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Bibliometric analysis of Sci-Hub downloads by Egyptian researchers

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Abstract
In this study we present an in-depth bibliometric analysis of Sci-Hub downloads by Egyptian researchers based on the 2017 download log file. The study reveals that Egyptian researchers heavily rely on Sci-Hub, generating a substantial 1,357,526 download requests in 2017, with 65% of these occurring outside regular working hours. Cairo emerges as a central hub for this activity, contributing 81.58% of total downloads. Journal articles constitute the majority of downloads at 82.36%, followed by conference papers (12.89%). A discernible trend shows a preference for recent papers published between 2012 and 2017, highlighting the demand for up-to-date research. The analysis also highlights prominent publishers, including IEEE, Elsevier, Wiley, and Springer, as preferred sources for Egyptian researchers. "Journal of the American Chemical Society" and "Journal of Applied Physics" stand out among accessed journals, while IEEE-associated conferences, notably "IEEE Power and Energy Society General Meeting," dominate conference paper downloads. Examining journal accessibility via the Egyptian Knowledge Bank (EKB) reveals that 62.84% of journals are accessible, with Science Direct as the leading provider (28.37%). However, a significant gap emerges as 87.39% of downloaded conference papers remain inaccessible through EKB. Furthermore, a semantic analysis highlights recurring themes such as "systems," "review," "analysis," "treatment," "power," and "energy," reflecting the key research areas of Egyptian researchers. Overall, this study offers valuable insights into Sci-Hub's role in supplementing Egyptian researchers' resource access and underscores the need for comprehensive resource coverage and accessibility enhancements.

Keywords Sci-Hub · Egyptian researchers · Bibliometric analysis · Egyptian knowledge bank · Log file analysis

Introduction

Access to scientific articles is vital for global researchers, playing a pivotal role in advancing knowledge and fostering high-quality research. However, the prevalent business model of scientific journals, marked by high subscription costs and individual

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article fees, hampers accessibility, leaving approximately 75% of scholarly documents inaccessible across disciplines (Bosman & Kramer, 2018). Notably, prestigious journals maintain articles behind paywalls, impeding scientific progress (Galian et al., 2023), with a disproportionate impact on researchers in lower-income countries Himmelstein et al. (2018).

In response to these challenges, initiatives such as the Research4Life program and various open-access initiatives have been implemented to provide unrestricted online access to scholarly literature (Research4Life, 2023; Suber, 2012). While these initiatives demonstrate progress in addressing accessibility issues, they also highlight the persistent need for additional efforts to enhance accessibility to scientific literature (Mekonnen et al., 2022).

An alternative solution to limited access emerged in 2011 with the launch of Sci-Hub by Alexandra Elbakyan, a software developer and neurotechnologist (Bohannon, 2016a). Sci-Hub's primary objective is to provide free and unrestricted access to scientific knowledge for individuals worldwide (Sci-Hub, 2023). Initially used primarily by Russian researchers, the platform rapidly gained popularity globally, illustrating its potential to meet the widespread demand for accessible research articles beyond geographical boundaries (Elbakyan & Bozkurt, 2021).

The recognition of Sci-Hub's benefits has led to extensive research on the analysis of downloaded papers from the platform, leading to several notable studies. Bohannon's analysis revealed 28 million download requests in six months, highlighting Sci-Hub's significant value globally (Bohannon, 2016b). Greshake's comparative study explored user motivations, emphasizing biases toward newer articles and specific disciplines, showcasing Sci-Hub's diverse user base (Greshake, 2017). Himmelstein et al. (2018) showcased the platform's extensive database, surpassing university access, underscoring its vital role for researchers. Owens' study outlined the global impact of Sci-Hub, with India and China leading in downloads, raising legal and ethical concerns (Owens, 2022).

Studies also investigated Sci-Hub's discipline-specific impacts. Andročec's analysis in computer science found 607,023 papers downloaded, including those from prominent publishers like IEEE, Elsevier BV, and Springer Nature (Andročec, 2017). Till et al.'s bibliometric review of medical article downloads highlighted users from low- and middle-income countries, emphasizing accessibility challenges (Till et al., 2019). In contrast, Kornienko's study on food industry journals indicated lower demand compared to prestigious general science journals (Kornienko, 2020).

Regional investigations demonstrated Sci-Hub's global impact, with Machin-Mastromatteo et al. (2016) noting 12.54% of global downloads in Latin America. In India, Singh et al. (2021a) reported over 13 million papers accessed, while Moskovkin et al. (2021), identified 1.5 million downloads among Russian researchers. Broader issues were explored by Gardner et al. (2017), assessing Sci-Hub's impact on interlibrary loan services, open access levels in Indian research output (Singh et al., 2020), and Sci-Hub's impact on Indian research visibility (Singh et al., 2021b). Additionally, Buehling et al. (2022) investigating free access in mathematics. Geng et al. (2022) studied scientists' downloading patterns, providing insights into work habits.

Despite the significant contributions of previous research in advancing our understanding of Sci-Hub usage and its implications, there remains a considerable gap in knowledge concerning the specific patterns and trends among Egyptian users. This knowledge gap is particularly significant considering Egypt's position as the seventh-ranked country in terms of Sci-Hub usage, trailing behind Iran, China, India, Russia, USA, and Brazil (Bohannon, 2016b). To bridge this gap, the present study aims to conduct a comprehensive bibliometric analysis of Sci-Hub downloads by Egyptian researchers, providing localized insights

into their behaviors and preferences when accessing scientific literature through the Sci-Hub platform.

Objectives

This study has three primary objectives: (1) to conduct a comprehensive analysis and quantification of the volume of papers downloaded by Egyptian researchers from Sci-Hub; (2) to evaluate the accessibility of the downloaded papers within the EKB platform; and (3) to provide support to the EKB administration in the strategic curation of a pertinent collection of electronic resources tailored to meet the specific research needs of the Egyptian academic community. By addressing these objectives, the study endeavors to contribute to the enhancement of research support and resource management within the academic landscape of Egypt.

Materials and methods

Data source

The primary data source for this study was the 2017 download log file acquired from Sci-Hub, as detailed by (Elbakyan, 2018). The log file encompasses crucial information in eight key fields: Timestamp, DOI, IP identifier, User identifier, Country (determined using GeoIP), City (determined using GeoIP), Latitude, and Longitude. It is noteworthy that the log file's substantial size was 14.5 GB, providing an extensive dataset for analysis.

Data extraction

Handling large files can be challenging, especially when the available hardware resources are inadequate to handle their size. Consequently, researchers had to implement multiple steps to extract the necessary data concerning download requests made by Egyptian researchers from the log file. To address this issue, the main log file was initially partitioned into 179 smaller segments, each sized at 80 MB. This division process was facilitated using the mingw-w64 program. Following the partitioning, OpenRefine was utilized to efficiently extract the relevant data associated with Egyptian researchers from these smaller segmented files. The extracted data was then saved in CSV format, enabling seamless further processing and analysis.

To organize the data effectively, Microsoft Access 365 was employed to create a database. The extracted CSV files were then imported into a single table, resulting in a total of 1,357,526 records. This consolidated dataset provided a comprehensive view of the download requests made by Egyptian researchers. Two queries were developed to refine the data. The first query focused on extracting the coordinates of the downloaded papers' locations within Egypt, enabling a geographical analysis. This query yielded 86 unique records, representing distinct geographic locations within Egypt where the downloaded papers originated. The second query aimed to extract the unique DOIs (Digital Object Identifiers) of the downloaded papers. This query resulted in 892,228 unique DOI records, representing the individual research papers that were downloaded by Egyptian researchers.

Identification of downloaded paper locations

The geographic locations of the downloaded papers were identified on Google Maps using the Latitude and Longitude data. This enabled the visualization of the distribution of downloaded papers across different regions in Egypt.

Retrieval of metadata

In order to enhance data analysis, the researchers utilized Zotero-6.0.18, a reference management software, and employed four desktop PCs to extract metadata from the CrossRef database for the unique DOIs obtained earlier. The extracted metadata included various details such as item type, publication year, author, title, publication title, ISBN, ISSN, DOI, URL, and other relevant information. Among the 892,228 unique DOIs, metadata records were successfully retrieved for 891,651 DOIs. However, metadata for 577 DOIs could not be retrieved. The inability to retrieve metadata for these DOIs may be attributed to factors such as incomplete information, unavailability in the CrossRef database, or temporary issues with the internet connection during the retrieval process. After retrieving the metadata, it was stored in CSV files to ensure compatibility for further processing and analysis. These CSV files were then imported into Microsoft Excel, providing a convenient platform for additional examination and exploration of the data.

Analysis techniques

In order to extract valuable insights from the downloaded papers, a variety of analysis techniques were utilized. These techniques involved examining factors such as the distribution of papers based on publication type, publication year, publisher, and other relevant characteristics. Additionally, word clouds were created using the Voyant-Tool to visually represent the frequency of specific terms found in the titles of the most downloaded papers.

Results

Distribution of requests by timespan

The data analysis revealed that Egyptian researchers submitted a significant number of requests to Sci-Hub in 2017, totaling 1,357,526. Notably, 65% of these requests (881,928) occurred outside regular working hours, while the remaining 35% (475,598) took place during standard working hours (9:00 to 16:00). Examining the patterns of paper downloads, a distinct trend emerged. The majority of activity happened during the night, peaking between 21:00 and 0:00, constituting about 25% of total requests. Additionally, a second peak occurred in the afternoon, from 12:00 to 15:00, accounting for approximately 21% of requests. Morning hours had a lower download percentage (around 7%), gradually increasing from 9:00 to 15:00 (see Fig. 1). This suggests a preference among Egyptian researchers for using Sci-Hub during non-working hours, particularly at night.

The data in Fig. 2 displays the distribution of download requests from Sci-Hub across weekdays. Notably, Saturday, classified as a weekend day, leads with the highest

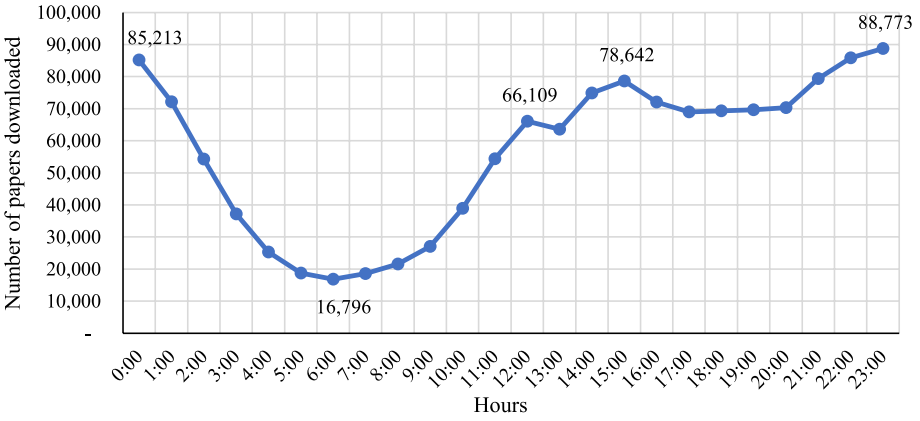

Fig. 1 Distribution of requests by daily hours

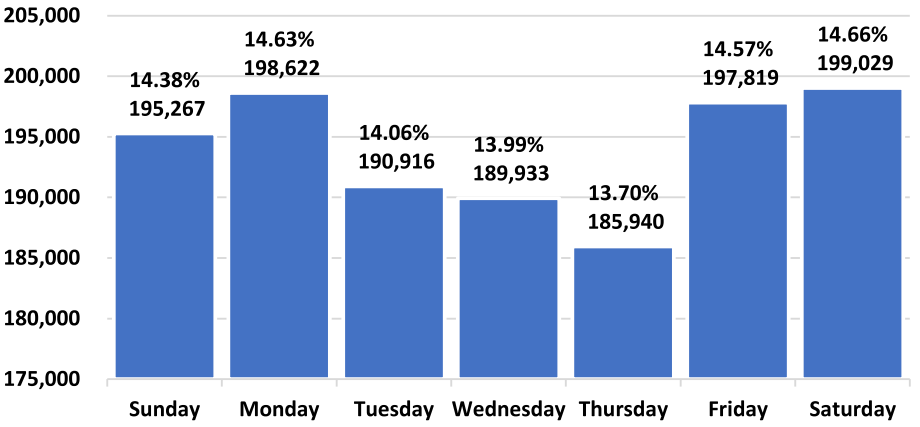

Fig. 2 Distribution of requests by days of the week

download requests at 199,029 (14.66% of the total), closely followed by Monday at 198,622 (14.63% of the total). Friday, Sunday, and Tuesday also exhibit substantial download activity, each contributing to around 14% of the total requests.

Locations of requests within Egypt

The analysis of Sci-Hub download requests by Egyptian researchers reveals a substantial concentration, with Cairo comprising 81.58% (1,107,437) of the total, followed by Alexandria at 6.43% (87,246), and Giza at 3.73% (50,671). The top three governorates collectively contribute 91.74%, highlighting a regional emphasis on accessing scholarly content. The remaining 27 governorates account for 8.26% (112,172) of the download requests.

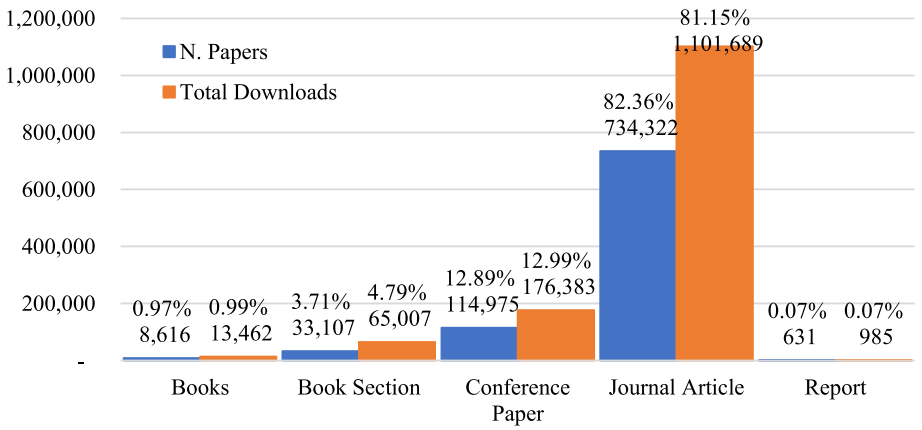

Fig. 3 Distribution of downloaded papers by document types and total of downloads

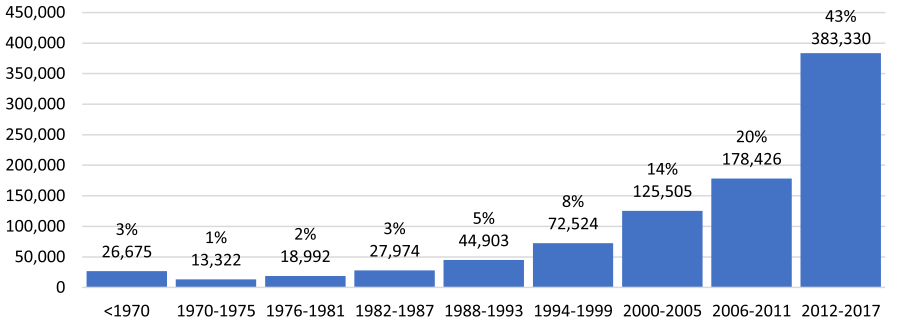

Fig. 4 Distribution of downloaded papers by published year

Types of downloaded papers

In 2017, Egyptian researchers exhibited substantial engagement with Sci-Hub, downloading a total of 891,651 research papers, accessed 1,357,526 times. Figure 3 illustrates the distribution of these papers, emphasizing various document types. Journal articles constituted the majority, with 82.36% of downloads (734,322 articles), reflecting the researchers' reliance on this format for primary research and knowledge. Conference papers also played a significant role, comprising 12.89% of downloads (114,975 papers). Furthermore, Egyptian researchers displayed notable interest in book chapters and books from Sci-Hub, indicating a comprehensive approach to research and learning.

Distribution of downloaded papers by published year

Figure 4 presents a distribution of downloaded papers by their published years, revealing distinct temporal trends in the preferences of Egyptian researchers using Sci-Hub. The data underscores a clear emphasis on recent research, with the highest percentage of downloads (43%) attributed to papers published between 2012 and 2017. Substantial

percentages are also observed for the 2006–2011 (20%) and 2000–2005 (14%) periods, indicating a preference for contemporary literature. Conversely, there is a declining interest in papers from earlier years, with only 3% of downloads associated with papers published before 1970. This temporal analysis highlights the dynamic nature of research interests among Egyptian researchers, reflecting a focus on staying abreast of the latest scientific developments.

Publishers of downloaded papers

The top 10 publishers, as revealed in Fig. 5, play a significant role in shaping the preferences of Egyptian researchers utilizing Sci-Hub. The leading publishers include IEEE (16.4%), Elsevier (15.7%), and Wiley (11.2%). IEEE and Elsevier predominantly offer conference papers (65.4%) and journal articles (89.8%), respectively. Wiley focuses on journal articles (94.1%), while Springer provides a mix of journal articles (81.5%), book Sects. (12.3%), and books (6.1%). Other publishers, such as Taylor & Francis, ACS, LWW, OUP, Sagepub, and Scitation, also contribute to the downloaded papers. Overall, 74.53% of the total downloaded papers by Egyptian researchers on Sci-Hub come from these top 10 publishers, underscoring their significant impact on shaping the information landscape for researchers.

Distribution of downloaded journal articles by journals

Egyptian researchers demonstrated diverse engagement with scholarly literature by downloading 734,322 journal articles from 18,216 different journals. The top 10 most downloaded journals, highlighted in Table 1, reveal diverse interests, with a focus on chemistry and physics-related content evident through dominant ACS and physics journals. Notably, the "Journal of the American Chemical Society" and "Journal of Applied Physics" lead in downloads. The data reflects researchers' diverse interests, encompassing journals

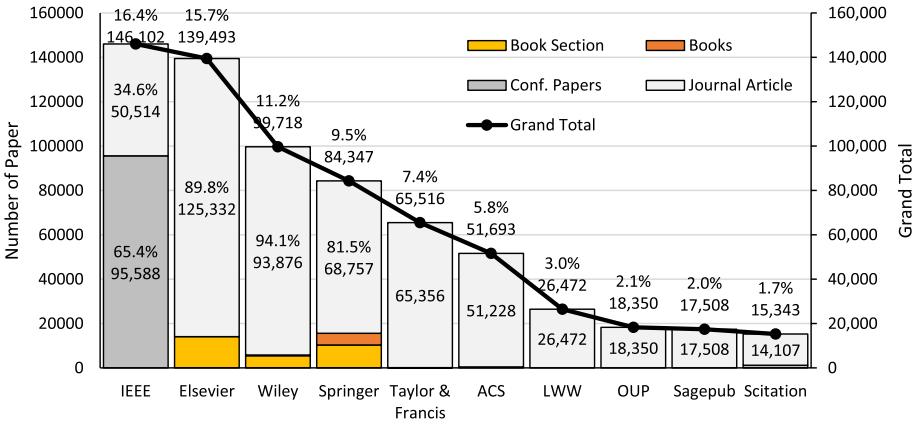

Fig. 5 Top 10 publishers by number of downloaded papers

Table 1 Top 10 most downloaded journals

Rank	Journal	No. downloads	Publisher	EKB access
1	Journal of the American Chemical Society	4,345	ACS	No
2	Journal of Applied Physics	4,325	Scitation	No
3	Journal of Agricultural and Food Chemistry	3,944	ACS	No
4	Physical Review B	3,868	APS	No
5	Applied Physics Letters	3,574	Scitation	No
6	Journal of Medicinal Chemistry	3,528	ACS	No
7	Science	3,406	Science	No
8	The New England Journal of Medicine	3,015	NEJM	No
9	The Lancet	2,939	Elsevier	Yes, Science direct
10	ACS Applied Materials & Interfaces	2,606	ACS	No

like "Science," "The New England Journal of Medicine," and "The Lancet." Interestingly, all the listed journals, except for "The Lancet," lack access through the EKB.

Distribution of downloaded conference papers by conference

Egyptian researchers exhibit a strong interest in accessing conference papers, as evidenced by the download of 114,975 papers from 7,452 conferences, according to Table 2. The "IEEE Power and Energy Society General Meeting" emerges as the most popular conference, with 1247 downloaded papers, followed by the "IEEE Antennas and Propagation Society International Symposium (APSURSI)" with 1,096 papers and the "IEEE Vehicular Technology Conference" with 1,044 papers. Notably, IEEE-affiliated conferences dominate the top 10, emphasizing the significant influence of this professional organization in attracting researchers.

The data spans diverse coverage years, showcasing the evolving nature of research and progress in various disciplines. This allows researchers to explore historical developments, track emerging trends, and identify ongoing areas of interest. The conferences cover a broad range of topics, reflecting the multidisciplinary interests of Egyptian

Table 2 Top 10 most downloaded conferences

Rank	Conference name	No. downloads	Coverage years
1	IEEE Power and Energy Society General Meeting	1,247	2003–2016
2	IEEE Antennas and Propagation Society International Symposium	1,096	1988–2017
3	IEEE Vehicular Technology Conference	1,044	1977–2017
4	IEEE International Conference on Communications	1,007	1990–2017
5	IEEE Global Communications Conference	943	1991–2016
6	IEEE Annual Conference of IEEE Industrial Electronics	917	1987–2017
7	IEEE International Solid-State Circuits Conference	876	1968–2017
8	IEEE Engineering in Medicine and Biology Society	872	1988–2017
9	IEEE International Symposium on Circuits and Systems	868	1988–2017
10	SPE Annual Technical Conference and Exhibition	758	1979–2017

researchers, including power and energy, antennas and propagation, vehicular technology, communications, industrial electronics, solid-state circuits, and biomedical engineering.

Distribution of book chapters by book series

Egyptian researchers have downloaded book chapters from a wide range of 11,624 different book series, as revealed in the data analysis. Table 3 highlights the top 10 most frequently downloaded book series by these researchers, providing insights into their specific research interests. The Methods in Enzymology book series tops the list, with 505 downloads, indicating a significant interest in enzymology research and experimental methods. The second-ranking Bergey's Manual of Systematics of Archaea and Bacteria reflects researchers' engagement in microbiology and the study of microorganisms.

Notable book series in the top 10 include the Handbook of Clinical Neurology, Encyclopedia of Applied Plant Sciences, and Ullmann's Encyclopedia of Industrial Chemistry, revealing diverse research interests in clinical neurology, plant sciences, and industrial chemistry, respectively. The inclusion of reference materials such as The Encyclopedia of Ancient History and eLS (Encyclopedia of Life Sciences) indicates researchers' interest in historical research and life sciences. Analyzing Table 3 reveals the notable influence of Elsevier and Wiley, each featuring in five book series, signifying their substantial roles as leading publishers. ACS, with one series, emphasizes its commitment to delivering quality content in chemistry-related research.

Availability of downloaded papers via EKB

The EKB was introduced by the Egyptian government in 2016 as an online knowledge platform and digital library. Its primary objective is to grant Egyptian citizens, students, and researchers access to a vast range of educational resources, encompassing books, research papers, academic journals, and multimedia content. To achieve this goal, the

Table 3 Top 10 most downloaded book series

Rank	Book series title	Publisher	No. of downloads
1	Methods in Enzymology	Elsevier	505
2	Bergey's Manual of Systematics of Archaea and Bacteria	Wiley	493
3	Handbook of Clinical Neurology	Elsevier	306
4	Encyclopedia of Applied Plant Sciences	Elsevier	220
5	Ullmann's Encyclopedia of Industrial Chemistry	Wiley	211
6	The Encyclopedia of Ancient History	Wiley	205
7	eLS (Encyclopedia of Life Sciences)	Wiley	155
8	Advances in Heterocyclic Chemistry	Elsevier	143
9	Wiley Encyclopedia of Management	Wiley	133
10	Studies in Surface Science and Catalysis	Elsevier	106
10	ACS Symposium Series	ACS	106

EKB collaborates with numerous providers and publishers to offer users an extensive collection of electronic resources. Some of the notable providers and publishers associated with the EKB include Elsevier, Springer Nature, Wiley, IEEE, SAGE, CABI Academy, Clarivate Web of Science, Cochran Library, EBSCO host, Emerald Publishing, Institute of Engineering and Technology (IET), IOP Publishing, JSTOR, LexisNexis, The NEJM, ProQuest, and Wolters Kluwer.

Availability of downloaded journals via EKB

The study assessed the accessibility of journals downloaded from Sci-Hub through the EKB by examining a sample of 1604 journals with a minimum of 100 articles, representing 66.34% of total journal article downloads (487,128). Manual queries on ekb.org.eg revealed that 62.84% (1008 journals) were accessible through EKB, while 37.16% (596 journals) were not. Figure 6 illustrates the distribution of downloaded journals across EKB databases, with Science Direct, Wiley, and Springer holding the largest shares. The top three databases collectively cover over 70% of the available journals, highlighting the concentration of downloaded journals within specific EKB databases and the prominence of certain platforms in providing access to scholarly literature.

Availability of downloaded conference papers via EKB

A study assessed the accessibility of downloaded conference papers from Sci-Hub within EKB subscriptions. The sample included 1420 conference papers downloaded at least 7 times, totaling 15,324 downloads. A manual search within EKB subscriptions, utilizing

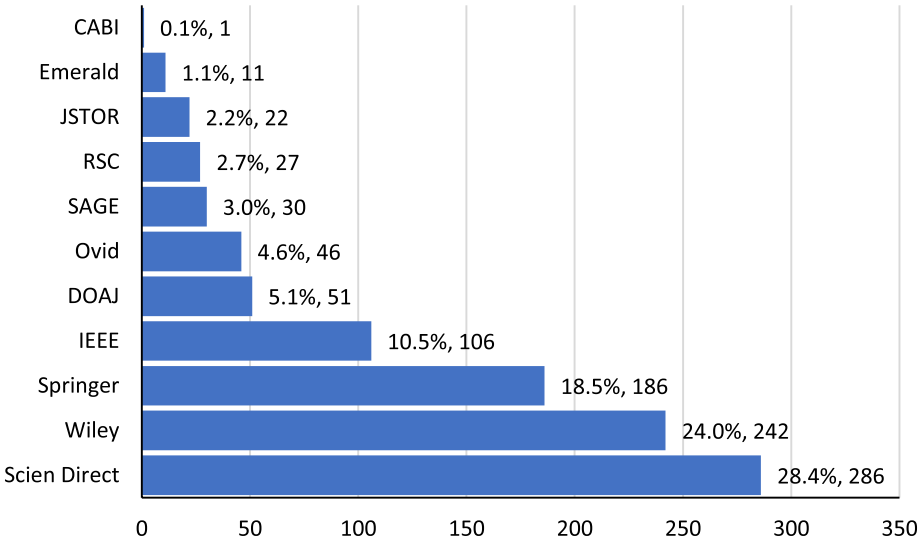

Fig. 6 Distribution of downloaded journals by EKB databases

the IEEE subscription and federated search, revealed that the majority (87.39%) of these conference papers were not accessible through EKB. However, 12.61% of the papers (179) were accessible through official academic channels within the EKB. This data highlights the limited availability of certain conference papers through EKB subscriptions, emphasizing the need for researchers to explore alternative avenues for accessing academic content.

Research trends analysis

The research trends analysis focused on highly downloaded papers by Egyptian researchers, encompassing both journal articles and conference papers with a minimum of 7 downloads. The dataset included 10,213 papers, downloaded 108,649 times, representing 8.5% of overall downloads. The titles of these papers contributed 127,534 words and comprised 15,154 unique word forms. Voyant Tools was utilized to create a visually appealing word cloud based on the titles, providing a concise and engaging representation of the prevalent research trends among Egyptian researchers.

The word cloud, illustrated in Fig. 7, reveals key terms that dominate the downloaded papers. "Systems" emerges prominently with 805 occurrences, suggesting a strong emphasis on systemic approaches across diverse disciplines. Following closely, "based" appears 696 times, indicating a reliance on established frameworks within research domains. Notably, "power" (404) and "energy" (340) signify a robust interest in power-related domains, encompassing energy systems, wind, control, design, and energy conversion/storage.

Medical and healthcare research emerges as a prominent theme, evident in terms like "treatment" (441 occurrences), "disease" (221), and "cancer" (221). This underscores a dedicated focus on advancing knowledge in medical treatment, disease management, and

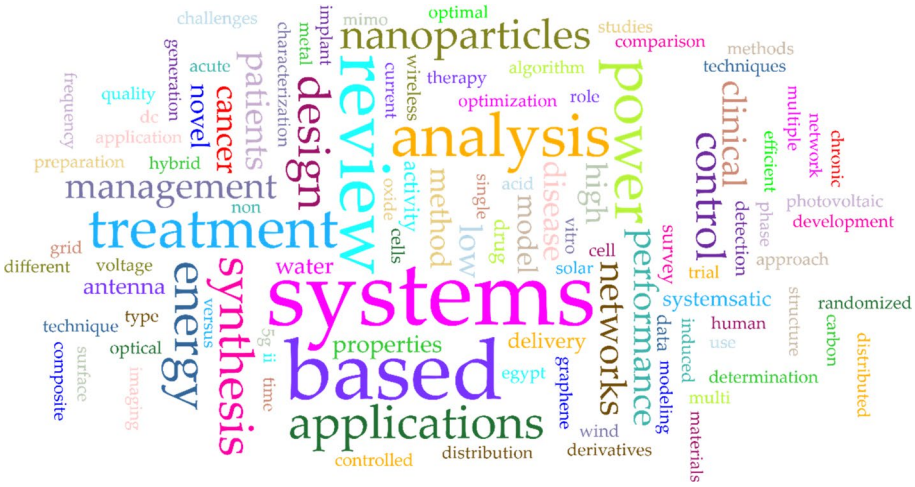

Fig. 7 Word cloud with top 100 most frequent words in highly downloaded papers. Most 20 frequent words in the word cloud: systems (805); based (696); review (570); analysis (467); treatment (441); power (404); synthesis (345); applications (343); energy (340); design (318); control (304); nanoparticles (299); clinical (256); networks (254); patients (247); performance (244); management (241); low (221); high (221); disease (221); cancer (221)

therapies for various conditions. Communication technologies play a substantial role, as reflected in terms like "networks" (254 occurrences), "wireless," and "5g," indicating active research engagement in wireless communication networks, 5G technologies, and challenges associated with cognitive and heterogeneous networks.

Nanotechnology and material science are evident through terms like "nanoparticles" (299 occurrences), "synthesis" (345), and "applications" (345). This emphasizes a substantial focus on the synthesis, characterization, and applications of nanoparticles, particularly in drug delivery and cancer-related research. Overall, the word cloud analysis offers a nuanced understanding of the diverse and multidisciplinary research interests driving the scholarly activities of Egyptian researchers.

Discussion

The study aimed to analyze the characteristics of papers downloaded by Egyptian researchers from Sci-Hub. The study utilized the 2017 download log file from Sci-Hub to gain insights from the data. The findings revealed that in 2017, Egyptian researchers downloaded a total of 1,357,526 papers from Sci-Hub. A comparison with 2015 data, where the number of paper requests by Egyptian researchers was 515,190 (Bohannon, 2016b), showed a significant increase of 2.6 times in just two years, indicating a remarkable growth rate of 163.5%. These results highlight the escalating reliance of Egyptian researchers on Sci-Hub as a vital resource for accessing scholarly papers.

The analysis of Sci-Hub usage among Egyptian researchers revealed a distinct trend in accessing scholarly papers, particularly during non-working hours, predominantly at night. Notably, the peak demand for downloads occurred between 21:00 and 0:00. These findings support prior research that indicates scientists often dedicate their time to work during off-hours and weekends (Wang et al., 2012). At the country level, this study's findings align with previous research, which observed a similar trend among scientists in China and Japan who engage in additional work during specific evening hours (Geng et al., 2022). However, on a global level, the usage pattern of Sci-Hub differs, with the lowest activity recorded around 04:00 and peaks during 10:00–11:00 and 14:00–15:00 (Geng et al., 2022). The flow of Sci-Hub activity over time mirrors the working lives of researchers, gradually increasing throughout the day and subsiding but never ceasing as night falls (Bohannon, 2016b). These differences indicate diverse usage patterns of Sci-Hub across countries, which can be influenced by factors such as working cultures and the availability of official academic platforms.

The examination of the data reveals a consistent pattern of paper downloads throughout the week, with the highest demand occurring on Fridays and Saturdays, which correspond to the weekends in Egypt. This observation implies that scholars often turn to Sci-Hub during their leisure hours or outside of their typical workdays. This consistent trend aligns with the findings of prior research conducted by Wang et al. (2012), which suggested that researchers frequently extend their work hours and utilize their available free time, including weekends, for engaging in research-related activities. As a result, the heightened download activity during weekends could signify scholars' dedication to advancing their academic endeavors during periods when they have more flexibility and uninterrupted time. It is worth noting that a comparative analysis with download activity patterns in India reveals an interesting contrast. The research conducted by Singh et al. (2021a) demonstrates that Indian scholars exhibit a higher average rate of download requests on

weekdays in comparison to weekends. This discrepancy indicates a potential divergence in the utilization of Sci-Hub between different countries. Factors such as distinct work and study habits, as well as variations in the availability of alternative resources, could contribute to these differing patterns.

The analysis reveals that Cairo governorate emerges as the primary hub for paper downloads from Sci-Hub in Egypt, mainly due to the presence of prestigious educational and research institutions in the city. This pattern aligns with similar observations in other countries such as the United States, Europe (Bohannon, 2016b), India (Singh et al., 2021a), and Russia (Moskovkin et al., 2021). These studies consistently reveal that Sci-Hub usage tends to concentrate in regions with active academic researchers and major urban areas. This phenomenon indicates a global trend where researchers, including those in Egypt, access Sci-Hub more frequently in areas with established research communities, prestigious academic institutions, and research centers. The concentration of Sci-Hub usage in these regions can be attributed to the availability of resources, institutional subscriptions, and well-equipped libraries, which contribute to a higher level of research activity and, consequently, a greater reliance on Sci-Hub for accessing scholarly papers.

The observed preference of Egyptian researchers for downloading journal articles from Sci-Hub, as evidenced by 82.36% of their total downloads, aligns with broader trends in academic research. This trend is not unique to Egypt, as Andročec's, 2017 study similarly identified journal papers as the dominant resource for computer science downloads from Sci-Hub, with conference proceedings and book chapters following. Moreover, Himmelstein et al.'s comprehensive (2018) study reinforced this pattern by revealing that Sci-Hub's extensive collection of 56.3 million articles featured a predominant focus on journal articles, constituting 90.6% of the collection. The consistency across these studies underlines the global reliance on Sci-Hub for accessing scholarly content, particularly emphasizing the pivotal role of journal articles in the research landscape. Researchers, both in Egypt and internationally, appear to prioritize the accessibility of journal articles facilitated by platforms like Sci-Hub, contributing to the broader discourse on open access and scholarly communication.

Egyptian researchers showcase a notable leaning towards accessing recent papers, particularly during the period from 2012 to 2017, showcasing their dedication to staying up-to-date with the latest research findings. This focus on recent publications aligns with similar trends observed in other regions as well. For instance, a study by Singh et al. (2021a) revealed that Indian researchers predominantly downloaded research papers from the period of 2000 to 2016, indicating a shared interest among Indian scholars in accessing current research. Moreover, the pattern of prioritizing recent papers extends beyond Egypt and India. Machin-Mastromatteo et al. (2016) conducted a study focused on Latin America, which found that the majority of downloaded papers in the region were also very recent. This finding further reinforces the notion that scholars from various geographical areas share a common interest in accessing the most up-to-date research literature. The preference for recent papers among scholars worldwide highlights the dynamic nature of scholarly research and the significance of staying current with the latest advancements in their respective fields. Rapid developments and breakthroughs are often published in recent papers, making them crucial resources for researchers to incorporate cutting-edge information into their own work.

The data reveals a significant concentration of academic literature downloads among a select group of prominent publishers by Egyptian researchers from Sci-Hub. Notably, IEEE, Elsevier, Wiley, and Springer stand out as the top players, collectively representing a substantial portion of the downloaded papers. Interestingly, this pattern of preference for

specific publishers is not unique to Egypt, as similar trends have been observed in other regions as well. For instance, in India, researchers heavily rely on IEEE, Springer Nature, Elsevier, and Wiley, accounting for a notable 60% of the total research papers downloaded (Singh et al, 2021a). Similarly, in Latin America, Springer and Wiley Blackwell emerge as the largest academic publishers with significant download numbers (Machin-Mastromatteo et al., 2016). Additionally, in Russia, prominent publishers with high download numbers include Elsevier, Springer Nature, Wiley Blackwell, American Chemical Society, and IEEE (Moskovkin et al., 2021).

The consistency in the list of leading publishers across different countries underscores the global influence and popularity of these publishing houses within Sci-Hub. One of the contributing factors to this phenomenon is the high coverage rates of these publishers on the Sci-Hub platform, as previously reported by Himmelstein et al. (2018). Remarkably, Elsevier boasts an impressive coverage rate of 96.9%, Springer Nature 89.7%, Wiley-Blackwell 94.7%, and IEEE 98.6%. This extensive availability of content on Sci-Hub further reinforces their prominence among scholars. In addition to the high coverage rates mentioned earlier, several other factors contribute to the popularity of these publishers within Sci-Hub. Firstly, they possess extensive journal portfolios that cover diverse subject areas, providing researchers with a wide range of research articles to access. Moreover, these publishers are renowned for their commitment to publishing high-quality research, making their content highly sought after by scholars seeking reliable and reputable sources.

The analysis of the top 10 most downloaded papers by Egyptian researchers shows a robust interest in diverse subjects, spanning various sources like journal articles, conference papers, book chapters, and books. The broad range of disciplines covered, including engineering, medicine, and physics, reflects the scholars' curiosity and multidisciplinary approach to research. Their appreciation for both contemporary and older research demonstrates a desire to explore knowledge from different time periods.

Egyptian researchers have accessed journal articles from a diverse range of 18,216 journals. Notably, the "Journal of the American Chemical Society" and the "Journal of Applied Physics" are among the most popular choices, indicating a significant focus on chemical and applied physics research among Egyptian researchers. Interestingly, a study revealed that Indian researchers also share a preference for these same top journals, suggesting common research interests between the two countries (Singh et al., 2021a). One of the reasons behind this widespread use of certain journals is the high coverage rates offered by Sci-Hub, a platform that provides access to prestigious journals, as highlighted in a study by Himmelstein et al. (2018). This further emphasizes the importance of Sci-Hub in facilitating access to scholarly literature for researchers, including Egyptian researchers who heavily rely on it to access articles from reputable journals.

The top 10 most downloaded conferences and book series by Egyptian researchers on Sci-Hub reveal a diverse research landscape across disciplines like power and energy, antennas, vehicular technology, and healthcare. Spanning various coverage years, these resources enable researchers to explore historical developments and track emerging trends, fostering collaborative efforts and knowledge exchange among scholars with shared interdisciplinary interests.

The analysis of downloaded papers accessibility through the EKB reveals significant disparities in accessing scholarly content. Among the top 10 downloaded journal articles, only three are accessible via the EKB, indicating a notable gap. A similar trend is observed in conference papers, where just one out of the top 10 downloaded papers holds EKB access. This suggests a lack of comprehensive coverage for high-demand materials. A broader view reveals that 62.84% of 1604 examined journals are EKB-accessible, with

Science Direct, Wiley, and Springer being the dominant accessible publishers. However, 37.16% of journals remain beyond EKB's reach. When analyzing 1420 conference papers, a substantial 87.39% of those downloaded from Sci-Hub lack EKB access. In contrast, only 12.61% of conference papers offer EKB accessibility. Consequently, Egyptian researchers heavily rely on Sci-Hub as an alternative source to access these papers. This issue raises a red flag regarding the availability of essential research materials through official channels, emphasizing the need for the EKB to improve its collection and accessibility of journal articles and conference literature. Addressing this challenge would ensure that scholars have proper access to high-quality research and support the advancement of knowledge across various fields.

Interestingly, despite the availability of a wide range of journals through EKB, a significant number of Egyptian researchers still prefer using Sci-Hub to download journal articles. This preference is not limited to geographic regions and has been observed among individuals even at universities in the United States and Europe with library access to journals (Bohannon, 2016b). Convenience plays a pivotal role in this choice, as users find Sci-Hub a convenient one-stop destination to retrieve articles, regardless of whether they are available through open-access journals (Andročec, 2017). Moreover, other factors contributing to the preference for Sci-Hub include a lack of awareness regarding library services and time constraints that hinder physical visits to the library (Pastor-Ramon et al., 2023). These factors significantly influence researchers' decisions to rely on Sci-Hub as a quick and easily accessible resource.

The word cloud analysis of highly downloaded papers by Egyptian researchers offers a snapshot of diverse and multidisciplinary research interests. Key themes include a strong emphasis on systemic and established frameworks in energy-related domains, reflected in terms like "systems," "based," "power," and "energy." Medical and healthcare research emerges prominently, with a focus on treatments, diseases, and cancer-related studies. Active engagement in communication technologies is evident through terms like "networks" and "5g," showcasing researchers' involvement in wireless communication and technology challenges. Nanotechnology and material science themes, including "nanoparticles" and "synthesis," highlight a focus on innovative solutions, particularly in drug delivery and cancer research. The analysis suggests a dynamic research landscape with potential for impactful and collaborative endeavors in various fields.

Conclusions

In this comprehensive bibliometric analysis of Sci-Hub downloads by Egyptian researchers in 2017, distinctive trends emerged, revealing unique usage patterns. The researchers downloaded 1,357,526 papers, with peak activity during non-working hours, particularly at night, and heightened demand on weekends, indicating a commitment to research during leisure hours. Cairo governorate stood out as a focal point for downloads, aligning with global trends in regions with established research communities. Researchers exhibited a strong preference for journal articles, constituting 82.36% of total downloads, reflecting a global emphasis on the significance of journals in scholarly work. The commitment to accessing recent papers mirrored international trends among scholars. Key publishers like IEEE, Elsevier, Wiley, and Springer dominated downloads, highlighting their global influence within the Sci-Hub platform. The top 10 downloaded papers showcased a diverse research landscape, spanning engineering, medicine, and physics, indicative of scholars'

multidisciplinary approach. Despite the availability of journals through the official EKB, the persistent preference for Sci-Hub underscores ongoing challenges in ensuring proper access to essential research materials. Further investigation is needed to understand the reasons behind this preference. The word cloud analysis depicted collaborative research interests across various domains, emphasizing the potential for impactful interdisciplinary research endeavors in Egypt. Overall, the study contributes valuable insights into Sci-Hub usage patterns in Egypt and underscores the need to address challenges in ensuring access to high-quality research materials through official channels.

Limitations

The study faces a significant limitation due to reliance on Sci-Hub's 2017 download log file, introducing a temporal constraint. Although the dataset captures usage patterns for that year comprehensively, the dynamic nature of academic research and evolving open-access platforms suggest potential variations over time. Consequently, caution is advised in interpreting findings, highlighting the imperative of incorporating more recent data. This temporal limitation may impact the accuracy of subscription suggestions based on the study, urging researchers and stakeholders to exercise prudence in decision-making.

Future research

In this section, the study provides future research directions, addressing aspects not covered in current research but highlighted by previous literatures. First and foremost, the literature highlights variations in gold–green and black open access for research output (Singh et al., 2020). To enhance comprehension of scholarly communication in Egypt, it is crucial to explore these variations within the context of Egyptian research. A second avenue of exploration, identified in previous studies, centers on the impact of Sci-Hub on increasing the visibility of research papers (Singh et al., 2021b). Building upon this, investigating Sci-Hub's impact on Egyptian research paper visibility is crucial. Lastly, an unexplored dimension in current research pertains to the use and perception of researchers toward Sci-Hub and institutional platforms (Mejia et al., 2017; Pastor-Ramon et al., 2023). Focusing on Egyptian researchers, future work could delve into their attitudes and practices concerning Sci-Hub and the EKB. Such an inquiry holds the potential to offer valuable insights into the scholarly information-seeking behaviors within the Egyptian academic community, contributing to a comprehensive understanding of the academic landscape in the country.

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Author contributions IRO conceptualized and designed the study, collected, and analyzed the bibliometric data from Sci-Hub, and interpreted the results in the context of Egyptian scholarly activity. HAHA assisted in collecting data, refining the research methodology, and contributed to the discussion of implications. Both authors collaborated closely in drafting and revising the manuscript.

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Declarations

Conflict of interest The authors declare that there is no conflict of interest associated with this research study.

References

Andročec, D. (2017). Analysis of Sci-Hub downloads of computer science papers. *Acta Universitatis Sapientiae, Informatica, 9*(1), 83–96. https://doi.org/10.1515/ausi-2017-0006

Bohannon, J. (2016a). The frustrated science student behind Sci-Hub. *Science*. https://doi.org/10.1126/science.352.6285.511

Bohannon, J. (2016b). Who's downloading pirated papers? Everyone. *Science, 352*(6285), 508–512. https://doi.org/10.1126/science.352.6285.508

Bosman, J., & Kramer, B. (2018). Open access levels: A quantitative exploration using of Science and data. *PeerJ Preprints, 6*, e3520v1. https://doi.org/10.7287/peerj.preprints.3520v1

Buehling, K., Geissler, M., & Strecker., D. (2022). Free access to scientific literature and its influence on the publishing activity in developing countries: The effect of Sci-Hub in the field of mathematics. *Journal of the Association for Information Science and Technology, 73*(9), 1336–1355. https://doi.org/10.1002/asi.24636

Elbakyan, A. (2018, Jan 18). *Sci-Hub download log of 2017*. Retrieved April 21, 2023, from Zenodo: https://zenodo.org/record/1158301

Elbakyan, A., & Bozkurt, A. (2021). A critical conversation with Alexandra Elbakyan: Is she the Pirate Queen, Robin Hood, a Scholarly Activist, or a Butterfly Flapping its Wings? *Asian Journal of Distance Education, 16*(1), 111–118.

Galina, C. S., Martínez, J. F., & Murphy, B. D. (2023). Constraints on research in biological and agricultural science in developing countries: The example of Latin America. *Publications, 11*(22), 22. https://doi.org/10.3390/publications11020022

Gardner, G. J., McLaughlin, S. R., & Asher, A. D. (2017). Shadow libraries and you: Sci-Hub usage and the future of ILL. *ACRL 18th National Conference, "At the Helm"*. Baltimore, Maryland: ACRL. Retrieved June 5, 2023, from https://alair.ala.org/handle/11213/17772

Geng, Y., Cao, R., Han, X., Tian, W., Zhang, G., & Wang, X. (2022). Scientists are working overtime: When do scientists download scientific papers? *Scientometrics, 127*(11), 6413–6429. https://doi.org/10.1007/s11192-022-04524-1

Greshake, B. (2017). Looking into Pandora's Box: The content of Sci-Hub and its usage. *Research*. https://doi.org/10.12688/f1000research.11366.1

Himmelstein, D. S., Romero, A. R., Levernier, J. G., Munro, T. A., McLaughlin, S. R., Greshake Tzovaras, B., & Greene, C. S. (2018). Sci-Hub provides access to nearly all scholarly literature. *eLife, 7*, e32822. https://doi.org/10.7554/eLife.32822

Kornienko, V. Y. (2020). Analysis of requests for journals Nature Food and npj Science of Food by the data of the SCI-HUB service for the first half of 2020. *Теория и практика переработки мяса, 5*(2), 35–38. doi:https://doi.org/10.21323/2414-438X-2020-5-4-35-38

Machin-Mastromatteo, J. D., Uribe-Tirado, A., & Romero-Ortiz, M. E. (2016). Piracy of scientific papers in Latin America: An analysis of Sci-Hub usage data. *Information Development, 32*(5), 1806–1814. https://doi.org/10.1177/0266666916671080

Mejia, C. R., Valladares-Garrido, M. J., Miñan-Tapia, A., Serrano, F. T., Tobler-Gómez, L. E., Pereda-Castro, W., . . . Valladares-Garrido, D. (2017). se, knowledge, and perception of the scientific contribution of Sci-Hub in medical students: Study in six countries in Latin America. *PloS one, 12*(10), e0185673. doi: https://doi.org/10.1371/journal.pone.0185673

Mekonnen, A., Downs, C., Effiom, E. O., Kibaja, M., Lawes, M. J., Omeja, P., . . . Chapman, C. A. (2022). Can I afford to publish? A dilemma for African scholars. *Ecology letters, 4*, 711–715. doi: https://doi.org/10.1111/ele.13949

Moskovkin, V. M., Gakhova, N. N., & Nabokov, A. Y. (2021). Downloading articles by Russian researchers using the Sci-Hub resource. *Scientific and Technical Information Processing, 48*(3), 159–167. https://doi.org/10.3103/S0147688221030059

Owens, B. (2022). Sci-Hub downloads show countries where pirate paper site is most used. *Nature*. https://doi.org/10.1038/d41586-022-00556-y

Pastor-Ramon, E., Aguirre, O., García-Puente, M., María Morán, J., & Herrera-Peco, I. (2023). Sci-Hub use among Spanish researchers: Enemy or a learning opportunity for libraries? *Journal of Information Science*. https://doi.org/10.1177/01655515221142432

Research4Life. (2023). *The five Research4Life content collections*. Retrieved June 13, 2023, from https://www.research4life.org/about/programs/

Sci-Hub. (2023). *Sci-Hub - about*. Retrieved June 6, 2023, from https://sci-hub.se/about

Singh, V. K., Piryani, R., & Srichandan, S. (2020). The case of significant variations in gold–green and black open access: Evidence from Indian research output. *Scientometrics, 124*, 515–531. https://doi.org/10.1007/s11192-020-03472-y

Singh, V. K., Srichandan, S. S., & Bhattacharya, S. (2021a). Is Sci-Hub Increasing Visibility of Indian Research Papers? An analytical evaluation. *Journal of Scientometric Research, 10*(1), 130–134. https://doi.org/10.5530/jscires.10.1.16

Singh, V. K., Srichandan, S. S., & Bhattacharya, S. (2021b). What do Indian Researchers Download from Sci-Hub? An analytical introspection. *Journal of Scientometric Research, 10*(2), 259–264. https://doi.org/10.5530/jscires.10.2.40

Suber, P. (2012, Feb 9). *Timeline of the Open Access Movement*. Retrieved June 4, 2023, from https://dash.harvard.edu/bitstream/handle/1/4724185/suber_timeline.htm

Till, B. M., Rudolfson, N., Saluja, S., Gnanaraj, J., Samad, L., Ljungman, D., & Shrime, M. (2019). Who is pirating medical literature? A bibliometric review of 28 million Sci-Hub downloads. *The Lancet Global Health, 7*(1), e30–e31. https://doi.org/10.1016/S2214-109X(18)30388-7

Wang, X., Xu, S., Peng, L., Wang, Z., Wang, C., Zhang, C., & Wang, X. (2012). Exploring scientists' working timetable: Do scientists often work overtime? *Journal of Informetrics, 6*(4), 655–660. https://doi.org/10.1016/j.joi.2012.07.003