Gaming the Metrics? Bibliometric Anomalies and the Integrity Crisis in Global University Rankings

Lokman I. Meho (0000-0003-0623-4652)*
Department of Internal Medicine, American University of Beirut, Beirut, Lebanon

ABSTRACT: Global university rankings have transformed how certain institutions define success, often elevating metrics over meaning. This study examines universities with rapid research growth that suggest metric-driven behaviors. Among the 1,000 most publishing institutions, 98 showed extreme output increases between 2018-2019 and 2023-2024. Of these, 18 were selected for exhibiting sharp declines in first and corresponding authorship. Compared to national, regional, and international norms, these universities (in India, Lebanon, Saudi Arabia, and the United Arab Emirates) display patterns consistent with strategic metric optimization. Key findings include publication growth of up to 965%, concentrated in STEM fields; surges in hyper-prolific authors and highly cited articles; and dense internal co-authorship and citation clusters. The group also exhibited elevated shares of publications in delisted journals and high retraction rates. These patterns illustrate vulnerabilities in global ranking systems, as metrics lose meaning when treated as targets (Goodhart's Law) and institutions emulate high-performing peers under competitive pressure (institutional isomorphism). Without reform, rankings may continue incentivizing behaviors that distort scholarly contribution and compromise research integrity.

Keywords: bibliometric indicators; delisted journals; hyper-prolific authorship; questionable publication practices; research integrity; retractions; university rankings

1. INTRODUCTION

Over the past two decades, global university rankings have profoundly reshaped academic priorities, institutional strategies, and the governance of higher education (Ahlers & Christmann-Budian, 2023; Hazelkorn & Mihut, 2021; Shen et al., 2023). Rankings published by the Academic Ranking of World Universities (Shanghai Ranking), QS, Times Higher Education, and U.S. News have elevated bibliometric indicators (such as publication and citation counts) to central status in assessing institutional performance (Kochetkov, 2024; Rhein & Nanni, 2023; Sheeja et al., 2018). These metrics now influence everything from strategic planning and resource allocation to faculty hiring and funding decisions.

This transformation, however, has produced unintended consequences that can be understood through Goodhart's Law, which posits that "when a measure becomes a target, it ceases to be a good measure" (Dezhina, 2022; Fire & Guestrin, 2019). In academic research, once universities link publication and citation metrics to rankings, rewards, or national prestige, they would no longer remain reliable indicators of research performance. Instead, these metrics can become susceptible to over-

* To whom all correspondence should be made: lmeho@aub.edu.lb

optimization, strategic inflation, and institutional behavior shifts prioritizing metric attainment over scholarly contribution (Hladchenko, 2025).

Evidence suggests that universities under reputational or performance pressures have engaged in metric-maximizing behaviors (Bhattacharjee, 2011; Biagioli et al., 2019; Catanzaro, 2024; Moosa, 2024; Pachter, 2014; Trung, 2020). These behaviors include, among others, hyper-prolific authorship (Conroy, 2024; Ioannidis et al., 2024; Moreira et al., 2023), publication and citation clustering within closed institutional networks (Li et al., 2019; Silva et al., 2020), strategic publication in journals that offer visibility with minimal editorial gatekeeping (Gedik et al., 2024; Hladchenko, 2025; Maisonneuve, 2025; Teixeira da Silva, 2024), and other questionable authorship practices such as gift or guest authorship (Morreim & Winer, 2023; Xie et al., 2021), ghost authorship (Pruschak & Hopp, 2022; Teixeira da Silva & Dobránszki, 2016), sold authorship (Abalkina, 2023; Chirico & Bramstedt, 2023; Ibrahim et al., 2025), and multi-affiliation inflation (Halevi et al., 2023; Hottenrott et al., 2021; Kuan et al., 2024). While not all such practices are unethical, they cast doubt on the interpretability of bibliometric indicators and the extent to which rankings reflect genuine scholarly impact. In extreme cases, these behaviors may erode the very value of the metrics they intended to represent (Abalkina et al., 2025; Gruber, 2014; Oravec, 2017).

This study investigates a subset of universities whose bibliometric trajectories exhibit patterns consistent with the above concerns. Specifically, this study addresses two research questions:

1. What bibliometric patterns characterize certain universities with extraordinary research expansion, and how do these patterns differ from national, regional, and international norms?
2. What do these patterns reveal about the vulnerabilities of global ranking systems, and how might they affect the interpretation of research integrity, scholarly contribution, and academic evaluation practices?

Through this analysis, the study highlights how performance pressures and metric-based incentives shape institutional behaviors in ways that challenge prevailing assumptions about academic excellence. While some of the observed trends may reflect legitimate capacity-building or internationalization efforts, others raise questions about the growing gap between what is counted and what counts (Olive et al., 2023). As discussed later in this study, the convergence of such behaviors across diverse settings also reflects a deeper process of institutional isomorphism—the tendency of organizations to imitate prevailing models in the pursuit of legitimacy.

The study aims to inform policymakers, ranking agencies, universities, publishers, and authors about the significant risks associated with metric-driven distortions in academic evaluation. It underscores the urgent need for greater transparency, accountability, and contextualization in using bibliometric indicators to ensure that research metrics accurately reflect genuine scholarly contributions.

2. MATERIALS AND METHODS

2.1. Study Group Selection and Rationale

The study employed a multi-stage approach to detect universities with unusual trends in research output and authorship roles between 2018-2019 and 2023-2024, a period selected to capture post-pandemic developments while minimizing transient disruptions from COVID-19 (Ioannidis et al., 2021; Raynaud et al., 2021; Zammarchi et al., 2024). The analysis focused on journal articles and reviews, excluding publications with more than 100 co-authors to reduce noise from mass collaborations.

Using SciVal data (May 1, 2025), the analysis began with the 1,000 most-publishing universities worldwide in 2023-2024. From this group, the study identified 98 institutions with publication growth rates exceeding 140% between 2018-2019 and 2023-2024 (over five times the global average increase of 28% during the same period), isolating extreme outliers. Among these, a subset demonstrated sharp declines in research leadership roles, measured by first and corresponding authorship rates, which serve as recognized indicators of intellectual contribution and oversight (Chinchilla-Rodríguez et al., 2024; Kharasch et al., 2021). Sixteen institutions showed declines exceeding 35% in first authorship and 15% in corresponding authorship over the study period. These thresholds reflect declines at least five times the global averages, where first authorship fell from 55% to 51%, and corresponding authorship from 54% to 52%. The remaining 82 universities exhibited an average decline of 2% (median = -1%) in first authorship rate and an 8% increase (median = +8%) in corresponding authorship rate.

A parallel InCites analysis identified two additional institutions (KL University and Najran University) with bibliometric patterns consistent with the study group. This dual-source approach mitigated limitations associated with reliance on a single data source, strengthening the study's robustness. The final sample (study group) comprised 18 universities across India (7), Lebanon (1), Saudi Arabia (9), and the United Arab Emirates (1). All Indian and Lebanese institutions were private. University ages ranged from under 25 years (11 institutions) to over 50 years (3 institutions). Faculty sizes varied from fewer than 1,000 academics (5 institutions) to over 2,000 (7 institutions). Thirteen institutions included medical schools. Expanding the analysis to the top 1,500 universities would have identified 15 additional qualifying institutions (see Appendix I).

2.2. Control Groups Selection and Rationale

The study employed national, regional, and international control groups to contextualize the study group's trends.

- **National Benchmark:** Each study group university was compared against its national aggregate research data (India, Lebanon, Saudi Arabia, and the United Arab Emirates) to assess whether observed trends reflected national shifts or institution-specific behaviors.

- **Regional Benchmark:** Four universities—one from each represented country—were selected based on consistent top-tier performance in global rankings (e.g., Shanghai Ranking): Indian Institute of Science (India), American University of Beirut (Lebanon), Khalifa University (UAE), and King Abdullah University of Science and Technology (Saudi Arabia). These institutions served as stable, high-performing comparators.

- **International Benchmark:** Four top Shanghai Ranking institutions—Massachusetts Institute of Technology (MIT), Princeton University (Princeton), ETH Zurich, and the University of California, Berkeley (UC Berkeley)—were chosen for their global excellence and disciplinary similarity to the study group. The analysis excluded institutions with extreme disciplinary skew, such as Caltech (67% physics output) and Harvard, Oxford, and Stanford (over 50% medical publications). Study and control group universities maintained medical output near 15%, ensuring fairer cross-institutional comparisons.

2.3. Bibliometric Analysis

The analysis assessed whether the study group's rapid research growth reflected genuine academic development or structural incentives affecting authorship and publishing. Key indicators included:

- Overall and Subject-Specific Research Output (SciVal and Essential Science Indicators): Measured research productivity and evaluated whether growth was broad or concentrated.

- First and Corresponding Authorship Rates (InCites): Tracked intellectual contribution and leadership via affiliated researchers' first/corresponding authorship shares.

- Hyper-Prolific Authorship (SciVal): Analyzed to determine whether extreme publication rates reflected genuine productivity or strategic behavior aimed at inflating metrics. The study defines hyper-prolific authors (HPAs) as producing 40 or more articles in a calendar year, balancing anomaly detection with disciplinary norms. Elsevier provided a list of authors with 40 or more articles, identifying 11,323 HPAs during the study period, excluding articles with over 100 co-authors. This represents 0.05% of approximately 24 million authors, highlighting the rarity and potential ethical implications of extreme productivity patterns. Notably, 19% achieved HPA status for the first time in 2023-2024.

- Articles in Delisted Journals (Scopus and Web of Science): Identified 627,000 articles (2018-2024) from 969 journals delisted by Scopus/Web of Science due to ethical/quality concerns. The articles were linked to institutions worldwide to examine patterns of reliance on questionable venues.

- Retraction Rates (Retraction Watch, PubMed, Scopus, Web of Science): Matched 32,420 retracted articles to SciVal records (2018-2024). To account for retraction

delays, the analysis included 2022 publications, alongside 2018-2019 and 2023-2024, to better account for recent institutional behaviors while capturing near-complete retraction data (Fang et al., 2012; Gedik et al., 2024). As of May 1, 2025, 10,995 articles from 2022 had been retracted, compared to 3,070 from 2023 and 1,762 from 2024.

- Highly Cited Articles (SciVal): Identified articles ranked among the world's top 2% most cited as a proxy for research visibility, prestige, or excellence, offering broader disciplinary representation than the 1% threshold used in other ranking systems, such as the annual Clarivate's Highly Cited Researchers.

- Collaboration Patterns: Tracked major collaborators (universities accounting for at least 2% of an institution's total publications), identified changes between 2018-2019 and 2023-2024, and cross-referenced the identity of the collaborators with the Shanghai Ranking to assess alignment with higher- or lower-profile institutions.

Data were derived from Scopus, Web of Science, SciVal, and InCites. Appendix II details all materials and methods used in the study, including selection criteria, bibliometric indicators, analytical approaches, and data sources.

3. Results

3.1. Overall Research Output Surge

Between 2018-2019 and 2023-2024, universities within the study group exhibited substantial increases in research output, often far exceeding national, regional, and international benchmarks. Institutions in India recorded publication growth from 243% to 766%, compared to a national average of 50%. The Lebanese American University (LAU) reported a 908% increase, while Lebanon's national growth rate increased by 102%, or 17% when excluding LAU. In Saudi Arabia, the national research output increased by 170%, or 120% when excluding study group universities, whereas the study group institutions grew between 220% and 965%. The University of Sharjah reported a 267% increase, surpassing the national average of 165% in the United Arab Emirates (Table 2, Figure 1)

Table 2. Increases in research output of study and control group universities and their respective countries

University (year founded)	Type	Number of articles published		% of increase from 2018-2019 to 2023-2024		World ranking in # of articles	
STUDY GROUP		**2018-2019**	**2023-2024**	**Institution**	**Country**	**2018-2019**	**2023-2024**
CU (India, 2012)	Private	521	4,478	760%	50%	1500+	601
Chitkara (India, 2010)	Private	331	2,865	766%	50%	1500+	941
GLA (India, 2010)	Private	383	3,070	702%	50%	1500+	888
KL (India, 1980)*	Private	625	3,823	512%	50%	1500+	958*
LPU (India, 2005)	Private	1,503	5,160	243%	50%	1164	514
SIMATS (India, 2005)	Private	3,037	10,418	243%	50%	656	187
UPES (India, 2003)	Private	489	2,662	444%	50%	1500+	1000

LAU (Lebanon, 1924)	Private	576	5,804	908%	102%	1500+	442
KKU (Saudi Arabia, 1988)	Public	2,070	11,096	436%	170%	905	166
KSU (Saudi Arabia, 1957)	Public	8,492	27,186	220%	170%	169	20
NU (Saudi Arabia, 2006)*	Public	380	2,450	545%	170%	1500+	990*
PSAU (Saudi Arabia, 2009)	Public	1,245	8,519	584%	170%	1308	262
PNU (Saudi Arabia, 1970)	Public	818	8,709	965%	170%	1500+	247
TU (Saudi Arabia, 2004)	Public	996	5,166	419%	170%	1483	512
UQU (Saudi Arabia, 1981)	Public	1,124	5,704	407%	170%	1394	451
UOH (Saudi Arabia, 2006)	Public	534	3,118	484%	170%	1500+	875
UT (Saudi Arabia, 2006)	Public	705	3,350	375%	170%	1500+	823
UOS (United Arab Emirates, 1997)	Public	1,256	4,611	267%	165%	1303	576
REGIONAL GROUP							
IISc (India, 1909)	Public	4,124	4,556	10%	50%	480	587
AUB (Lebanon, 1866)	Private	2,234	2,113	-5%	102%	855	1209
KAUST (Saudi Arabia, 2009)	Private	3,599	4,813	34%	170%	549	554
KU (United Arab Emirates, 2017)	Public	1,780	3,894	119%	165%	1029	700
INTERNATIONAL GROUP							
ETH Zurich (Switzerland, 1855)	Public	12,584	13,685	9%	14%	83	110
MIT (United States, 1861)	Private	15,115	15,528	3%	1%	56	83
Princeton (United States, 1746)	Private	6,896	7,443	8%	1%	245	325
UC Berkeley (United States, 1868)	Public	14,218	13,883	-2%	1%	66	106

Institutions are represented by their acronyms or popular names. **India:** Chitkara=Chitkara University, CU=Chandigarh University, GLA=GLA University, IISc=Indian Institute of Science (Bangalore), KL=KL University, LPU=Lovely Professional University, SIMATS=Saveetha Institute of Medical and Technical Sciences, UPES=University of Petroleum and Energy Studies. **Lebanon:** AUB=American University of Beirut, LAU=Lebanese American University. **Saudi Arabia:** KAUST=King Abdullah University of Science and Technology, KKU=King Khalid University, KSU=King Saud University, NU=Najran University, PNU=Princess Nourah Bint Abdulrahman University, PSAU=Prince Sattam Bin Abdulaziz University, TU=Taif University, UOH=University of Ha'il, UQU=Umm Al-Qura University, UT=University of Tabuk. **Switzerland:** ETH Zurich. **United Arab Emirates:** KU=Khalifa University, UOS=University of Sharjah. **United States:** MIT=Massachusetts Institute of Technology, Princeton=Princeton University, UC Berkeley=University of California, Berkeley. Percentages for AUB and UC Berkeley are not shown due to respective declines of 5% and 2%. **Data Source:** SciVal (May 1, 2025). *The data for KL and NU in this Table are based on InCites.

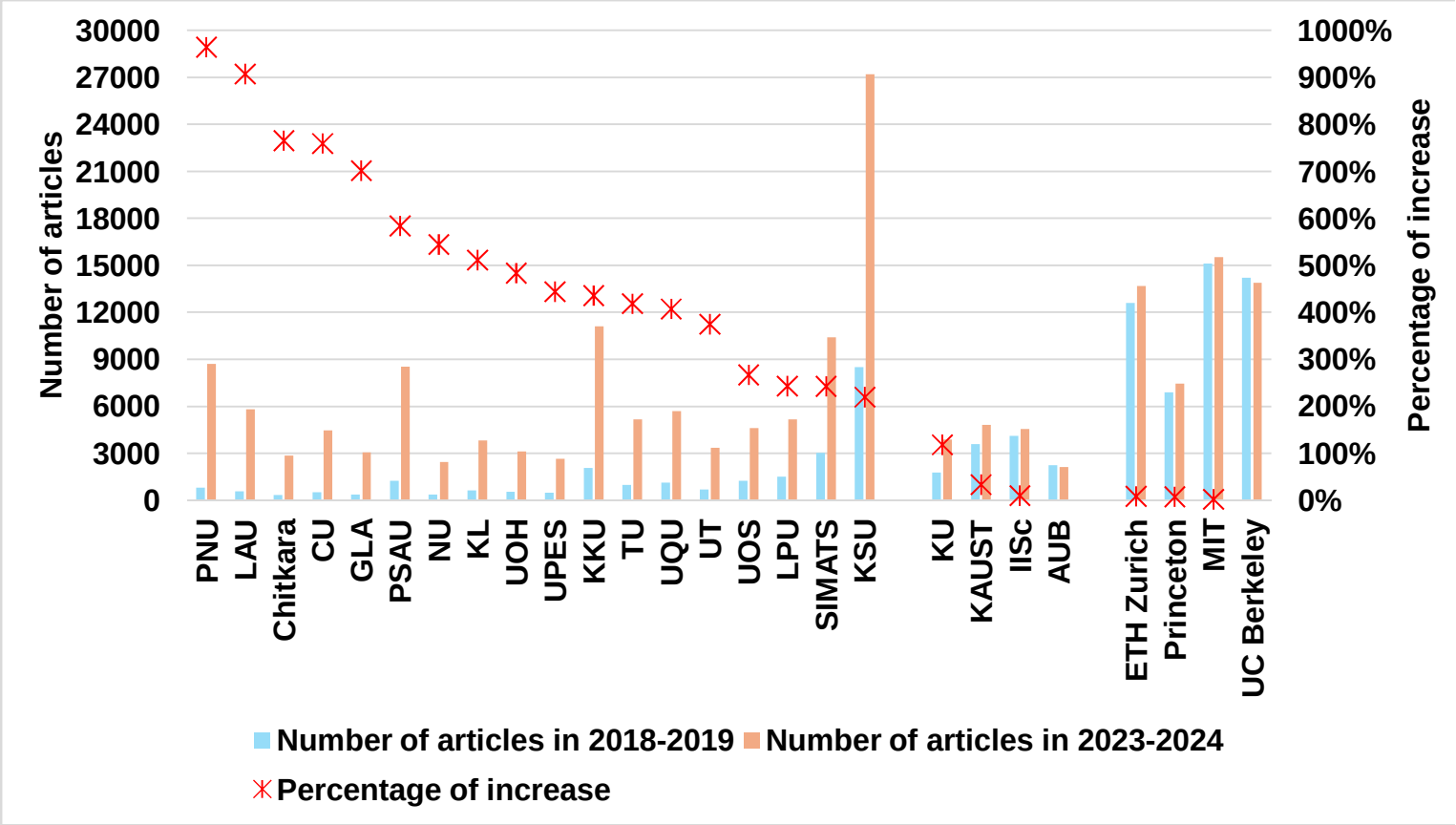

Figure 1. Extent of research growth among universities in the study, regional, and international groups between 2018-2019 and 2023-2024. A blank space separates the study group (left) from the regional group (middle) and international group (right). The increase percentages for AUB and UC Berkeley do not appear because they dropped in research output by 6% and 3%, respectively. **Data Source:** SciVal (May 1, 2025). The data for KL and NU in this Figure are based on InCites.

In contrast, universities in the regional and international benchmark groups exhibited lower or stagnant growth, often falling below national trends. Growth in the regional benchmark group ranged from a 5% decline to a 119% increase, while national averages spanned 50% to 170%. International benchmark institutions recorded modest or negative changes, with output ranging from -2% to +9%, relative to national growth rates of 1% to 14%.

The research output gains among the study group universities led to a significant upward movement in global research rankings. In 2018-2019, only one institution in the study group ranked among the top 500 most-publishing universities; two others fell between 501st and 1000th place. By 2023-2024, seven study group universities reached the top 500, and the median global rank for all 18 institutions improved from over 2,000th to 545th (Figure 2, Table 2).

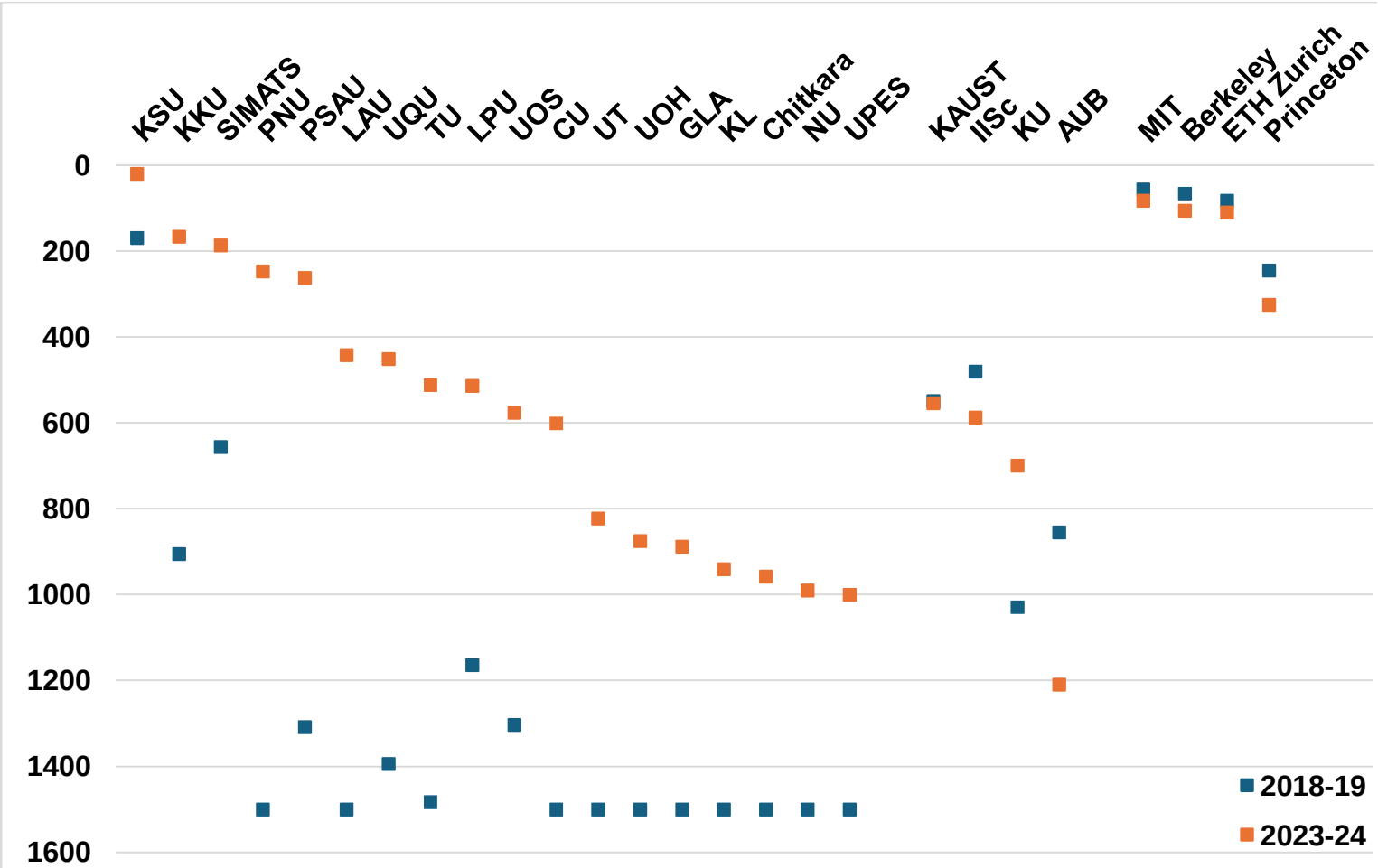

Figure 2. Changes in global research output rankings between 2018-2019 and 2023-2024 for universities in the study, regional, and international groups. Ten universities ranked below 1,500 are depicted at 1,500th for visualization purposes. **Data Source:** SciVal (May 1, 2025). The data for KL and NU in this figure are based on InCites.

Performance varied among regional comparators. For example, the Indian Institute of Science's research output grew by 10%, yet dropped from 480th to 587th in global publication rankings, while Khalifa University improved from just over 1,000th to 700th. Among international comparators, the median ranking fell from 75th to 108th, with two universities exiting the global top 100. These shifts reflect relative changes in global publication volume, where rapid expansion among institutions in other regions affected the relative standing of traditionally stable universities.

In Shanghai Ranking, which places substantial weight on research output, the visibility of study group institutions also improved. In 2018-2019, only one university from the group appeared in the top 1,000. By 2024, nine study group universities were listed (Figure 3).

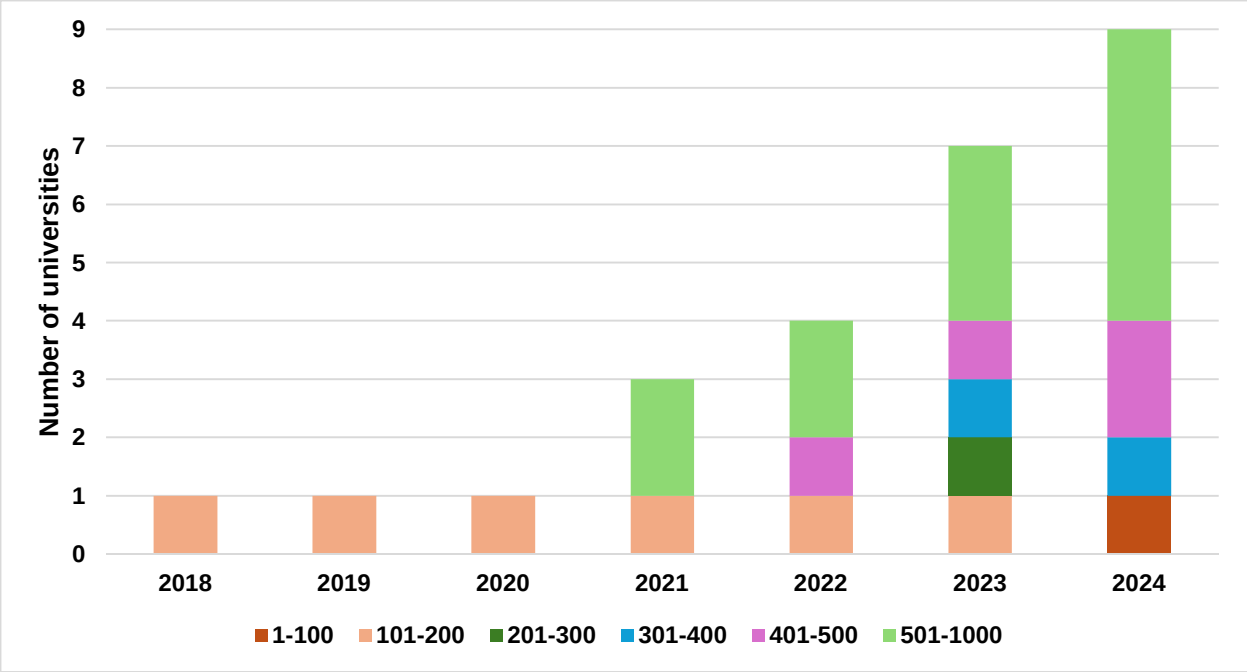

Figure 3. Study Group Institutions by Shanghai Ranking Tier (2018-2024)

Several study group institutions made notable advances. Princess Nourah Bint Abdulrahman University debuted in the 301-400 range, the highest tier among the 35 new entrants in 2023. Three universities entered the 601-800 band, while 31 others debuted at 801-1,000. Similarly, the Lebanese American University first appeared in 2024, entering the 501-600 tier. Among 40 new entrants that year, five debuted at the 701-800 tier, and the remainder entered the 801-1,000 range. In addition to new entries, Taif University and King Khalid University advanced by 600 and 400 positions, respectively, within two years of their initial inclusion in 2021 (Table 1S). Only three other universities worldwide demonstrated similar rank mobility during that timeframe.

In India, where the National Institutional Ranking Framework (NIRF) is highly relevant to policy, none of the seven study group institutions ranked among the top 40 before 2019, and only two were in the top 100. By 2024, four universities were ranked in the top 40 and six in the top 100, indicating significant domestic profile gains.

By contrast, regional benchmark universities experienced stagnant or declining Shanghai Ranking performance while international benchmark universities retained their positions in the top global tiers, showing stable performance over time without significant fluctuations.

3.2. Inflation in Discipline-Specific Research

The increase in research output among study group universities becomes even more pronounced at the disciplinary level. In 2018-2019, only one study group university

ranked among the world's top 100 most-publishing institutions in any of the 21 subject categories tracked by Clarivate's Essential Science Indicators. By 2023-2024, however, seven of the 18 study group universities collectively appeared 34 times among the top 100 across 13 subject categories. These gains occurred primarily in STEM fields, including chemistry, computer science, engineering, materials science, mathematics, pharmacology and toxicology, and physics (Figure 4, Table 2S).

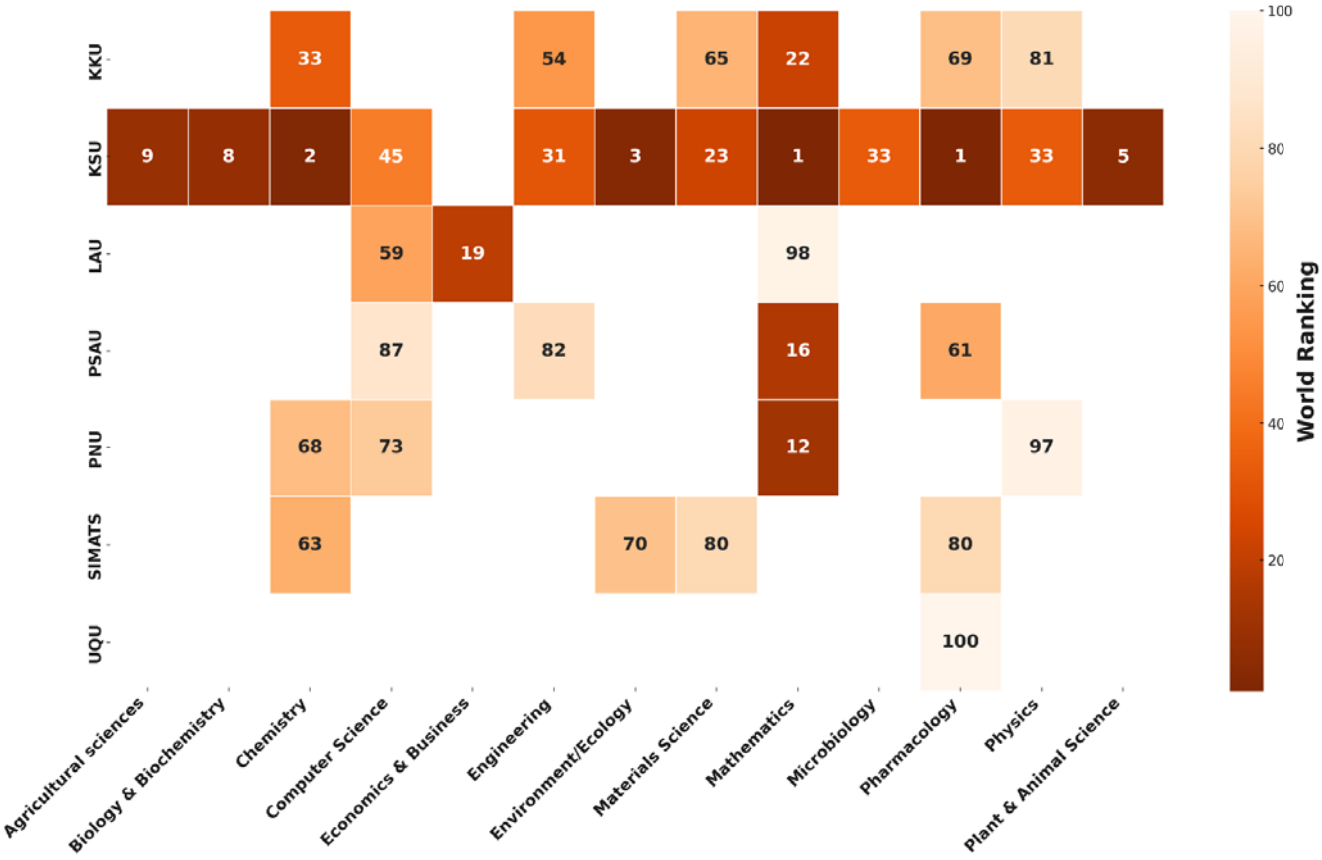

Figure 4. World Rankings of Study Group Universities Across Subject Categories (2023-2024, Top 100 Only). KKU=King Khalid University, KSU=King Saud University, LAU=Lebanese American University, PNU=Princess Nourah Bint Abdulrahman University, PSAU=Prince Sattam Bin Abdulaziz University, SIMATS=Saveetha Institute of Medical and Technical Sciences, UQU=Umm Al-Qura University. **Data source:** Essential Science Indicators, via InCites (May 2025).

A closer examination of these patterns highlights the extent of subject-specific concentration. For example, the Saveetha Institute of Medical and Technical Sciences, which had no representation among the world's top 1,000 most-published universities in any discipline in 2018-2019, appeared in four top-100 subject categories by 2023-2024. This figure surpassed all other Indian universities combined, except for the Vellore Institute of Technology, which also appeared in four categories. Similarly, the Lebanese American University, Prince Sattam Bin Abdulaziz University, and Princess Nourah Bint

Abdulrahman University, none of which offer PhD programs, secured top-100 rankings on 11 occasions across seven subject categories. Notably, apart from three Chinese institutions, only Harvard University outperformed King Saud University in the number of subject areas in which it ranked among the world's top ten most-publishing institutions, a total of seven categories.

Despite these substantial advances in STEM fields, study group universities did not exhibit similar progress in clinical medicine or the social sciences (including public health). In 2023-2024, the highest ranking in clinical medicine was 180th (King Saud University), and none of the other 17 institutions appeared in the global top 500 for that field. Similarly, only two study group universities ranked among the top 500 in the social sciences. This contrast is particularly notable given that 13 study group institutions maintain sizable medical and health sciences colleges, suggesting a possible disciplinary imbalance in research expansion.

In contrast, regional control group universities did not appear in the global top 100 most-published institutions in any subject area. Meanwhile, institutions in the international control group experienced declines in disciplinary rankings: their collective appearances in the top 100 dropped from 47 instances in 2018-2019 to thirty-five in 2023-2024, a reduction likely driven partly by the entry of study group universities into these top tiers.

3.3. Decline in First and Corresponding Author Publications

An analysis of authorship trends reveals a marked decline in the first and corresponding authorship rates among study group universities, diverging substantially from global and national patterns. Between 2018-2019 and 2023-2024, the average first authorship rate across these institutions fell by 44%, declining from 52% to 29%, more than six times the 7% global decline over the same period. Corresponding authorship rates decreased by 38%, from 52% to 32%, a decline over 13 times steeper than the 3% global average.

By 2023-2024, the decline was so steep that eight study group universities ranked among the ten lowest globally in first authorship rates, and 12 appeared in the bottom 20 (Table 3). The most extreme case was the Lebanese American University, where, based on InCites data, the first authorship rate dropped from 57% in 2018-2019 to 18% in 2023-2024, the sharpest decline recorded among all global institutions. King Khalid University and Taif University also experienced considerable reductions.

A country-level breakdown further contextualizes these shifts. Among Indian institutions in the study group, first authorship rates declined by an average of 45% (median: 45%), compared to a national decline of 3.5%. The Lebanese American University's 69% drop was over seven times Lebanon's national average decline of 10% (excluding LAU). Saudi institutions in the study group reported an average decrease of 46% (median: 40%), more than double the national decline of 21%. The University of Sharjah saw a 24% reduction, compared to an 18% national decline in the United Arab Emirates. Corresponding authorship rates followed similar trajectories across all four countries.

In contrast, authorship trends at the regional and international control institutions remained relatively stable, with only modest declines in first and corresponding authorship rates over the same period.

Table 3. Decline in the proportion of, and world rank in, first and corresponding authorship rates

	First authorship rate (%)			World ranking in first authorship rate		Corresponding authorship rate (%)			World ranking in correspondence. authorship rate	
GROUP	2018-19	2023-24	Decline	2018-19	2023-24	2018-19	2023-24	Decline	2018-19	2023-24
STUDY										
CU	59	31	-48%	343	993	52	35	-31%	610	981
Chitkara	66	32	-51%	211	988	56	40	-28%	452	915
GLA	72	38	-47%	93	960	68	38	-44%	160	962
K L	71	42	-40%	117	863	64	41	-36%	228	880
LPU	67	46	-31%	183	644	62	49	-21%	278	593
SIMATS	58	34	-42%	400	986	51	47	-8%	625	635
UPES	63	35	-45%	265	981	60	44	-26%	314	760
LAU	57	18	-69%	420	999	58	32	-45%	383	994
KKU	49	17	-66%	773	1000	48	16	-66%	787	1000
KSU	49	24	-51%	821	997	52	28	-47%	585	997
NU	44	45	3%	957	712	53	33	-39%	542	993
PSAU	49	28	-42%	788	996	50	39	-22%	680	940
PNU	47	29	-38%	878	995	32	24	-23%	1000	998
TU	58	20	-65%	393	998	52	20	-61%	605	999
UQU	48	34	-29%	860	987	43	34	-20%	952	987
UOH	53	50	-5%	592	501	52	40	-23%	600	928
UT	52	31	-41%	621	992	49	29	-40%	760	996
UOS	51	39	-24%	702	939	57	48	-16%	410	625
REGIONAL										
IISc	67	62	-7%	206	214	67	64	-6%	163	230
AUB	61	53	-13%	300	400	62	53	-14%	275	440
KAUST	50	47	-7%	610	625	57	54	-5%	405	430
KU	52	43	-18%	756	811	56	51	-9%	422	490
INTERNATIONAL										
ETH Zurich	54	51	-6%	532	467	51	48	-5%	633	592
MIT	48	43	-12%	846	840	48	44	-7%	792	770
Princeton	52	47	-10%	618	600	50	48	-5%	680	630
UC Berkeley	50	44	-13%	740	762	48	44	-9%	767	793

Data source: InCites (May 1, 2025).

3.4. Rise in Hyper-Prolific Authorship

The number of HPAs, defined in this study as individuals publishing 40 or more articles in a calendar year, has risen globally. However, the increase accelerated most sharply among the study group universities. Between 2018-2019 and 2023-2024, the number of HPAs affiliated with study group institutions rose by 1,252%, from 29 to 392 (Figure 5). This growth is over 12 times the global increase of 101% (from 3,226 to 6,488 HPAs globally, excluding study group institutions). It significantly exceeds the 163% increase observed among regional control universities and the 89% increase among international controls. Notably, 17 of the 392 HPAs in the study group achieved this status simultaneously at two or more study group universities due to listing multiple affiliations in the same year.

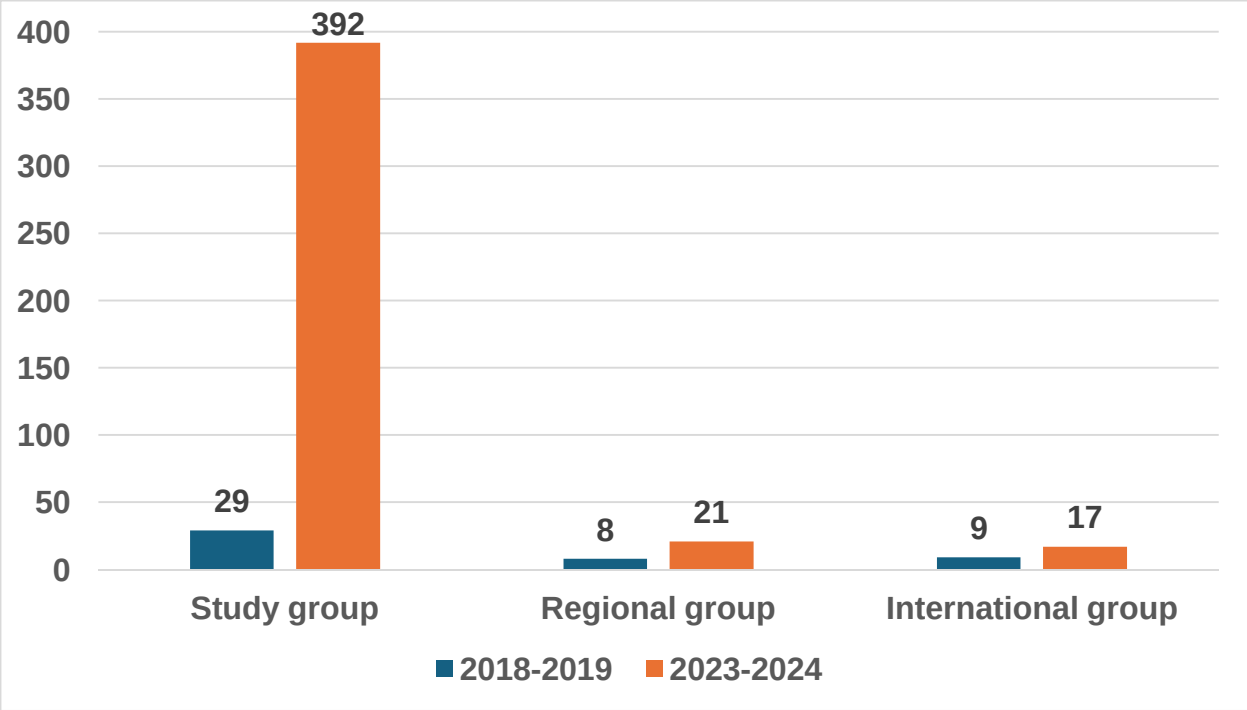

Figure 5. Increase in hyper-prolific authors among study and control group universities, 2018-2019 vs. 2023-2024. Data Source: SciVal (May 1, 2025).

The distribution of HPAs varied widely across institutions. King Saud University experienced the most significant increase, from four HPAs in 2018-2019 to 151 in 2023-2024, representing a 3,675% rise, the highest recorded globally. Similarly, the Lebanese American University, which had no HPAs before 2022, reported 36 HPAs in 2023-2024 (Figure 6). One illustrative case is the Saveetha Institute of Medical and Technical Sciences (SIMATS), which highlights potential tensions between research quantity and quality. In 2018-2019, SIMATS had 16 HPAs, but 80% of their articles were published in journals later delisted from Scopus or Web of Science. Excluding those journals, none of the authors would have met the 40-article threshold used to classify HPAs.

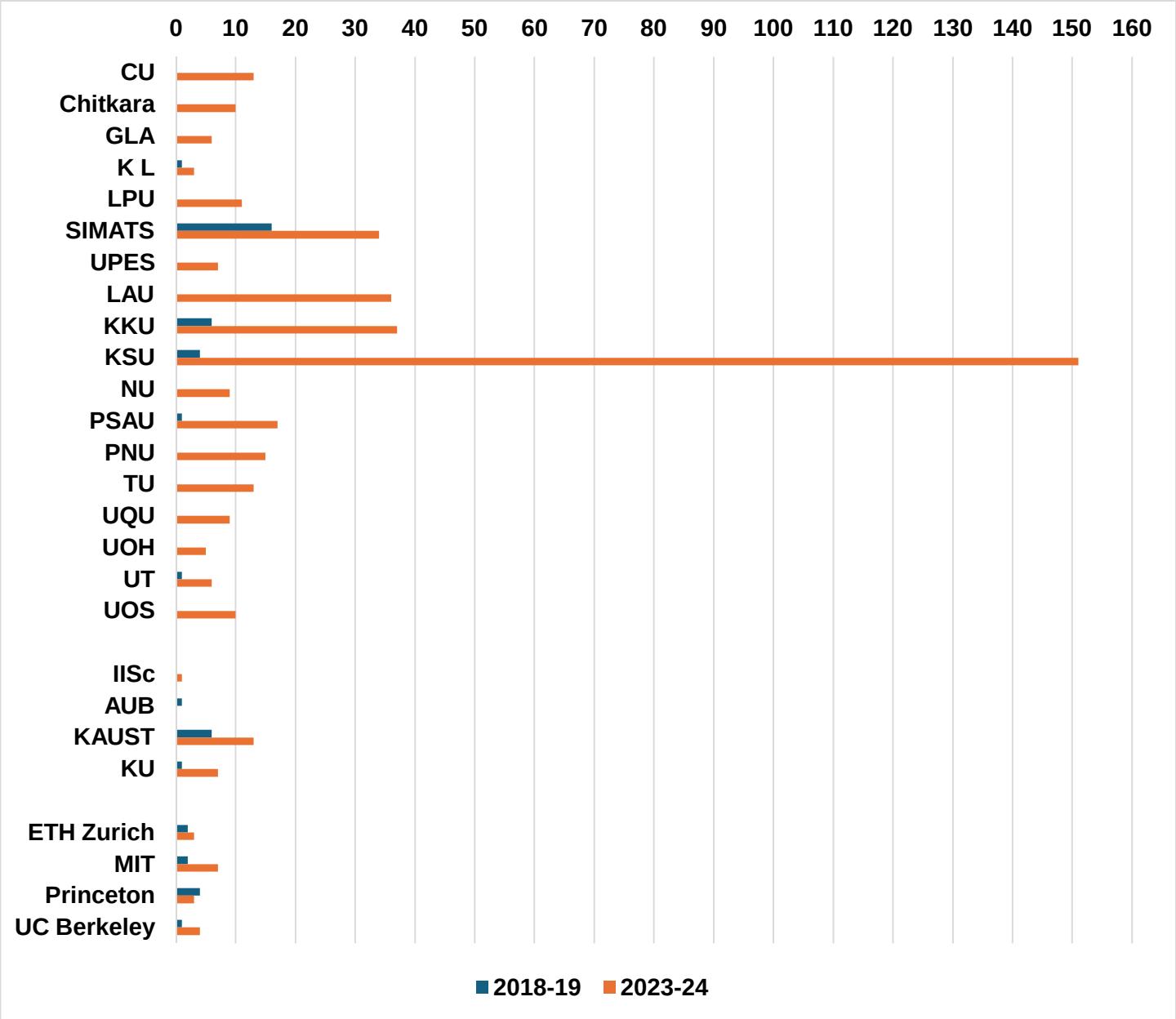

Figure 6. Changes in the number of hyper-prolific authors at universities in the study and control groups between 2018-2019 and 2023-2024. Data Source: SciVal (May 1, 2025).

A defining characteristic of HPAs affiliated with study group institutions is their recent emergence and relatively short institutional tenure. Among those identified in 2023-2024, 53% had never attained hyper-prolific status before, based on publication records dating back to 2004. This proportion is substantially higher than that observed in the regional comparison group (33%) and the international group (22%). Per SciVal, the average institutional tenure of the 2023-2024 HPAs in the study group—that is, the number of years they had been publishing under their current institutional affiliation—was nine years, compared to 11 years in the regional group and 19 years in the

international group. While shorter tenure in the study group may, in part, reflect the relatively young age of some of its institutions, this explanation is not sufficient. Notably, 64% of the study group's HPAs were affiliated with universities founded over 35 years ago. By contrast, 62% of the regional group's HPAs were affiliated with King Abdullah University of Science and Technology, an institution established in 2009, where the average HPA tenure was 14 years as of 2025. These findings underscore the more recent and abrupt onset of prolific authorship behavior within the study group.

Significant increases in individual research productivity accompanied the sharp rise in hyper-prolific authorship at study group universities. The average annual output per HPA in these institutions rose from 12 articles in 2018-2019 to 53 in 2023-2024, a 342% increase. By contrast, HPAs in the regional control group increased from 28 to 47 articles annually (68% growth), and HPAs in the international group increased from 26 to 52 (100% growth).

Three illustrative cases underscore the diverse patterns of hyper-prolific authorship evident among study group universities. One case involves a researcher who, between January 2021 and April 2025, listed two to six simultaneous study group affiliations in 477 articles, often spanning multiple countries and regions. A second case typifies a sudden productivity surge, with a publishing career that starts with three articles in 2019 increasing to an average of 123 annually from 2021 to 2024, including a listing of 2-3 concurrent study group institutions located in 2-3 different countries. The third case illustrates a case of a university leader who, after assuming a deanship, saw an abrupt rise in output from an average of one article per year from the mid-2000s to 2021, to 229 in 2022, and over 500 in 2023 (all without co-authors from their institution) (Table 3S).

Despite their substantial publication volume, the h-index of HPAs affiliated with study group universities maintained modest scores. Among 2023-2024 HPAs in the study group, the average h-index was 39, with a median of 32. In comparison, regional group HPAs had an average h-index of 80 (median: 75), and international group HPAs averaged 88 with a median of 84. These disparities underscore the recent emergence and accelerated publishing pace of HPAs in the study group, in contrast to the more sustained profiles typically observed among HPAs in more established academic environments.

3.5. Publications in Delisted Journals and Retraction Patterns

Between 2018-2019 and 2023-2024, 16 of the 18 study group universities reduced the share of their research output published in journals subsequently delisted by Scopus or Web of Science. For example, KL University and the Saveetha Institute of Medical and Technical Sciences decreased their proportions from over 75% to under 16%. Among Saudi universities, the median share of output in delisted journals declined from 11% to 6% during the same period. By contrast, the Lebanese American University saw a nearly fourfold increase, and the University of Sharjah recorded a 33% rise in publications in delisted venues.

Despite the reduction, study group universities remain disproportionately represented among institutions with the highest publication volumes in delisted journals. In 2023-2024, they accounted for 15 of the top 50 universities globally by proportion of output in these venues. KL University ranked second, with 15% of its total output appearing in delisted journals. Saveetha Institute, while showing marked improvement, still ranked 14th globally by proportion and 4th by volume. King Saud University published 986 articles in delisted journals, the second-highest number worldwide during this period (see Table 4S).

In contrast, institutions in the regional and international control groups maintained consistently low engagement with delisted journals. None appeared in the global top 100 by either proportion or volume. On average, regional control universities published fewer than 50 articles in delisted journals during the entire study period, comprising less than 1% of total output. International comparator institutions exhibited near-zero publication shares, reflecting enduring adherence to selective publishing practices and editorial standards.

A parallel concern is the steep rise in retraction counts and rates among study group institutions, particularly from 2022 onward, a year included here to account for the inherent delays in retraction processes. For example, the Saveetha Institute of Medical and Technical Sciences saw its retractions climb from one in 2018-2019 to 123 in 2022 and 163 in 2023-2024. King Saud University followed a similar trajectory, with retractions increasing from 16 to 164 in 2022 and 101 in the subsequent two years. The Lebanese American University, which had no prior retractions, reported 26 retracted publications in 2023-2024 (see Figure 7, Table 5S).

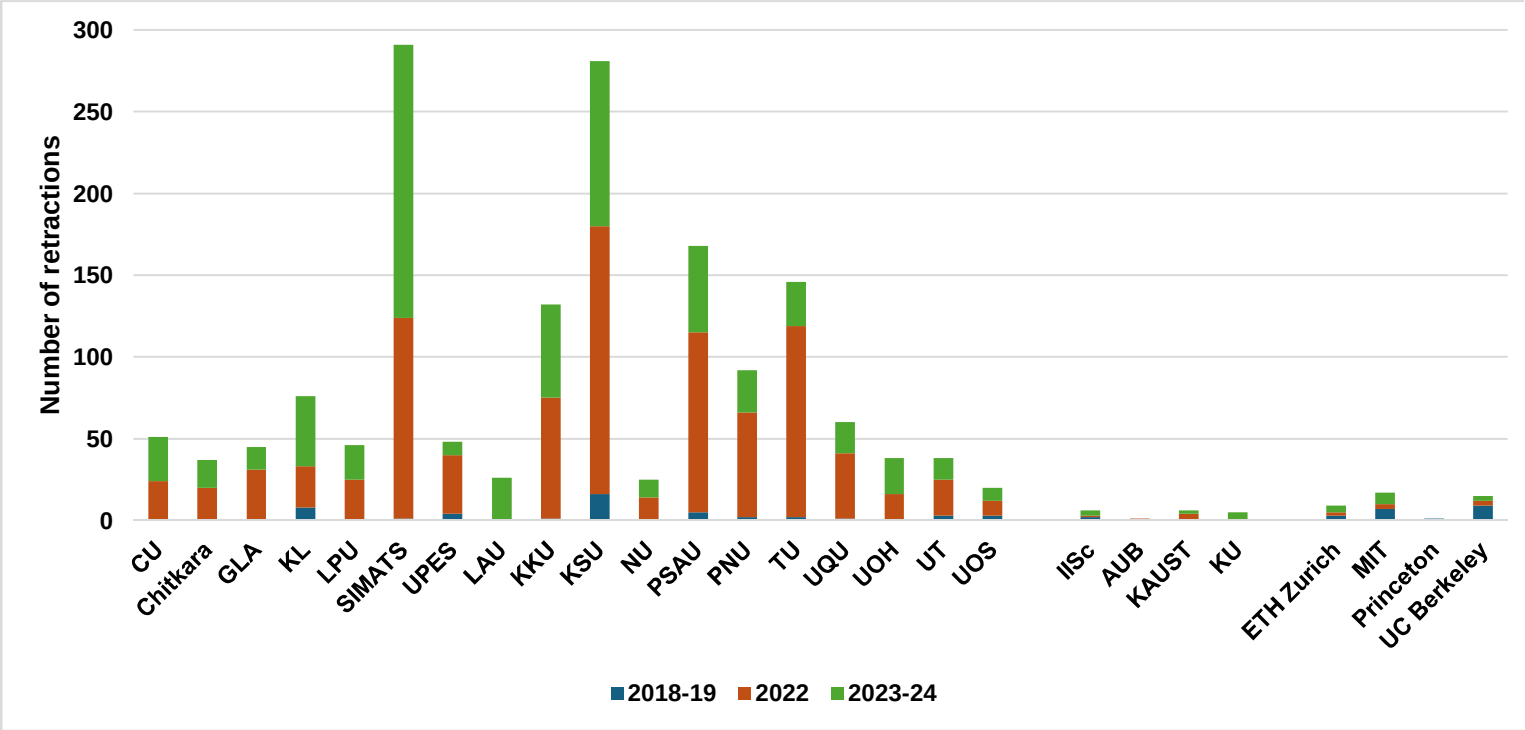

Figure 7. Retraction counts at the study, regional, and international group universities

When normalized per 1,000 published articles, the study group's retraction rates were among the highest globally. In 2022, they accounted for 15 of the top 50 highest-retraction-rate universities worldwide. In 2023-2024, they comprised 15 of the top 25 among the 1,000 most-publishing institutions. This marks a dramatic shift from 2018-2019, when only one study group member, the University of Petroleum and Energy Studies, ranked in the global top 50, and most did not appear in the top 500.

In contrast, regional and international control universities maintained consistently low retraction rates across all analyzed years. Most recorded zero or near-zero retractions, reflecting more robust editorial oversight and institutional research integrity mechanisms.

3.6. Highly Cited Publications

Between 2018-2019 and 2023-2024, the number of study group universities' publications ranked among the world's top 2% most cited rose from 706 to 7,683 articles, representing a 988% increase. This growth outpaced the group's 326% increase in total research output, suggesting that factors beyond increased publication volume drove the rise in highly cited articles. The proportion of highly cited publications rose from 2.5% to 6.5%, indicating a significant expansion in the share of output achieving top citation thresholds.

By comparison, regional control universities recorded a 58% increase in highly cited articles and a 31% increase in total output. However, their share of highly cited publications declined, from 6.0% to 5.0%. The international control group saw a more pronounced shift: while overall output rose by 4%, highly cited publications fell by 25%, and the corresponding share declined from 8.5% to 6.2%.

The surge in highly cited articles was widespread among the study group. For instance, King Khalid University increased its highly cited output from 26 to 878 articles, a 3,277% rise, against a 436% increase in total production. KL University and the University of Petroleum and Energy Studies, which had no highly cited publications in 2018-2019, produced 205 and 265 such articles by 2023-2024, respectively (Table 6S).

Global rankings in this category also shifted substantially. In 2018-2019, none of the study group universities ranked among the world's top 200 institutions by proportion of highly cited articles, and only five ranked within the top 201-500. By 2023-2024, 17 study group institutions entered the top 200, 11 reached the top 100, and nine ranked in the top 50. The most dramatic ascent was that of the Lebanese American University, which rose from 646th to 1st place globally by this measure.

This rapid ascent in citation metrics coincided with the formation of dense inter-institutional citation networks within the study group in 2023-2024. To examine these dynamics, we identified "major citation contributors" as institutions accounting for at

least 1% of the citations received by a university's highly cited articles. Sensitivity analysis guided the selection of this threshold: higher cutoffs (e.g., 2%) excluded relevant contributors, while lower cutoffs (e.g., 0.5%) diluted the signal with weaker ties. Cross-checking against total citation data—not limited to the top 2% of articles—produced comparable patterns, reinforcing the robustness of the findings.

Across the study group, the top sources of citations to highly cited publications were the study group universities themselves, followed by other external institutions. On average, each study group university had 17 major citation contributors, including 9.5 from within the study group, highlighting a strong pattern of internal cross-citation. As illustrated in Figure 8, these dynamics form a dense web of bilateral or reciprocal citation activity among study group institutions. Beyond the group, the analysis identified 136 more universities (or 54 after accounting for overlap) as significant citation contributors. Notably, none of these universities ranked among the world's top 100, fewer than 10% ranked within the top 101-500, and approximately 67% were unranked by Shanghai Ranking. Examples of frequently recurring external contributors include Al-Azhar University (Egypt), Graphic Era University (India), The Islamia University of Bahawalpur (Pakistan), Ural Federal University (Russia), Northern Border University (Saudi Arabia), and Yeungnam University (South Korea), each cited five or more study group universities' highly cited papers at a 1% or higher level.

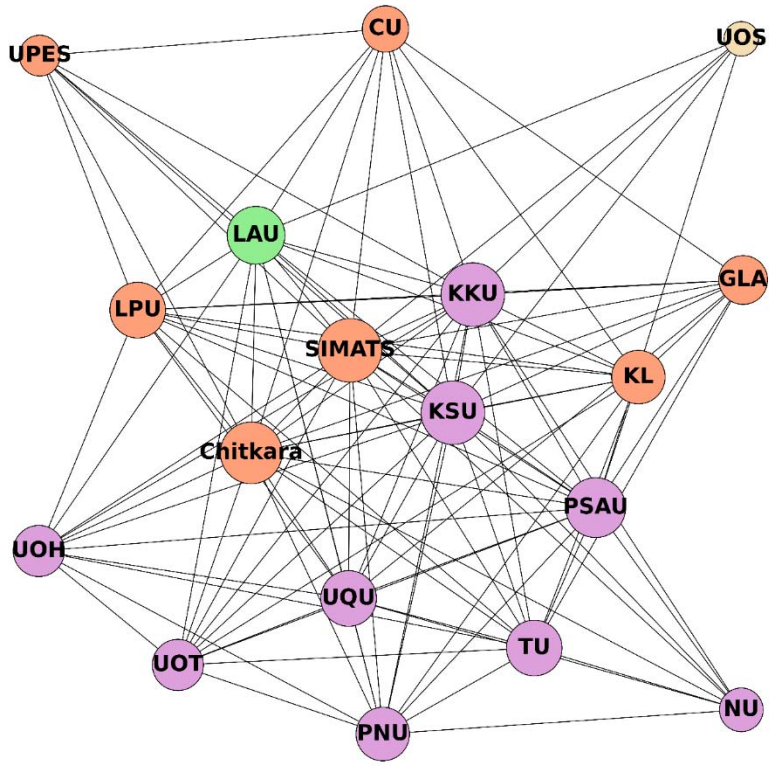

Figure 8. Internal network of major citation contributors to study group universities' highly cited publications, 2023-2024. Node sizes represent the degree of each node, which refers to the number of direct connections (or links) a university has with others in the network. These connections are based on citation activity, where a link indicates that one university contributed to at least 1% of the citations

received by another university's high-impact articles during the analyzed period, either unidirectionally or bidirectionally (reciprocally). Nodes with more connections appear larger, indicating greater centrality or influence within the citation structure. Node colors denote cluster membership, grouping institutions that are more densely interconnected. The layout is optimized to maximize spatial separation for visual clarity and highlight the underlying structure of inter-institutional citation relationships.

In contrast, regional and international control universities received citations from prominent institutions. Regional comparators averaged 14 major contributors, including Harvard, Tokyo, Toronto, and Tsinghua. On average, international comparators had 22 major contributors, including Harvard, Cambridge, Stanford, Caltech, and Yale. Ninety-three percent of regional group contributors ranked among the global top 200, while 95% of international group contributors ranked in the top 100.

Two prominent citation patterns emerged among study group universities:

1. Citation Hubs: A subset of institutions, including Chitkara University, King Khalid University, King Saud University, and Saveetha Institute of Medical and Technical Sciences, served as citation hubs, contributing significantly to their own highly cited articles and those of multiple other study group members.
2. Elevated Self-Citation Rates: Study group institutions exhibited higher self-citation rates than both control groups, with a median of 6.0%, compared to 3.5-4.0% in the regional and international groups (Table 7S).

3.7. The Role of External Contributors in Research Growth

To assess whether shifts in collaboration patterns contributed to the surge in research output among study group universities, the analysis examined how their external partnerships evolved. Specifically, we examined the number, identity, and academic standing of each institution's primary external collaborators, defined as organizations contributing to at least 2% of a university's total publications during a given period, based on a sensitivity analysis.

Table 10S shows that the number of major collaborators expanded markedly. In 2018-2019, study group universities averaged ten major collaborators. By 2023-2024, this number more than doubled to 26 per university. Of these, 15 were either new collaborators or previously minor contributors whose co-authorship share increased fivefold or more, indicating a substantial intensification of collaborative activity within a short timeframe.

Some institutions experienced especially pronounced shifts. For example, Saveetha Institute of Medical and Technical Sciences increased its major collaborators from one to 22. Twenty of these were either new or significantly more engaged. Princess Nourah Bint Abdulrahman University expanded from 16 to 40 major collaborators, with 16 classified as new or intensified. The Lebanese American University demonstrated the most dramatic change, increasing from eight to 42 major collaborators, 39 of whom

were new or had significantly intensified their collaboration levels between 2018-2019 and 2023-2024.

By contrast, regional and international control universities exhibited only modest changes in their collaboration profiles. Regional universities increased from three to six major collaborators, and international comparators from 12 to 18. Neither group showed meaningful growth in new or intensified partnerships, suggesting more stable and selective collaboration networks.

Further analysis revealed that a substantial share of the new or intensified collaborators of study group universities were fellow members of the same study group. On average, 41% of intensified collaborations occurred between peer institutions within the group. For instance, Chandigarh University reported 17 such partnerships, nine involving fellow study group universities (Table 11S).

Figure 9 visualizes this evolving internal network, comparing the study group's internal collaboration activity in 2018- 2019 with that of 2023-2024. The map shows limited to non-existent collaborations between the study group universities in 2018-2019. Indeed, six universities do not even appear on the map, indicating they had no notable partnership with each other or other study group members. Within five years, the network evolved into a dense web of connections representing significant bilateral collaborations. For example, the Lebanese American University is connected to 11 other study group members, indicating extensive co-authorship activity involving the University.

Many of the remaining collaborators outside this internal network were institutions with limited international academic visibility, totaling 167 in 2023-2024 (or 95 after removing overlap). Among these, 1% ranked among the global top 100 (based on the Shanghai Ranking), 5% were in the top 101-500, and 80% were unranked. Examples of frequently recurring partners include Future University (Egypt), Anna University and Graphic Era University (India), Jazan University and Northern Border University (Saudi Arabia), and Yeungnam University (South Korea), each serving as a major collaborator for five or more study group universities.

The extent to which these patterns reflect genuine collaboration, as opposed to questionable authorship and publication practices, warrants further investigation. Future studies should examine whether these affiliations represent substantive institutional engagement or are primarily nominal. As mentioned previously, 17 of the 392 HPAs in the study group achieved this status simultaneously at two or more study group universities due to listing multiple affiliations in the same year.

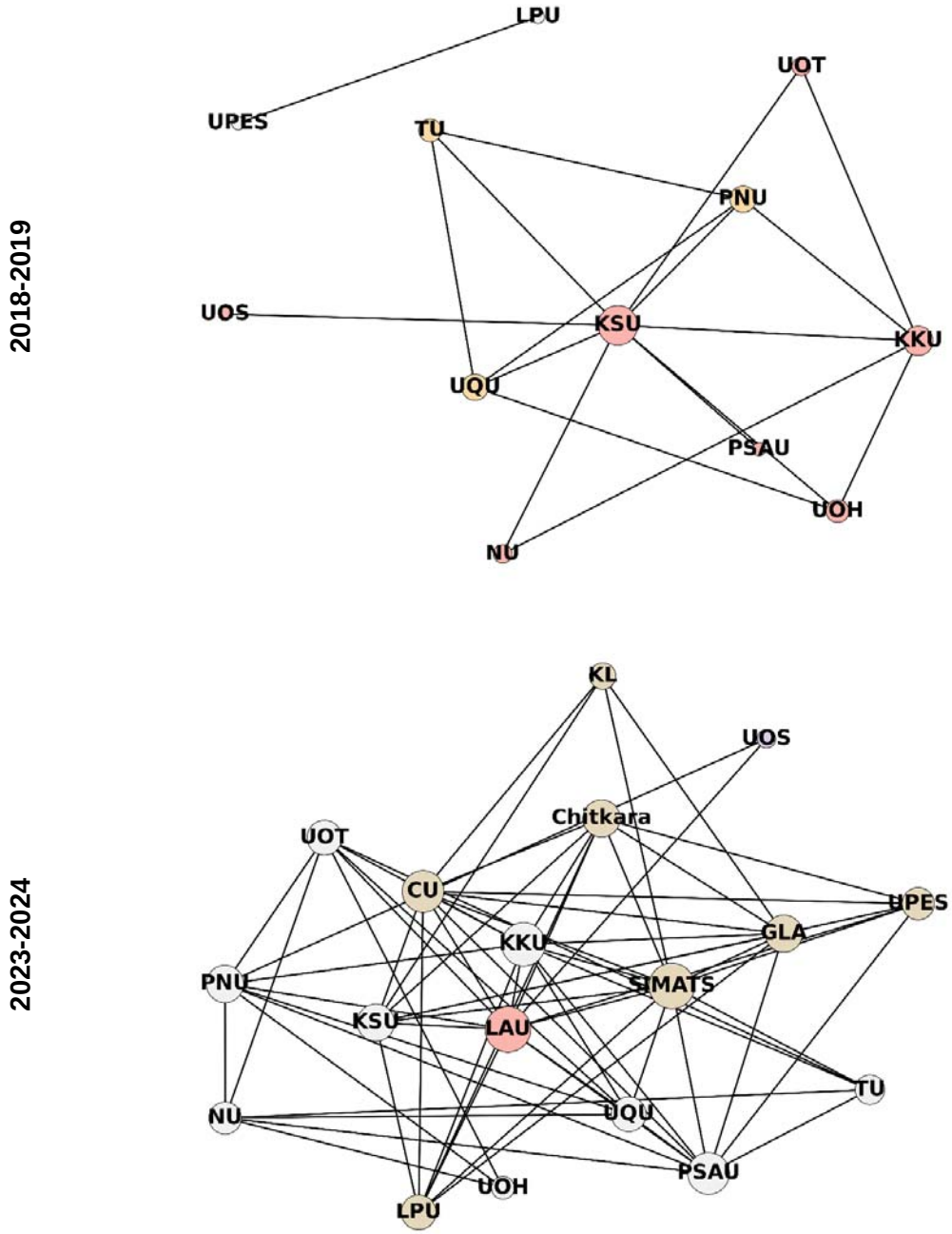

Figure 9. Collaboration network among study group universities (2018-2019 vs. 2023-2024). Node sizes represent the degree of each node, which refers to the number of direct connections (or links) a university has with others in the network. These connections are based on co-authorship activity, where a link indicates that one university contributed to at least 2% of another university's total publications during the analyzed period, either unidirectionally or bidirectionally. Nodes with more connections appear larger, reflecting greater centrality or influence within the collaboration structure. Node colors indicate cluster membership, grouping institutions that are more densely interconnected. The layout is optimized to maximize spatial separation for visual clarity and highlight the underlying structure of inter-institutional relationships.

4. Discussion

This study reveals systemic patterns of metric-driven behaviors among universities with extraordinary research output growth. While such growth is not inherently problematic, the co-occurrence of authorship declines, hyper-prolific authorship, rising retraction rates, and anomalous citation structures suggests deliberate metric optimization. These behaviors expose the vulnerabilities of ranking-based evaluation systems that prioritize quantity over scholarly substance. These dynamics are best understood through the intersecting lenses of Goodhart's Law and institutional isomorphism. Goodhart's Law warns that once a metric becomes a target, it loses its effectiveness as a measure, a pattern visible when publication counts, citation rates, and international co-authorships are pursued as ends. As global rankings increasingly reward these indicators, some universities have responded not by enhancing academic substance but by strategically optimizing the metrics themselves. The result is a distortion in what these metrics were originally intended to signify. At the same time, institutional isomorphism, particularly in its mimetic form, helps explain how such behaviors spread. Under intense reputational and policy pressures, institutions emulate the visible strategies of seemingly successful peers, even when these strategies lack contextual appropriateness or ethical grounding (Hazelkorn & Mihut, 2021; Reymert, 2021; Rhein & Nanni, 2023). This imitation manifests in abrupt disciplinary shifts, inflated collaboration profiles, and affiliations with hyper-prolific authors—practices that mimic elite institutions superficially but diverge from their deeper scholarly rigor. The convergence of these two forces—metric distortion and behavioral imitation—creates a feedback loop that normalizes questionable practices and undermines the integrity of academic evaluation on a systemic scale.

4.1 Strategic Growth in Research Output and Disciplinary Concentration

The magnitude and speed of publication growth among study group universities, often exceeding 400% within five years, raise questions about the feasibility of such expansion through organic academic development alone. While increases in research productivity can result from investments in faculty, doctoral programs, infrastructure, and funding—as is the case with China's recently founded Southern University of Science and Technology (2011) and Westlake University (2018)—the scale and associated bibliometric anomalies reported here suggest more strategic, and potentially opportunistic drivers. Notably, the growth was disproportionately concentrated in STEM fields. Several institutions with limited research legacy or without doctoral programs entered the global top-100 publication rankings in engineering, computer science, and materials science, among others. While focused growth can reflect specialization or emerging strengths, the abrupt and widespread nature of these gains, especially alongside elevated rates of hyper-prolific authorship and publication in delisted journals, points to targeted efforts to maximize ranking impact. By contrast, study group institutions made minimal advances in clinical medicine, health sciences, or social sciences, despite maintaining sizable programs in these areas. This imbalance may reflect the greater editorial scrutiny and methodological rigor required in these fields, which could constrain rapid, volume-focused publishing strategies.

4.2 Declines in First and Corresponding Authorship

The marked decline in first and corresponding authorship rates emerges as one of the clearest indicators of potential strategic authorship behavior. These roles are proxies for intellectual leadership and institutional ownership of scholarly work. In the study group, declines far exceeded national and global baselines, suggesting that some universities may be outsourcing substantive intellectual contributions or engaging in reciprocal authorship schemes to inflate publication and citation metrics. Abalkina (2023) documents a Russia-based paper mill that sold authorship slots globally, providing an illustrative precedent. Similarly, Vasconez-Gonzalez et al. (2024) have mapped the growing influence of authorship sales, AI-generated research content, and paper mills in regions under intense performance pressure, including emerging research systems such as Saudi Arabia. While a range of explanations may exist, including internationalization or collaborative expansion, the magnitude, speed, and consistency of these declines across institutions point to more intentional reconfigurations (Maisonneuve, 2025). When viewed alongside other bibliometric anomalies, the erosion of lead authorship roles strengthens the case for performance-driven optimization.

4.3 Hyper-Prolific and Multi-Affiliated Authorship: Inflating Institutional Metrics

The sharp increase in HPAs represents a significant bibliometric anomaly. Although high productivity is not inherently problematic, the context in which it occurs is crucial. In the study group, many HPAs are recent entrants with limited histories of scholarly productivity. Additionally, the study highlights how multiple institutional affiliations can inflate indicators of international collaboration. As shown in Table 3S, HPAs affiliated with study group universities frequently list multiple concurrent affiliations, often spanning several countries. While such practices are not necessarily unethical, their prevalence may artificially enhance institutional profiles, distorting collaboration metrics' validity. Growing evidence reinforces these concerns. Ioannidis and Maniadis (2024) report a notable rise in researchers producing over 60 publications annually in countries such as Saudi Arabia, often spurred by financial incentives tied to output and citation counts. Meho and Akl (2025) show that multi-affiliation patterns are widespread and frequently used to boost institutional performance metrics without substantive cross-institutional collaboration. Hottenrott et al. (2021) estimate that a significant share of international co-authorships are nominal, relying solely on secondary affiliations. Gök and Karaulova (2023) observe that multi-affiliations are increasingly employed as strategic tools in metric-driven environments, while Lin et al. (2025) report that more than half of scientific publications now include at least one multi-affiliated author, often without transparent documentation of collaborative engagement. These findings underscore the need for refined bibliometric indicators distinguishing nominal from meaningful collaboration.

4.4 Integrity of Journals and Retractions

A key concern is the sustained engagement of study group universities with journals delisted from major bibliometric databases due to deficiencies in peer review, editorial transparency, or ethical standards (Cortegiani et al., 2020). Although some institutions improved their publishing practices between 2018-2019 and 2023-2024, the group remained disproportionately represented among the top global contributors to such venues. This raises questions about research quality and institutional oversight. Parallel to this trend, study group universities experienced sharp increases in retraction counts and rates, unlike regional and international comparators, which maintained near-zero retraction levels. Ioannidis et al. (2025) show that authors with retracted publications often exhibit high self-citation rates, short academic tenures, and unusually high publication volumes—profiles that closely align with the hyper-prolific authors documented here. These patterns suggest that aggressive publication expansion may strain internal quality control systems, increasing susceptibility to unreliable or unethical publishing practices.

4.5 Citation Networks and Unusual Collaboration Patterns

Citation behavior presents further anomalies. Study group institutions exhibited higher self-citation rates than regional and international control groups. They receive a disproportionate share of citations from peer institutions within the same group or from external universities with limited academic visibility. The presence of dense internal citation loops and a sharp rise in highly cited articles, outpacing overall output growth, suggests the possibility of coordinated citation practices or “citation cartels.” A growing body of evidence supports this interpretation: national science policies tied to performance incentives have been linked to country-level citation anomalies, the rise of coercive or reciprocal citation schemes, and citation-for-sale practices, all of which increasingly blur the line between organic impact and strategic inflation (Baccini & Petrovich, 2023; Chawla, 2024; Ibrahim et al., 2025; Ioannidis & Maniadis, 2024). Collaboration data reinforce this picture. The number of major collaborators surged up to 22-fold within five years, with most new partners lacking global academic standing and mirroring the study group's publication behaviors. Indeed, 80% of the study group’s most frequent external collaborators were unranked globally, suggesting that partnership decisions may be driven by strategic goals influenced by opportunities for metric enhancement rather than substantive academic alignment.

4.6 Historical Precedents and the Fragility of Metric-Driven Growth

Historical cases illustrate the risks associated with metric-centric strategies. In Vietnam, Duy Tan University and Ton Duc Thang University experienced rapid publication growth between 2016 and 2020, leading to their inclusion in the 601-700 band of the Shanghai Ranking by 2021. However, subsequent investigations revealed that some of this growth resulted from controversial authorship arrangements, including secondary affiliations that universities extended to international researchers (Trung, 2020). Following public scrutiny and regulatory intervention (Oransky, 2024), both institutions experienced sharp declines in output, and by 2023, neither remained in the Shanghai Ranking. Similar trajectories are emerging within the study group. For example, Taif

University's output surged from 480 articles in 2018 to 4,673 in 2022, before falling to 2,356 in 2023 and rebounding modestly to 2,807 in 2024. Its Shanghai Ranking placement dropped accordingly, from the 201-300 band in 2023 to 401-500 in 2024. These patterns suggest a broader arc: rapid ascension through aggressive metric accumulation, followed by correction or collapse once incentive structures shift or public scrutiny intensifies. These cases underscore the fragility and unsustainability of bibliometric gains achieved through aggressive optimization strategies. Institutions that prioritize rapid output inflation without building parallel infrastructure risk long-term reputational harm and scholarly stagnation. Short-term gains are vulnerable to collapse under minimal scrutiny or policy changes, revealing the limits of performance systems that reward metrics without context.

4.7 The Role of Ranking Systems in Shaping Institutional Behavior

Global university ranking systems play a pivotal role in shaping institutional priorities, yet they continue to reward volume- and citation-based indicators with limited regard for how those metrics are generated. As Teixeira da Silva (2024) argues, these systems often lack safeguards against manipulation and rarely impose meaningful sanctions, even when irregularities are documented. For example, regarding mutual voting syndicates among 21 universities across seven Arab countries, Times Higher Education responded by neutralizing the votes but retained all institutions in its rankings that year (Watkins, 2024), signaling a tolerance for superficial compliance rather than substantive accountability.

4.8 Conclusion

While some of the patterns observed in this study may reflect legitimate institutional growth or responses to national policy incentives, the breadth, intensity, and co-occurrence of bibliometric anomalies among the study group suggest more deliberate forms of metric optimization. Rapid increases in publication volume are not inherently problematic; however, when accompanied by steep declines in lead authorship, the proliferation of HPAs, sustained engagement with delisted journals, abnormal citation patterns, and rising retraction rates, the plausibility of organic or policy-driven explanations diminishes considerably. These behaviors are not isolated. They diverge markedly from the trajectories of comparator institutions and cut across multiple indicators and data sources. Although this study does not presume misconduct or intent, the patterns reveal a deeper structural issue: performance metrics have become targets. As a result, global ranking systems risk rewarding visibility over value and quantity over quality, inadvertently incentivizing practices that distort the scholarly record and undermine the credibility of academic evaluation.

5. Implications and Recommendations

The findings of this study expose a systemic misalignment between the metrics rewarded by global university rankings and the foundational values of academia. Evaluation systems centered on publication volume, citation counts, and international

collaborations have created perverse incentives that prioritize visibility over verifiable substance, leading to a dangerous dissociation of research quantity from quality.

Among the clearest indicators of this distortion are the erosion of first and corresponding authorship roles, the normalization of hyper-prolific authorship, inflated citation and collaboration networks, and continued engagement with journals delisted for ethical or editorial lapses. These patterns collectively undermine academic attribution, mentorship cultures, research integrity, and the reliability of bibliometric indicators (Moher et al., 2020). Institutions that pursue short-term gains by maximizing output, without parallel investments in infrastructure, training, and governance, risk reputational correction and long-term stagnation when scrutiny intensifies. To address these challenges, coordinated action is needed across the academic ecosystem.

Universities and institutional leadership should recommit to scholarly values by rejecting metric-driven strategies that prioritize output over integrity and reinforcing ethical authorship norms aligned with ICMJE and COPE guidelines. They should also implement internal monitoring systems to track retraction rates, self-citation patterns, and publication venues. They should conduct audits to distinguish meaningful collaborations from symbolic multi-affiliations and invest in long-term research capacity.

Ranking systems should incorporate integrity-sensitive indicators (e.g., normalized retraction rates and shares of output in delisted journals) and implement red-flag detection systems (e.g., abrupt HPA surges, reciprocal citation patterns, or excessive use of delisted journals) to identify sudden bibliometric surges, anomalous citation patterns, or hyper-concentrated authorship networks. Where appropriate, annotate or temporarily suspend institutions under formal review to deter gaming behaviors. Promote transparency in data sources, weightings, and methods to build trust and accountability.

Governments and funding agencies should reconsider how performance metrics are embedded in national research evaluation frameworks. While initiatives like Saudi Arabia's Vision 2030 and India's NIRF aim to boost research competitiveness, they may unintentionally incentivize superficial growth strategies that prioritize volume over quality (see Alhuthali & Sayed, 2022; Singh & Rao, 2024). To counter this, eligibility for public funding should emphasize transparency, reproducibility, and societal relevance, rather than output alone. National frameworks should integrate integrity-sensitive indicators, including responsible authorship, meaningful collaboration, and responsiveness to retractions. Institutions that display recurring patterns of metric manipulation should face reduced funding access, while those investing in mentorship, interdisciplinary research, and capacity building should be rewarded accordingly.

Publishers and bibliometric platforms should strengthen editorial oversight and adopt automated integrity checks, including ORCID-linked author verification and algorithmic alerts for excessive productivity or citation anomalies (Catanzaro, 2024). They should ensure transparent reporting of editorial practices, peer review processes, and citation

behaviors, and improve tracking and flagging of publications from delisted or questionable journals across indexing databases.

Accreditation bodies should expand quality assurance frameworks to include formal research integrity audits and assess institutions' reliance on delisted journals, prevalence of multi-affiliations, and response to retractions. Where systemic anomalies are detected, these bodies should impose closer scrutiny and consider eligibility restrictions for accreditation or public funding.

Faculty members and researchers should uphold authorship integrity, mentor early-career scholars, and reject questionable publication venues. They should model responsible research practices that emphasize quality over quantity and serve as institutional anchors for scholarly authenticity in increasingly metric-driven environments.

These reforms can help reorient global academic systems from metric manipulation toward meaningful, verifiable, and ethically grounded scholarship. The integrity of the scholarly record, the credibility of academic evaluation, and the future of higher education depend on it.

6. Limitations and Directions for Future Research

This study has several limitations that should be considered when interpreting its findings. First, as a descriptive analysis, the study documents observable patterns in research output, authorship, citation, and collaboration, but does not apply inferential statistics or multivariate modeling. As such, it does not claim causal inference or generalizability beyond the institutions examined. Second, while bibliometric indicators can help identify anomalies, they do not constitute direct evidence of misconduct. These patterns should be treated as signals warranting further scrutiny rather than definitive proof of unethical behavior. Third, the study's use of a 40-article threshold to define hyper-prolific authorship may be appropriate for STEM fields but could underrepresent legitimate high productivity in disciplines with different publication norms, such as the humanities and social sciences. Fourth, articles published in delisted journals were classified based on their current indexing status. This may not fully capture the evolving nature of journal quality or editorial practices, especially since Scopus and Web of Science delist dozens of journals annually. Fifth, retraction data are inherently time-lagged. Many retractions occur years after publication, and recent papers may not yet have been withdrawn or corrected, potentially leading to underestimating actual retraction rates.

Despite these limitations, the study offers a robust and multi-dimensional framework for detecting emerging risks in academic evaluation. Building on this foundation, future research can extend and deepen these insights in several ways.

Longitudinal studies should assess the sustainability of ranking gains achieved through metric-intensive strategies, examining whether such gains persist or decline under

continued scrutiny. Qualitative investigations—including interviews with scholars, editors, and policymakers—can help unpack the motivations, incentives, and institutional pressures driving questionable practices.

Further methodological innovations are also needed. Future work should refine and validate integrity-sensitive bibliometric indicators such as authorship leadership rates, normalized retraction indices, and affiliation-weighted collaboration metrics. Citation and collaboration network analyses can be advanced to detect tightly linked ecosystems and reciprocal citation structures, which may signal strategic behavior. Lastly, comparative policy studies across national research funding regimes can show how different incentive structures influence institutional reliance on performance metrics and bibliometric optimization strategies.

These directions can help build a more nuanced and integrity-focused approach to research evaluation, prioritizing quality and transparency over volume and visibility.

References

Abalkina, A. (2023). Publication and collaboration anomalies in academic papers originating from a paper mill: Evidence from a Russia-based paper mill. Learned Publishing, 36(4), 689-702. https://doi.org/10.1002/leap.1574

Abalkina, A., Aquarius, R., Bik, E., Bimler, D., Bishop, D., Byrne, J., Cabanac, G., Day, A., Labbé, C., & Wise, N. (2025). 'Stamp out paper mills' — science sleuths on how to fight fake research. *Nature*, *637*(8048), 1047-1050. https://doi.org/10.1038/d41586-025-00212-1

Ahlers, A. L., & Christmann-Budian, S. (2023). The politics of university rankings in China. *Higher Education*, *86*(4), 751-770. https://doi.org/10.1007/s10734-023-01014-y

Alhuthali, S., & Sayed, A. A. (2022). Saudi Universities rapid escalation in academic ranking systems: Implications and challenges. *Controversial Ideas*, *2*(1), 8. https://doi.org/10.35995/jci02010008

Baas, J., Schotten, M., Plume, A., Côté, G., & Karimi, R. (2020). Scopus as a curated, high-quality bibliometric data source for academic research in quantitative science studies. *Quantitative Science Studies*, *1*(1), 377-386. https://doi.org/10.1162/qss_a_00019

Baccini, A., & Petrovich, E. (2023). A global exploratory comparison of country self-citations 1996-2019. *PLoS ONE*, *18*(12 December), Article e0294669. https://doi.org/10.1371/journal.pone.0294669

Bhattacharjee, Y. (2011). Saudi universities offer cash in exchange for academic prestige. *Science*, *334*(6061), 1344-1345. https://doi.org/10.1126/science.334.6061.1344

Biagioli, M., Kenney, M., Martin, B. R., & Walsh, J. P. (2019). Academic misconduct, misrepresentation and gaming: A reassessment. *Research Policy*, *48*(2), 401-413. https://doi.org/10.1016/j.respol.2018.10.025

Birkle, C., Pendlebury, D. A., Schnell, J., & Adams, J. (2020). Web of Science as a data source for research on scientific and scholarly activity. *Quantitative Science Studies*, *1*(1), 363-376. https://doi.org/10.1162/qss_a_00018.

Catanzaro, M. (2024). Citation manipulation found to be rife in math. *Science*, *383*(6682), 470. https://doi.org/10.1126/science.ado3859

Chawla, D. S. (2024). Self-citations in around a dozen countries are unusually high. *Nature*. https://doi.org/10.1038/d41586-024-00090-z

Chinchilla-Rodríguez, Z., Costas, R., Robinson-García, N., & Larivière, V. (2024). Examining the quality of the corresponding authorship field in Web of Science and Scopus. *Quantitative Science Studies*, *5*(1), 76-97. https://doi.org/10.1162/qss_a_00288

Chirico, F., & Bramstedt, K. A. (2023). Authorship commerce: Bylines for sale. Accountability in Research, 30(4), 246-251. https://doi.org/10.1080/08989621.2021.1982705

Conroy, G. (2024). Surge in number of 'extremely productive' authors concerns scientists. *Nature*, *625*(7993), 14-15. https://doi.org/10.1038/d41586-023-03865-y

Cortegiani, A., Ippolito, M., Ingoglia, G., Manca, A., Cugusi, L., Severin, A., Strinzel, M., Panzarella, V., Campisi, G., Manoj, L., Gregoretti, C., Einav, S., Moher, D., & Giarratano, A. (2020). Citations and metrics of journals discontinued from Scopus for publication concerns: The GhoS(t)copus Project. *F1000Research*, *9*, Article 415. https://doi.org/10.12688/f1000research.23847.2

Dezhina, I. (2022). The publication race in Russian universities as an impediment to academic freedom. *Demokratizatsiya*, *30*(1), 135-157.

Fang, F. C., Steen, R. G., & Casadevall, A. (2012). Misconduct accounts for the majority of retracted scientific publications. *Proceedings of the National Academy of Sciences of the United States of America*, *109*(42), 17028-17033. https://doi.org/10.1073/pnas.1212247109

Fire, M., & Guestrin, C. (2019). Over-optimization of academic publishing metrics: Observing Goodhart's Law in action. *GigaScience*, *8*(6), Article giz053. https://doi.org/10.1093/gigascience/giz053

Gedik, M. S., Kaya, E., & Kilci, A. İ. (2024). Evaluation of retracted articles in the field of emergency medicine on the web of science database. *American Journal of Emergency Medicine*, *82*, 68-74. https://doi.org/10.1016/j.ajem.2024.05.016

Gök, A., & Karaulova, M. (2024). How “international” is international research collaboration? *Journal of the Association for Information Science and Technology*, *75*(2), 97-114. https://doi.org/10.1002/asi.24842

Gruber, T. (2014). Academic sell-out: how an obsession with metrics and rankings is damaging academia. *Journal of Marketing for Higher Education*, *24*(2), 165-177. https://doi.org/10.1080/08841241.2014.970248

Halevi, G., Rogers, G., Guerrero-Bote, V. P., & De-Moya-Anegón, F. (2023). Multiaffiliation: a growing problem of scientific integrity. *Profesional de la Informacion*, *32*(4), Article e320401. https://doi.org/10.3145/epi.2023.jul.01

Hazelkorn, E., & Mihut, G. (2021). *Research Handbook on University Rankings: Theory, Methodology, Influence and Impact*. Edward Elgar Publishing Ltd. https://doi.org/10.4337/9781788974981

Hladchenko, M. (2025). Ukrainian universities in QS World University Rankings: when the means become ends. *Scientometrics*, *130*(2), 969-997, Article e13636. https://doi.org/10.1007/s11192-024-05165-2

Hottenrott, H., Rose, M. E., & Lawson, C. (2021). The rise of multiple institutional affiliations in academia. *Journal of the Association for Information Science and Technology*, *72*(8), 1039-1058. https://doi.org/10.1002/asi.24472

Ibrahim, H., Liu, F., Zaki, Y., & Rahwan, T. (2025). Citation manipulation through citation mills and pre-print servers. *Scientific Reports*, *15*(1), Article 5480. https://doi.org/10.1038/s41598-025-88709-7

Ioannidis, J. P. A., & Maniadis, Z. (2024). Quantitative research assessment: using metrics against gamed metrics. *Internal and Emergency Medicine*, *19*(1), 39-47. https://doi.org/10.1007/s11739-023-03447-w

Ioannidis, J. P. A., Collins, T. A., & Baas, J. (2024). Evolving patterns of extreme publishing behavior across science. *Scientometrics*, *129*(9), 5783-5796. https://doi.org/10.1007/s11192-024-05117-w

Ioannidis, J. P. A., Klavans, R., & Boyack, K. W. (2018). Thousands of scientists publish a paper every five days. *Nature*, *561*(7722), 167-169. https://doi.org/10.1038/d41586-018-06185-8

Ioannidis, J. P. A., Pezzullo, A. M., Cristiano, A., Boccia, S., & Baas, J. (2025). Linking citation and retraction data reveals the demographics of scientific retractions among highly cited authors. *PLoS Biology*, *23*(1), Article e3002999. https://doi.org/10.1371/journal.pbio.3002999

Ioannidis, J. P. A., Salholz-Hillel, M., Boyack, K. W., & Baas, J. (2021). The rapid, massive growth of COVID-19 authors in the scientific literature. *Royal Society Open Science*, *8*(9), Article 210389. https://doi.org/10.1098/rsos.210389

Kharasch, E. D., Avram, M. J., Bateman, B. T., Clark, J. D., Culley, D. J., Davidson, A. J., Houle, T. T., Jiang, Y., Levy, J. H., London, M. J., Sleigh, J. W., & Vutskits, L. (2021). Authorship and Publication Matters: Credit and Credibility. *Anesthesiology*, *135*(1), 1-8. https://doi.org/10.1097/ALN.0000000000003830

Kochetkov, D. (2024). University rankings in the context of research evaluation: A state-of-the-art review. *Quantitative Science Studies*, *5*(3), 533-555. https://doi.org/10.1162/qss_a_00317

Kuan, C. H., Chen, D. Z., & Huang, M. H. (2024). Dubious cross-national affiliations obscure the assessment of international research collaboration. Journal of Informetrics, 18(2), Article 101496. https://doi.org/10.1016/j.joi.2024.101496

Li, W., Aste, T., Caccioli, F., & Livan, G. (2019). Reciprocity and impact in academic careers. *EPJ Data Science*, *8*(1), Article 20. https://doi.org/10.1140/epjds/s13688-019-0199-3

Lin, C. S., Huang, M. H., & Chen, D. Z. (2025). The inter-institutional and intra-institutional multi-affiliation authorships in the scientific papers produced by the well-ranked universities. *Journal of Informetrics*, *19*(1), Article 101635. https://doi.org/10.1016/j.joi.2024.101635

Maisonneuve, H. (2025). Predatory journals and paper mills jeopardise knowledge management. *Bulletin du Cancer*, *112*(1), 100-110. https://doi.org/10.1016/j.bulcan.2024.12.002

Meho, L. I., & Akl, E. A. (2025). Using bibliometrics to detect questionable authorship and affiliation practices and their impact on global research metrics: A case study of 14 universities. *Quantitative Science Studies*, *6*, 63-98. https://doi.org/10.1162/qss_a_00339

Moher, D., Bouter, L., Kleinert, S., Glasziou, P., Sham, M. H., Barbour, V., Coriat, A. M., Foeger, N., & Dirnagl, U. (2020). The Hong Kong principles for assessing researchers: Fostering research integrity. *PLoS Biology*, *18*(7), Article 3000737. https://doi.org/10.1371/journal.pbio.3000737

Moosa, I. A. (2024). *Publish or perish: Perceived benefits versus unintended consequences*. Edward Elgar Publishing Ltd. https://doi.org/10.4337/9781035307807

Moreira, E., Meira, W., Gonçalves, M. A., & Laender, A. H. F. (2023). The rise of hyperprolific authors in computer science: characterization and implications. *Scientometrics*, *128*(5), 2945-2974. https://doi.org/10.1007/s11192-023-04676-8

Morreim, E. H., & Winer, J. C. (2023). Guest authorship as research misconduct: definitions and possible solutions. *BMJ Evidence-Based Medicine*, *28*(1), 1-4. https://doi.org/10.1136/bmjebm-2021-111826

Olive, R., Townsend, S., & Phillips, M. G. (2023). 'Not everything that can be counted counts, and not everything that counts can be counted': Searching for the value of metrics and altmetrics in sociology of sport journals. *International Review for the Sociology of Sport*, *58*(3), 431-454. https://doi.org/10.1177/10126902221107467

Oransky, I. (2024). Meet the founder of a 100,000-strong Facebook group driving change in scientific integrity in Vietnam. *Retraction Watch*. https://retractionwatch.com/2024/10/31/meet-the-founder-of-a-100000-strong-facebook-group-driving-change-in-scientific-integrity-in-vietnam/. Accessed April 26, 2025.

Oravec, J. A. (2017). The manipulation of scholarly rating and measurement systems: constructing excellence in an era of academic stardom. *Teaching in Higher Education*, *22*(4), 423-436. https://doi.org/10.1080/13562517.2017.1301909

Pachter, L. (2014). To some a citation is worth $3 per year. https://liorpachter.wordpress.com/2014/10/31/to-some-a-citation-is-worth-3-per-year/ (accessed April 24, 2024).

Pranckutė, R. (2021). Web of Science (WoS) and Scopus: the titans of bibliographic information in today's academic world. *Publications*, *9*(1), Article 12. https://doi.org/10.3390/publications9010012

Pruschak, G., & Hopp, C. (2022). And the credit goes to ... - Ghost and honorary authorship among social scientists. *PLoS ONE*, *17*(5), 22, Article e0267312. https://doi.org/10.1371/journal.pone.0267312

Raynaud, M., Goutaudier, V., Louis, K., Al-Awadhi, S., Dubourg, Q., Truchot, A., Brousse, R., Saleh, N., Giarraputo, A., Debiais, C., Demir, Z., Certain, A., Tacafred, F., Cortes-Garcia, E., Yanes, S., Dagobert, J., Naser, S., Robin, B., Bailly, É.,…Loupy, A. (2021). Impact of the COVID-19 pandemic on publication dynamics and non-COVID-19 research production. *BMC Medical Research Methodology*, *21*(1), Article 255. https://doi.org/10.1186/s12874-021-01404-9

Reymert, I. (2021). Bibliometrics in Academic Recruitment: A Screening Tool Rather than a Game Changer. *Minerva*, *59*(1), 53-78. https://doi.org/10.1007/s11024-020-09419-0

Rhein, D., & Nanni, A. (2023). The impact of global university rankings on universities in Thailand: don't hate the player, hate the game. *Globalisation, Societies and Education*, *21*(1), 55-65. https://doi.org/10.1080/14767724.2021.2016375

Sheeja, N.K, Mathew K.S., & Cherukodan, S. (2018). Impact of scholarly output on university ranking. *Global Knowledge, Memory and Communication*, *67*(3), 154-165. https://doi.org/10.1108/GKMC-11-2017-0087

Shen, W., Zha, Q., & Liu, C. (2023). From rejection to acceptance: the institutionalization of adopting university ranking outcomes as policy and strategic tools in China since the 1980s. *Policy Reviews in Higher Education*, *7*(2), 229-248. https://doi.org/10.1080/23322969.2023.2209655

Silva, J., Aparício, D., Ribeiro, P., & Silva, F. (2020). FOCAS: Penalising friendly citations to improve author ranking. Proceedings of the ACM Symposium on Applied Computing,

Singh, A., & Rao, V. R. (2024). Unpacking inconsistencies in the NIRF rankings. *Current Science*, *126*(11), 1321-1324. https://doi.org/10.18520/cs/v126/i11/1321-1324

Teixeira da Silva, J. A. (2024). How are global university rankings adjusted for erroneous science, fraud and misconduct? Posterior reduction or adjustment in rankings in response to retractions and invalidation of scientific findings. *Journal of Information Science*. https://doi.org/10.1177/01655515241269499

Teixeira da Silva, J. A., & Dobránszki, J. (2016). Multiple Authorship in Scientific Manuscripts: Ethical Challenges, Ghost and Guest/Gift Authorship, and the Cultural/Disciplinary Perspective. *Science and Engineering Ethics*, *22*(5), 1457-1472. https://doi.org/10.1007/s11948-015-9716-3

Trung, N.V. (August 24, 2020). Thành tích ảo trong nghiên cứu khoa học: Dán nhãn mác giả trong công bố khoa học. thanhnien.vn. Retrieved April 24, 2024. https://thanhnien.vn/thanh-tich-ao-trong-nghien-cuu-khoa-hoc-185987431.htm. See also: https://en.wikipedia.org/wiki/Duy_Tan_University

Vasconez-Gonzalez, J., Izquierdo-Condoy, J. S., Naranjo-Lara, P., Garcia-Bereguiain, M. Á., & Ortiz-Prado, E. (2024). Integrity at stake: confronting "publish or perish" in the developing world and emerging economies. *Frontiers in Medicine*, *11*, Article 1405424. https://doi.org/10.3389/fmed.2024.1405424

Watkins, David (2024). Reputation voting behaviour in the Arab University Rankings. https://www.timeshighereducation.com/world-university-rankings/reputation-voting-behaviour-arab-university-rankings (accessed April 26, 2025).

Xie, Y., Wang, K., & Kong, Y. (2021). Prevalence of Research Misconduct and Questionable Research Practices: A Systematic Review and Meta-Analysis. *Science and Engineering Ethics*, *27*(4), 41. https://doi.org/10.1007/s11948-021-00314-9

Zammarchi, G., Carta, A., Columbu, S., Frigau, L., & Musio, M. (2024). A scientometric analysis of the effect of COVID-19 on the spread of research outputs. *Quality and Quantity*, *58*(3), 2265-2287. https://doi.org/10.1007/s11135-023-01742-4

Funding: None

Competing interests: The author declares that he is affiliated with a university that is a peer institution to one of the universities included in the study group.

Data and materials availability: All data are in the text, tables, and charts.

APPENDIX I: Additional Universities Meeting Selection Criteria (Top 1001-1500 Analysis)

Name	Country	Articled in delisted journals, 2018-2019	Articled in delisted journals, 2023-2024	Retractions rate per 1,000 articles, 2018-2019	Retractions rate per 1,000 articles, 2022	Retraction rate per 1,000 articles, 2023-2024	Top 2% most cited articles, 2018-2019 (%)	Top 2% most cited articles, 2023-2024 (%)	Articles, 2018-2019	Articles, 2023-2024	Research growth from 2018-2019 to 2023-2024 (%)	First authorship rate, 2023-2024 (%)	Change in 1st authorship rate from 2018-19 to 2023-24	Corresponding authorship rate, 2023-2024 (%)	Change in corresponding authorship rate from 2018-19 to 2023-24	Hyper-prolific authors, 2023-2024
DIU	Bangladesh	121 (46%)	149 (9%)	8	30	5	2.3%	7.6%	263	1,649	527%	24	-47%	29	-12%	5
FUE	Egypt	11 (5%)	78 (4%)	9	21	8	0.4%	9.1%	235	1,953	731%	13	-73%	25	-32%	6
GEU	India	28 (16%)	169 (7%)	0	80	5	4.7%	8.4%	171	2,521	1374%	24	-58%	41	-22%	6
UU	India	41 (36%)	94 (6%)	9	129	5	0.9%	9.5%	113	1,707	1411%	13	-80%	17	-74%	6
MUS	Iraq	77 (59%)	157 (6%)	0	40	15	0.8%	7.2%	130	2,428	1768%	11	-72%	16	-59%	7
AAU	Jordan	51 (27%)	168 (10%)	0	2	2	0.5%	7.8%	188	1,691	799%	24	-67%	33	-53%	3
ASU	Jordan	40 (17%)	246 (10%)	0	5	6	0.4%	6.2%	243	2,378	879%	27	-53%	17	-60%	5
MEU	Jordan	31 (29%)	259 (14%)	0	0	5	0.9%	8.3%	108	1,795	1562%	26	-48%	27	-43%	4
INTI	Malaysia	46 (35%)	179 (11%)	0	0	1	0.8%	3.8%	133	1,624	1121%	25	-44%	35	-6%	8
SU	Malaysia	39 (5%)	120 (5%)	0	1	2	5.4%	11.9%	735	2,426	230%	22	-38%	36	-27%	10
UMT	Pakistan	23 (4%)	99 (5%)	2	25	2	2.7%	9.8%	554	1,807	226%	47	-4%	39	-17%	2
NBU	Saudi Arabia	45 (13%)	209 (10%)	3	18	3	0.3%	5.0%	356	1,993	460%	36	-52%	39	-41%	2
YZU	Taiwan	24 (3%)	50 (3%)	1	0	2	1.1%	8.5%	731	1,820	149%	21	-59%	39	-32%	7
IU	Turkey	9 (3%)	53 (3%)	0	7	2	0.4%	5.5%	269	1,907	609%	23	-35%	35	4%	6
AU	United Arab Emirates	43 (20%)	150 (7%)	0	28	5	0.5%	5.5%	216	2,223	929%	22	-50%	36	-25%	11

Acronyms listed in the order they appear in the Table: DIU=Daffodil International University, FUE=Future University in Egypt, GEU=Graphic Era University, UU=Uttaranchal University, MUS=Al-Mustaqbal University College, AAU=Al Ahliyya Amman University, ASU=Applied Science Private University, MEU=Middle East University, Jordan, INTI=INTI International University, SU=Sunway University, UMT=University of Management and Technology, NBU=Northern Borders University, YZU=Yuan Ze University, IU=Istinye University, AU=Ajman University. **Data Source:** SciVal (May 1, 2025). All except Saudi Arabia's NBU are private universities. None had HPAs in 2018-2019 except Malaysia's SU, which had one.

APPENDIX II: DETAILED MATERIALS AND METHODS

2.1. Study Group Selection and Rationale

This study employed a structured, multi-stage approach to identify universities exhibiting significant anomalies in research output and authorship between 2018-2019 and 2023-2024. These timeframes were selected to capture recent shifts in research dynamics while mitigating distortions caused by the uneven impact of the COVID-19 pandemic on global research activity (Ioannidis et al., 2021; Raynaud et al., 2021; Zammarchi et al., 2024). Analyzing two-year intervals allowed for the identification of sustained trends rather than short-term fluctuations.

In alignment with established bibliometric studies and research evaluation frameworks (e.g., Clarivate's Highly Cited Researchers List, Leiden Ranking, Nature index, and Stanford-Elsevier Global Ranking of Scientists), the analysis focuses exclusively on journal articles and reviews (collectively referred to as "articles"). Additionally, to prevent distortions associated with large-scale collaborations in fields such as particle physics and genomics, articles with more than 100 co-authors were excluded.

The initial dataset comprised the 1,000 most-published universities worldwide in 2023-2024, as identified using SciVal on May 1, 2025. These institutions were selected because of their substantial research output and potential impact on regional and global university rankings. From this group, we applied a stringent selection threshold, narrowing the list to 97 universities that demonstrated a publication growth rate exceeding 140% between 2018-2019 and 2023-2024, more than five times the global average increase of 28%. The goal was to ensure the analysis focused solely on extreme outliers rather than variations associated with typical growth trajectories.

Next, we analyzed authorship trends, focusing on first and corresponding authorship rates, which serve as key indicators of intellectual contribution and leadership. While first authors are typically responsible for conducting and drafting the research, corresponding authors often serve as senior authors, overseeing the study and taking primary responsibility for its submission, revisions, and scientific integrity, regardless of their position in the byline (Chinchilla-Rodríguez et al., 2024; Kharasch et al., 2021). At the institutional level, a sharp decline in these authorship roles over a short period may signal shifts in contribution dynamics, including changes in how research leadership is distributed, attributed, or reported.

To identify universities undergoing pronounced changes in research leadership patterns, we applied additional selection criteria from the group of 97 universities: a decline of more than 35% in the share of articles with first authorship by affiliated researchers, and a decline of more than 15% in corresponding authorship rates, both between 2018-2019 and 2023-2024. These thresholds were chosen because they represent declines more than five times the global averages of 7% and 3%, respectively, capturing institutions experiencing substantial shifts in research leadership, rather than normal fluctuations. Globally, the first authorship rate among academic

institutions declined from 55% to 51%, and the corresponding authorship rate from slightly less than 54% to 52%.

Applying these selection criteria via SciVal, we identified 16 universities with exceptional research output growth and significant declines in first or corresponding authorship rates. To enhance the robustness of the analysis and account for institutions indexed differently in SciVal, we replicated the selection process using InCites and identified two additional universities—KL University and Najran University—that met the same criteria: over 140% publication growth, a decline in first authorship rate of more than 35%, and a decline in corresponding authorship rate of more than 15%.

Although using two different bibliometric platforms introduces a degree of data source heterogeneity, SciVal and InCites draw from overlapping publication databases (Scopus and Web of Science, respectively) and offer comparable bibliometric indicators. Including these two institutions ensured broader regional representation and enhanced the generalizability of findings. Their bibliometric patterns were consistent with the rest of the study group, and this dual-source strategy reduced limitations associated with reliance on a single data platform, thereby strengthening the robustness of the study design.

Referred to hereafter as the study group, these 18 universities represent a diverse set of institutions across multiple countries, highlighting the global nature of challenges associated with bibliometric-based evaluation. Ten are public universities in Saudi Arabia and the United Arab Emirates, while the remaining eight are private universities in India and Lebanon. Institutional characteristics varied widely, with histories ranging from 15 to 25 years (11 institutions), 26 to 50 years (four institutions), to over five decades (three institutions), and faculty sizes ranging from fewer than 1,000 academic staff members (five institutions) to 1,001-2,000 (six institutions) and over 2,000 (seven institutions). Thirteen universities have medical colleges.

Finally, it should be noted that expanding the analysis to include the 1,500 most-publishing universities, instead of only the top 1,000, would have identified 15 additional institutions that met the same selection criteria. Detailed bibliometric data for these institutions are presented in Appendix I.

2.2. Control Groups Selection and Rationale

To provide a robust analytical framework, the study adopted a multi-tiered comparative design incorporating national, regional, and international control groups. This methodology contextualized the research growth and authorship patterns observed in the study group against broader academic trends.

National Benchmark: Each study group university was compared to its national research environment using aggregated publication and citation data from India, Lebanon, Saudi Arabia, and the United Arab Emirates. This level of comparison was

designed to assess whether observed patterns were reflective of national-level shifts or specific to individual institutions within the study group.

Regional Benchmark: Four universities, one from each country represented among the study group, were selected as regional controls based on their consistent high placement across major global rankings—e.g., QS World University Rankings, Academic Ranking of World Universities (ARWU), Times Higher Education World University Rankings (THE). The selected institutions included the Indian Institute of Science, Bangalore (India); the American University of Beirut (Lebanon); Khalifa University (United Arab Emirates); and King Abdullah University of Science and Technology (Saudi Arabia). These institutions served as regionally prominent examples of stable, research-intensive universities.

International Benchmark: Universities were selected by systematically reviewing the 2023-2024 Shanghai Ranking in descending order until four institutions were identified that aligned with the study group's research composition. The final sample included the Massachusetts Institute of Technology (MIT), Princeton University, ETH Zurich, and the University of California, Berkeley (UC Berkeley), each recognized for excellence in scientific output, global reputation, and consistency in research performance. The number of international comparators was limited to four to ensure methodological symmetry with the regional benchmark group.

Certain institutions were excluded based on disciplinary disproportionality. For instance, the California Institute of Technology was excluded due to the overwhelming concentration of its publications in physics, astronomy, and earth sciences (comprising over 67% of total output). Similarly, universities such as Harvard, Oxford, and Stanford were excluded because more than 50% of their research output was in medicine, a level of concentration not observed in the study, regional, or international comparator groups, where medical research accounted for approximately 15% of total output. This discipline-based matching strategy was implemented to enhance the interpretability and relevance of comparative analyses.

2.3. Bibliometric Analysis

This study employed a comprehensive bibliometric analysis to assess whether the extraordinary advances in research performance among study group universities reflect genuine academic expansion or system-level incentives that may influence authorship and publication behavior. The selection of the bibliometric indicators was guided by two primary objectives: (1) detecting anomalies suggestive of shifts in authorship attribution practices and (2) evaluating the impact of these trends on institutional research performance. These indicators include:

Overall Research Output: The total number of articles published (per SciVal), measuring an institution's research productivity.

Subject-Specific Research Output: The distribution of publications across disciplines (per Essential Science Indicators), assessing whether research growth is broad-based or concentrated in specific fields.

First and Corresponding Authorship Rates: The proportion of publications where institutional researchers are listed as first or corresponding authors (per InCites), reflecting the university's research leadership.

Hyper-Prolific Authorship: The number of authors publishing an exceptionally large number of articles in a calendar year. The phenomenon has increasingly drawn scrutiny due to its potential implications for research integrity and authorship ethics. Ioannidis et al. (2018) initially defined hyper-prolific authors (HPAs) as those producing 72 or more publications in a calendar year, including articles, conference papers, substantive comments, and reviews. They found that 70% of such authors acknowledged not meeting the International Committee of Medical Journal Editors' criteria in over a quarter of their publications. More recently, Moreira et al. (2023) characterized HPAs as "anomalous," citing unsustainable productivity patterns often linked to concentrated collaborative networks or recurring use of specific publication venues.

This study adopts a threshold of 40 or more articles in a calendar year, balancing the need to detect anomalies while accounting for disciplinary norms and legitimate variation in output across fields. HPAs were identified using the following methods:

1. **Extraction by Country:** retrieving from SciVal the Scopus IDs of all authors in every country worldwide who published over 39 articles in any year between 2018 and 2024.
2. **Extraction by Field and Subfield:** extracting from SciVal the Scopus IDs of the 500 most published authors in any year in each of the 27 SciVal-defined fields and within major subfields of large domains such as engineering and medicine. This was done to account for author mobility and changes in national affiliations.
3. **Extraction by ORCID:** using InCites to identify over 10,000 authors with ORCID IDs who had published at least 40 articles in any year between 2018 and 2024. These ORCID IDs were used to retrieve the corresponding Scopus IDs in SciVal.
4. **List of HPAs from Elsevier.** Upon request, Elsevier provided a list of all authors included in SciVal with 40 or more articles during 2018-2024. Methods 1-3 matched 95% of the data provided by Elsevier.

We then used SciVal to track each author's annual publication output, excluding articles with more than 100 co-authors. In total, 11,323 unique authors met the hyper-prolific threshold in at least one year between 2018 and 2024. These HPAs represent 0.05%, or 1 in every 2,000, of the approximately 24 million authors active during the study period, underscoring the rarity of such extreme productivity. Among these HPAs, 19% reached this status for the first time in their careers in 2023-2024 (based on data from 2004 to 2024).

Publications in Delisted Journals: The number of articles published in journals that Scopus or Web of Science stopped indexing due to significant quality and ethical concerns. This indicator was used to measure reliance on less rigorously vetted publication venues. As of May 1, 2025, these journals included 857 titles delisted by Scopus and 163 by Web of Science. After eliminating overlap, the final count stood at 969 unique delisted journals, 936 of which were found in Scopus, with 1.5 million

articles in the database (627,000 published during the study period**,** 2018-2024). These articles were retrieved and linked to universities globally, including the study and control groups.

Retraction Rates: The share of an institution's publications that were formally retracted due to misconduct, methodological error, or ethical violations. This metric is normalized by total research output to allow cross-institutional comparison. Elevated or rising retraction rates over a short period may indicate vulnerabilities in research oversight, authorship practices, or institutional review processes. To identify retractions, we compiled and loaded to SciVal the DOIs and PubMed IDs of all publications classified as "Retraction" in Retraction Watch, and "Retracted" or "Retracted Publication" in PubMed, Scopus, and Web of Science. In total, 32,420 retracted articles from the study period were matched to SciVal records and then linked to institutions and countries worldwide. Per Web of Science, 93% of retractions are journal articles.

Because retractions often occur years after publication, we extended the analysis to include articles from 2022, alongside 2018-2019 and 2023-2024, to better account for recent institutional behaviors while capturing near-complete retraction data (Fang et al., 2012). As of May 1, 2025, 10,995 articles from 2022 had been retracted, compared to 3,070 from 2023 and 1,762 from 2024, highlighting the importance of including 2022 for a meaningful trend analysis.

Highly Cited Articles: The number of articles ranked among the world's top 2% most cited, used as a proxy for scholarly excellence. Highly cited articles are integral to institutional rankings and reputation systems. While many ranking systems use the top 1% as a benchmark (e.g., Clarivate's Highly Cited Researchers), this study used a 2% threshold to provide a broader and statistically robust evaluation of institutional performance across disciplines.

Collaboration-Based Indicators of Questionable Practices: This indicator assesses whether changes in research output are associated with shifts in institutional collaboration patterns. Major collaborators were defined as external entities accounting for at least 2% of an institution's total publications during a given period. This threshold was chosen to identify sustained and potentially influential partnerships while filtering out incidental or short-term collaborations. Using SciVal, we tracked changes in the number and identity of major collaborators between 2018-2019 and 2023-2024.

To evaluate the academic standing of these collaborators, we cross-referenced them with the Shanghai Ranking, allowing us to explore whether institutional growth was associated with partnerships involving globally ranked institutions or those with less established academic profiles.

2.3.1. Data Sources and Tools

We obtained the bibliometric data for this study from four primary sources: Scopus, Web of Science, SciVal, and InCites. Scopus (Elsevier) and Web of Science (Clarivate) are

among the world's largest multidisciplinary abstract and citation databases, widely used for bibliometric research and institutional assessment. As of May 1, 2025, Scopus indexed approximately 20 million articles and Web of Science approximately 18 million articles published between 2018 and 2024 (Baas et al., 2020; Birkle et al., 2020; Pranckutė, 2021).

SciVal (Elsevier) and InCites (Clarivate) are advanced bibliometric analytics platforms that draw on Scopus and Web of Science, respectively. Both platforms offer a wide range of indicators to assess research productivity, citation impact, collaboration networks, subject area distribution, and authorship roles at the institutional and national levels. These tools were used to extract and analyze the metrics described in Section 2.3, allowing for cross-platform validation and the triangulation of findings.

SUPPLEMENTARY TABLES

Table 1S. Shanghai Ranking of study and control group universities, 2018-2024

	ARWU (Shanghai) world ranking**						
GROUP	2018	2019	2020	2021	2022	2023	2024
STUDY							
CU (India)	NR	NR	NR	NR	NR	NR	NR
Chitkara (India)	NR	NR	NR	NR	NR	NR	NR
GLA (India)	NR	NR	NR	NR	NR	NR	NR
KL (India)	NR	NR	NR	NR	NR	NR	NR
LPU (India)	NR	NR	NR	NR	NR	NR	NR
SIMATS (India)	NR	NR	NR	NR	NR	NR	801-900
UPES (India)	NR	NR	NR	NR	NR	NR	NR
LAU (Lebanon)	NR	NR	NR	NR	NR	NR	501-600
KKU (Saudi Arabia)	NR	NR	NR	801-900	601-700	401-500	401-500
KSU (Saudi Arabia)	151-200	151-200	151-200	101-150	101-150	101-150	90
NU (Saudi Arabia)	NR	NR	NR	NR	NR	NR	NR
PSAU (Saudi Arabia)	NR	NR	NR	NR	801-900	501-600	601-700
PNU (Saudi Arabia)	NR	NR	NR	NR	NR	301-400	301-400
TU (Saudi Arabia)	NR	NR	NR	801-900	401-500	201-300	401-500
UQU (Saudi Arabia)	NR	NR	NR	NR	NR	801-900	701-800
UOH (Saudi Arabia)	NR	NR	NR	NR	NR	NR	NR
UT (Saudi Arabia)	NR	NR	NR	NR	NR	NR	NR
UOS (United Arab Emirates)	NR	NR	NR	NR	NR	901-1000	701-800
REGIONAL							
IISc (India)	401-500	401-500	501-600	401-500	301-400	301-400	401-500
AUB (Lebanon)	601-700	601-700	601-700	701-800	701-800	701-800	801-900
KAUST (Saudi Arabia)	201-300	201-300	201-300	201-300	201-300	201-300	201-300
KU (United Arab Emirates)	NR	NR	NR	NR	801-900	801-900	601-700
INTERNATIONAL							
ETH Zurich	19	19	20	21	20	20	21
MIT	4	4	4	4	3	3	3
Princeton	6	6	6	6	6	6	7
UC Berkeley	5	5	5	5	5	5	5

Table 2S. Changes in research output (count and top-100 world ranking) by subject category

Name	# of articles, 2018-2019	# of articles, 2023-2024	World ranking in # of articles, 2018-2019	World ranking in # of articles, 2023-2024
Agricultural Sciences (n=1)				
Study Group				
King Saud University	327	1,316	**82**	**9**
International Group				
None ranked among the world's 100 most published				
Biology & Biochemistry (n=1)				
Study Group				
King Saud University	627	1,226	**69**	**8**
International Group				
Massachusetts Institute of Technology	968	973	**21**	**23**
University of California, Berkeley	760	686	**40**	**54**
ETH Zurich	665	584	**60**	**86**
Chemistry (n=4)				
Study Group				
King Saud University	1,104	5,333	**66**	**2**
King Khalid University	313	1,993	**552**	**33**
Saveetha Institute of Medical and Technical Sciences	19	1,340	**2001-3000**	**63**
Princess Nourah Bint Abdulrahman University	114	1,286	**1001-1500**	**68**
International Group				
ETH Zurich	1,366	1,118	**43**	**84**
Massachusetts Institute of Technology	1,263	939	**51**	**Dropped out**
University of California, Berkeley	1,140	909	**63**	**Dropped out**
Computer Science (n=4)				
Study Group				
King Saud University	375	749	**57**	**45**
Lebanese American University	37	613	**1001-1500**	**59**
Princess Nourah Bint Abdulrahman University	22	505	**1501-2000**	**73**
Prince Sattam Bin Abdulaziz University	32	473	**1001-1500**	**87**
International Group				
Massachusetts Institute of Technology	472	482	**41**	**82**
ETH Zurich	362	447	**62**	**91**
University of California, Berkeley	291	244	**99**	**Dropped out**
Economics & Business (n=1)				
Study Group				
Lebanese American University	47	518	**734**	**19**
International Group				
Massachusetts Institute of Technology	421	421	**11**	**39**
University of California, Berkeley	388	397	**22**	**48**
ETH Zurich	289	247	**55**	**Dropped out**
Engineering (n=3)				
Study Group				
King Saud University	794	3,453	**145**	**31**
King Khalid University	242	2,293	**602**	**54**
Prince Sattam Bin Abdulaziz University	148	1,667	**910**	**82**
International Group				
ETH Zurich	1,248	1,465	**75**	**Dropped out**
Massachusetts Institute of Technology	1,604	1,245	**43**	**Dropped out**
University of California, Berkeley	1,132	857	**86**	**Dropped out**
Environment/Ecology (n=2)				

Study Group				
King Saud University	313	1,888	**208**	**3**
Saveetha Institute of Medical and Technical Sciences	7	659	**3001-4000**	**70**
International Group				
ETH Zurich	914	836	**19**	**40**
University of California, Berkeley	865	776	**21**	**49**
Geosciences (n=0)				
Study Group				
None ranked among the world's 100 most published				
International Group				
ETH Zurich	1,353	1,433	**10**	**12**
Massachusetts Institute of Technology	628	567	**53**	**75**
University of California, Berkeley	655	504	**49**	**97**
Princeton University	527	501	**82**	**99**
Immunology (n=0)				
Study Group				
None ranked among the world's 100 most published				
International Group				
Massachusetts Institute of Technology	277	348	**85**	**79**
Materials Science (n=3)				
Study Group				
King Saud University	651	2,676	**116**	**23**
King Khalid University	288	1,345	**344**	**65**
Saveetha Institute of Medical and Technical Sciences	27	1,159	**2001-3000**	**80**
International Group				
Massachusetts Institute of Technology	1,139	966	**47**	**100**
ETH Zurich	798	874	**84**	**Dropped out**
University of California, Berkeley	795	688	**85**	**Dropped out**
Mathematics (n=5)				
Study Group				
King Saud University	246	945	**127**	**1**
Princess Nourah Bint Abdulrahman University	19	607	**1501-2000**	**12**
Prince Sattam Bin Abdulaziz University	62	526	**760**	**16**
King Khalid University	75	489	**654**	**22**
Lebanese American University	4	294	**2001-3000**	**98**
International Group				
ETH Zurich	427	458	**20**	**29**
Massachusetts Institute of Technology	529	435	**8**	**33**
University of California, Berkeley	452	427	**18**	**34**
Princeton University	404	392	**28**	**45**
Microbiology (n=1)				
Study Group				
King Saud University	107	305	**190**	**33**
International Group				
Massachusetts Institute of Technology	267	235	**30**	**61**
University of California, Berkeley	216	202	**58**	**85**
ETH Zurich	180	141	**82**	**Dropped out**
Molecular Biology & Genetics (n=0)				
Study Group				
None ranked among the world's 100 most published				
International Group				
Massachusetts Institute of Technology	1,221	1,150	**10**	**8**
University of California, Berkeley	554	462	**68**	**79**
ETH Zurich	440	393	**96**	**Dropped out**

Neuroscience & Behavior (n=0)				
Study Group				
None ranked among the world's 100 most published				
International Group				
Massachusetts Institute of Technology	572	576	**81**	**91**
Pharmacology & Toxicology (n=5)				
Study Group				
King Saud University	510	1,346	**23**	**1**
Prince Sattam Bin Abdulaziz University	135	475	**316**	**61**
King Khalid University	101	439	**444**	**69**
Saveetha Institute of Medical and Technical Sciences	29	411	**1001-1500**	**80**
Umm Al-Qura University	88	348	**510**	**100**
International Group				
None ranked among the world's 100 most published				
Physics (n=3)				
Study Group				
King Saud University	326	1,202	**286**	**33**
King Khalid University	269	784	**353**	**81**
Princess Nourah Bint Abdulrahman University	21	678	**2001-3000**	**97**
International Group				
Massachusetts Institute of Technology	1,921	1,705	**9**	**15**
Princeton University	1,388	1,234	**22**	**29**
ETH Zurich	1,218	1,128	**26**	**39**
University of California, Berkeley	1,209	1,054	**29**	**46**
Plant & Animal Science (n=1)				
Study Group				
King Saud University	426	1,712	**128**	**5**
International Group				
University of California, Berkeley	545	428	**78**	**Dropped out**
None ranked among the world's 100 most published				
Psychiatry/Psychology (n=0)				
Study Group				
None ranked among the world's 100 most published				
International Group				
University of California, Berkeley	489	434	**88**	**Dropped out**
Social Sciences, general (n=0)				
Study Group				
None ranked among the world's 100 most published				
International Group				
University of California, Berkeley	1,239	1,062	**35**	**64**
Space Science (n=0)				
Study Group				
None ranked among the world's 100 most published				
International Group				
University of California, Berkeley	1,130	1,254	**6**	**9**
Massachusetts Institute of Technology	761	1,083	**19**	**14**
Princeton University	783	1,015	**17**	**15**
ETH Zurich	351	362	**71**	**81**

Data source: Essential Science Indicators, via InCites (May 2025). None of the regional control group universities appeared in the global top 100 most-published institutions by subject.

Table 3S. Illustrative cases of hyper-prolific authorship at study group universities

Case description	Case data
Case 1: A hyper-prolific author (HPA) affiliated with a study group university published 477 articles between 2021 and 2025, listing an average of four institutional affiliations per publication. Most articles included two to six simultaneous affiliations, often spanning two to three countries and multiple world regions. Nearly all the institutions involved exhibited bibliometric patterns consistent with the broader trends observed among the study group universities.	Middle East University Jordan 276 Universiti Sains Malaysia 246 Al Al-Bayt University 245 Applied Science Private University 243 Al-Ahliyya Amman University 241 Amman Arab University 178 Sunway University 109 Lebanese American University 107
Case 2: This author began publishing three articles in 2019, sharply increasing to 37 publications in 2020. Between 2021 and 2024, the author averaged 123 articles per year. Most of these publications included multiple concurrent affiliations across 2-3 countries, with each affiliated institution appearing in over 100 articles.	2024 152 2023 105 2022 93 2021 143 2020 37 2019 3
Case 3: Initially averaging one publication per year over 14 years, this author's output increased dramatically after being appointed dean, reaching 230 articles in 2022 and 510 in 2023, with no co-authors from their home institution. In 2024, output fell to 54 publications, and no articles were published in 2025. The abrupt rise and subsequent decline raise questions about the sustainability and structure of such publication trajectories, particularly in leadership contexts.	2024 55 2023 509 2022 229 2021 1 2014 1 2013 1 2010 3 2008 1

Data Source: Scopus (May 1, 2025).

Table 4S. Number and proportion of articles published in delisted journals, 2018-2019 and 2023-2024

	Articles in delisted journals		% of total output		World ranking in # of articles in delisted journals	
	2018-19	2023-24	2018-19	2023-24	2018-19	2023-24
STUDY GROUP						
Chandigarh University	299	293	57.4%	6.5%	4	25
Chitkara University	117	182	35.3%	6.4%	13	27
GLA University	99	180	25.8%	5.9%	23	36
Koneru Lakshmaiah Education Foundation	2550	576	77.3%	15.1%	2	2
Lovely Professional University	517	281	34.4%	5.4%	15	45
Saveetha Institute of Medical and Technical Sciences	2,421	874	79.7%	8.4%	1	14
University of Petroleum and Energy Studies	132	129	27.0%	4.8%	21	58
Lebanese American University	10	359	1.7%	6.2%	496	29
King Khalid University	236	657	11.4%	5.9%	44	34
King Saud University	697	986	8.2%	3.6%	64	79
Najran University	35	151	10.4%	6.2%	53	30
Prince Sattam Bin Abdulaziz University	163	683	13.1%	8.0%	36	16
Princess Nourah Bint Abdulrahman University	93	528	11.4%	6.1%	46	31
Taif University	121	385	12.1%	7.5%	40	20
Umm Al-Qura University	96	363	8.5%	6.4%	63	26
University of Hail	59	172	11.0%	5.5%	50	42
University of Tabuk	71	196	10.1%	5.9%	58	37
University of Sharjah	45	220	3.6%	4.8%	219	60
REGIONAL GROUP						
Indian Institute of Science, Bangalore	37	39	0.9%	0.9%	710	633
American University of Beirut	38	27	1.7%	1.3%	503	438
King Abdullah University of Science and Technology	17	31	0.5%	0.6%	936	744
Khalifa University of Science and Technology	23	70	1.3%	1.8%	603	271
INTERNATIONAL GROUP						
Swiss Federal Institute of Technology Zurich	30	23	0.2%	0.2%	997	995
Massachusetts Institute of Technology	46	28	0.3%	0.2%	991	991
Princeton University	10	9	0.1%	0.1%	1000	998
University of California at Berkeley	58	44	0.4%	0.3%	962	958

Data Source: Scopus and Web of Science (May 1, 2025).

Table 5S. Number, proportion, and world rank in retractions

	Articles retracted			Retractions per 1,000 articles			World ranking in retraction rate		
	2018-19	2022	2023-24	2018-19	2022	2023-24	2018-19	2022	2023-24
STUDY GROUP									
Chandigarh University	0	24	27	0.0	18.1	6.0	NA	20	9
Chitkara University	0	20	17	0.0	25.5	5.9	NA	9	10
GLA University	0	31	14	0.0	33.4	4.6	NA	3	15
Koneru Lakshmaiah Education Foundation	8	25	43	2.4	20.9	11.2	114	15	2
Lovely Professional University	0	25	21	0.0	16.7	4.1	NA	28	21
Saveetha Institute of Medical & Technical Sciences	1	123	167	0.3	46.8	16.0	681	1	1
University of Petroleum and Energy Studies	4	36	8	8.2	25.9	3.0	26	7	35
Lebanese American University	0	0	26	0.0	0.0	4.5	NA	NA	17
King Khalid University	1	74	57	0.5	14.8	5.1	542	37	13
King Saud University	16	164	101	1.9	18.6	3.7	147	19	27
Najran University	0	14	11	0.0	14.6	4.5	NA	39	16
Prince Sattam Bin Abdulaziz University	5	110	53	4.0	25.7	6.2	57	8	7
Princess Nourah Bint Abdulrahman University	2	64	26	2.4	17.9	3.0	110	21	36
Taif University	2	117	27	2.0	25.3	5.2	138	10	12
Umm Al-Qura University	1	40	19	0.9	13.9	3.3	308	44	29
University of Hail	0	16	22	0.0	11.5	7.1	NA	60	6
University of Tabuk	3	22	13	4.3	17.5	3.9	54	24	24
University of Sharjah	3	9	8	2.4	4.3	1.7	116	193	91
REGIONAL GROUP									
Indian Institute of Science, Bangalore	2	1	3	0.5	0.4	0.7	538	654	294
American University of Beirut	0	1	0	0.0	0.8	0.0	NA	466	NA
King Abdullah University of Science and Technology	0	4	2	0.0	1.8	0.4	NA	338	421
Khalifa University of Science and Technology	0	0	5	0.0	0.0	1.3	NA	NA	142
INTERNATIONAL GROUP									
Swiss Federal Institute of Technology Zurich	3	2	4	0.2	0.3	0.3	755	717	547
Massachusetts Institute of Technology	7	3	7	0.5	0.4	0.5	563	675	402
Princeton University	1	0	0	0.1	0.0	0.0	809	NA	NA
University of California at Berkeley	9	3	3	0.6	0.4	0.2	437	662	648

Data Source: PubMed, Retraction Watch, Scopus, and Web of Science (May 1, 2025).

Table 6S. Proportion of articles ranked among the world's 2% most cited, 2018-2019 and 2023-2024

	# of articles ranked among world's top 2% most cited		% of total research output ranked among the world's top 2%		World ranking in % of top 2% articles		Increase in output from 2018-19 to 2023-24	
	2018-19	2023-24	2018-19	2023-24	2018-19	2023-24	Top 2%	Overall
STUDY GROUP								
CU	13	386	2.5%	8.6%	630	14	2869%	760%
Chitkara	12	204	3.6%	7.1%	370	35	1600%	766%
GLA	9	213	2.3%	6.9%	661	41	2267%	702%
KL	0	205	0.0%	5.4%	995	134	20500%	512%
LPU	53	349	3.5%	6.8%	390	47	558%	243%
SIMATS	64	872	2.1%	8.4%	712	15	1263%	243%
UPES	0	265	0.2%	10.0%	995	3	26500%	444%
LAU	14	783	2.4%	13.5%	646	1	5493%	908%
KKU	26	878	1.3%	7.9%	900	22	3277%	436%
KSU	336	1,141	4.0%	4.2%	277	280	240%	220%
NU	10	203	3.0%	8.3%	501	17	1930%	545%
PSAU	33	466	2.7%	5.5%	592	122	1312%	584%
PNU	15	462	1.8%	5.3%	781	140	2980%	965%
TU	14	295	1.4%	5.7%	872	105	2007%	419%
UQU	11	338	1.0%	5.9%	942	84	2973%	407%
UOH	15	170	2.8%	5.5%	565	127	1033%	484%
UT	26	182	3.7%	5.4%	351	130	600%	375%
UOS	53	271	4.2%	5.9%	232	87	411%	267%
Total/Average	**706**	**7,683**	**2.5%**	**6.5%**			**988%**	**326%**
REGIONAL GROUP								
IISc	91	102	2.2%	2.2%	690	785	12%	10%
AUB	62	54	2.8%	2.6%	574	713	-13%	-5%
KAUST	361	419	10.0%	8.7%	2	12	16%	34%
KU	73	354	4.1%	9.1%	256	9	385%	119%
Total/Average	**584**	**890**	**5.0%**	**6.0%**			**58%**	**31%**
INT'L GROUP								
ETH Zurich	841	724	6.7%	5.3%	26	144	-14%	9%
MIT	1,685	1196	11.1%	7.7%	1	25	-29%	3%
Princeton	529	395	7.7%	5.3%	10	139	-25%	8%
UC Berkeley	1,112	798	7.8%	5.7%	9	101	-28%	-2%
Total/Average	**3,928**	**2,722**	**8.5%**	**6.2%**			**-25%**	**4%**

Data Source: SciVal (May 1, 2025).

Table 7S. Major citation contributors to the top 2% most cited articles (≥1% citation share)

	CU	Chitkara	GLA	KL	LPU	SIMATS	UPES	LAU	KKU	KSU	NU	PSAU	PNU	TU	UQU	UOH	UOT	UOS	Oth
CU	4%	Y			Y	Y		Y	Y	Y									1
Chitkara	Y	16%			Y	Y			Y	Y			Y						6
GLA	Y	Y	6%		Y	Y			Y	Y		Y		Y	Y				12
KL	Y	Y	Y	6%	Y	Y		Y	Y	Y		Y	Y						11
LPU	Y	Y	Y		7%	Y			Y	Y		Y							5
SIMATS	Y	Y	Y		Y	12%			Y	Y									4
UPES	Y	Y			Y	Y	3%	Y	Y	Y									0
LAU		Y			Y	Y		5%	Y	Y		Y	Y						3
KKU	Y	Y			Y	Y		Y	8%	Y		Y	Y	Y	Y		Y		8
KSU		Y				Y			Y	9%		Y	Y	Y					2
NU		Y				Y			Y	Y	4%	Y	Y	Y	Y				10
PSAU		Y				Y		Y	Y	Y		6%	Y	Y	Y	Y			6
PNU		Y				Y		Y	Y	Y		Y	7%	Y	Y	Y	Y		14
TU		Y		Y	Y	Y			Y	Y		Y	Y	5%	Y	Y	Y		14
UQU		Y			Y	Y		Y	Y	Y		Y	Y	Y	5%	Y	Y		12
UOH		Y			Y	Y		Y	Y	Y		Y	Y	Y	Y	5%	Y		16
UOT		Y		Y		Y		Y	Y	Y		Y	Y	Y	Y		5%		12
UOS						Y		Y	Y	Y		Y						4%	0
	IISc	AUB	KAUST	KU															
IISc	3%																		9
AUB		1%																	11
KAUST			4%																27
KU				4%															4
	ETH	MIT	Princeton	UCB															
ETH	4%		Y																8
MIT		3%	Y	Y															18
Princeton			4%	Y															34
UCB		Y	Y	4%															21

This table should be read as follows: the main citation contributors to CU (Chandigarh University's) top 2% most cited articles are CU itself (with a self-citation rate of 4%), six fellow study group institutions, and one other university beyond the study group. **Data Source:** SciVal (May 1, 2025).

Table 8S. Number of institutions appearing as major co-authoring partners (≥2% co-authorship rate)

	Count of major collaborating institutions, 2018-2019	Count of major collaborating institutions, 2023-2024	New or intensified collaborators*
STUDY GROUP			
Chandigarh University	5	20	17
Chitkara University	9	26	22
GLA University	6	23	22
Koneru Lakshmaiah Education Foundation	2	20	15
Lovely Professional University	4	19	13
Saveetha Institute of Medical and Technical Sciences	1	22	20
University of Petroleum and Energy Studies	5	23	18
Lebanese American University	8	42	39
King Khalid University	12	27	11
King Saud University	7	7	3
Najran University	13	26	14
Prince Sattam Bin Abdulaziz University	13	33	12
Princess Nourah Bint Abdulrahman University	16	40	16
Taif University	22	29	8
Umm Al-Qura University	14	31	12
University of Hail	20	28	6
University of Tabuk	18	34	18
University of Sharjah	9	19	8
Average per institution	**10**	**26**	**15**
REGIONAL GROUP			
Indian Institute of Science, Bangalore	3	2	0
American University of Beirut	4	12	1
King Abdullah University of Science and Technology	1	0	0
Khalifa University of Science and Technology	4	9	2
Average per institution	**3**	**6**	**1**
INTERNATIONAL GROUP			
Swiss Federal Institute of Technology Zurich	8	8	0
Massachusetts Institute of Technology	8	20	0
Princeton University	17	29	0
University of California at Berkeley	12	15	0
Average per institution	**12**	**18**	**0**

***Institutions that are new or have increased their collaboration activity over five times compared to 2018-2019 levels. Data Source: SciVal (May 1, 2025).

Table 9S. Major collaborators of the study group universities (≥2% collaboration rate), 2018-2019 vs. 202 2024

2018-2019																			
	CU	Chitkara	GLA	KL	LPU	SIMATS	UPES	LAU	KKU	KSU	NU	PSAU	PNU	TU	UQU	UOH	UOT	UOS	Other*
CU																			6
Chitkara																			8
GLA																			6
KL																			2
LPU																			4
SIMATS																			1
UPES					Y														4
LAU																			8
KKU										Y									10
KSU												Y	Y						5
NU									Y	Y									12
PSAU										Y									12
PNU									Y	Y				Y	Y				12
TU										Y			Y		Y				19
UQU										Y				Y					11
UOH									Y	Y					Y				16
UOT									Y	Y									16
UOS										Y									9
2023-2024																			
	CU	Chitkara	GLA	KL	LPU	SIMATS	UPES	LAU	KKU	KSU	NU	PSAU	PNU	TU	UQU	UOH	UOT	UOS	Other*
CU		Y	Y		Y	Y	Y	Y	Y	Y		Y							8
Chitkara	Y		Y		Y	Y	Y	Y	Y	Y									14
GLA	Y	Y		Y	Y	Y			Y	Y		Y							14
KL	Y					Y				Y									12
LPU	Y	Y	Y			Y		Y	Y	Y									6
SIMATS	Y	Y	Y	Y	Y			Y	Y	Y		Y							11
UPES	Y	Y				Y		Y		Y		Y							12
LAU	Y	Y			Y	Y	Y		Y	Y		Y	Y		Y			Y	28
KKU						Y		Y				Y	Y	Y	Y				5
KSU																			3
NU												Y	Y	Y	Y	Y	Y		8
PSAU			Y			Y			Y		Y		Y	Y	Y				5
PNU									Y			Y				Y	Y		12
TU						Y			Y		Y	Y					Y		3
UQU						Y		Y	Y		Y	Y	Y				Y		5
UOH											Y		Y				Y		3
UOT								Y	Y				Y	Y	Y	Y			12
UOS								Y					Y						6

Institutions marked in red, bolded font are coauthors for at least 2% of each other's publications. **Data Source:** SciVal (May 1, 2025).