with a slight predominance (1% point) for the female gender.

Analysis of the FWCI for first authors, displayed in Figure 9, shows a pattern similar to that observed for all authors, with statistically significant differences between genders in most fields (Table 5). Social Sciences, Life Sciences, Health Sciences and Multidisciplinary fields show a significantly lower FWCI for women, corroborating the persistence of the gender disparity even in first authorship positions. Social Sciences, once again, demonstrates the largest difference, with a mean FWCI of 0.79 for women and 1.09 for men ($p = 0.00242$). The magnitude of this difference, 30% points, indicates a considerable disadvantage for women as first authors in this field. The pattern is repeated in Life Sciences (mean FWCI of 1.24 for women and 1.48 for men, $p < 0.00001$) and Health Sciences (mean FWCI of 0.86 for women and 0.90 for men, $p < 0.00001$), with smaller but statistically significant percentage differences, as indicated by the Mann–Whitney test. Physical Sciences, however, continues to present a slightly higher mean FWCI for women (0.98) compared to men (0.97), a difference that, although small, is statistically significant ($p < 0.00001$). In Multidisciplinary research, the difference in mean FWCI between men (3.43) and women (2.95) is significant ($p = 0.00406$), suggesting a possible influence of specific areas within this broader field, similar to the pattern observed for all authors.

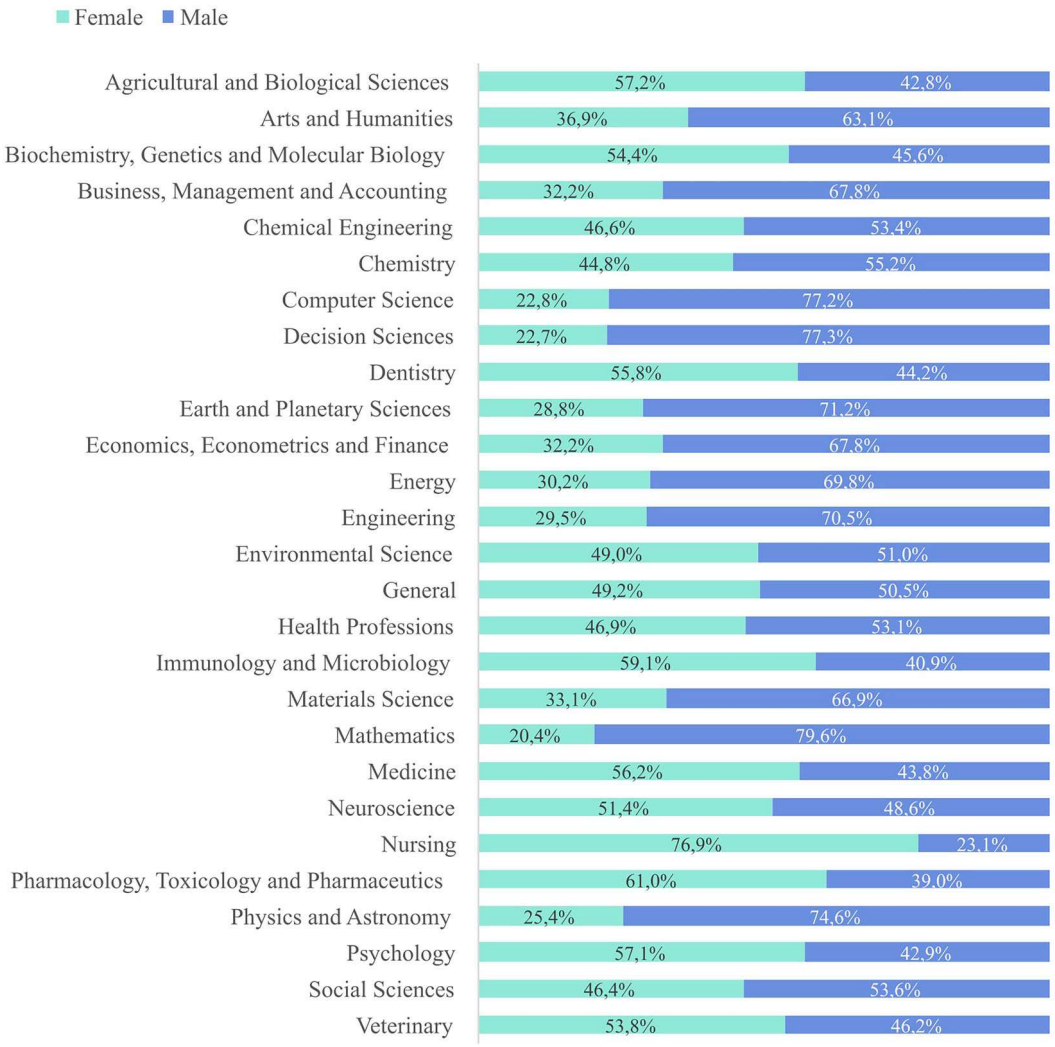

Figure 8. Participation of first authorship, by gender and areas of knowledge (ASJC), in UNICAMP publications (2019–2023). *Source:* Prepared by the authors.

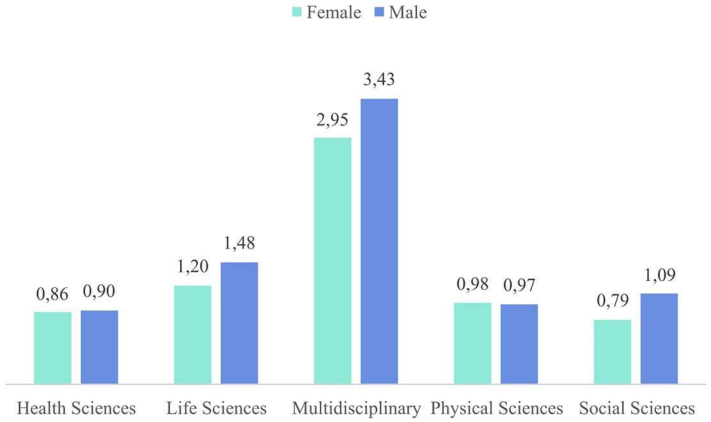

Figure 9. Impact normalized by area and gender of first authorship in UNICAMP (2019–2023). *Source:* Prepared by the authors.

Furthermore, the confidence intervals for the mean FWCI in each field demonstrate that, with the exception of Physical Sciences, the intervals for men and women do not overlap, indicating a clear separation in citation impact between genders. Analysis of standard deviations reveals greater data dispersion for men in Life Sciences and Multidisciplinary research, while in Social Sciences and Physical

Table 5. Field-Weighted Citation Impact (FWCI) Statistics for UNICAMP Publications with female first authors (2019–2023) by field of study and gender.

	Mean		Median		Standard deviation		95% Confidence interval of the mean		
Area	Female	Male	Female	Male	Female	Male	Female	Male	*p* Value (Mann–Whitney)
Social Sciences	0.79	1.09	0.37	0.42	1.27	2.15	0.75–0.82	1.05–1.14	0.00242
Life Sciences	1.2	1.48	0.6	0.61	2.85	3.9	1.17–1.22	1.44–1.51	$p < 0.0001$
Physical Sciences	0.98	0.97	0.61	0.56	1.2	1.38	0.97–1.00	0.96–0.98	$p < 0.0001$
Health Sciences	0.86	0.9	0.55	0.58	1.11	1.11	0.86–0.87	0.89–0.91	$p < 0.0001$
Multidisciplinary	2.95	3.43	0.84	0.9	4.79	5.17	2.85– 3.05	3.31–3,54	0.00406

Source: Prepared by the authors.

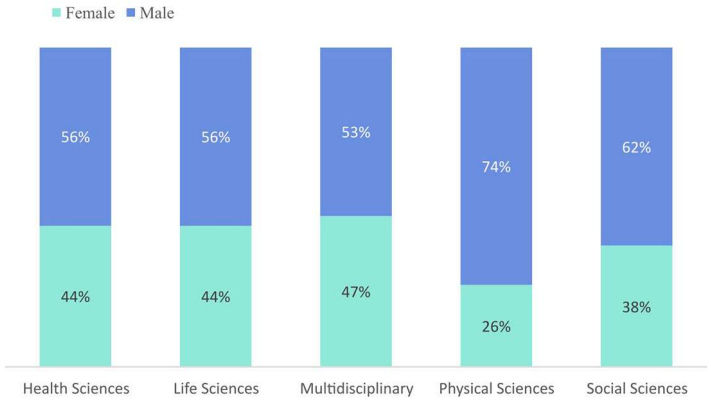

Figure 10. Participation of last authorship, by gender and major areas of knowledge (ASJC), in UNICAMP publications (2019–2023). *Source:* Prepared by the authors.

Sciences, the dispersion is similar between genders. Health Sciences demonstrates less data dispersion for both genders, with standard deviation values close to 1.11. These findings reinforce the complexity of gender dynamics in scientific production and highlight the need for more in-depth analysis that considers intersectional factors. As pointed out by Leaper and Brown (2018), sexism rarely operates in isolation. It intertwines with other forms of discrimination, such as racism, classism and homophobia, creating even more significant barriers for women who belong to multiple marginalized groups. The intersectionality of these oppressions can manifest in scientific production in various ways, affecting not only the quantity of publications but also their impact and visibility. For example, Black, Indigenous and low-income women may face additional challenges in accessing resources, participating in collaborations and having their research recognized by the scientific community. Investigating how these intersectional factors impact scientific production at Unicamp is crucial for the development of more effective and equitable institutional policies that promote inclusion and value diversity in all its forms. Future studies should delve deeper into this intersectional analysis to provide insights for creating a truly just and inclusive academic environment.

3.2.2. Last authorship

Among the 25,138 publications collected, 14,247 (56.7%) had the last authorship with affiliation to UNICAMP. Of these, 9228 (65%) were males and 5013 (35%) were females. Female underrepresentation as the last author is a predominant reality in all major areas of knowledge, as presented in Figure 10. This imbalance is even more pronounced in the area related to Physical Sciences, where women represent only 26% of publications. Additionally, the participation of women as last author in the Social Sciences was 38%.

The analysis of the temporal evolution of the participation of genders as last author in scientific production shows the same fluctuations that occurred in the total number of authors and first authorship, from 2021 on, as presented in Table 6.

According to Figure 11, female presence as the last author prevails in only 3 of the 27 areas analyzed: Nursing (65%), Psychology (57%) and Veterinary Medicine (51%). Nevertheless, it is important to note the underrepresentation of women in areas, such as Computer Science, Decision Sciences and

Table 6. Number of publications, by gender, major areas of knowledge (ASJC), and year in publications with last authorship of UNICAMP (2019–2023).

	2019		2020		2021		2022		2023	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Health Sciences	332	423	346	443	397	509	363	459	328	387
Life Sciences	337	427	385	462	421	538	329	473	312	351
Multidisciplinary Sciences	29	27	24	32	35	29	20	25	14	23
Physical Sciences	341	1118	356	983	401	1123	381	1002	319	996
Social Sciences	180	269	175	244	172	327	179	273	147	291

Source: Prepared by the authors.

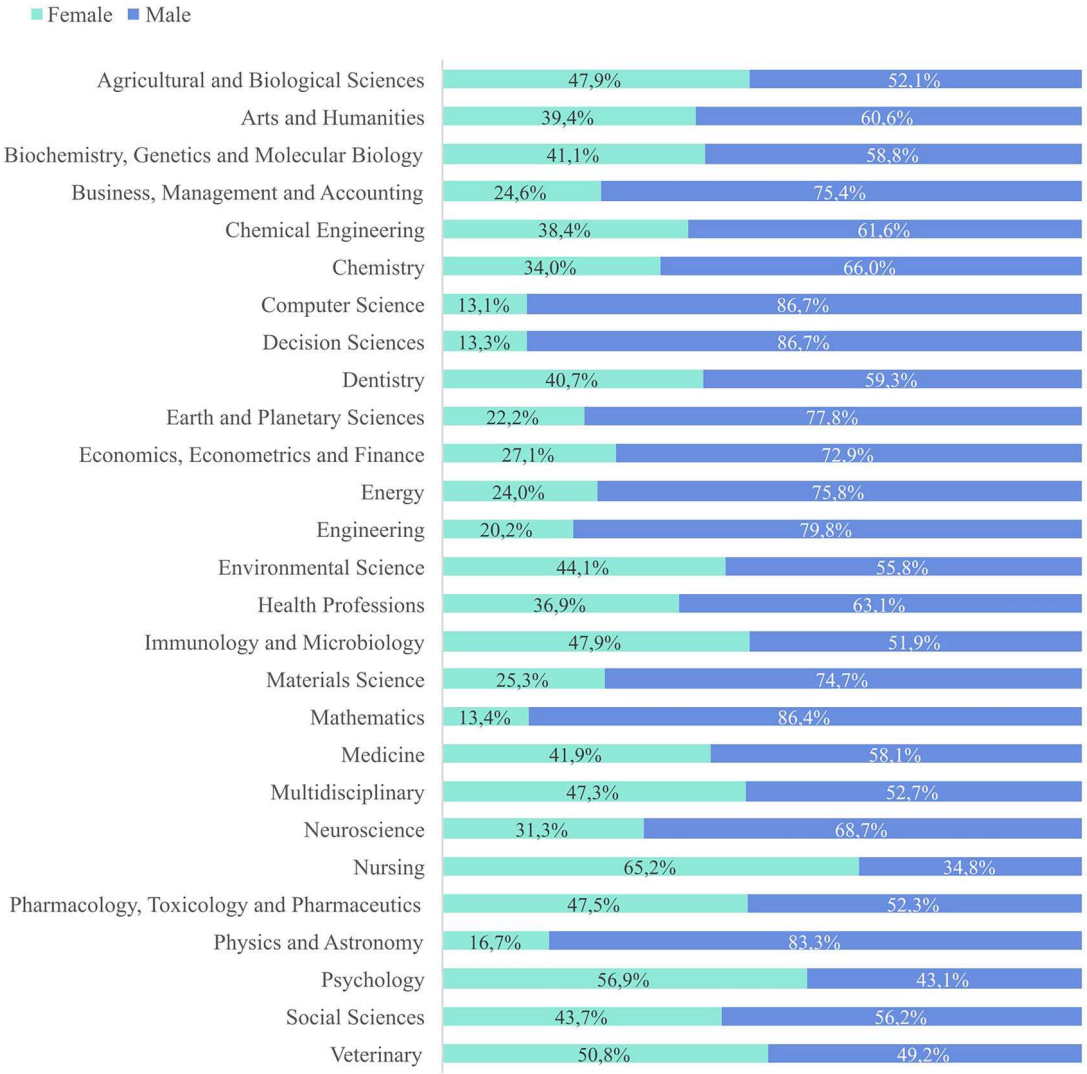

Figure 11. Participation of last authorship, by gender and areas of knowledge (ASJC), in UNICAMP publications (2019–2023). *Source:* Prepared by the authors.

Mathematics, where the proportion of women as last author is only 13% in all of them. These figures highlight the urgent need to implement measures to promote gender equity in areas that have historically been dominated by men in scientific production.

When comparing the normalized impact (FWCI) between the genders of the last authors by area (Figure 12) in the analyzed period, it is possible to observe significant differences in the areas of Multidisciplinary Sciences (39% points below the male gender), Social Sciences (34% points below the male gender) and Life Sciences (28% points below the male gender). In Health Sciences, the disparity is smaller, with only 3% points below the male gender. In Physical Sciences, the scenario stabilizes.

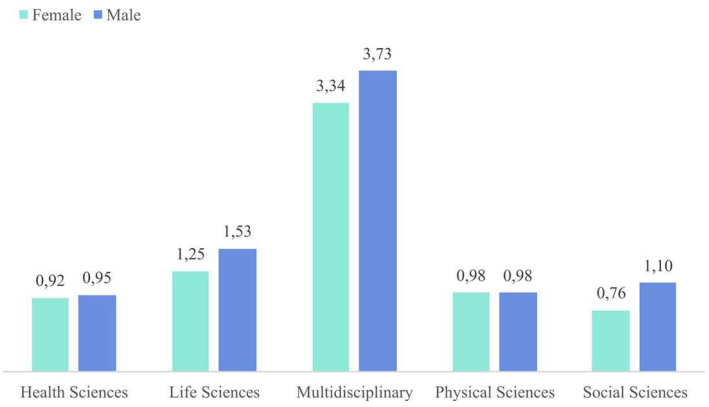

Figure 12. Impact normalized by area and gender of last authorship in UNICAMP (2019–2023). *Source:* Prepared by the authors.

Table 7. Field-Weighted Citation Impact (FWCI) Statistics for UNICAMP Publications with female last authors (2019–2023) by field of study and gender.

	Mean		Median		Standard deviation		95% Confidence interval of the mean		
Area	Female	Male	Female	Male	Female	Male	Female	Male	*p* Value (Mann–Whitney)
Social Sciences	0.76	1.1	0.35	0.37	1.22	2.73	0.73–0.79	1.04–1.16	0.09255
Life Sciences	1.25	1.53	0.6	0.61	2.92	3.97	1.22–1.27	1.49–1.56	$p < 0.0001$
Physical Sciences	0.98	0.98	0.61	0.56	1.2	1.53	0.97–0.99	0.96–0.99	$p < 0.0001$
Health Sciences	0.92	0.95	0.56	0.58	1.22	1.36	0.91–0.93	0.94–0.96	$p < 0.0001$
Multidisciplinary	3.34	3.73	0.71	0.84	5.17	5.39	3.22–3.46	3.61–3.86	$p < 0.0001$

Fonte: Autoria própria.

Analysis of the FWCI by field of knowledge for last authors, as presented in Table 7, reveals persistent statistically significant differences between genders, particularly in Multidisciplinary research, Life Sciences and Health Sciences. In Multidisciplinary research, the mean FWCI for women (3.34) is substantially lower than that of men (3.73), with a significant *p* value ($p < 0.00001$) obtained from the Mann–Whitney test. This difference, corresponding to 39% points, represents the largest disparity among the fields investigated, highlighting gender inequality in last authorship positions, often associated with research leadership and supervision. Life Sciences also exhibits a significantly lower mean FWCI for women (1.25) compared to men (1.53), with $p < 0.00001$. Health Sciences presents a similar pattern, with a lower mean FWCI for women (0.92) than for men (0.95), with the difference being statistically significant ($p < 0.00001$). In Social Sciences, a lower mean FWCI is observed for women (0.76) compared to men (1.10); however, this difference does not reach statistical significance at the 5% level ($p = 0.09255$), indicating that the observed difference may be due to sampling variation.

In Physical Sciences, although the mean FWCI is practically identical for men (0.98) and women (0.98), the statistical analysis reveals important nuances. Despite the apparent equivalence of the means, the Mann–Whitney test indicates a statistically significant difference ($p < 0.00001$). This seemingly contradictory result is clarified by analyzing the median and confidence intervals. The median for women (0.61) is higher than the median for men (0.56), suggesting that despite the similar mean, the distribution of FWCI data for women may be slightly shifted toward higher values. Furthermore, the overlap of the 95% confidence intervals for the mean FWCI of men and women, coupled with the low *p* value, indicates that although there is a statistically significant difference, the magnitude of this difference is small, and the FWCI values for both genders are quite similar. The data dispersion, measured by the standard deviation, is similar for men (1.53) and women (1.20) in Physical Sciences, suggesting comparable variability in the impact of publications between genders. This trend of higher FWCI for women in Physical Sciences, consistent across all authorship positions analyzed (overall, first author and last author), suggests a possible positive effect of lower female representation, leading to greater visibility and impact for publications by those who overcome the barriers to entry in this field of knowledge. The apparent equality in mean FWCI masks a potential advantage for women in terms of the median, indicating that a greater number of women achieve FWCI values equal to or higher than those of men. Therefore, the

analysis of Physical Sciences reinforces the need for a more granular and multifaceted approach to understanding the complex interplay between gender and scientific impact.

3.2.3. Comparative analysis of female participation as first, last and total authors

When comparing female participation as first and last author with the total number of authors (Figure 13), notable differences were observed in two major areas: Multidisciplinary Sciences and Physical Sciences. Although women represent 53% of authors in Multidisciplinary Sciences, this proportion drops to 49% in the position of first author and 47% in the position of last author. In Physical Sciences, the disparity is most pronounced in the last authorship, with only 26% of women occupying this position, compared to 34% as first author and a total of 33%.

These data show that, despite the increase in female participation in UNICAMP's scientific production, women still do not occupy prominent authorship positions with the same frequency as men. The reasons for this discrepancy need to be further investigated, considering the specificities of each area and author attribution practices.

Figure 14 shows the areas in which the total percentage of female participation exceeded the average between the female participation as first and last author, allowing a more comprehensive analysis of the areas most affected by the gender disparity in authorship. In this analysis, 11 areas stood out, with three of them presenting the greatest impact: Economics, Econometrics and Finance (+4% points); Neuroscience (+9% points); and Physics and Astronomy (+6% points). These results suggest that attention should be directed not only to areas with low female representation, according to the results already pointed out above, but also to those where there is a discrepancy between the proportion of women authors and their presence in the positions of first and last authorship.

It can be concluded that the analysis carried out provides important information for guiding efforts to reduce the gender disparity in authorship, not only in areas with low female representation, but also where there is an imbalance between female participation and their presence in prominent positions. In this context, it is observed that gender disparity is an even broader and more complex issue. For this reason, it is important to understand the power dynamics and cultural norms that shape scientific communication, to build a fairer and more inclusive scenario for all researchers, with actions that stimulate women's scientific production, reducing gender inequality.

3.3. Analysis of gender representation in UNICAMP publications: success rate of proposals submitted to and approved by FAPESP

To assess gender representativeness in research funded by FAPESP, we analyzed the qualification rate of proposals submitted to the agency and the success rate of proposals submitted and qualified, considering the gender of the main researcher.

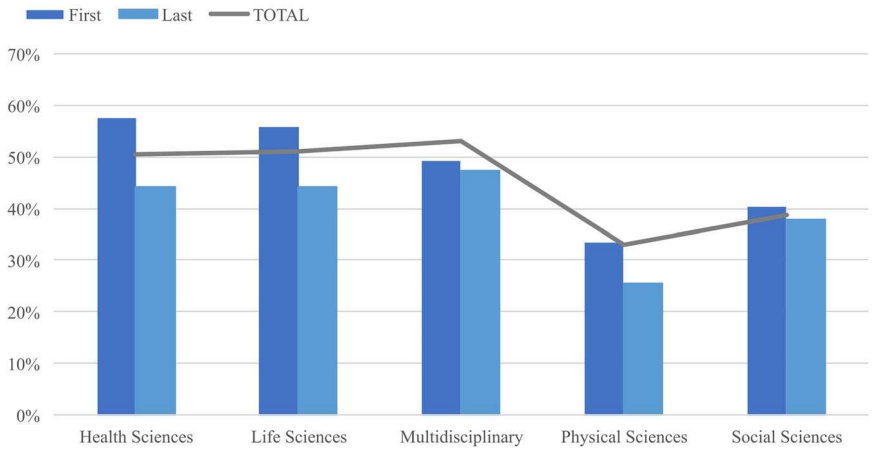

Figure 13. Percentage of female participation as first, last and total number of authors, by areas (ASJC), in UNICAMP publications (2019–2023). *Source:* Prepared by the authors.

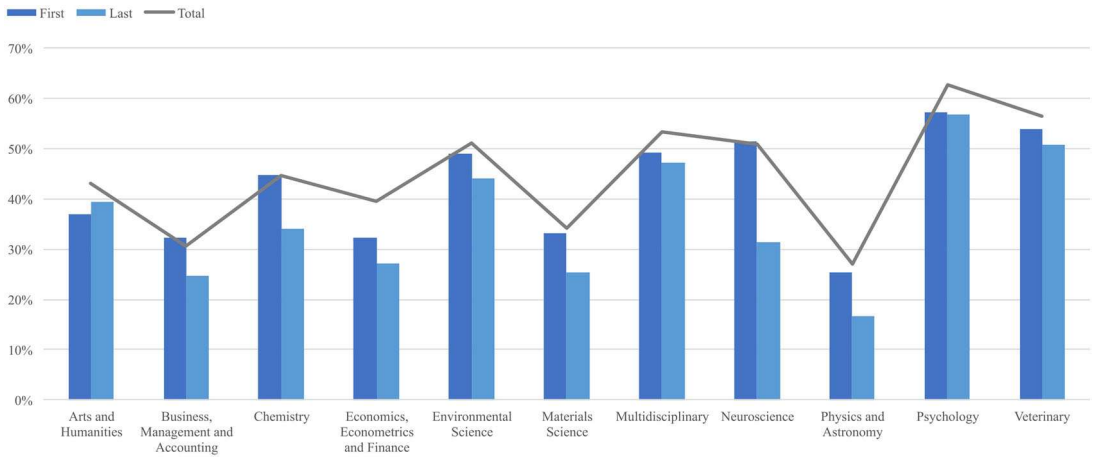

Figure 14. Percentage of female participation as first, last and total number of authors, by most impacted areas (ASJC) in UNICAMP publications (2019–2023). *Source:* Prepared by the authors.

Table 8. Distribution of proposals submitted, qualified, and approved by FAPESP by gender of the main researcher of UNICAMP (2019–2023).

	Number of proposals submitted			Number of proposals qualified			Number of proposals approved		
Year of submission	Female	Male	Not informed	Female	Male	Not informed	Female	Male	Not informed
2019	2255	2227	0	1678	1666	0	639	703	0
2020	1371	1314	0	1181	1150	0	380	407	0
2021	1256	1171	2	1088	999	1	481	454	0
2022	1392	1276	0	1232	1125	0	599	611	0
2023	1361	1431	0	1223	1270	0	664	684	0
Total	7635	7419	2	6402	6210	1	2763	2859	0

Source: FAPESP – Planning, Study and Indicator Management (GIP) | Power BI Process Reports. Retrieved on 05/14/2024.

Qualified proposals are those that have passed the formal analysis of compliance with the submission requirements, and are therefore considered suitable for merit evaluation. The qualification rate corresponds to the proportion of qualified proposals compared to the total proposals sent to FAPESP. The success rate, in turn, represents the proportion of proposals approved compared to the total proposals submitted. Finally, the success rate of qualified proposals considers exclusively those proposals that have passed formal analysis, evaluating the proportion of approvals within this specific group.

Table 8 presents the distribution of proposals submitted, qualified and approved by FAPESP from 2019 to 2023, separating the data by gender of the main researcher.

Figure 15 shows the qualification rate of the proposals submitted and indicates that, for both women and men, it has remained at a high and growing level over the years, in addition to having similar rates. Notably, from 2021 onward, female authors have become predominant in the qualified proposals.

The qualification rate for research proposals is a relevant indicator for PRP and UNICAMP, reflecting the attention to deadlines and criteria of researchers in the submission of projects. The detailed analysis of the reasons for non-approval, including specific information on failures in the submission of documents, data management plans and other aspects, would allow the PRP, by the Grant Office, to communicate effectively to all researchers how to improve their proposals, contributing to increase the qualification rate and, consequently, the chance of success.

The analysis of the data represented in Figure 16 reveals an increasing trend in the success rate over the years, both for men and women. However, one can observe that the success rate of men remains higher than that of women, both for submitted and qualified proposals. In 2019, the success rate of proposals submitted by men (32%) was 4% points higher than the rate of women (28%). This gap has fluctuated over the years, and in 2023, women outperformed men, with 49% success in their submitted proposals, whereas men achieved 48%.

Despite the overall increase in the success rate for both genders, the analysis suggests that the gender disparity persists, but with some nuances since 2023. The persistence of this difference, even with the apparent improvement in the rate of women in 2023, requires further investigation to find the

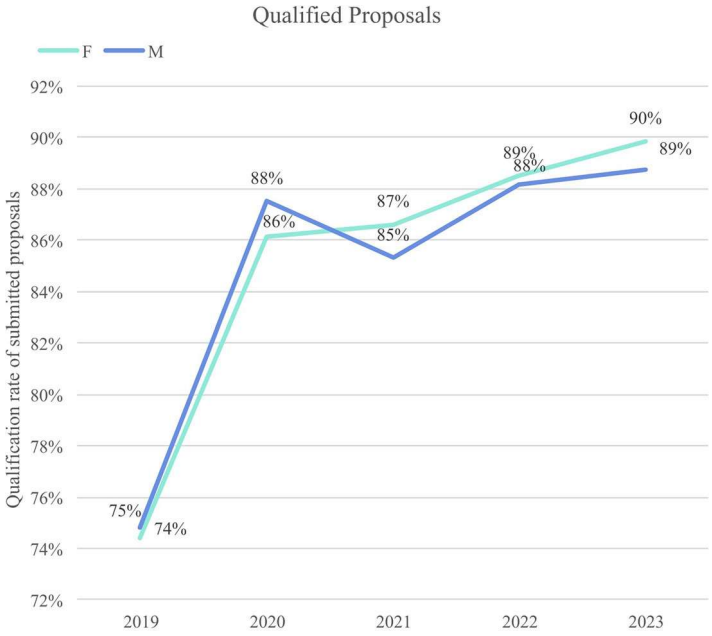

Figure 15. Qualification rate, by gender of the proponent, of UNICAMP proposals submitted to FAPESP (2019–2023). *Source:* FAPESP – Planning, Study and Indicator Management (GIP) | Power BI Process Reports. Retrieved on 05/14/2024.

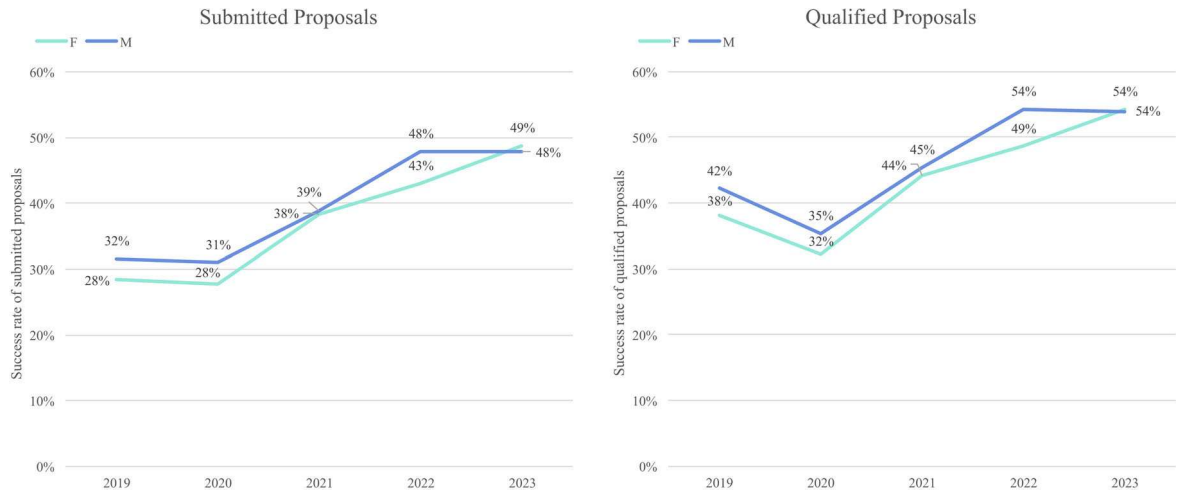

Figure 16. Success rate, by gender of the proponent, of UNICAMP proposals submitted to FAPESP (2019–2023). *Note:* The success rate does not include 125 proposals under analysis or four others whose results were not disclosed. *Source:* FAPESP – Planning, Study and Indicator Management (GIP) | Power BI Process Reports. Retrieved on 05/14/2024.

causes behind this disparity. Analyzing the theme of research, the type of project, and the background of the researchers can help in understanding the nuances of this difference and in developing more effective actions to promote gender equity in access to research resources.

4. Discussion

This study, based on data extracted from the Scopus database from 2019 to 2023, aimed to investigate gender representation in UNICAMP publications, considering first and last authorship positions as well as the success rate of proposals submitted to São Paulo Research Foundation (FAPESP), stratified by the principal investigator's gender. Following the approach of Signorella et al. (1993), we recognize the importance of distinguishing between different types of measures to capture nuances in gender schemas. Thus, in addition to the quantitative analysis of authorship in its various positions, qualitative indicators, such as the research themes according to the SDGs and the Normalized Impact (FWCI), were

explored to infer potential biases and attitudes toward female participation in different areas of knowledge. This scientometric approach sought to provide a comprehensive understanding of gender disparities in academic output and research funding at UNICAMP.

The results reveal a female underrepresentation in UNICAMP's scientific productions, with 58% of men and 42% of women. Although male authorship predominates, this research reveals significant variations across major knowledge areas. The major areas of Health Sciences, Life Sciences and Multidisciplinary Sciences are more balanced, whereas Physical Sciences and Social Sciences have a predominant male presence. The results indicate that, although female participation in STEM areas is still lower, the difference concerning SHAPE areas was less significant, with a percentage of female participation close to 43.6% for STEM and 45% for SHAPE.

A detailed analysis of the knowledge areas shows that women's participation stands out in areas such as Multidisciplinary Sciences, Agriculture and Biological Sciences, Immunology and Microbiology, Toxicology and Pharmacy, Veterinary Medicine, Nursing and Psychology. Greater equity was also observed in areas, such as Medicine, Environmental Science and Neuroscience. However, female representation is still significantly lower in fields, such as Decision Sciences, Mathematics, Computer Science, Engineering, Earth Sciences, Physics and Astronomy, Energy, Administration, Materials Science and Economics.

The analysis of the first and last authorship positions reveals a less equitable scenario. Despite the growth of female participation in first authorship in the major areas of Life Sciences and Health Sciences, overall participation and last authorship decreased. The large Multidisciplinary Sciences and Physical Sciences areas highlight a significant difference between the total percentage of women in the positions of first and last authorship. While Multidisciplinary Sciences present a difference of 4% between the total percentage of women and participation in first authorship and 6% in last authorship, Physical Sciences presented a reduction of 7% in last authorship, despite the growth of 0.5% in first authorship, suggesting a greater disparity of prominent positions in these fields.

The analysis of the temporal evolution of the period demonstrated a drop in female scientific production after 2021. This pattern, identified in all areas of knowledge and in the positions of first and last authorship, suggests a possible impact of the COVID-19 pandemic on women's academic careers. It is plausible that the intensification of domestic responsibilities and care for children, older people and people with disabilities, disproportionately attributed to women during the pandemic, has limited the time and resources available for research. These factors, when interacting with broader social and academic structures, reflect how gender inequalities emerge and are perpetuated in complex systems.

In this context, the theory of dynamic systems, as discussed by Martin and Ruble (2010), provides a theoretical framework for understanding how gender inequalities unfold over time. The approach highlights that social systems, such as the academic environment, are shaped by interactions between individuals, institutions and cultural norms. These systems can stabilize patterns of inequality (attractors), but they can also be altered by disruptions, such as institutional policies or external events that promote qualitative changes. Applying this perspective allows for interpreting events like the pandemic not just as momentary barriers, but as part of dynamic processes that reinforce or challenge gender disparities in academia.

Analysis of FWCI revealed statistically significant differences between genders across major fields of knowledge (Table 3). Social Sciences, Life Sciences, Physical Sciences, Health Sciences and Multidisciplinary research all showed a significantly lower FWCI for women ($p < 0.0001$, Mann–Whitney test), supporting the hypothesis of lower visibility for female research in these areas. The largest disparity was observed in Social Sciences, where the mean FWCI for women was 0.81, substantially lower than for men (1.22). In contrast, Physical Sciences presented a different scenario. Although numerically small, the difference in mean FWCI between women (1.04) and men (1.03) was statistically significant ($p < 0.0001$). The overlapping confidence intervals and the higher median for women in Physical Sciences suggest that, despite publishing less, women in this field achieve a comparable or even higher citation impact than men.

Analysis of FWCI stratified by authorship position (first and last) largely corroborates the inequality patterns observed in the overall analysis of UNICAMP's scientific output. For both first and last authors, FWCI was significantly lower in Life Sciences ($p < 0.0001$ for both positions) and Health Sciences ($p < 0.0001$ for both positions). Social Sciences presented a distinct pattern between authorship positions. While FWCI was significantly lower for women in first authorship positions ($p = 0.00242$), with a substantial 30% point difference between means, in last authorship positions this difference, while numerically present (34% points),

did not reach statistical significance ($p = 0.09255$). This result suggests that for last authors in Social Sciences, the observed FWCI difference may be attributable to sampling variation, warranting future investigations with greater statistical power to elucidate this issue.

Physical Sciences, however, remained the only exception to this general pattern of inequality, presenting a slightly higher FWCI for women in both first and last authorship positions. The difference, although small, was statistically significant in both positions ($p < 0.0001$). Analysis of the median and confidence intervals revealed that in Physical Sciences, women, despite lower representation, achieve comparable or even higher citation impact than men. This consistent trend, observed in both the overall analysis and by authorship position, reinforces the need to investigate the factors contributing to this unique scenario in Physical Sciences, such as the potential influence of collaborative networks among female researchers, a focus on higher-impact topics or the existence of specific incentive policies for women in this field.

The analysis considering the SDGs showed that, although UNICAMP women stand out in themes related to peace (SDG 16), reduction of inequalities (SDG 10), eradication of poverty (SDG 1) and gender equality (SDG 5), female participation is lower in SDGs related to clean energy (SDG 7), sustainable cities and communities (SDG 11), and industry, innovation and infrastructure (SDG 9). Although STEM areas have had a quantitative percentage close to SHAPE areas, the thematic focus of research may still persist in the gender stereotypes of classifications. These results open doors for studies that investigate the causes behind this disparity, exposing the factors that influence female participation in different objectives, and allowing the elaboration of more effective strategies for the promotion of gender equity.

The analysis of success rates in research funding applications submitted to FAPESP reveals the persistence of gender disparity, even with the general increase in the success rate for both genders and with the equivalence observed in 2023. It is possible that the equivalence of the success rate between male and female proponents is the result of some actions of FAPESP aimed at gender equity, but the difference, observed over the years, indicates the need for a thorough investigation to understand its causes. The analysis of the research theme, the type of project and the history of the researchers can help PRP and PRPG identify potential biases and create more effective actions for UNICAMP, aiming to promote gender equity in access to research resources.

It is important to note that this study has some limitations. The first one lies in the use of a gender inference method based on names, which may not accurately reflect the gender identity of all authors. Ideally, data collection on gender identity should be done by self-declaration, ensuring greater accuracy and respect for diversity. In addition, the research focused on the scientific production indexed in the Scopus database, which, although comprehensive, does not represent the totality of UNICAMP's scientific production.

5. Implications and relevance of the results

The results of this study highlight the complexity of gender inequalities in science, emphasizing the underrepresentation of women in leadership positions, the persistence of gender stereotypes, and the impact of the COVID-19 pandemic. These findings suggest that, to promote greater equity and inclusion at Unicamp, coordinated and thoughtful actions may be necessary. Below are some potential implications and actions that could be considered to advance in this direction.

5.1. Institutional policies for gender equity

The underrepresentation of women, especially in fields, such as exact and technological sciences (STEM), can limit both the potential of female researchers and the diversity of scientific contributions. In this regard, various institutional policies can be implemented to mitigate this inequality. A promising strategy lies in investing in mentorship programs and support for female leadership. By providing targeted support and training for leadership skill development, it is possible to strengthen women's participation in prominent positions and, consequently, positively influence power dynamics within institutions. Furthermore, promoting equality in the authorship of scientific works stands out as another key aspect. Establishing clear guidelines for authorship attribution, combined with effective monitoring mechanisms, can ensure greater fairness in recognizing women's contributions and combat practices that may render their work invisible.

5.2. Academic impact and strategies to reduce inequalities

The data indicates that, in areas such as the Physical Sciences, the impact of women's research is comparable, or even superior, to that of men, suggesting that inequalities are not solely due to the quality or productivity of the research. However, disparities in impact are still observed in other fields, such as Social Sciences and Life Sciences. In this context, it becomes imperative to implement strategies aimed at mitigating these inequalities and promoting greater equity in the recognition of women's scientific work. A promising approach lies in encouraging interdisciplinary collaboration. By fostering the creation of collaborative networks that integrate female researchers from different fields, it is possible to enhance the visibility of women, especially in disciplines where challenges of representation and recognition still persist. Such collaborations can strengthen the impact of their research, break down barriers related to gender perception, and consequently promote greater equity in science. Similarly, the implementation of scientific visibility strategies emerges as an essential complement. Encouraging women's participation in scientific events and promoting the dissemination of their work are effective measures to expand their reach and make a more significant impact on the academic community, ensuring that their contributions are properly recognized and valued.

5.3. Incentives for female participation in STEM

The lower representation of women in fields such as Mathematics, Engineering and Computer Science suggests that interventions may be necessary to tackle gender stereotypes that emerge from childhood. Therefore, reversing this situation requires a multifaceted approach that addresses the root causes of the problem and encourages female participation at all levels. In this context, institutional campaigns can play a fundamental role. Initiatives that debunk gender stereotypes and showcase successful female role models in STEM can inspire future generations to identify with these fields. By highlighting the diversity of careers and possible trajectories within these disciplines, such campaigns help build a more inclusive and accessible image of the scientific domain. Additionally, targeted financial support can sustain women's participation in STEM in the long term. Specific funding programs for fields with lower female representation, offering not only financial assistance but also mentorship and access to adequate infrastructure, can create a more favorable environment for the development of successful careers and the overcoming of structural barriers.

5.4. Implications for future studies

The study highlights gaps that need to be addressed in future research to deepen the understanding of gender dynamics in scientific production and support the development of more effective policies. In this regard, several lines of investigation appear promising.

First, intersectionality emerges as a fundamental aspect to be explored. Investigating how gender, race, class, sexual orientation and other social factors intersect and influence women's academic trajectories is essential for a more comprehensive analysis and the development of inclusive policies that consider the diversity of experiences and challenges faced by female researchers. Incorporating socioeconomic and demographic data can enrich this analysis, providing a more detailed overview of existing inequalities.

Second, understanding the barriers faced by women in science requires a methodological approach that combines both quantitative and qualitative analyses. The use of interviews and focus groups, in addition to statistical data, enables a deeper understanding of the specific challenges encountered by female researchers across different fields of knowledge. This methodological integration can contribute to the formulation of more effective and tailored support strategies.

Third, assessing the impact of institutional policies is crucial to ensuring that implemented measures are effective and promote gender equity sustainably. Analyzing the effectiveness of initiatives such as mentorship programs, incentives for female participation and actions against harassment, while identifying best practices, is important for strengthening gender equity in scientific production. Furthermore, as highlighted by Bao and Huang (2022), institutional changes can have different impacts on various groups,

necessitating a detailed evaluation of the effects of these interventions. Therefore, it is essential to investigate how researchers from diverse academic and institutional backgrounds respond to these policies.

Additionally, any intervention should be accompanied by mechanisms that allow for the measurement of its outcomes over time, preventing well-intentioned policies from resulting in unintended consequences, such as reinforcing stereotypes or creating new institutional barriers. To achieve this, the evaluation of these initiatives should go beyond traditional quantitative indicators, such as the number of publications and citations and include qualitative dimensions, such as a sense of belonging, opportunities for collaboration, and subjective experiences within academic environments.

Finally, contextualizing the results through comparative analyses between institutions can reveal patterns, best practices and strategies applicable to different settings. Comparing UNICAMP with other universities allows for the identification of similarities and differences, facilitating the adaptation of successful strategies to the local context and contributing to the improvement of institutional policies aimed at achieving gender equity in science.

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