MAPPING THE CYBER SECURITY RESEARCH HORIZON IN INDIA: AN IN-DEPTH ANALYSIS OF CURRENT TRENDS AND GLOBAL PERSPECTIVES

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Abstract
This article presents a comprehensive overview of current trends in cybersecurity research. The authors have collected the required data from the Scopus database to analyse the cyber security research and explore individual institutions' websites for relevant information on cyber security education and jobs. Drawing on a thorough examination of recent studies and developments, the paper delves into the evolving landscape of cybersecurity concerns within the Indian context. The article also ascertain the prevailing status of cybersecurity research trends both in India and globally, this study analyze the contributions of top researchers from India and around the world, assess the leading ten countries involved in cybersecurity research, investigate collaborative efforts in cybersecurity research involving India. This article serves as a valuable resource for gaining insights into the intricate and dynamic realm of cybersecurity in India.

Keywords:
Cybersecurity; Cyber threats; Network Security; Financial Security; National Security; Research Trends; Scopus

Introduction

The Internet is one of the most significant twentieth-century inventions that have had a huge impact on our lives. Today, the internet has enabled us to break down all barriers and adopt a new way of communication through which we can interact with each other within a second. Due to this innovation, people's perceptions have been changing. Now, we fully depend on the Internet and its services to perform our daily activities. The global community is becoming more and more interconnected. India's rapid digitization has transformed the nation's economy and society, offering countless benefits, but it has also made the country more susceptible to cyber threats. As the world increasingly relies on the digital realm, the importance of cybersecurity in India cannot be overstated.

On July 1, 2015, Hon' Prime Minister Shri Narendra Modi started the Digital India flagship programme. The main aim of this flagship programme is to transform India into a digitally enabled society and knowledge economy (https://csc.gov.in/digitalIndia).Under the Digital India programme, nine growth pillars have been identified by the Government of India and multiple ministries and departments. Cybersecurity is becoming more and more crucial in the digital world. The majority of work is now completed with the assistance of digital resources. There have been numerous situations in which customers'/clients' personal information has been disclosed. Keeping in mind that a number of sectors are attempting to maintain their customer confidence by implementing strong cyber security systems at the organizational level. As a result, cyber security is critical to protecting digital assets from the potentially disastrous repercussions of a breach of security.

Literature Review

The evolution of cybersecurity serves as a defensive mechanism, safeguarding cyberspace against attacks, damage, misuse, and economic espionage. In the era of rapid digital transformation, the

significance of cybersecurity is becoming one of the prime concerns of every nation. Cybersecurity concerns have grown steadily as information technology (IT) has evolved.

Elango et al (2023) employed scientometric tools to map cybersecurity research publications in India. The research aimed to identify and characterize the work of Indian (co)authors, leveraging the Scopus database. Key areas of focus included yearly trends, top authors and institutions, collaborating countries, preferred sources, and the most cited publications. By utilizing MS-Excel, Bibliometrix R Package, VOSviewer, and UCINET, the study delved into conceptual and social structures. Notably, India ranked fourth globally, experiencing a substantial uptick in publications. Over the last three years, approximately 70% of papers published, predominantly in the form of conference papers

Loan, Bisma and Nahida (2022) carried out a scientometric analysis of cyber security literature indexed in the core collection of the Web of Science for a period of ten years (2011–2020). During the study period, cybersecurity research exhibited a rising trend, peaking in 2020 with 1,581 publications, a 715% increase from 2011 (221). Ninety-three countries globally contributed, with the USA leading (23.55%), followed by China (23.24%), South Korea (5.31%), UK (5.28%), and India (4.25%).

Dhawan, Gupta and Elango (2020) conducted a scientometric study on global cyber security research output from 1998–2019. During the 22-year span, cyber security research demonstrated a substantial 46.41% growth, averaging 5.05 citations per paper. Approximately 15% of papers received external funding. The top 10 countries contributed significantly, representing 76.52% of the subject's output, with the United States leading at 43.75% global productivity.

Rai, Singh & Varma (2019) analyzed 2720 cyber security documents from 2001-2018, retrieved from Scopus and observed that the USA led in publications and funding. India ranked fourth in contributions but lacked substantial funding. Collaboration in cybersecurity research had grown, emphasizing the need for strategic planning in Indian defence. The study underscored the importance of past preventive measures backed by continuous research for an effective defence strategy in cyberspace.

Abbas et al. (2019) invstigated the research that delved into the utilization of artificial intelligence in cybersecurity. The investigation visualized shifts in structure, identified focal points, and highlighted emerging trends within AI studies. To evaluate hotspots and trends, five assessment criteria were employed, and a heat map was utilized to pinpoint global regions contributing to research on AI applications in cybersecurity.

Objectives of the study

The following objectives are given below:

1. To identify the current status of cyber security research trends in India and around the world;
2. To identify top cyber security researchers from India vs global;
3. To find out top ten countries and their collaboration;
4. To find out India's cyber security research collaborations;
5. To find out word cloud of some prominent keywords;
6. To find out Top ten research papers based on their citations;

Methodology

Researchers have collected the required data from the Scopus database to analyse the cyber security research trends in India and compare it with the global level. The Scopus is an internationally recognized multidisciplinary bibliographic database. It is the primary database for conducting this present study. The process of research is given below in the fig.1. Information regarding cybersecurity job opportunities was obtained from analysing websites of a few reputed institutions.

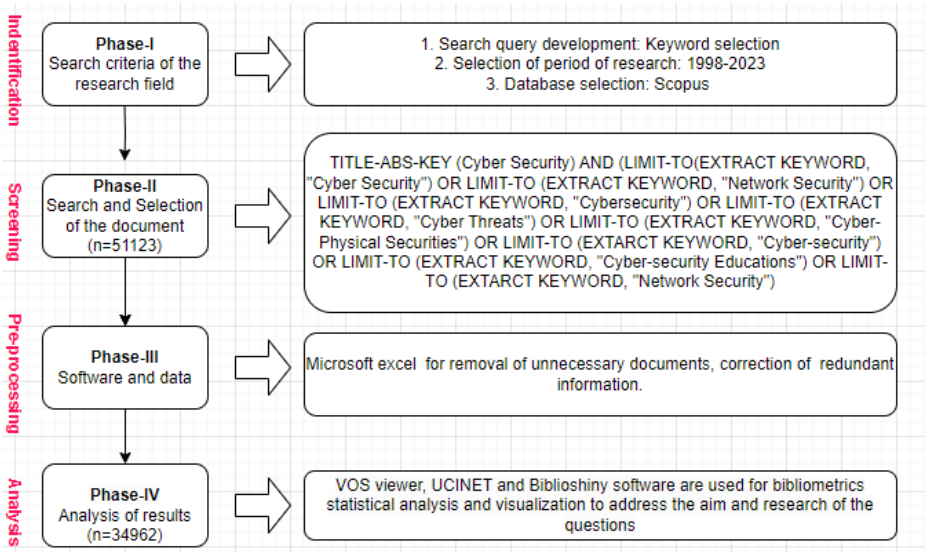

Fig.1: Step-by-step research process

Cyber security research trends

Figure 2 shows the number of cyber security research publications in India and in the rest of the world from 2014-2023. The graph shows that the number of cyber security research publications in India has increased steadily over the past decade, from 32 in 2014 to 1,048 in 2023. Global cybersecurity research also rose, but at a slower pace. In 2023, there will be 5,459 cybersecurity research publications worldwide. The growth of cybersecurity research community in India is likely due to several factors such as increasing digitization of Indian economy and society, increasing threat of cyber-attacks from domestic and international actors, money increasing investment in cyber security and education and training in India. The growth of the cybersecurity research community in India is a positive one. It will also help India defend against cyber-attacks and develop new cyber security technologies and solutions.

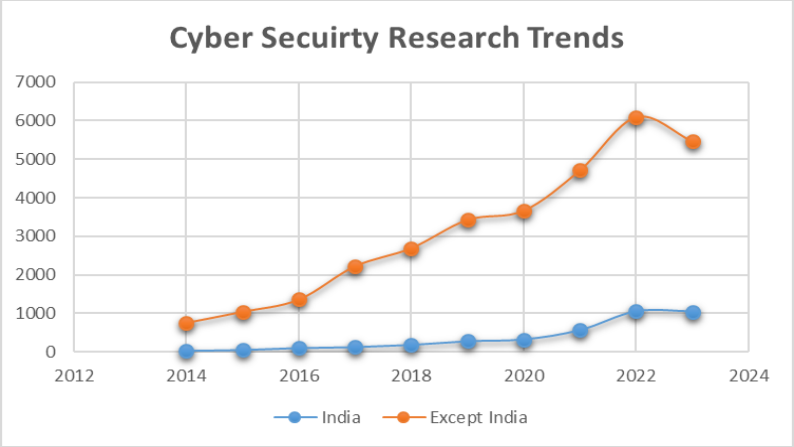

Fig. 2: Cyber security research trends

Top cyber security researchers India Vs Global

Table 1 illustrates the leading authors in the field of cybersecurity research, both within India and globally. In the Indian context, Gupta, B.B. stands out as the foremost author, affiliated with NIT Kurukshetra, contributing significantly with 36 publications, 942 citations, and an impressive h-Index of 14. Followed by Soman, K.P. from Amrita Vishwa Vidyapeetham, Coimbatore, securing the second position with 22 publications, 1795 citations, and an h-Index of 11. On the global stage, Zhu, Q. from New York University, New York, United States, emerges as the preeminent author in cybersecurity research, with 65 publications, 1158 citations, and an exceptional h-Index of 22. Followed by Govindarasu, M. from Iowa State University, Ames, United States, occupying the second position with 50 publications, 1555 citations, and an h-Index of 15. This comprehensive overview illustrates the impressive contributions of these distinguished authors and provides insights into their scholarly impact nationally and internationally.

Table-1: Cyber security researcher India Vs Global

India					Global				
Author Name	NP	Organization	Citation	h-index	Author Name	NP	Organization	Citation	h-index
Gupta, B.B.	36	NIT Kurukshetra	942	14	Zhu, Q.	65	New York University, New York, United States	1158	22
Soman, K.	22	Amrita Vishwa Vidyapeetham, Coimbatore	1795	11	Govindarasu, M.	50	Lowa State University, Ames, United States	1555	15
Kumar, N.	20	Shri Ramswaroop Memorial University, Barabanki, India	694	13	Kotenko, I.	50	St. Petersburg Federal Research Center of the Russian Academy of Sciences, Saint Petersburg, Russian Federation	348	12
Panigrahi, B.K.	19	IIT Delhi	298	8	Choo, K.K.R.	49	The University of Texas at San Antonio, San Antonio, United States	1677	18
Das, A.K.	18	IIIT Hyderabad	480	9	Kozik, R.	49	Bydgoszcz University of Science and Technology, Bydgoszcz, Poland	521	13

Janet, B.	16	National Institute of Technology	145	7	Bou-Harb, E.	46	The University of Texas at San Antonio, San Antonio, United States	1237	15
Shukla, S.	15	IIT Kanpur	34	3	Shetty, S.	44	Old Dominion University, Norfolk, United States	325	10

Top ten countries based on the number of publications

Table-2 demonstrates the leading countries and their research contribution globally. Among the top ten most productive countries, the United States leads in international research (Dhawan, Gupta & Elango, 2020). The United States ranks highest with 9735 documents and 135713 citations, followed by China with 4066 documents and 49414 citations. India holds the third position with 3840 documents and 24762 citations. Subsequently, the United Kingdom, Australia, Italy, Canada, Germany, Saudi Arabia, and South Korea followed. Given India's considerable population and the increasing use of smartphones, there is a pressing need for research in cybersecurity. Therefore, it is imperative for Indian researchers to engage in extensive research and development efforts to contribute substantively to the nation's progress.

Table: 2 Top ten countries based on the number of publications

Rank	Country	Documents	Citations
1	United States	9735	135713
2	China	4066	49414
3	India	3840	24762
4	United Kingdom	2451	32205
5	Australia	1343	30642
6	Italy	1243	14200
7	Canada	1082	18276
8	Germany	1076	7958
9	Saudi Arabia	1003	10455
10	South Korea	889	12822

Global research trends in cyber security

Cybersecurity is an ever-evolving field, and global trends in cybersecurity continue to evolve with the emergence of new threats and technologies. A robust network of collaboration has emerged among countries involved in this research domain. At least 150 countries contributed at least one article to the

body of knowledge, while 126 countries boast a minimum of five published articles. Figure 3, generated using VOSviewer software, depicts the density visualization of the country network, revealing the largest interconnected set comprising 126 countries. The size of the circles and the font size correspond to the relative importance of each country within the collaboration network. The United States of America, China and India are the most prominent countries in the field of "Cyber Security". The United States has the most publications with 9735 documents with most citations 135713, followed by China with 4066 documents with 49414 citations, and India 3840 documents and 24762 citations. Table 1 shows the top 10 countries based on the number of publications. The next countries are the United Kingdom (2451 publications), Australia (1343 publications), Italy (1243 publications), Canada (1082 publications), Germany (1076 publications), Saudi Arabia (1003 publications), and South Korea (889 publications).

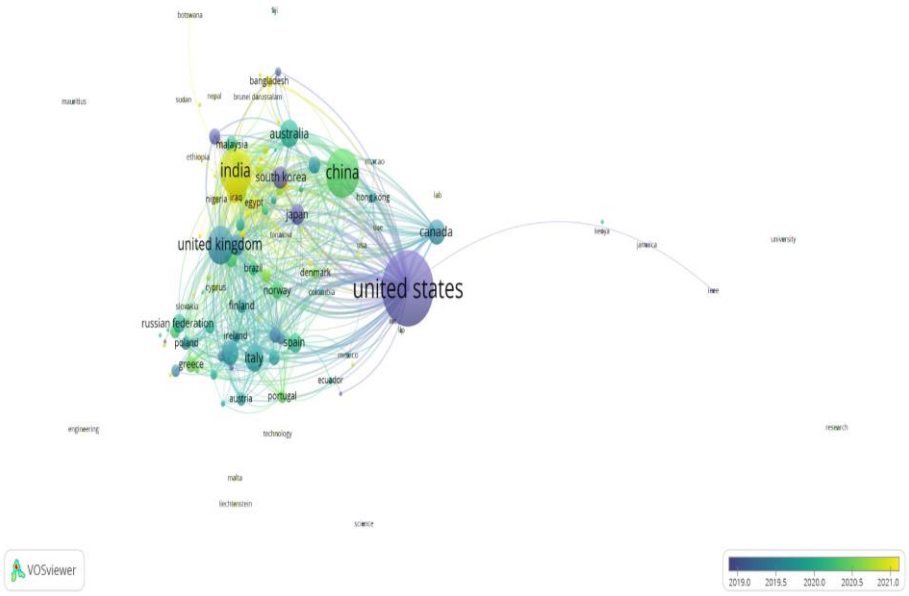

Fig: 3: Global trends in Cyber security

India's cyber security research collaboration with other Countries at Global level

The figure illustrates the leading contributors to research papers of India collaborating with other countries. The United States ranks highest in the number of documents collaborated with India with 217 documents followed by the United Kingdom with 141 documents. Australia holds the third highest number of documents with 66. Subsequently, China, Taiwan, Malaysia, United Arab Emirates, South Korea etc. followed. Countries Bermuda, Cameroon, Colombia, Cyprus, Ecuador, Faroe Islands, and Iceland are the countries with the least number of collaborations in cyber security research over the period.

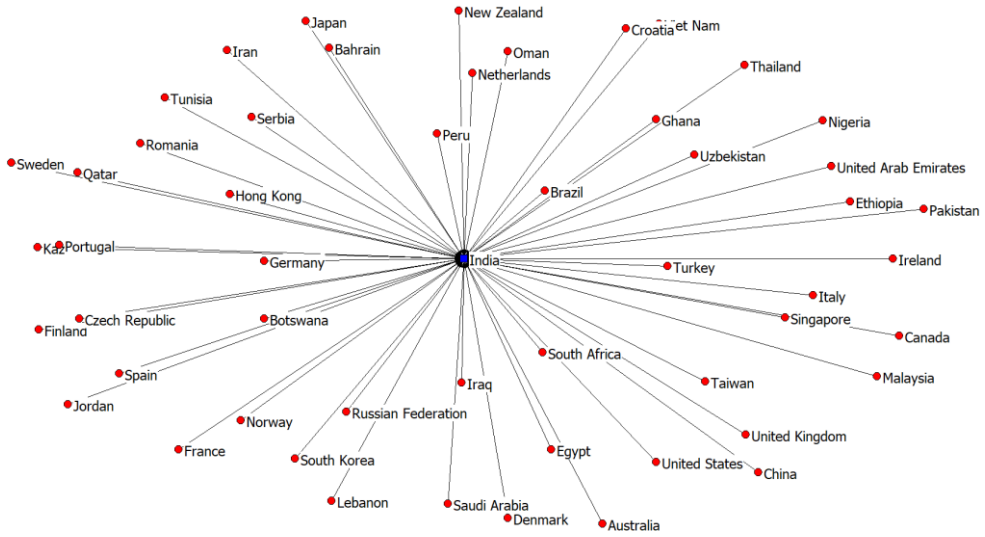

Fig 4: India's cyber security research collaboration with other Countries at Global level

Top ten research papers based on their citations

Table 3 shows the highly cited research on diverse cybersecurity topics. Table 3 also presents the most referenced publications according to Scopus (Parida, Singh & Nayak, 2022). The most cited article "The internet of things for health care: A comprehensive survey" authored by Islam S.M.R. [et al.] published in 2015 has the highest number of citations 2025 followed by "A Survey of Data Mining and Machine Learning Methods for Cyber Security Intrusion Detection" by Buczak A.L.; Guven E. published in 2016 has 1791 citations and "Attack detection and identification in cyber-physical systems" authored by Pasqualetti F.; Dorfler F.; Bullo F. published in 2013 has 1546citations.

Table 3: Top ten research papers based on their citations

S.N.	Authors	Title	Year	Bibliographic Details	Document Type	Citations
1	Islam S.M.R. [et al.]	The internet of things for health care: A comprehensive survey	2015	IEEE Access, 3, 10.1109/ACCESS.2015.2437951	Article	2025
2	Buczak A.L.; Guven E.	A Survey of Data Mining and Machine Learning Methods for Cyber Security Intrusion Detection	2016	IEEE Communications Surveys and Tutorials, 18,2, 10.1109/COMST.2015.2494502	Article	1791
3	Pasqualetti F.; Dorfler F.; Bullo F.	Attack detection and identification in cyber-physical systems	2013	IEEE Transactions on Automatic Control, 58,11, 10.1109/TAC.2013.2266831	Article	1546
4	Kolias C. [et al.]	DDoS in the IoT: Mirai and other botnets	2017	Computer, 50,7,10.1109/MC.2017.201	Article	1276
5	Yan Y. [et al.]	A survey on smart grid communication infrastructures: Motivations, requirements and challenges	2013	IEEE Communications Surveys and Tutorials, 15,1, 10.1109/SURV.2012.021312.00034	Review	994
6	Sridhar S.; Hahn A.; Govindarasu M.	Cyber-physical system security for	2012	Proceedings of the IEEE,100,1, 10.1109/JPROC.2011.2165269	Article	895

		the electric power grid				
7	You X. [et al.]	Towards 6G wireless communication networks: vision, enabling technologies, and new paradigm shifts	2021	Science China Information Sciences, 64,1, 10.1007/s11432-020-2955-6	Review	864
8	Mo Y. [et al.]	Cyber-physical security of a smart grid infrastructure	2012	Proceedings of the IEEE, 100,1, 10.1109/JPROC.2011.2161428	Article	852
9	Staniford S.; Paxson V.; Weaver N.	How to 0wn the internet in your spare time	2002	Proceedings of the 11th USENIX Security Symposium	Conference paper	843
10	Vinayakumar R. [et al.]	Deep Learning Approach for Intelligent Intrusion Detection System	2019	IEEE Access,7, 10.1109/ACCESS.2019.2895334	Article	835

Conclusion

The cybersecurity research scenario in India has provided a comprehensive understanding of the current trends and global perspectives. As we navigate the complex web of cyber threats and vulnerabilities, it is clear that India is emerging as a key player in meeting the challenges of the rapidly evolving digital landscape. As the digital landscape evolves, so do the threats hidden within it. The study showed the multifaceted nature of cybersecurity research in India, highlighting a vibrant ecosystem of innovation, collaboration and adaptability. Researchers, practitioners, and policymakers alike are actively engaged in pioneering projects to enhance the nation's cyber resilience. Concerted efforts to bridge the gap between academia, industry and government have created a synergy that keeps India at the forefront of global cybersecurity development. The global perspective emphasizes the connections between cybersecurity challenges and solutions. In a world where digital borders are blurred, cooperation between countries is paramount. India, with its growing awareness and commitment to cybersecurity, is poised to play a key role in international efforts to strengthen the digital sector against emerging threats.

Looking ahead, it is clear that cybersecurity research in India is dynamic and growing. The trends highlighted in this study serve as a guiding pillar for future efforts, identifying areas that require further research and investment As technology advances, our approach to the cybersecurity assessment is also proactive and forward-thinking. Essentially, this in-depth study not only serves as a snapshot of the current state of cybersecurity research in India but also charts the course for the journey ahead. By embracing innovation, promoting collaboration and evolving the global mindset, India is poised to carve out a unique niche in the cybersecurity sector. The challenges may be daunting, but with strategic infrastructure and a shared commitment to excellence, India is well-positioned to shape the future of

cybersecurity globally. By working together, staying informed and staying vigilant, we can strengthen our defences and help create a more secure and robust digital future.

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