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Research Article

Author Productivity and Lotka's Law in Nursing Research Output as Mirrored in the Nursing Journal of India, 2010-2024

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ABSTRACT

Lotka's law is one of the empirical laws in bibliometric research. Present study analysis 661 research articles (excluding 3 Hindi versions) from 15 volumes (2010-2024) of the Nursing Journal of India which were produced by 1412 authors. The study highlights trends in research output distribution, authorship patterns, collaboration degrees, collaborative indices, year wise author productivity, and identifies leading contributors. In 2015, 47 papers were produced by 80 authors, which resulted in the highest author productivity at 0.58 papers per author. Overall productivity per author for the entire period is calculated at 0.47, with a total author productivity 1412 for 661 outputs, reflecting a healthy contribution of authors throughout the years. The highest number of papers belongs to single-authored, with a total of 321 papers produced by 321 individual authors. There are 1411 personal authors and 1 corporate author. Among leading collaborators, Latha Venkatesan emerged as the most prolific author, having published 11 papers during the period. In all, DC and CI for the data set of this study come out to be 0.5143 and 2.1361 respectively. This study examines validation of Lotka's Law considering author productivity for the data set in nursing research output. It explores variations in Lotka's Law using the Lotka's exponent value of n=3.4 (calculated through Sen's method) and n=2 (for the ideal case, as per Lotka's method). A significant gap was observed between the expected [Y(E)] and observed values [Y(O)] with n=2, showing that the difference of 1.4 between the two values indicates a noticeable divergence. The analysis concludes that Lotka's Law holds with an exponent of n=3.4 in nursing, contrasting with the lower exponent of n=2 used in exact sciences. This suggests that nursing research has fewer authors contributing multiple articles, which leads to a higher n value compared to the exact sciences. Thus, the observed distance highlights that Lotka's Law does not align well with the nursing literature for this dataset when applying n=2 (the ideal value according to Lotka).

Keywords: Author productivity, Bibliometric study, Lotka's exponent, Lotka's Law, Nursing research, Sen's calculation method, The Nursing Journal of India (NJI), Trained Nurses' Association of India (TNAI).

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INTRODUCTION

Nursing is a highly respected and esteemed profession, playing a crucial role in the healthcare system. It is a dynamic and vital field that focuses on patient care, clinical skills, and compassionate service. In the past, professional nursing training did not exist in India, and the profession was not widely recognized or valued by society. Nurses, particularly women in the field, did not receive the dignity or social status they deserved. Today, however, nursing education and research have reached new heights, securing a prominent place in healthcare and education worldwide. Both theoretical and practical knowledge are emphasized in nursing education to prepare skilled professionals.

Author Productivity

Generally, author productivity is counted as: *total number of papers divided by total number of authors.* For example, there are 300 papers contributed by 500 authors. Author productivity=300/500=0.75, a fractional authorship. In case of Lotka's Law, for collaborative papers, Lotka gave one credit to all the authors. He did not think of fractional authorship. From above example, the author productivity is to be considered as 500 as per Lotka's Law (Sen, 2010).

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Lotka's Law

Alfred J. Lotka was a mathematician, and supervisor of mathematical research in the Statistical Bureau of the Metropolitan Life Insurance Company from 1942 to 1933. It was during the time, 1926, that his definitive work, later called Lotka's Law, was produced. His investigation was a productivity analysis. Lotka's work on an frequency distributions of scientific productivity presented an analysis of the number of publications listed in Chemical Abstracts from 1907 to 1916 with the frequency of publications of the authors. His general formula was developed to observe the relation between the frequency Y of persons making X contributions as "X^n Y=constant." Finding the value of the constant from his study when *n*=2, he observed that "the number of persons making 2 contributions is about one-fourth of those making one; the number making 3 contributions is about one -ninth, etc.; the number making n contributions is about $1/n^2$ of those making one, and the proportion, of all contributions, that make a single contribution, is about 60%" (Hertzel, n.d.). It means that out of all the authors in a given field, 60% will have just one publication and 15% will have two publications (i.e.$1/2^2$ x 60). 7% authors will have three publications (i.e. $1/3^2$ x 60), and so on (Lotka, 1926; Dutta, 2019; Tunga, 2020; Kumar, 2010). Lotka's Law can be expressed as:

$$X^n Y=C$$

$$\text{Or } Y=C/X^2, \text{ when } n = 2\text{-------- [Eqn. 1]}$$

Where,

X stands for the contributions and n is exponent that is constant for a given data,

Y stands for the number of authors, and

C is constant.

Nursing Research in India

Nursing research in India has evolved significantly over the years, building on the foundation of international developments in the field, particularly those initiated by Florence Nightingale in the mid-1800s. Nightingale's contributions, especially her pioneering work during the Crimean War and her 1859 publication Notes on Nursing: What it is and What it is Not, laid the groundwork for the scientific approach to nursing. These efforts were instrumental in shaping nursing education, practice, and administration across the world. In India, the role of the Trained Nurses' Association of India (TNAI) has been central to the advancement of nursing research. TNAI's initiatives, including the launch of The Nursing Journal of India in 1910, have provided a platform for the dissemination of research findings. The establishment of the *Central Institute of Nursing and Research* in Greater Noida in 2009 further strengthened the focus on research and development in the nursing field. This institution plays a critical role in advancing nursing education and research within India. The growth of nursing education in India has been marked by significant milestones. The Auxiliary Nurse Midwife (ANM) program, introduced in the 1950s, focused on maternal health, laying the foundation for nursing in the country. The *four-year B.Sc. Nursing* program was introduced in 1946 at institutions like RAK College of Nursing, Delhi, and CMS College of Nursing, Vellore. By 1960, the *M.Sc. Nursing* program was established at RAK College of Nursing, and by the 1980s, advanced courses such as the *M. Phil* in nursing were also introduced. Notably, *Dr. Edith Buchanan*, the first Indian nurse to receive a *Ph.D. in Nursing*, did so from *Columbia University* in 1953, marking a historical moment for the profession in India. The Ph.D. in Nursing program was later initiated in India at PGIMER, Chandigarh, in 1985, with Ms. Jogindravati Gupta being the first recipient (JaypeeDigital.com, n.d.; Sharma, *et al*., 2021; TNAIOnline, n.d.; Venkatesan *et al*., 2023). These milestones reflect the growing importance of research and education in advancing the nursing profession in India, ultimately contributing to better healthcare outcomes and an enhanced understanding of nursing practice and education.

The Nursing Journal of India (NJI)

The Nursing Journal of India (NJI), published by the Trained Nurses' Association of India (TNAI), holds a significant place in the history of nursing literature in India, with over a century-long legacy. First published in 1910 as a monthly periodical, it later transitioned to a bi-monthly publication, available in February, April, June, August, October, and December each year. The journal carries the ISSN 009-6503 and continues to serve as a key platform for nursing-related knowledge dissemination. As of 2023, the impact factor of the NJI is 0.037, and it boasts an h-index of 7 and a g-index of 10, as per data from Exaly.com. (Exaly.com, n.d.). These metrics indicate that the journal is well-regarded, though it may not be at the top in terms of citations when compared to some other academic publications. Despite this, the NJI remains widely respected and accepted by nursing institutes, researchers, and professionals both within India and internationally (Exaly.com, n.d.). The primary aim of the NJI is to promote excellence in nursing practice, education, research, and policy development, especially within the context of the Indian healthcare system. Through its publications, it offers a vital platform for nurses, educators, researchers, and administrators to share knowledge, experiences, and innovations, ultimately enhancing the quality of nursing care and contributing to the ongoing advancement of nursing as a profession in India. The journal is indexed in *Crossref* and the *TNAI Database*, providing broad accessibility to its content. Notably, NJI was also indexed in *Scopus* from 1965 to 2015, further enhancing its visibility in global academic circles (Exaly.com, n.d.; TNAIjournal, 2023).

REVIEW OF LITERATURE

The application of Lotka's law across various subject fields has been a significant area of study. A. J. Lotka's (1926) empirical analysis of the frequency distribution of scientific productivity led to the formulation of his famous law, which has since been explored in various academic contexts. D. K. Gupta (1987, 1989, 1992) made notable contributions by applying Lotka's law to study author productivity and trends in different domains. His research covered subjects such as entomological research in Nigeria (1900-1973), exploration geophysics, and African psychological literature (1966-1975). Pao (1985) also presented a robust testing procedure for validating Lotka's law. However, some scholars, including Sen (2010), have critiqued Pao's method, suggesting it may not always yield reliable results for every data set. Prof. B. K. Sen, a key figure in Indian bibliometrics, has also used Lotka's law in various subject fields. Notably, Sen (1996), in collaboration with Taib and Hassan, examined the validation of the law within the field of Library and Information Science (LIS) literature, using data from LISA for the years 1992 and 1993. A work of Sen and Gan (1990) expanded on various applications of Lotka's law. Kumar (2010) also used Pao's method for calculating the law's parameters. Recent studies have continued to apply Lotka's law across various disciplines. For instance, Rathika, Thanuskodi, and Sudhakar (2020) examined the law in relation to marine pollution literature, and Tunga (2020) focused on horticultural literature to test its validity. Chander and Singh (2021) explored authorship patterns in books written in the Punjabi language, while Gujral and Shrivarama (2021) used the law to investigate collaborative authorship patterns in the field of health informatics (2009-2019). Thus, Lotka's law has been using in author produtivity in different science subjects and non-science fields for long period and becomes one of the emperical laws in bibliometric studies. Present study tries to examine validation of Lotka's law for the data set of nursing research as refelcted in the Nursing Journal of India for the period 2010-2024.

OBJECTIVES

The main objectives of the study are

a) To find out chronological distribution of research outputs in NJI, 2010-2024,

b) To determine year wise authorship pattern and author productivity,

c) To measure the degree of collaboration and collaborative index,

d) To observe compatibility between Lotka's exponent n=2 and n≠2,

e) To calculate author productivity,

f) To identify leading authors,

g) To examine the validation of Lotka's Law.

SCOPE AND METHODOLOGY

This study explores research productivity, patterns of collaboration, and author productivity in the field of nursing by analysing articles published in *The Nursing Journal of India, the* official publication of the Trained Nurses' Association of India (TNAI), founded in 1910. With a history spanning nearly 114 years, the journal represents one of the most longstanding and respected sources of nursing scholarship in India. The analysis focuses on a 15-year publication period, from 2010 to 2024, providing a substantial dataset for bibliometric examination. While relying on a single journal may not capture the full range of global or interdisciplinary authorship trends, the chosen journal's historical legacy, consistent publication record, and national relevance render it a meaningful case for focused study. Within the context of Indian nursing research, the journal's output offers a concentrated view of authorship behaviour and scholarly activity over time. In this investigation, the journal's 15-year publication dataset is treated as a cohesive body of work, that may treat as similar in nature to the lifetime contributions of a single, highly productive author. This approach facilitates the application of bibliometric methods to assess patterns of authorship frequency and collaboration. Central to the study is an evaluation of whether the observed distribution of author contributions aligns with Lotka's Law, which posits that a small number of authors contribute the majority of publications in a given field. The analysis thus seeks to determine the extent to which the journal's 15-year authorship data align with the theoretical expectations of Lotka's Law, providing insights into the nature of author productivity in the Indian nursing research landscape.

A total of 664 citing articles were identified across volumes CI to CVX, comprising 102 issues published between 2010 and 2024. Of these, three articles were published in Hindi (in Vol. CII, 2021; Vol. CV, 2014; and Vol. CXIII, 2022) and were excluded from the analysis, leaving 661 English-language articles for the study. The data were extracted from these 661 research articles, transferred into Microsoft Excel and Word for organization, and subsequently arranged by year. Various tabulations were prepared, including publication frequency by volume and issue, types of authorship patterns, distribution of single vs. multiple authorship, analysis of individual author productivity and degree of collaboration, etc. To assess author productivity in testing Lotka's law validation, firstly individual author names were counted and sorted largest to smallest by the number of publications of each author and harvested number of authors (observed) that is called observed values in the Law. Secondly, observed values (i.e. taken as Y in the law) were again arranged by the number of publications (i.e. 1, 2, 3…, considered as X in the law). Then, number of authors (expected/ calculated) i.e. expected/calculated values

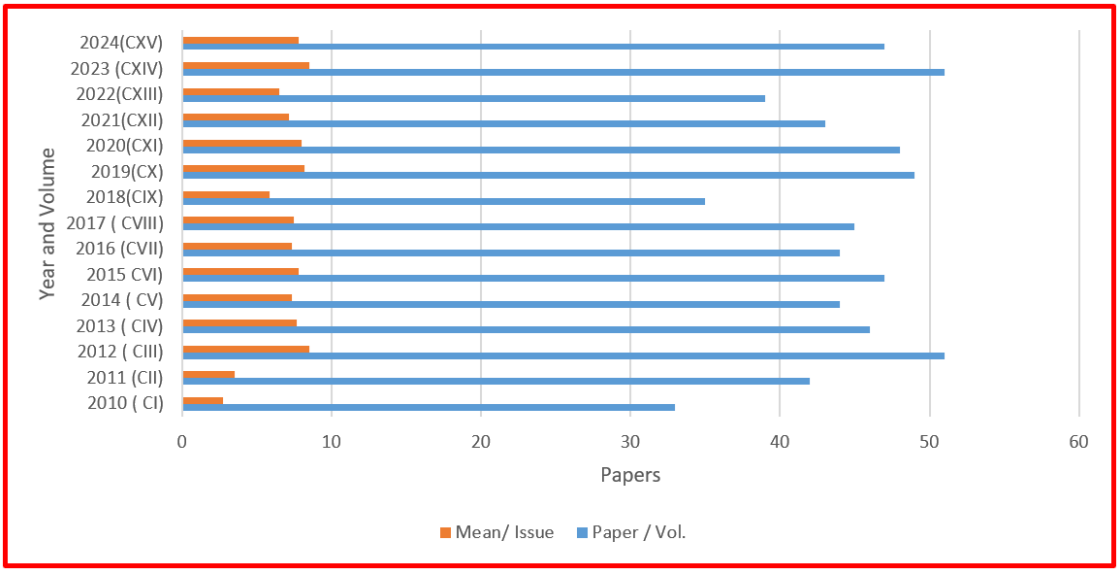

Figure 1: Bar diagrams showing volume wise papers/ year and mean per issue.

were computed considering present data set i.e. number of publications (X), and number of authors (Y as observed) of this study using Lotka's original exponent (n=2) for the ideal case, and Sen's method was used for the calculated exponent (i.e. value of n). Expected (E) number of authors (Y) has expressed as EY in this study. Finally, the results derived from the data were analysed and discussed in detail.

DATA ANALYSIS AND DISCUSSION

Distribution of Articles by Volume and Issue (2010-2024)

Table 1 presents a detailed breakdown of the research output published in the Nursing Journal of India from 2010 to 2024. The journal has consistently maintained a steady flow of papers throughout these years. From 2012 to 2024, each issue typically featured between 5 and 11 articles, resulting in a total of 92 to 103 papers published annually. In contrast, during the early years of 2010-2011, the number of articles published was relatively lower, with an average of 1 to 4 papers per issue across 11 issues. Notably, the 12th issue of volume CII (2011) included 11 papers, which deviated from the usual range. Despite these variations in issue-specific output, the journal managed to consistently place between 97 and 108 papers in each volume, contributing to the overall regularity in its publication. The study has considered a total of 644 articles written in both English and Hindi. Of these, 661 articles (99.55%) were published in English, and the remaining 3 articles (0.45%) were in Hindi. This language distribution demonstrates a clear preference for English-language publications. The journal's average output per volume is approximately 44 articles (calculated as 664 papers over 15 volumes), with the average number of papers published per issue standing at around 7 (664 papers divided by the total number of issues, 102 i.e. 6.51). Given the absence of authorship data for the three Hindi articles, this analysis primarily focuses on the 661 English-language articles as the primary source material for the study. Figure 1 represents chronologically volume wise papers and mean per issue.

Year-wise Distribution of Papers and Author Productivity

The research outputs from 2010 to 2024, as presented in Table 2, reveal significant variations in the number of papers published and author productivity across different years. The highest number of papers, 51 each, was published in both 2012 and 2023. In 2012, these 51 papers were contributed by 100 authors, resulting in a productivity of 0.52 papers per author. In 2023, the same number of papers was published, but by 137 authors, yielding a lower productivity of 0.37 papers per author. Following these years, the research output remained substantial. In 2019, 49 papers were published by 86 authors, showing a productivity per author of 0.56. The year 2020 saw 48 papers published by 124 authors, with a productivity per author of 0.38. Additionally, 47 papers were produced by 80 authors in 2015, which resulted in the highest author productivity at 0.58 papers per author. Across all the years, a total of 661 research articles were published by 1412 authors. Out of these, 1411 were personal authors, and 1 was a corporate author. The overall productivity per author for the entire period is calculated at 0.47, with a total author productivity figure of 1412, reflecting a healthy contribution of authors throughout the years. In summary, while certain years showed higher author productivity, the total trend indicates consistent author involvement, contributing to a steady stream of research outputs across the 15-year span.Bottom of Form

Year wise Authorship Pattern

Table 3 illustrates the year-wise authorship pattern, showing the distribution of research papers based on the number of authors. The highest number of papers was single-authored, with

a total of 321 papers produced by 321 individual authors. This was followed by 159 two-authored papers, contributed by 318 authors, and 99 three-authored papers, written by 297 authors. Other authorship categories include 29 four-authored papers (involving 116 authors), 18 five-authored papers (90 authors), and 10 six-authored papers (60 authors). There were also 9 seven-authored papers, involving 63 authors, and a few papers with even more authors. Notably, a single paper was published by a corporate author. In terms of year-wise distribution, the highest number of single-authored papers (30, or 9.35%) was published in 2012, followed by 29 papers (9.03%) in 2019. Other years with significant single-authored publications include 2013 and 2017, each with 28 papers (8.73%), and 2015 with 26 papers (8.09%). The number of single-authored papers remained relatively consistent across the years, with 24 papers (7.47%) in 2016. For two-authored papers, the year 2023 saw the highest number (16 papers, or 10.07%), followed by 14 papers (8.80%) in 2014. Other years with notable two-authored publications include 2018, 2021, and 2024, each with 13 papers (8.18%), and 2013 and 2017, each contributing 12 papers (7.54%). Among the 99 three-authored papers, the majority appeared in 2020, with 12 papers (12.12%), followed by 11 papers (11.11%) in 2024. The years 2015 and 2022 each contributed 10 papers (10.10%) to this category. These figures suggest that the presence of three-authored papers remained relatively steady over time, with fluctuations in specific years. In the case of four-authored papers, the highest number (6 papers, or 20.70%) was published in 2024, followed by 4 papers (13.79%) in 2011, 2020, 2021, and 2023. Similarly, for five-authored papers, the greatest number (4 papers, or 22.22%) was recorded in 2023, followed by 3 papers (16.67%) in 2020. Other years with multiple five-authored papers include 2012, 2013, 2019, 2021, and 2022, each with 2 papers (11.11%). For six-authored papers, the year 2024 saw the highest number of publications (3 papers), followed by 2 papers each in 2020 and 2021. The remaining years saw minimal publications in this category, with only 1 or 2 papers in each year. The category of seven-authored papers saw minimal contributions, with 1 or 2 papers published across several years. Similarly, for the eight- and nine-authored papers, only 1 to 2 papers appeared in the entire period from 2010 to 2024. Additionally, three mega-authored papers were identified: one 11th-authored paper, one 12th-authored paper, and one 15th-authored paper, all published in 2021 and 2022. These high-author papers reflect the collaborative nature of certain research efforts, although they are rare. Finally, in 2021, a single paper was published by a corporate author, marking the only occurrence of corporate authorship in this period.

Authorship Pattern-wise Author Productivity

Table 4 shows author productivity as per authorship pattern. According to the authorship pattern, the highest number of

Table 1: Volume and Issue wise Publications in NJI: 2010-2024.

Year	Vol	Issues												Total Papers	Mean per Issue	Language	
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII			EP	HP
2010	CI	4	4	3	3	2	3	1	3	2	2	3	3	33	2.75	33	
2011	CII	4	2	2	4	2	2	2	3	4	2	4	11	42	3.5	41	1
2012	CIII	9	11	6	8	8	9	-	-	-	-	-	-	51	8.5	51	
2013	CIV	5	9	7	8	7	10	-	-	-	-	-	-	46	7.67	46	
2014	CV	9	6	9	6	6	8	-	-	-	-	-	-	44	7.33	43	1
2015	CVI	7	7	7	9	8	9	-	-	-	-	-	-	47	7.83	47	--
2016	CVII	8	5	7	8	8	8	-	-	-	-	-	-	44	7.33	44	--
2017	CVIII	8	7	7	8	8	7	-	-	-	-	-	-	45	7.5	45	--
2018	CIX	5	7	5	5	6	7	-	-	-	-	-	-	35	5.83	35	--
2019	CX	7	5	9	9	10	9	-	-	-	-	-	-	49	8.17	49	--
2020	CXI	9	8	8	8	8	7	-	-	-	-	-	-	48	8.0	48	--
2021	CXII	8	7	7	6	8	7	-	-	-	-	-	-	43	7.17	43	--
2022	CXIII	6	7	6	7	7	6	-	-	-	-	-	-	39	6.5	38	1
2023	CXIV	9	8	8	10	9	7	-	-	-	-	-	-	51	8.5	51	--
2024	CXV	8	7	6	8	9	9							47	7.83	47	-
Total	--	106	100	97	107	106	108	3	6	6	4	7	14	664	6.51	661	3
%-age	--	15.97	15.06	14.60	16.12	15.97	16.26	0.46	0.9	0.9	0.6	1.06	2.1	100		99.55	0.45

Abbreviations: EP=English Papers; HP=Hindi Papers

Table 2: Chronological list of research articles and types of authorship.

Year	No. of publications	%-age	Authorship		Total Authors	Productivity per author	Yearly Author Productivity (as per Lotka's Law)
			Personal	Corporate			
2010	33	4.99	49	-	49	0.67	49
2011	41	6.21	74		74	0.55	74
2012	51	7.72	100		100	0.52	100
2013	46	6.95	74		74	0.62	74
2014	43	6.51	80	--	80	0.54	80
2015	47	7.12	80	--	80	0.58	80
2016	44	6.65	77	--	77	0.57	77
2017	45	6.8	86	--	86	0.52	86
2018	35	5.29	61	--	61	0.57	61
2019	49	7.41	86	--	86	0.56	86
2020	48	7.26	124	--	124	0.38	124
2021	43	6.51	123	01	124	0.35	124
2022	38	5.74	106	--	106	0.35	106
2023	51	7.72	137	--	137	0.37	137
2024	47	7.12	154		154	0.31	154
Total	661	100	1411	01	1412	0.47	1412

papers was single-authored, i.e. 321 papers, 48.56% of the overall publications. The next most common category was two-authored papers, with 159 papers (24.05%) contributed by pairs of authors. Three-authored papers came next, with 99 papers (14.98%), while four-authored papers accounted for 29 papers (4.38%). Five-authored papers contributed 18 papers (2.73%), and six-authored papers followed closely with 10 papers (1.52%). The number of seven-authored papers was 9 (1.36%), and nine-authored papers amounted to 6 papers (0.92%). Additionally, eight-authored and ten-authored papers each contributed 3 papers. The remaining authorships were spread across papers with 11th, 12th, and 15th authorship, with one paper each in these categories. The total author productivity, as measured by the full credit share of each author, stands at 661. Figure 2 highlights paper-author ratio using bar diagrams.

Name-wise Prolific Authors

Table 5 outlines the individual name wise author productivity in nursing research published in the Nursing Journal of India (NJA) of the TNAI during the period from 2010 to 2024. A total of 1,150 authors name wise contributed to the production of 661 research papers over this decade. Among these, *Latha Venkatesan* emerged as the most prolific author, having published 11 papers during the period. Following her, two authors-*Nanthini Subbiah and Poonam Joshi*-each published 9 papers, securing the second position. *Anil Kumar Parashar* occupied the third spot with 8 publications. A group of nine authors, including *Kamlesh K. Sharma, Manju Vatsa, Meena Ganapathy, N. Kokilavani, Nilima Sonawane, Ramachandra, Rathish Nair, Shani Sd, and Sunita Srivastava*, each contributed 5 papers. Additionally, another group of nine authors-*Arunjyoti Barauah, Bijayalakshmi Dash, Bindu Shaiju, Jyoti Sarin, R. Sudha, Radha Saini, Ramandeep Kaur, Varsha Rawat, and Vijayalakshmi Poreddi*-produced 4 papers each during the decade. The study also includes 26 authors who wrote 3 papers each, 94 authors who contributed 2 papers each, and a large group of 1,004 authors who each wrote a single paper during the period from 2010 to 2024.

Degree of Collaboration (DC)

Degree of Collaboration, by the formula:

$$DC = Nm / (N_m + N_s) = 340 / (340 + 321) = 0.5143$$

Table 6 shows calculation for Degree of Collaboration (DC) i.e. degree of relationship among authors. DC has been calculated by total multiple-authored paper divided by total paper. In this case, DC for the data set comes out to be 0.5143.

Collaborative Index (CI)

CI can be calculated for the data set of this study by the following formula:

$$CI=TA/\ TP=1412/661=2.1361$$

Lotka's Law of Author Productivity

In this study, two methods were employed to examine author productivity by applying Lotka's exponent "n" along with validating Lotka's Law. The study considered two cases for the value of "n": one where "n" was set to 2, representing an ideal case, and another where "n" was allowed to vary, as it does not always remain constant across different subjects or over time within the same subject (Sen, 2010; Gujral and Shrivarama, 2021). The study aims to compare the observed and expected values, testing the validity of Lotka's law for the dataset at hand. Table 7 presents the expected values derived from both methods, offering a comparative analysis of the results.

Equations for Lotka's Law is,

$$X^n\ Y=C.\text{---------- [Eqn. 2]}$$

Method A: $n=\neq 2$.

Calculation for finding value of C

Putting the value of X =1, corresponding Y=1004 as given in 1st row in Table 7.

we get from the [Eqn. 2],

$$\text{Or } 1^n \text{ x } 1004=C, \text{ [since } 1^n=1]$$

$$\text{Or } C= 1 \text{ x } 1004=1004$$

Calculation for finding value of n

Putting the data of 2nd row of the table that is X=2, Y=94, and C= 1004 (calculated as above) in the [Eqn. 2].

We get,

$$2^n \text{ x } 94 = 1004$$

$$\text{Or } 2^n =1004/94=10.6808$$

Taking log both sides,

$$\log 2^n=\log 10.6808$$

$$\text{Or n log } 2=\log 10.6808$$

$$\text{Or n x } 0.301 =1.028 \text{ [by putting the value of log.]}$$

Table 3: Year wise authorship pattern and author productivity.

Year	1A		2A		3A		4A		5A		6A	
	TP	%	TP	%	TP	%	TP	%	TP	%	TP	%
2010	25	7.79	4	2.52	3	3.03						
2011	25	7.79	6	3.77	5	5.05	4	13.79			1	10.00
2012	30	9.35	8	5.04	8	8.08	1	3.45	2	11.11		
2013	28	8.73	12	7.54	4	4.04			2	11.11		
2014	21	6.56	13	8.18	6	6.06	2	6.89				
2015	26	8.09	10	6.28	10	10.10	1	3.45				
2016	24	7.47	11	6.92	7	7.07	1	3.45			1	10.00
2017	28	8.73	8	5.03	5	5.05	1	3.45				
2018	18	5.60	12	7.55	4	4.04						
2019	29	9.03	14	8.80	2	2.03			2	11.11	1	10.00
2020	16	4.98	10	6.28	12	12.12	4	13.79	3	16.67	2	20.00
2021	14	4.36	13	8.18	4	4.04	4	13.79	2	11.11	2	20.00
2022	13	4.05	9	5.66	10	10.10	1	3.45	2	11.11		
2023	16	4.98	16	10.07	8	8.08	4	13.79	4	22.22		
2024	8	2.49	13	8.18	11	11.11	6	20.70	1	5.56	3	30.00
TP	321	100	159	100	99	100	29	100	18	100	10	100
TA	321		318		297		116		90		60	
TP: TA	1:1		1 : 2		1 : 3		1 :4		1 : 5		1 : 6	

Abbreviations: 1A=One-authored paper, 2A= Two authored paper, so on. CoP= Corporate-authored paper; GT= Gross total; TP= Total papers; TA= Total authors; GT= Grand Total. ** 38=15 +11 +12; AP= Author productivity.

Table 3: Year wise authorship pattern.

Year	7A		8A		9A		10A		>10A		CoP		GT
	TP	%	TP	%	TP	%	TP	%	TP	%	TP	%	
2010	1	11.11											33
2011													41
2012	1	11.11			1	16.66							51
2013													46
2014	1	11.11											43
2015													47
2016													44
2017	1	11.11	2	66.67									45
2018	1	11.11											35
2019	1	11.11											49
2020					1	16.66							48
2021							1	33.33	2	66.67	1	100	43
2022	1	11.11			1	16.66			1	33.33			38
2023					1	16.66	2	66.67					51
2024	2	22.23	1	33.33	2	33.36							47
TP	9	100	3	100	6	100	3	100	3	100	1	100	661
TA	63		24		54		30		38**		1		1412
TP: TA	1 :7		1 : 8		1: 9		1 :10		1 : 13		1 : 1		

Or n=1.028 / 0.301=3.4152 or 3.4 (approximately).

Therefore, n=3.4, that is, n ≠ 2.

(i)Calculation of Expected number of authors

Now, expected (E) number of authors (Y) can be expressed as [Y(E)] and for calculation of Y(E), the [Eqn. 2] can be re-formed as:

$$Y(E)=C/ Xn \text{ ----------[Eqn. 3]}$$

For X=1 from the 1st row in the Table 7, $Y(E)=1004/1^{3.4}=1004/ 1$ [since $1^{n=}1$]=1004

For X=2, $Y(E)=1004/ 2^{3.4} = 95.11=95$.

For X=3, Y(E)= $1004/ 3^{3.4}=23.96=24$ and so on.

(i)Method B: n =2 in an ideal case

Using inverse square law of Lotka, expected number of authors [Y (E)] can be calculated from [Eqn. 3] as follows:

(ii)Calculation of C

Taking n=2, X= 1 in the 1st row and corresponding Y=1004 in 2nd row in the Table 7,

$$C= 1004 \times 1^2 = 1004 \times 1=1004$$

(iii)Calculation for Expected number of authors

Therefore, expected number of authors [Y (E)] can be calculated here as:

Putting X=1 and C=1004 in the [Eqn. 3],

$$Y(E)=1004/ 1^2=1004 \times 1= 1004$$

When X=2, $Y(E)= 1004/ 2^2=1004/4=251$

Similarly, X=3, $Y (E)=1004/ 3^2=111.5=112$, and so on.

Validation of Lotka's Law

Table 7 presents a comparative analysis of observed and expected author productivity frequencies to test the applicability of Lotka's Law to the dataset derived from The Nursing Journal of India (2010-2024). Lotka's Law, a foundational principle in bibliometrics, posits that the number of authors publishing n papers is about $1/n^2$ of those publishing a single paper, suggesting a consistent inverse-square relationship. However, the exponent in Lotka's formula-typically taken as 2 in its original form-can vary depending on the nature of the discipline, the dataset, and the method of calculation.

In this study, two different methods were employed to determine the expected number of authors, each using a different value of the Lotka's exponent n. Method A applied an exponent of n=3.4, a value calculated using Sen's method, a statistical approach that adjusts the exponent based on the actual data distribution.

Method B, in contrast, used the conventional n=2, following the original formulation proposed by Lotka. The value of n is found to be higher in this study compared to exact sciences as the number of authors contributing two or more (i.e. multi-authored) papers are less in this field.

The comparison of actual observed values Y(O) with the expected values E-A and E-B from Methods A and B, respectively, reveals several important insights. Most notably, the expected values derived using n=3.4 (E-A) show a much closer alignment with the observed author frequencies. This suggests that author productivity in the field of Indian nursing, as reflected in this journal's data, does not conform well to the classic inverse-square law (n=2), but rather follows a steeper decline in productivity, as captured more accurately by an exponent of 3.4. This deviation implies that in this dataset, a relatively smaller number of authors contribute multiple papers, and a much larger proportion publish only once-a common pattern in specialized or regionally focused disciplines. The larger exponent reflects a steeper drop-off in productivity, indicating limited repeated contribution by the majority of authors. In other words, the value of n is found to be

Table 4: **Author productivity by authorship patterns.**

Authorship	Number of Publications	%-age	Cum-%-age	Author productivity
Personal				
Single-authored	321	48.56	48.56	321
Two-authored	159	24.05	72.61	318
Three-authored	99	14.98	87.59	297
Four-authored	29	4.38	91.97	116
Five-authored	18	2.73	94.70	90
Six-authored	10	1.52	96.22	60
Seven-authored	9	1.36	97.58	63
Eight-authored	3	0.45	98.03	24
Nine-authored	6	0.92	98.95	54
Ten-authored	3	0.45	99.40	30
Eleventh-authored	1	0.15	99.55	11
Twelfth-authored	1	0.15	99.70	12
Fifteen-authored	1	0.15	99.85	15
Corporate	1	0.15	100	1
Total	661	100		1412

Note: Total collection of papers 664 -3 Hindi versions.

Table 5: **Name-wise Prolific contributors in nursing research during 2010-2023.**

Rank	Paper(s) by each author	Author's name	Number of authors (observed)
1	11	Latha Venkatesan [01]	1
2	9	Nanthini Subbiah; Poonam Joshi [02]	2
3	8	Anil Kumar Parashar [01]	1
4	6	Anice George; Lily Podder; Roy K George; Ulfat Amin [04]	4
5	5	Kamlesh K Sharma; Manju Vatsa; Meena Ganapathy; N Kokilavani; Nilima Sonawane; Ramachandra; Rathish Nair; Shani Sd; Sunita Srivastava [09]	9
6	4	Arunjyoti Barauah; Bijayalakshmi Dash; Bindu Shaiju; Jyoti Sarin; R Sudha; Radha Saini; Ramandeep Kaur; Varsha Rawat; Vijayalakshmi Poreddi [09]	9
7	3	26 authors with 3 papers each	26
8	2	94 authors with 2 papers each	94
9	1	1004 authors with 1 paper each	1004
Total		1150 authors (name wise)	1150

Table 6: **Degree of Collaboration among authors.**

Sl. No.	Authorship Pattern	Publications	%-age
1	Single Authored papers	321 (= N_s)	48.56
2	Multiple Authored papers	340 (=N_m)	51.44
Total		661	100

Table 7: **Number of expected authors with the value of exponent *n*=3.4, and 2.**

No. of Contributions (X)	No. of authors (Y) - Observed [O] = Y (O)	%-age	No. of authors(Y)- Expected (E) = Y (E) (from Lotka's equation: $Y = C / X^n$)		Distance value between observed [Y(O)] and Expected [Y(E)] values	
			Expected Value (E-A) by Sen's Method (A): n=3.4	Expected Value (E-B) by Lotka's Method (B): n=2 (in an ideal case)	From E-A	From E-B
1	1004	87.31	1004	1004	0	0
2	94	8.18	95	251	1	157
3	26	2.26	24	112	2	86
4	9	0.78	9	63	0	54
5	9	0.78	4	40	5	31
6	4	0.35	2	28	2	24
8	1	0.08	0.85	16	0.15	15
9	2	0.18	0.57	12	1.43	10
11	1	0.08	0.29	8	0.71	7
Total	1150	100	1140	1535		

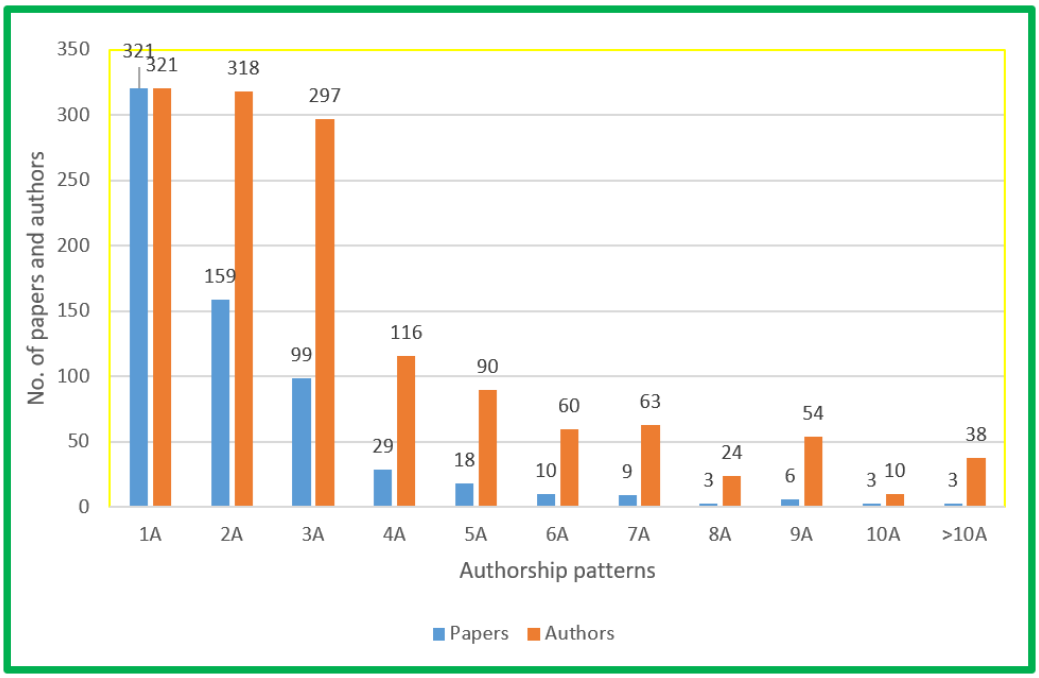

Figure 2: Bar diagrams showing paper-author ratio by type of authorship patterns. Abbreviations: 1A= single authored, 2A= Two-authored, etc.

higher in this study compared to exact sciences as the number of authors contributing two or more (i.e. multi-authored) papers are less in this dataset.

Further, the total number of authors predicted by Method A (1,140) is much closer to the actual number of unique authors (1,150), with only a marginal difference of 10 authors. On the other hand, Method B, using the standard exponent of N = 2, predicts a significantly higher number of authors (1,535), overestimating by 385 authors. This substantial gap indicates that the classic form of Lotka's Law may not be appropriate for this dataset and may lead to misleading interpretations if applied without contextual adjustment.

Moreover, when the variation between the actual and expected frequencies is examined across the range of author productivity (e.g., authors with 1, 2, 3, or more publications), the deviations for Method A remain consistently small. In contrast, Method B exhibits large discrepancies, especially as the number of publications per author increases. This further supports the argument that n=3.4, as derived through empirical fitting (Sen's method), offers a significantly better representation of the distribution in this context.

The substantial difference of 1.4 between the two exponent values (3.4 vs. 2) underscores the importance of calculating the exponent specific to the dataset under investigation rather than relying on the default value. The findings suggest that author productivity in the Indian nursing research landscape, at least as represented in

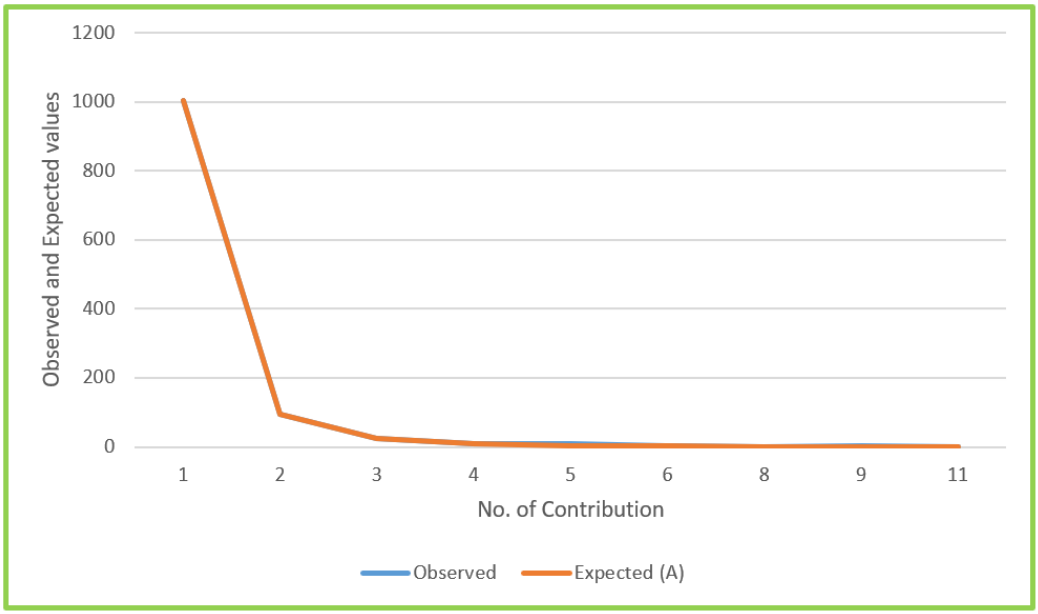

Figure 3: Closeness with observed and expected A curves indicating validation of Lotka's law.

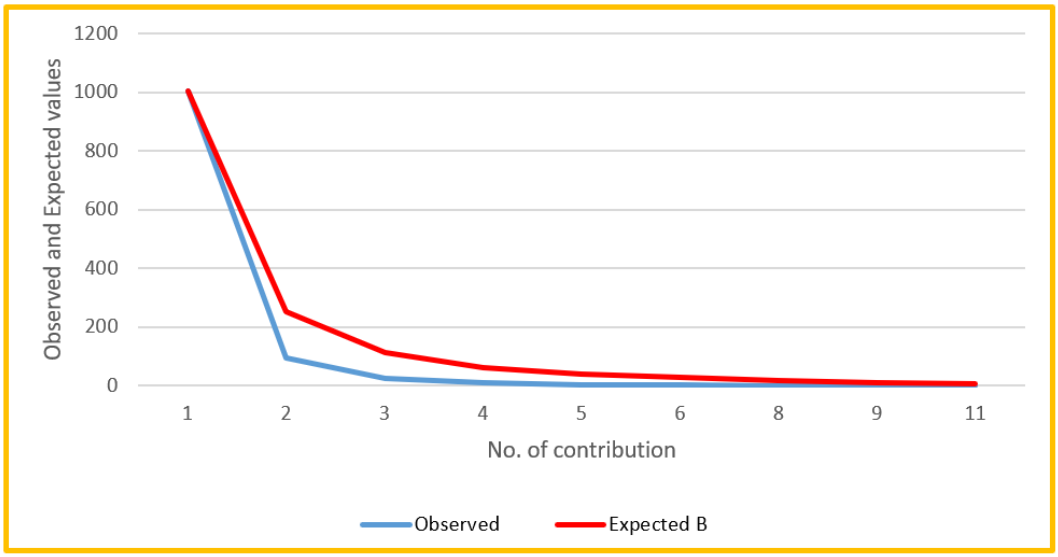

Figure 4: Matching of observed curve with expected B curves.

this journal, follows a pattern where high-frequency contributors are rarer than what Lotka's original law would predict.

The bibliometric analysis clearly indicates that the dataset adheres more closely to a modified form of Lotka's Law with an exponent of 3.4. This value more accurately reflects the observed author productivity trends in The Nursing Journal of India. The study not only validates the utility of Lotka's Law in analysing authorship patterns but also highlights the necessity of adapting its parameters to specific fields and datasets to ensure accurate and meaningful interpretations. These findings contribute to a more nuanced understanding of publication behaviour in Indian nursing research and can inform future bibliometric evaluations in similar subject areas.

Figure 3 illustrates the closeness between the observed curve and the expected curve generated using Method A, whereas the expected curve from Method B deviates significantly as seen in Figure 4. The actual and expected values from Method A align so closely that the observed curve is barely visible in the figure. However, a slight distinction can be seen in certain areas of the observed curve in Figure 3.

CONCLUSION

NJI is a more than hundred years old famous nursing journal in India, regularly published by Trained Nurses' Association of India (TNAI) since 1910. Based on the above data during 2010-2024 and analysis, the following conclusions can be drawn:

1. Uniformity in Publications: Uniformly an average number of papers per year has been publishing in NJI, 2010-2024 that is proved by mean difference shown in Table 1. The journal's average output per volume is approximately 44 articles (calculated as 664 papers over 15 volumes), with the average number of papers published per issue standing at around 7 (664 papers divided by the total number of issues, 102 i.e. 6.51).

2. Number of Authors Involved: Overall, total 1412 authors were engaged in the production of 664 research articles, and individual name wise credit of authorship of 664 papers went to 1150 authors.

3. Lotka's Law Validation: The dataset largely follows Lotka's Law when the exponent "n" is set to 3.4, as calculated using Sen's method. This method provides a better fit between the observed and expected values, suggesting that the author productivity in this study adheres closely to the expected distribution described by Lotka's Law.

4. Impact of Different Exponents: A significant difference was observed between the two values of "n" (3.4 and 2). When "n" was set to 2, the expected values deviated substantially from the actual data, indicating that this value was less suitable for this particular dataset. In contrast, the use of "n"=3.4 resulted in expected values that were much closer to the actual values, providing a more accurate reflection of author productivity.

5. Method Comparison: The graphical representation (Figure 1) further corroborates the findings, where Method A (using "n"=3.4) shows a closer alignment between the observed and expected values, whereas Method B (using "n"=2) reveals a greater discrepancy, indicating that Method A yields a more reliable fit for this dataset. Total author productivity count to be 1140 in Method A and 1535 in B where it is observed that a far distance exists between total number of authors (observed) i.e. 1150 and 1535 compared to 1140. The value of n in Method A is higher than Method B because the number of authors contributing multi-authored papers are less in the nursing filed for the data set of this study.

6. Subject-Specific Variability: As noted in the study, the value of Lotka's exponent "n" varies across different subjects and over time within the same subject (Sen, 2010; Gujral and Shrivarama., 2021). This study highlights the importance of selecting the appropriate value of "n" for different research fields to ensure accurate modeling of author productivity.

In conclusion, the findings suggest that for this particular dataset, Lotka's Law holds true when using an exponent of 3.4, and this method provides a more accurate representation of the author productivity trend. Thus, it is confirmed that Lotka's Law follows the literature of nursing for the data set in this study.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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