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Testing Lotka's Law and Pattern of Author Productivity in the Maharashtra University of Health Services (MUHS) Consortium: A Bibliometric Approach

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Abstract:

This study aims to analyze the productivity patterns of authors in Health Science using publications indexed in Maharashtra University of Health Services (MUHS) Consortium from 2001 to 2013 based on Lotka's Law. Lotka's Law of scientific productivity provides a platform for studying inequality in authors' productivity patterns in a given field and over a specified period. This study covers all the journal articles on Health Sciences over a period of Ten years (2001-2013) in Maharashtra University of Health Services (MUHS) Consortium, of which 20724 articles were reported to have been published during this period. The findings of the study reveal that in the productivity distribution for authors on the subject of Health Sciences/Medicine, only co-authors and non-collaborative authors' categories fit in the Lotka's Law, whereas all-authors and first-author categories differ from the distribution of Lotka's inverse square law. The Lotka's law on authorship productivity of E-Journals of health Science has been tested to confirm the applicability of the law to the present data set. A K-S test was applied to measure the degree of agreement between the distribution of the observed set of data against the inverse general power relationship and the theoretical value of $\alpha = 2$. It is found that the inverse square law of Lotka follows as such.

Keywords: Lotka's Law, Productivity Patterns, Co-authorship Index (CAI), Kolmogorov-Smirnov Test (K-S Test), Collaborative Co-Efficient (CC). Bibliometric Study, Scientometrics, Maharashtra University of Health Services (MUHS) Consortium, Health Science Journals

Introduction:

Scientometrics is the field of study which concerns itself with measuring and analysing scientific literature. Scientometrics is a sub-field of bibliometrics. Major research issues include the measurement of the impact of research papers and academic journals, the understanding of scientific citations, and the use of such measurements in policy and management contexts.^[1] In practice there is a significant overlap between scientometrics and other scientific fields such as information systems, information science, science of science policy, sociology of science, and metascience. (Glossary of Thompso, 2008).

The basic purpose of the present is to analyze the collected data of 10 online monthly journals in the subject of Health Science. International E-Journals in the subject of medicine are distributed in different volumes and issues which are to be considered for the present study. Time from start is of 13 years from the year 2001 to 2013.

The present study is based on 20724 articles in E-journals of Health Science. For present study data has been collected from 10 Medicine E-Journals during Jan. 2001- Dec. 2013 which are indexed in Health Science consortium Nashik. The present study focuses on authorship patterns, co-efficient for collaborative authors, the average growth rate, and relative growth rate, contribution made by authors in the view of research productivity, authorship pattern and collaboration of E-Journals of health Science. The data has been analyzed by using various parameters which is presented in tabular and graphical from these table and graphs are presented as per the sequence of objective of the present study.

Review of Literature:

The number of authors contributing to scholarly publications in terms of authorship pattern is an instructing part of any bibliometric study. A count of number of authors contributing to articles offers some indication to degree of collaboration between authors. Cronin (2001) comment, authorship as” undisputed coin of the real in academic “and” absolutely central to the academic reward system”.

Vimala and Pulla Reddy, V (1996) traced “authorship pattern and collaborative research in zoology with a sample of 19,323 journal citations figured in the theses on zoology accepted for the award of the doctoral degree by Sri Venkateswara University, Tirupati, India” (p. 1).

Zafrunnisha and Pulla Reddy (2009) studied the authorship pattern and collaborative research in the field of psychology.

Amsaveni and Vasanthi (2013) revealed “the trend in authorship pattern and collaborative research in network security with a sample of 8051 articles downloaded from the database of web of knowledge during 2002 to 2011 (one decade) with 5343 LCS and 44721 TGCS measure” (p. 52).

Karisiddappa, Maheswarappa, and Shirol (1990) studied the authorship pattern and collaborative research in psychology, based on the data collected from *Psychological Abstracts* for the year 1988.

Mahapatra (1980); carried out study in Further, if the number of articles in a subject doubles during a given period then the difference between the logarithms of numbers at the beginning and at the end of this period must be the logarithm of the number 2.

Mahapatra (1985); assessed the Relative Growth Rates (RGR) is a measure to study the increase in number of articles / pages per unit of articles/ pages per unit of time. Teague et al., (1981)

Suradkar P.A. and Dr. Dalve Daya (2016) carried out the study presents the trends in authorship pattern and authors collaborative research in Academic Emergency Medicine Journal with a sample of 3586 articles during the period 2001-2013.

Lotka's Law was calculated following the methods proposed by Pao (1985) according the Lotka's Law the numbers of authors (y_x). With x number of articles is universally proportional to x . The relation is expressed by the formula;

$$X^n \cdot Y_x = c$$

Lotka's, 1926 stated that Where Y_x is the number of authors producing x number of articles in a given research field and c and n are constant that can be estimated for the observe data set. All thought many authors take a value of 2 as the value of the exponent, as Lotka's did in his paper.

Data Analysis:

In the present study of E-Journals in during Jan. 2001- Dec. 2013 which are indexed in Health Science consortium Nashik. The analysis was done as per the parameters laid down in objectives of the study.

Objective of the study:

1. To measure and calculate the Relative Growth Rate and Doubling Time Publications.
2. To find out Authorship Pattern: Journals wise.
3. To indicate Co-Authorship.
4. To find out Authorship Productivity Pattern.
5. To observe the Chi-Square Test for Productivity of Authors.
6. To examine the validity of KS Test of goodness of fit.
7. To observe the Productivity Index (PI).
8. The analyses the research trend with Co-Efficient for Collaborative Authors.

Analysis and Interpretation of the result:

1. Relative growth rate and Doubling Time publications

In order to identify the relative growth rate, the researcher has adopted a model developed by Mahapatra. The relative growth rate is the increase in the number of publications per unit of

time. The mean relative growth rate, R-(1-2) over a specified period of interval can be calculated from the following equation.

$$R(1-2) = \frac{W2 - W1}{T2 - T1}$$

Where,

R (1-2) = Mean Relative Growth Rate over the Specified Period interval;

W1 = log w1 (Natural log of initial number of publications)

W2 = log w2 (Natural log of initial number of publications)

T2-T1= the unit Difference between the initial time and final time.

R (a) = Relative Growth Rate per unit publication per unit of time (Year)

Doubling Time

Doubling Time for publications can be calculated by the following formula:

$$\text{Doubling time for publications } Dt(a) = 0.693/R(a)$$

Table No.1: Relative Growth Rate and Doubling Time of Publications

Year	No. of Publication	Cumulative No of publication	Log _e 1 ^P	Log _e 2 ^P	[R(P)]	Mean [R(P)]	[Dt(p)] 0.693/R(P)	Mean [Dt(p)]
2001	1256	1256	-----	7.135	-----	0.345		2.575
2002	1372	2628	7.135	7.873	0.738		0.939	
2003	1380	4008	7.873	8.296	0.423		1.638	
2004	1453	5461	8.296	8.605	0.309		2.243	
2005	1388	6849	8.605	8.831	0.226		3.066	
2006	1565	8414	8.831	9.037	0.206		3.364	
2007	1512	9926	9.037	9.202	0.165		4.200	
2008	1635	11561	9.202	9.355	0.153	0.123	4.529	5.769
2009	1647	13208	9.355	9.488	0.133		5.211	
2010	1577	14785	9.488	9.601	0.113		6.133	
2011	1636	16421	9.601	9.706	0.105		6.600	
2012	2335	18756	9.706	9.839	0.133		5.211	
2013	1968	20724	9.839	9.939	0.1		6.930	

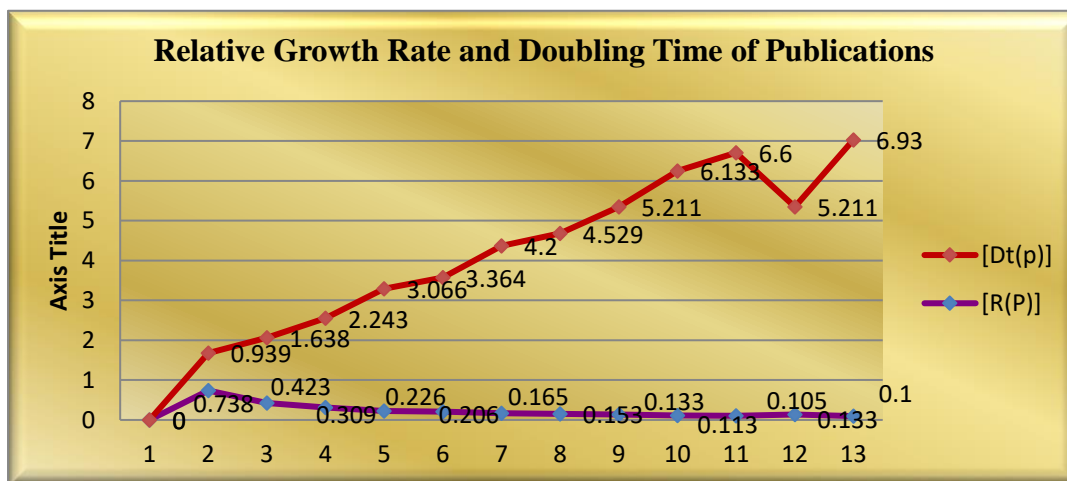


Figure No 1. Relative Growth Rate and Doubling Time of Publications

The Relative Growth Rate [R(P)] and Doubling Time [Dt(P)] of publications are derived and presented in table no 1 and Figure no.1. It can be noticed that Relative Growth Rate of publication [R(P)] decreased from the rate 0.738 in 2002 to 0.1 in 2013. The mean Relative Growth for the first seven year (i.e. 2002 to 2007) showed a growth rate of 0.345 where as the mean relative growth rate for the last six year (i.e. 2008 to 2013) reduced to 0.123. The corresponding Doubling Time for different year [Dt(P)] gradually increased from 0.939 in 2002 to 6.930 in 2013.

The mean Doubling Time for the first five year seven year (i.e. 2002 to 2007) was only 2.757 which were increased to 5.769 during the last six year (i.e. 2008 to 2013). Thus as the rate of growth of publication was decreased, the corresponding Doubling Time was increased.

2. Authorship Pattern.

Authorship pattern of the articles is presented in the Table-2. The study reveals that total of (70521) authors have contributed the 20724 articles leaving the frequencies of author. The average number of authors per article found to be 3.40.

Table no. 2. Authorship pattern

Sr. No.	No. of Author	No. of Articles	Total No. of Authors	% of Articles	% of Authors	% Community of Articles	%Community of Authors
1	One Author	4354	4354	21.01	6.17	21.01	6.17
2	Two Author	3383	6766	16.32	9.59	37.33	15.77
3	Three Author	3122	9366	15.06	13.28	52.39	29.05
4	More than Three Author	9472	49642	45.71	70.39	98.1	99.44
5	Not Mention	393	393	1.90	0.56	100	100
Total		20724	70,521	100	100		

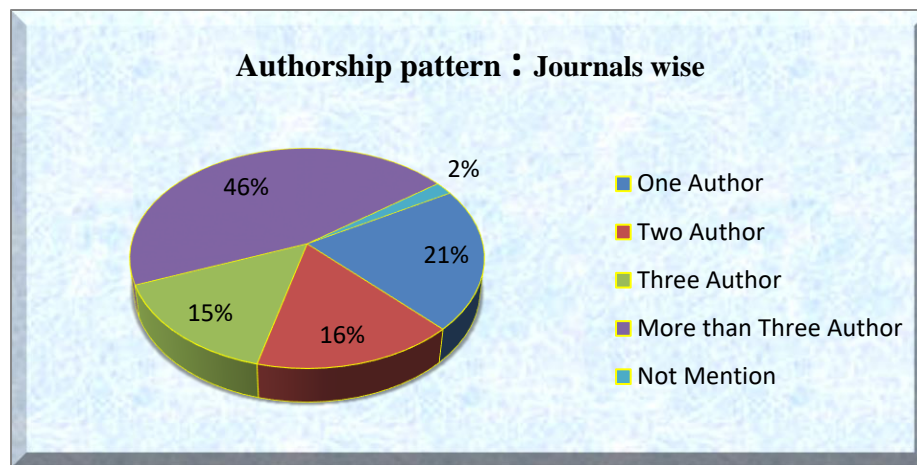


Figure No.2 Authorship pattern: Journals wise

Authorship pattern among Monthly E-Journal of medicine is given in the Table 2 and Figure no.2. Single authored papers contributions are 4354 (21.01%). Two authored papers account for 3383 (16.32%) followed by three authored papers 3122 (15.06%), more than three authored papers 9472 (45.71%) and not mentioned authored paper is 393(1.90%). The authorship pattern reveals a remarkable difference between the number of single author and multiple authors.

3. Co-Authorship

In order to assess the Pattern of Co-Authorship (CAI), the following formula suggested by Garg and Padhi has been employed.

$$CAI = \frac{N_{ij} / N_{io}}{N_{oj} / N_{oo}} \times 100$$

Where,

N_{ij} = Number of papers having authors in block i

N_{io} = Total output of block i

N_{oj} = Number of papers having j authors for all blocks

N_{oo} = Total number of papers for all authors and all blocks

CAI = 100 implies that a country's co-authorship effort for a particular type of authorship corresponds to the world average, CAI > 100 reflects higher than average co-authorship effort, and CAI < 100 lower than average co-authorship effort by that country for a given type of authorship pattern.

For calculating the co-authorship index for authors, countries have been replaced by block.

For this study, the authors have been classified into seven blocks; viz Single, Two, Three, Four, Five, Six and more than six authors and the results of Co-authorship index as per the formula have been presented in the Table No.3.

Table No.3: Co-Authorship

Year	Single Author		Two Authors		Three Authors		Four Authors		Five Authors		Six Authors		>Six Authors		Total
	No	CAI	No	CAI	No	CAI	No	CAI	No	CAI	No	CAI	No	CAI	
2001	333	126	259	126	198	105	139	87	91	77	71	68	153	79	1256
2002	308	107	243	108	167	81	138	79	115	90	121	107	224	106	1372
2003	331	114	214	95	202	97	180	103	114	88	96	84	203	96	1380
2004	319	104	215	91	249	114	163	88	122	90	115	96	230	103	1454
2005	312	107	248	109	198	95	155	88	125	96	115	100	235	110	1388
2006	309	94	281	110	235	100	216	109	156	107	114	88	237	98	1565
2007	288	91	225	91	255	112	213	111	177	125	117	93	207	89	1512
2008	359	105	259	97	234	95	192	93	179	117	125	92	259	103	1635
2009	362	105	274	102	289	116	216	103	111	72	131	96	238	94	1647
2010	331	100	229	89	225	95	215	108	184	125	156	120	222	91	1576
2011	315	92	251	94	225	91	194	94	155	101	163	120	303	120	1636
2012	352	72	344	90	359	102	302	102	256	117	266	138	404	112	2335
2013	435	105	341	106	286	96	304	122	153	83	126	77	277	91	1968
Total	4354		3383		3122		2627		1938		1716		3192		20724

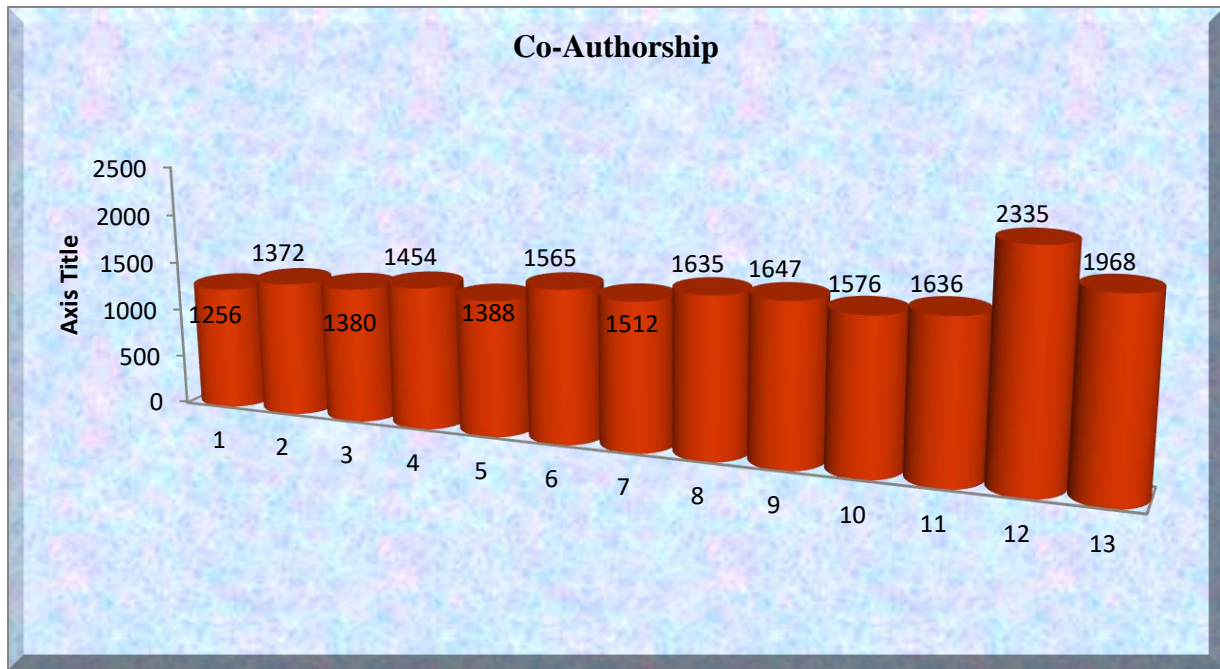


Figure No. 3 Co-Authorship

It is observed from the Table 3, & Figure no.3 the CAI for single authors is declined from 126 in the year 2001 to 105 in the year 2013. On the other hand, the CAI for double authors is enhanced from 126 in the year 2001 to 106 in the year 2013; the CAI for three authors is declined from 105 in the year 2001 to 96 in the year 2013. The CAI for four authors is declined from 87 in the year 2001 to 122 in the year 2013. The CAI for five authors is declined from 77 in the year 2001 to 83 in the year 2013. which indicates the pattern of co authorship is increasing among the contributions of the journal. On the other hand, there is a fluctuation trend of CAI for multi authored contributions.

4. Authorship Productivity Pattern.

The productivity of authors was measured in terms of the number of times a particular author was article during 2001-2013. The study revealed that few authors had been cited more number of times. The details of number of articles received by the authors are providing in table no.4 and figure no. 4.

Table No.4: Authorship Productivity Pattern

Number of Article (n)	Observed authors with 'n' Article (an)	Observed % of authors (100Xan/a1)	Expected number of authors (an=a1/n2)	Expected % authors predicted by Lotka's (100/n2)
One	4354	100	4354	100
Two	3383	77.70	1089	25

Three	3122	71.70	484	11.11
Four	2626	60.31	272	6.25
Five	1938	44.51	174	4
Six	1716	39.41	121	2.78
Seven	624	14.33	89	2.04
Eight	108	2.48	68	1.56
Nine	86	1.97	54	1.23
Ten	72	1.65	44	1
More than ten	2302	52.87	----	---

The productivity of authors was measured in terms of the number of times a particular author was cited during 2001-2013. Out of the total 20724 articles, minimum numbers (72) of authors were ten and maximum (4354) number of authors was only once. The study revealed that few authors had been cited more number of times.

The well known Lotka's law as applied to authors' productivity, it revealed that the observed percentage of authors varied from the expected percentage of authors as predicated by applying Lotka's equation.

5. Chi-Square Test for Productivity of Authors.

Chi-square test was further applied to compare the observed values with the expected values of author's productivity as per Lotka's law.

Table No. 5 Chi-Square Test for Productivity of Authors.

No. of Papers 'n'	Observed no .of authors with 'n' citation (Fi)	Expected of authors with 'n' citations (Pi)	(Fi-Pi)	(Fi-Pi) ²	(Fi-Pi) ² /pi
1	4354	4354	0	0	0
2	3383	1089	2295	5264730	4836.68
3	3122	484	2638	6960216	14387.22
4	2626	272	2354	5540728	20360.96
5	1938	174	1764	3111132	17863.64
6	1716	121	1595	2544202	21036.12
7	624	89	535	286378	3222.90
8	246	68	178	31673	465.56
9	319	54	265	70356	1308.87
10	358	44	314	98885	2271.13
11	286	36	250	62508	1737.14
12	375	30	345	118862	3931.13
13	108	26	82	6763	262.50
15	152	19	133	17596	909.29
16	172	17	155	24023	1412.44

18	194	13	181	32603	2426.10
20	132	11	121	14669	1347.62
22	86	9	77	5930	659.15
23	72	8	64	4067	494.07
25	68	7	61	3725	534.72
				Chi -Sq=3237.465, DF= 19, P-value=0.000	

The Chi Square distribution is very important because many test statistics are approximately distributed as Chi Square. Two of the more common tests using the Chi Square distribution are tests of deviations of differences between theoretically expected and observed frequencies (one-way tables) and the relationship between categorical variables (contingency tables). Numerous other tests beyond the scope of this work are based on the Chi Square distribution. Chi-square test was conducted to study whether credibility of authors is dependent on their contributions in different years. The Pearson Chi-square value 4.488 with 5 degrees of freedom is found to be insignificant at 0.05 level of significance ($p > 0.05$). Therefore, we may conclude that the attributes credibility of authors is independent of the contributions in year. The measure of association is found to be 3237.465 which highest.

The Chi-square formula:

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

$X^2 = O_i =$ Observed authors

$E_i =$ Expected authors

Expected of authors with 'n' papers (P_i) = $4354/n^2$

($F_i - P_i$) = Observed no .of authors (F_i) - Expected of authors (P_i)

Table Calculated Chi-square value (3237.465) was more than the table no 3.12.1. The value was highly significant 0.005 and the lotka's law was not applicable to the data. This may be due to the reason that it was tested here to article data which has got no limitation of area, subject or time.

6. KS Test of goodness of fit.

The productivity of the paper contribution of the medicine journal was verified to be in conformity with Lotka's inverse square law using Pao's method.

Table No. 6. KS Test of goodness of fit.

(X) No. of Paper	(Y) No. of Authors	Log (X)	Log (Y)	Log (XY)	Log (XX)	Observed Authors	Cumm. Observed Authors	Expect Authors	Cum expected Authors	D-Max
1	4354	0	3.63889	0	0	0.214	0.214	0.628	0.628	-0.414
2	3383	0.30103	3.5293	1.062425	0.090619	0.167	0.381	0.157	0.785	-0.404
3	3122	0.47712	3.49443	1.667262	0.227643	0.153	0.534	0.699	1.484	-0.95
4	2626	0.60205	3.41929	2.058584	0.362464	0.13	0.664	0.393	1.877	-1.213
5	1938	0.69897	3.28735	2.297759	0.488559	0.96	1.624	0.251	2.128	-0.504
6	1716	0.77815	3.23451	2.516934	0.605517	0.844	2.468	0.175	2.303	0.165
7	624	0.84509	2.78518	2.353728	0.714177	0.307	2.775	0.128	2.431	0.344
8	246	1.04139	2.39093	2.489891	1.084493	0.121	2.911	0.052	2.722	0.189
9	319	1.17609	2.50379	2.944682	1.383188	0.157	3.08	0.028	2.831	0.249
10	358	1.30102	2.55389	3.322662	1.692653	0.177	3.406	0.016	2.891	0.515
11	286	1.25527	2.45637	3.083408	1.575703	0.14	3.229	0.019	2.875	0.354
12	375	1.39794	2.57403	3.598339	1.954236	0.19	3.613	0.01	2.926	0.687
13	108	0.90308	2.03342	1.836341	0.815553	0.006	2.781	0.098	2.529	0.252
15	152	1.11394	2.18184	2.430439	1.240862	0.008	2.923	0.037	2.803	0.12
16	172	1.20411	2.23552	2.691812	1.449881	0.009	3.089	0.025	2.856	0.233
18	194	1.34242	2.2878	3.071188	1.802091	0.01	3.416	0.013	2.904	0.512
20	132	1.36172	2.12057	2.887623	1.854281	0.007	3.423	0.012	2.916	0.507
22	86	0.95424	1.93449	1.845968	0.910574	0.005	2.786	0.078	2.607	0.179
23	72	1	1.85733	1.857330	1.000000	0.004	2.79	0.063	2.67	0.12
25>	68	1.07918	1.8325	1.977597	1.164629	0.004	2.915	0.044	2.766	0.149
	20331	18.83281	52.35143	45.99397	20.41713					-1.213

Pao (1985) suggests the K-S test, a goodness-of-fit statistical test to assert that the observed author productivity distribution is not significantly different from an expected distribution. The hypothesis concerns a comparison between observed and expected frequencies. The test allows the determination of the associated probability that the observed maximum deviation occurs within the limits of chance. The maximum deviation between the cumulative proportions of the observed and expected frequency is determined by the following formula:

$$D = \max |F_0(x) - S_n(x)|$$

$F_0(x)$ = theoretical cumulative frequency

$S_n(x)$ = observed cumulative frequency

The test is performed at the 0.05 or at the 0.01 level of significance. When sample size is greater than 35, the critical value of significance is calculated by the following formula:

The critical value at the 0.05 level of significance: $\frac{1.36}{\sqrt{\sum y}}$

The critical value at the 0.01 level of significance: $\frac{1.63}{\sqrt{\sum y}}$

$\sum y$ = the total population under study

Total number of authors = 20331

$$D = \max |F_0(x) - S_n(x)| = -1.213$$

The critical value at the 0.01 level of significance: $\frac{1.63}{\sqrt{\sum y}} = \frac{1.63}{\sqrt{20331}} = 0.0114$

$$D < 0.0114$$

Where $F_0(x)$ is the expected relative frequency and $S_n(x)$ is the observed relative frequency of a sample of total number of authors (20331). Since the Kolmogorov- Smirnov D max of -1.213 given in Table 5 is smaller than the level of significance ($p = 0.01$) of 0.0114, Lotka's law has been found to be applicable to this sample of authors of Medicine journal.

7. Productivity Index (PI).

With regard to the above aspect of Lotka's law, the index called Productivity Index (PI) has been applied to identify the level of classification of authors. The PI is the logarithm of the values of n publications for each author.

Table 7: Productivity Index

Productivity Index (PI)	No. of Authors	% of Authors	% of Contributions	Level of contributions
PI = 0 (1 article)	4354	21.42	6.21	Intermediate Producers
0 < PI < 1 (2 - 9 articles)	13974	68.73	79.61	Larger producers
PI >= 1 (10 or more a)	2003	9.85	14.18	Occasional Producers

The PI Table 7, reveals that Intermediate producers (21.42% authors) who published only one paper each (PI = 0) contribute as much as 6.21% of total Health Science E-Journal literature while larger producers (68.73% authors) who published 2 – 9 papers (0 < PI < 1) contribute rest (79.61%) of Health Science E-Journal literature while Occasional Producers (9.85% authors) who published more than 10 papers & PI >=1) contribute rest (14.18%).

8. Co-efficient for collaborative authors.

To conduct such authorship analysis, the authors of publications are the main element of study. The “g” for the publications may be represented as g_p and the ‘g’ for the articles may be written as g_c . The degree of collaboration gives a picture of extent of collaboration among the authors.

To study the extent of research collaboration of authors, Subramanyam’s formula adopted for present study.

$$C = N_m / (N_s + N_m)$$

Where C = Degree of Collaboration of authors,

N_m = Number of Multiple authored papers,

N_s = Number of single authored papers

Table No.8: Co-efficient for collaborative authors

Number of Authors article	Number of publications	(%) from total personal author publication	Value of per N_m $g_p = \frac{N_m}{N_s + N_m}$
Total no of Personal author publications	20331	-----	-----
Number of single Author publications	4354 N_s	21.42	-----
Number of co-authors Publications	15977 N_m	78.58	0.79

Two authors Publications	3383	16.64	0.17
Three authors publications	3122	15.35	0.15
More than three Authors publications	9472	46.59	0.47

In the table no.8, Number of multiple authored articles N_m is 15977 Co-authored (Two, Three and More than three author) publications where as Number of single authored articles (N_s) is 4354.

$$\begin{aligned}
 g_p &= N_m / (N_s + N_m) \\
 &= 15977 / (4354 + 15977) \\
 &= 15977 / 20331 \\
 &= 0.79
 \end{aligned}$$

Value of Group Co-efficient for collaborative authors of publications, Among the 20331 articles of the health science journal published during 2001 to 2013, there were 21.42% written by single authors, 78.58% belonged to co-authors and 393 articles were not having name of any authors . The value of group co-efficient for publications (g_p) was 0.79. The degree of collaboration among the co-authors was minimum 0.15% in articles written by three authors and maximum 0.47% in more than three author's publications.

Conclusion:

The researchers concludes that corresponding Doubling Time for different year [Dt(P)] gradually increased from 0.939 in 2002 to 6.930 in 2013. It is found that three authored publications have the maximum share (45.71%) followed by single authored publications (21.01%). The study depicts that the value for single authored publication in the year 2001 is the highest (126). the value of CAI for six authored publications in the year 2012 is the highest (138). The Pearson Chi-square value 4.488 with 5 degrees of freedom is found to be insignificant at 0.05 level of significance ($p > 0.05$). according to the applicability of Lotka's law stated that the D-value 0.687. the above aspect of Lotka's law, the index called Productivity Index (PI) has been applied to identify the level of classification of authors. The value of group co-efficient for publications (g_p) was 0.79. The degree of collaboration among the co-authors was minimum 0.15% in articles written by three authors and maximum 0.47% in more than three author's publications.

References:

- Ahmad, Muneer and Batcha M, Sadik. (2019). Testing Lotka's Law and Pattern of Author Productivity in the Scholarly Publications of Artificial Intelligence. *Library Philosophy and Practice (e-journal)*. 2716. <https://digitalcommons.unl.edu/libphilprac/2716>
- Amsaveni, N., & Vasanthi, R. (2013). Authorship pattern and collaborative research in the field of network security. *Indian Journal of Applied Research*, 3(1), 52-54.
- Cronin, Blaise. Shaw, Debora And Barre, Kathryn La. (2001). A cast of thousands: coauthorship and sub authorship collaboration in the 20th century as manifested in the scholarly journal literature of psychology and philosophy, *jasist*, 54 (9):855–871.
- Karisiddappa, Maheswarappa, and Shirol (1990), Authorship Pattern and Collaborative Research in Psychology, *IASLIC Bulletin* 35(2) 1990, 73-78.
- Lotka, A.J. (1926). The frequency distribution of scientific Productivity. *Journal of the Washington Academy of Sciences*. 16(2), 317-324.
- Mahapatra, G. (1980). Scholarly use of web resources in LIS research: a citation analysis. *Library Review*, 55(9), 598-607.
- Mahapatra, M. (1985). On the validity of the theory of exponential growth of scientific literature. In 15th IASLIC conference proceedings: Banglor, *IASLIC*, P 61-70.
- Murugan, M., Saravanakumar R; and Thirumagal A. (2019) Lotka's Law and Pattern of Author Productivity of Information Literacy Research Output. *Library Philosophy and Practice (e-journal)*. 2509. <https://digitalcommons.unl.edu/libphilprac/2509>.
- Pao, M. L. (1985). Lotka's law: a testing procedure. *Information proceeding management* 21(4) 305-320
- Suradkar P.A. and Dr. Daya Dalve (2016). Authorship Pattern and Degree of Collaboration in Academic Emergency Medicine. *International Research: Journal of Library & Information Science*, Vol.6 No.1, 112-121.
- Thompso, M. (2008). Introduction to webometrics: Quantitative web research for the social sciences. New Yark: Morgan and Claypool.
- Vimala, V., & Reddy, V. P. (1996). Authorship pattern and collaborative research in the field of zoology. *Malaysian Journal of Library & Information Science*, Vol.1, no. 2: 43-50.
- Zafrunnisha and Pulla Reddy (2009), Authorship pattern and degree of collaboration in psychology, *Annals of Library and Information Studies*. January 2009.