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Scientometric Analysis of Literature on Public Health Using Scopus Database

Islam, Md. Nazmul

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Submitted by

Md. Nazmul Islam

Roll number: 1600047502, Registration: 2405, Session: 2015-2016

Supervisors

Dr. Partha Biplob Roy, Supervisor and Associate Professor
Department of Information Science and Library Management
University of Rajshahi, Rajshahi – 6205, Bangladesh

And

Dr. Md. Shariful Islam, Co-supervisor and Professor
Department of Information Science and Library Management
University of Rajshahi, Rajshahi – 6205, Bangladesh

Department of Information Science and Library Management
University of Rajshahi, Rajshahi – 6205, Bangladesh

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Declaration

I do hereby declare that the thesis entitled "**Scientometric Analysis of Literature on Public Health Using Scopus Database**" is my own work and to the best of my knowledge and belief it contains no material previously published or written by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university or institution.

08.10.2017

Md. Nazmul Islam

Place: Rajshahi

Date:

Dept. of Information Science & Library Management
University of Rajshahi, Rajshahi, Bangladesh
Phone: office +88 0721 711137

Certificate of Supervisors

We hereby certify that the thesis entitled "**Scientometric Analysis of Literature on Public Health Using Scopus Database**" submitted by **Md. Nazmul Islam** for the degree of *PhD* in Information Science and Library Management is a bonafide record of research done by him under our supervision and that this thesis has not formed the basis for any other degree, diploma, or similar qualification at any university or similar institution.

We also certify that this thesis represents an independent work on the part of the candidate.

08.10.17

Dr. Partha Biplob Roy

Supervisor & Associate Professor

Department of Information Science &

Library Management

University of Rajshahi, Rajshahi-6205, Bangladesh

E-mail: pbroy2000@yahoo.co.in

Cell: +88 01716 105666; Phone: +88 0721 711137(Work)

08.10.17

Dr. Md. Shariful Islam

Co-supervisor & Professor

Department of Information Science & Library Management

University of Rajshahi, Rajshahi-6205, Bangladesh

E-mail: sharif6islam@yahoo.com

Cell: +88 01712 206547; Phone: +88 0721 711137(Work) ; +88 0721 751076(Res.)

Dedicated to my respected parents, beloved wife and sweet daughter

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Md. Nazmul Islam

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List of Abbreviations

AAGR	Average Annual Growth Ratio
AAPP	Average Author Per Paper
ACPCP	Average Citation Per Cited Paper
ACPP	Average Citation Per Paper
AGR	Annual Growth Ratio
AI	Activity Index
APA	American Psychological Association
BIWS	Bibliometrics, Informetrics, Webometrics and Scientometrics
CAGR	Compound Annual Growth Rate
CC	Collaborative Coefficient
CI	Collaborative Index
CPP(CP)	Citation Per Paper for Cited Publication
CPP(TP)	Citation Per Paper for Total Publication
DC	Degree of Collaboration
Dt	Doubling time
LIS	Library and Information Science
MDGs	Millennium Development Goals
MeSH	Medical Subject Heading
OPAC	Online Public Access Catalogue
PH	Public Health
PPA	Productivity Per Author
RCC	Revised Collaborative Coefficient
RGR	Relative Growth Rate
RoG	Rate of Growth
Wos	Web of Science

Abstract

Objectives

Measuring global Public Health (PH) research output in a scientometric study is important because it reveals many facets of research including: priority areas, thriving fields, future growth of research output, values of research works, age of literature used and the information needs of researchers, scientists and subject experts, importance of different types of publication, the shape of development of a discipline at different times, regions etc. This study of the literature published on Public Health both quantitatively and qualitatively is the first of its kind. The main objective of the research is to assess the growth and development of public health literature globally and specifically within Bangladesh during the years 2000 to 2015 and review several components of scientometric study including the patterns of growth of literature, authorship, author collaboration and productivity, citation analysis and bibliometric laws.

Methodology

The current study is an exploratory research in nature reviewing secondary literature extracted from a bibliographic database and also analytical in nature with the application of suitable statistical and scientometric tools to strengthen the empirical validity. Various scientometric indicators including qualitative and quantitative indicators and a number of bibliometric laws were used at different levels of aggregation including micro, meso, and macro level. Scopus database was used as the source database to quantify and qualify data from various points of view during the period of 2000-2015. Various statistical tools including arithmetic mean, percentage, cumulative percentage, time series analysis, simple linear regression, correlation coefficient analysis, 'f-test', 't-test', ANOVA etc. were used and various scientometric indices were used for the study. The current study also used software including MS-Excel, SPSS, Harzing's Publish or Perish (PoP) to analyze and test the data.

Results

The year 2003 was the most productive year and the 2015 was the least productive year in Annual Growth Ratio (AGR) of public health published literature across the globe during the period under study. The average Relative Growth Rate (RGR) globally was 0.23 and at this rate the literature of public health doubles every 4.16 years. The average Rate of Growth (RoG) for

Bangladeshi production of literature was 1.20 with an average RGR value of 0.27. At the same rate of relative growth, the literature for Bangladesh doubles every 3 years. Globally, the average CC (Collaborative Coefficient) value for global authors was 0.37 demonstrating that there was no significant magnitude of collaboration among worldwide authors; however 92% of total publications output from Bangladesh were collaborated authors, the mean value of CC being 0.62.

The average Productivity Per Author (PPA) for global authors is 0.49 which means public health authors produced less than half a publication each year during the study period and this rate for Bangladeshi author is less than world's average (0.31). If we consider the Activity Index (AI) from 2009 to 2015 the research efforts of Bangladeshi authors were higher than world's research efforts (137.32). The Activity Index (AI) was maximum in 2015 (490.28) and the lowest in 2001 (12.06).The citation per publication for global authors was 14.21, which was 27.37 for Bangladeshi authors. Mr. McKee, having publication on public health (292) was the most prolific global author on public health, who had also highest h-index score (75) among the global authors. From the Bangladesh authorship, M. Yunus ranked highest number for publications on public health (21) and h-index score was highest for Mr. Ahsan (62).

It was found that research productivity of public health by Bangladeshi author conformed to Lotka's inverse law. On the other hand, Bradford's law of scattering fitted to the data of public health journal globally. It was also observed that Zipf's Law approximated the relationship between rank and frequency of keywords of public health. The results of all hypotheses were tested at 0.01 level of significance ($p<0.01$). It is interesting to note that all null hypothesis was rejected, which compelled to accept concerned alternative hypothesis to follow throughout.

There was always a trade-off relation between RGR and Dt (a) values. It was observed that inequality remains in the values of different measurements of collaboration (CI, DC and CC). The present research determined the level of collaboration by CC value which was never been revealed previously. For assessing an author's multiple cited rates by single publication ACPCP (Average Citation Per Cited Paper) was proposed.

Concluding Remarks

The assessment of public health literature with the help of scientometric indicators and bibliometric laws could be very useful to the researchers, scientists, library and information professionals, policy makers, and government agency relating to the concerned fields.

CHAPTER ONE

INTRODUCTION

1.1 Prelude

It has become increasingly important for library professionals/subject specialists to know the nature of research publications and pattern of growth of research output of different disciplines, and over different periods of time, due to the ever expanding knowledge resources available in different forms: books, periodical articles, reports, theses, patents, proceedings, web pages etc. Early 20th century statistical bibliography was of assistance to this challenge, and during the later part of that century was called Bibliometrics or Informetrics or Webometrics or Scientometrics, often abbreviated to BIWS. With these techniques it is easily possible to trace out many facets of research, including: the priority areas, thriving fields, future growth of research output, values of research works, age of literature used and the information needs of researchers, scientists and subject experts, importance of different types of publication, the shape of development of a discipline at different times, regions, affiliated institutions and subjects, and those which have helped in policy/decision making as well as scientific communication.

BIWS, as truly interdisciplinary fields, have strong links with the related research fields and fields of applications and services. These fields are traditionally strongly related with Library Science, Information Retrieval and Sociology of Science; on the other hand, results of such research and technology are applied as services for librarianship, scientific information and science policy (Glänzel , n.d.).

1.2 Scientometric and allied studies

The terms bibliometrics and scientometrics have been introduced almost simultaneously by Pritchard and by Nalimov and Mulchenko in 1969 (Glänzel, n.d.). Pritchard treated 'Bibliometric' as *Statistical Bibliography,* denoting the application of mathematics and statistical methods to books and other media of communication (Pritchard, 1969). Nalimov and Mulchenko used the Russian word 'Naukometriya' to explain scientometrics as "the application of those quantitative methods which are dealing with the analysis of science viewed as an information process" (Nalimov & Mulchenko, 1969). According to these

interpretations, scientometrics is restricted to the measurement of science communication, whereas bibliometrics is designed to deal with more general information processes, although nowadays both terms are used almost as synonyms (Glänzel, n.d.). The term scientometrics became more well-known, however, once the journal "Scientometrics" first appeared in 1978 (Garfield, 2009). The term 'Informetrics' comes from German term 'informetrie', and was first proposed by Nacke in 1979, and was treated as generic term for both bibliometrics and scientometrics leaning to policy studies (Hood & Wilson, 2001; Brookes, 1990).

The word "Scientometrics" is, basically, a combination of two words, *i.e.* 'Sciento' meaning "Science or Scientific" and 'Metrics' meaning "Measurement". So scientometrics implies measurement of science as discipline. More specifically, the term is mainly used for the scientific measurement study of all aspects of the literature of science and technology. The terms 'Bibliometrics' and 'Scientometrics' are often used synonymously, relating to the study of the dynamics of disciplines as reflected in the production of their literature. The term 'Informetrics' is perhaps the most general of the three terms and may include both bibliometrics and scientometrics. As a science of processing data for storage and retrieval 'Informetrics' covers that part of information science dealing with the measurement of information phenomena and the applications of mathematical methods to the discipline's problems, to bibliometrics and parts of information retrieval theory (Egghe, 2005; Hood & Wilson, 2001).

Both bibliometrics and scientometrics have been used interchangeably and synonymously over periods of time although these two have subtle differences in their activities. The study of Bibliometrics focuses on citation analysis, identifying the influence of authors and journals and the relationship among them. It helps library professionals, research scholars, interested users, and subject experts to decide to which journal to subscribe, where to publish, who are the leading authors, what are the ongoing research topics, looking backwards and forwards in a research domain from a specific time etc. Scientometric study, however, focuses on how concepts are being defined over time or in different domains, measuring the research impact, institutional development, scientific mapping, ranking of universities etc. The scope of Informetrics, finally, as stated by Tague-Sutcliffe (1992) is "very broad, including various areas of studies e.g. statistical aspects of language, word, and phrase frequencies; characteristics of authors and publications sources; citation analysis; use of recorded information; obsolescence of literature and growth of subject litertaure, databases, libraries".

Furthermore, scientometric methods denote the study of the scientific analysis of research production in the format of books, journal articles, conference proceedings etc., showing its growth and development, changing concept over period of time, pattern or structures, interrelationship, productivity, research impact, mapping etc.

The technique of scientometric/bibliometric is widely used in the Library and Information Science to explore the impact of a field, impact of a researcher or impact of a particular publication (as for example journal). It helps to identify the pattern of publication, authorship, and secondary journal coverage to gain insight into the dynamics of growth of knowledge in the areas under consideration. This can lead to better organization of information resources, which is essential for effective and efficient use. All significant compilations of science indicators heavily rely on publication and citation statistics and other, more sophisticated bibliometric techniques (Thanuskodi, 2010; Glänzel, 2003; Wikipedia, n.d.).

Informetrics covers the empirical studies of literature and documents, as well as theoretical studies of the mathematical properties of the laws and distributions that have been discovered (Hood & Wilson, 2001). Tague-Sutcliffe (1992) defined Informetrics, Bibliometrics and Scientometrics as follows:

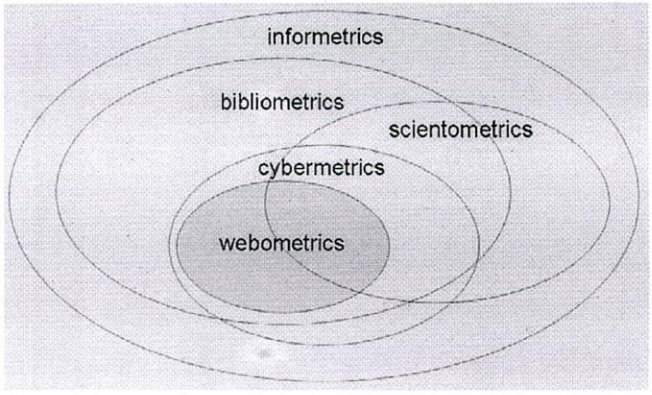
Informetrics is "the study of the quantitative aspects of information in any form, not just records or bibliographies, and in any social group, not just scientists".
Bibliometrics is "the study of the quantitative aspects of the production, dissemination and use of recorded information".
Scientometrics is "the study of the quantitative aspects of science as a discipline or economic activity".

Webometrics encompasses quantitative aspects of web page content analysis, web link structure analysis, web usage analysis, web technology analysis. Cybermetrics encompasses Internet mediated communication discussion groups, mailing lists, social networking including the web etc. Björneborn (2004) defined these fields as follows:

Webometrics is "the study of the quantitative aspects of the construction and use of information resources, structures and technologies on the web, drawing on bibliometric and informetric approaches."
Cybermetrics is "the study of the quantitative aspects of the construction and use of information resources, structures and technologies on the whole Internet, drawing on bibliometric and informetric approaches."

The scope of relationship among these allied terms is clear in following conceptual graph of Björneborn (2004):

Figure 1.1: Relationship among Informetrics, Bibliometrics, Scientometrics, Cybermetrics and Webometrics



In summery informetrics encompasses all the allied fields like bibliometrics, scientometrics, cybermetrics and webometrics. The field of webometrics is entirely encompassed by the fields of cybermetrics and bibliometrics. Scientometrics embraces the overlapping fields of bibliometrics, cybermetrics and webometrics.

1.2.1 Origin and growth of 'Scientometrics' and allied disciplines: a concise overview

The origin and gradual development of scientometrics and allied concept have been depicted in Table 1.1 (Zahedi, Costas & Wouters, 2014; Islam, 2013; Garfield, 2009; Sen, 2004 Hood & Wilson, 2001):

Table 1.1: Historical landmarks by the persons involved in the development of scientometrics and allied disciplines

Person(s)	Year	Contributions
Coles and Eales	1917	**First Recorded Study on Bibliometrics** Statistical Analysis of literature by counting titles, books and journal articles' (1543-1860)
Hulme	1923	**Introduced the term "Statistical Bibliography"** Analysis of journal articles with the productivity of countries
Gross & Gross	1927	**First recorded study on citation data**
Ranganathan	1948	**Introduced the term "Librarmetry"**

Person(s)	Year	Contributions
		Studying library operations by the application of statistics
Garfield	1950s 1960s	**Introduced the concept of "Unified citation index" and introduced "Science Citation Index (SCI)" and established "Institute for Scientific Information (ISI)"** Garfield is recognized as the 'father of modern citation indexing technique' and the 'founding father in automated indexing and retrieval information'
Price	1961 1963	**Published book "Science since Babylon" and "Little Science, Big Science"** Price was considered as the 'Father of Scientometrics' for his role on the use of quantitative indicators in formulating science policy, specially using HistCite software
Pritchard	1969	**Introduced the term "Bibliometrics" instead of "Statistical Bibliography"** Denoting the application of mathematics and statistical methods to books and other media of communication.
Nalimov and Mulchenko	1969	**First used the term Naukometriya (Russian language, later translated as Scientometrics)** The application of those quantitative methods dealing with the analysis of science viewed as an information process
Tibor Braun	1978	**Developed the journal "Scientometrics"** Leading to world wide recognition of the term Scientometrics
Nacke	1979	**Introduced the term "Informetrics"** As the study of quantitative aspects of information encompassing Bibliometrics, Scientometrics, Webometrics etc.
Bossy	1995	**Introduced the term "Cybermetrics"** Including all electronic resources

Person(s)	Year	Contributions
Almind and Ingwerson	1997	**First used the term "Webometrics"** Quantitative aspects of the World Wide Web (WWW) and all network based communication
Priem, Taraborelli, Groth, and Neylon	2010	**Introduced the term "Altermetrics" or alternative metrics rather than citation count or impact factor** Article level metrics in social/news media such as views, likes, downloads etc.

1.2.2 Three fundamental laws on 'Bibliometrics'/'Scientometrics'

There are several laws of Bibliometrics/ scientometrics used to assess the applicability in different disciplines. Among them basically there are three most across the globe: Lotka's inverse square law, Bradford's law of scattering, Zipf's law of word frequencies. The applicability of these laws is to be tested in the literature relating to public health in later part of this thesis.

(a) Lotka's law on author productivity (1926): This is one of the most discussed methods under bibliometrics and allied fields. Lotka provided the first model for the size-frequency distribution of items (papers) over sources (authors), which is actually known as the inverse square law. Lotka stated that the number of authors making "n" contributions is approximately 1\n_{2} of those making single publication. Lotka noted that the number of authors is inversely proportional to the number of papers. The contributions of authors making single contributions are approximately 60% of the entire publication in a specific field. This law can be applied to a variety of phenomenon for measuring scientific productivity (Friedman, 2015; Tague-Sutcliffe, 1992 Pao, 1985).

(b) Bradford's law on journal productivity (1934): Bradford pointed out that, if scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject and several groups and zones containing the same number of articles as the nucleus when the number of periodicals in the nucleus and succeeding zones will be 1: n: n^2. This law of scattering describes a quantitative relationship between journals and the papers they publish. Bradford contributed two theoretical approaches, one is a cumulative loglinear form of the rank frequency distribution and another one is the idea of a geometric series that represents

the increasing number of journals in the nucleus and surronding zones for a subject area, where the nucleus and the zones each containing equal number of papers but decreasing paper per journal (Sudhier & Abhila, 2011; Sudhier, 2010 ; Tague-Sutcliffe, 1992).

(c) Zipf's law with word frequency (1949): Zipf developed a size frequency and a rank frequency distribution for the distribution of word tokens over types. He showed that the frequency of a word is inversely proportional to the rank. When stated algebraically, Zipf's law is usually as rf=c, where r= rank and f = frequencies, but the law is probably most familiar in the graphic representation of a mathematically equivalent form as log r + log f = log c (Tague-Sutcliffe 1992; Fedorowicz, 1982; Wyllys, 1981).

1.3 Public Health (PH)

The dimension of health encompasses a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (WHO, 1946). In a study conducted by Institute of Medicine, public health is treated as the societal approach to protecting and promoting health. Generally through social, rather than individual, actions, public health seeks to improve the well-being of communities (As cited in Nurunnabi, Mahmood-uz-jahan & Tanira, 2010). The definition of public health is not the matter of wording but the fundamental concept of several complicated activities. In a symposium ("What Is Public Health", 1928), public health professionals were asked to indicate what the public health was meant to them. The summarized result of their thinking related to public health includes the following:

- Public health deals with the causes and conditions of health as well as of disease;
- Objects of public health are the elevation of the standard of well-being, increase of span of life, disease prevention, and adjustment of man to his environment. These objects are achieved in the individual and in social groups;
- The factors involved in terms of knowledge are related to biology, chemistry, education, medicine, engineering, nursing and law;
- Public health is made possible by individual and collective effort through official and voluntary agencies; and
- Public health is both a science and an art.

Public health refers to the activities to prevent diseases, promote health, and prolong life for the whole population. Therefore, the main objective of public health is to assure conditions for the people in order to be healthy. In two different studies conducted by Jakovljevic & Ogura and Porter found the scope of public health history as dynamic, which has been shaped by the evolution of diseases. In the last decades, health research has moved from the study of

sanitary reforms and the control of infectious diseases, to the study of the impact of epidemic and contagious diseases, and to the inclusion of social action initiatives taken in response of epidemic disasters. Thus, the scope of public health research has been expanded and broadened from a range of intellectual disciplines including the study of health economics, as well as social and political relations of health (As cited in Merigo & Nunez, 2016).

1.3.1 Incorporated concept and services of public health

Public health activities include community collaborations and partnerships for health and the identification of priorities for public health action (Callahan & Jennings, 2002). In 1920, Yale professor and respected health figure C.E.A. Winslow defined a classic definition of public health: *"the science and art of preventing disease, prolonging life and promoting health and efficiency through organized community effort for the sanitation of the environment, the control of communicable infections, the education of the individual in personal hygiene, the organization of medical and nursing services for the early diagnosis and preventive treatment of disease, and for the development of the social machinery to insure everyone a standard of living adequate for the maintenance of health, so organizing these benefits as to enable every citizen to realize his birthright of health and longevity"* ("What Is Public Health", 1928).

Winslow's definition has stood the test of time and arguably remains the most comprehensive and articulate definition today. The field of public health draws on and incorporates the expertise and skills of many other disciplines -- including biology, psychology, sociology, education, medicine, public policy and others. There are many specialties within the field of public health, yet all begin with training in the five foundations of public health: behavioral sciences/health education, bio-statistics, environmental health sciences, epidemiology, and health services administration (AAPHP, 2015).

Centres for Disease Control and Prevention (2014) defined public health as "all public, private, and voluntary entities that contribute to the delivery of essential public health services within a jurisdiction". It mentions ten essentials to describe public health activities:

- Monitor health status to identify and solve community health problems;
- Diagnose and investigate health problems and health hazards in the community;
- Inform, educate, and empower people about health issues;
- Mobilize community partnerships and action to identify and solve health problems;
- Develop policies and plans that support individual and community health efforts;
- Enforce laws and regulations that protect health and ensure safety;

- Link people to needed personal health services and assure the provision of health care when otherwise unavailable;
- Assure competent public and personal health care workforce;
- Evaluate effectiveness, accessibility, and quality of personal and population-based health services; and
- Research for new insights and innovative solutions to health problems.

1.3.2 Public health in Bangladesh

The history of public health services in Bangladesh can be traced back to the eighteenth and ninetieth centuries when the British East India Company ruled the undivided India. Formerly the health service was limited to urban areas and subsequently, the services extended to rural areas by establishing hospitals with a few beds. At that time most emphasis was given to sanitation. Later on due to the recommendation of the Plague commission in 1904, a few research laboratories were established for preparation of vaccines and sera. The 'Health Survey and Development Committee' was formed in 1946 in order to create graduate doctors and establish rural health centres. Thana (sub-district) health centre scheme was established in 1967 to provide integrated and comprehensive health care for all people. After the liberation war of Bangladesh the Ministry of Health and Welfare which has two directorates, one for health and another for family planning, is responsible for the formulation and implementation of the national health and population policies. The Health and Welfare administration is decentralized into seven divisions which divide into sixty four districts which are further divided into 545 thanas/upazilas (sub-district) and yet more divided into more than a thousand union (lowest tier of local government in Bangladesh) sub-centres responsible of local health and family planning activities including home services. The government of the people's republic of Bangladesh is now working toward achieving the Sustainable Development Goals, having previously worked toward the Millennium Development Goals (MDGs). Of the eight MDGs, three relate to health (child mortality, maternal health, and HIV/AIDS & malaria) (Ministry of health and family welfare, 2016; "Know Bangladesh", 2016; Amin *et al.,* 1999).

Bangladesh has been facing a number of challenges in public health and nutrition including: improving health care seeking behaviour, rapid urbanization which creates problems in sanitation, hygiene and supply of clean water, arsenic poisoning in drinking water, HIV/AIDS potentiality, communicable diseases, malnutrition and, environmental problems etc. These problems are due to a precarious water supply, unsanitary environment, poor nutrition, a high

population growth rate and inadequate health facilities. In order to improve these health conditions, community based public health program is recommended which should be related with health education, immunization, nutrition, maternity and child care, sanitation and pure water supply, etc (Amin *et al.,* 1999; "Public health", n.d.; "Health in Bangladesh", n.d.).

1.4 Statement of problem

Scientometrics is the most useful method for assessing the macro research output. Research sustains innovation and this is one of the main driving forces behind economic growth. Therefore, the ability to estimate research performance is vital for Governments to know the real worth of their research investments. Two different methods of evaluating research outputs are common in practice: counting the number of publications and measuring citations of authors and their publications. These methods of measurement are widely implemented internationally also for the recognition of the contribution of authors even for recommendations for Nobel Prizes (Sethukumari, 2015).

It is necessary to examine the status of Public health research in the country, its stronger and weaker areas of research, quantity and quality of research output, and the dynamics of research across institutions, sectors, geographical regions and subjects. Such a study may prove useful for Bangladeshi Science planners and policy makers to gain macro insights into the country's public health research system. On review of the literature it was found that, no such study has been conducted at macro level on the growth pattern of literature in the field of public health although a few number of journal articles, conference proceedings and reports have already been published on public health. Hence it is necessary to apply scientometric techniques on research output of public health to find out about its growth and development (Manickarajj, 2015). However, a scientometric study measuring research output globally has not been carried out yet. Therefore, it is proposed in this thesis to study quantitatively and qualitatively the literature published on Public Health (PH) extracted from Scopus bibliographic database by applying scientometric techniques.

1.5 Research objectives

The study was designed generally to assess the growth and development of public health literature during the period 2000-2015 both quantitatively and qualitatively. To achieve this, the following special objectives were devised:

A. **Assessment of growth of literature:**

- To investigate Annual Growth Ratio (AGR), Average Annual Growth Ratio (AAGR), and Compound Annual Growth Ratio (CAGR) of public health literature during 2000-2015
- To evaluate Relative Growth Ratio (RGR) and Doubling time (Dt) of public health literature
- To explore the predicted world wide future growth of literature on public health.

B. **Identification of authorship pattern, author collaboration and author productivity:**

- To analyze authorship patterns including single author , double author and so forth in the area of public health literature;
- To calculate degree of collaboration using various indices, for example Collaborative Index (CI), Degree of Collaboration (DC), Collaborative Coefficient (CC), Revised Collaborative Coefficient (RCC) etc.
- To measure author's productivity using various indices AAPP (Average Author Per Paper), PPA (Productivity Per Author) etc.

C. **Citation Analysis:**

- To trace out year-wise cited and un-cited publications on public health
- To identify highly cited publications on public health
- To study the implications of various citation indices on public health literature, for example Citation Per Paper (CPP) etc.

D. **Assessment of literature using various parameters and laws**

- To analyze public health literature using various parameters including literature produced by affiliated institutions, by country, document type, author, subject and sources of publications;
- To measure how articles on public health are scattered across journals using Bradford's laws of Scattering
- To show the relation between rank of words and frequencies of their appearance using Zipf's law of word occurrence.

E. **Extent of research on public health in Bangladesh**

- To examine growth of literature on public health in Bangladesh indexed by Scopus database during 2000-2015;

- To assess patterns, collaborations and productivity of authors and citation works on public health literature in Bangladesh;
- To study the implications of bibliometric/scientometric laws, for example Lotka's inverse square law etc. of public health literature in Bangladesh.

1.6 Research questions

A research question is associated with the problem statement and can be answered directly through the analysis of data (Derese, n.d.). To meet the objectives of the present research the following research questions were formulated:

i) What is about the world-wide growth and development of public health literature?
ii) What are the collaboration patterns of researchers on public health?
iii) What are the cited and un-cited publications on public health research?
iv) What are the contributions of Bangladeshi researchers to public health research?

1.7 Why a scientometric study on public health literature?

The example of 'computer and related technologies' which has been taught in various disciplines including Library and Information Science though the parent disciplines of these technologies, Computer Science & Engineering (CSE). Likewise bibliometric/scientometric techniques originated in Library and Information Science discipline and these can be implemented or applied in any discipline including public health as a discipline to observe the development of that particular subject, the pattern of growth, future expansion, and promising fields of research etc.

As research is a complex pursuit, it is often needed to analyse the outputs of research which are usually published in the form of journal articles, books, conference proceedings, reports, etc., and for various reasons. Some of these reasons behind scientometric analysis in public health literature are as follows:

- To exhibit the development and future expansion of the subject;
- Allocation of funds for research work;
- Awareness growing regarding value of research work;
- Help to identify future research priorities by analysing the strengths and weakness of research;

- Identify the best journal of this field to decide in which journal to submit his/her article should for publication;
- Identify best research and top researcher on the basis of impact factor;
- Locate potential collaborators; and
- To take management decision such as planning future staff, improving service pattern etc.

1.8 Scope and limitations of the research

The present study has been designed to focus on important aspects of research productivity on public health using scientometric techniques. The coverage of the study is confined to the bibliographic data downloaded from "Scopus" database covering the 16 years period of from 2000 to 2015. The study includes research articles, reviews, conference proceedings and reviews, editorial notes, letters, short surveys, books, book chapters, articles in press, erratum, business articles, and abstract report as sources of literature published on public health.

The followings are the limitations of the study:

- The study does not include primary data collected through survey or other research method directly from field;
- The study was confined to the secondary literature related with public health indexed by Scopus database only. The Scopus database is not the only database that index public health related literature world-wide;
- The study was limited to search result that fit to the search term "public health" and in some cases "Public health and Bangladesh" only;
- The present study has only been carried out with selected major bibliometric laws and scientometric indicators, although there are so many proven techniques and indicators of scientometric or bibliometric analysis; and
- Due to large data set selected for the study, in a few cases scientometric treatment has been given for a smaller segment of the literature, for example Lotka's laws to be applied for the productivity of authors in Bangladesh only.

1.9 Significance of the study

The present study describes the important features of public health research in terms of size and growth of research output irrespective of production by country, document types, author, subject and sources. This study examines the world wide progress and development of

research output on public health. It shows the year wise development of the literature by showing contributions of different affiliated institutions. It ranks the countries on the basis of contribution to research. It helps to find out the top authors on this field based upon their works cited by others to a larger extent. It exhibits the extent of public health research in Bangladesh by comparing the contributions of other countries' research output. Moreover, the study assists to discover the potential field, best authors and their works and productive journals by judging citation analyses and other measurements of publication quality which might inspire others to conduct future research.

1.10 Organization of thesis

The thesis is presented in following six chapters:

Chapter One — **Introduction:** This chapter highlights the concept, relationship, origin and development, and major laws of scientometric and allied disciplines, research questions, determination of research objectives, public health and its incorporated concept, public health in Bangladesh, necessity of Scientometric study in public health, statement of the problem, significance of research, scope and limitations of the study, and organization of thesis.

Chapter Two — **Literature Review:** This chapter deals with review of previously conducted country-wise research output on BIWS including theses, journal articles, books, websites etc.

Chapter Three — **Research Design and Methodology:** This chapter delineates research design and methodology portion of the theses consisting of description of Scopus database, design of literature review, area of study, formulation of research hypothesis, design of research method and framework, explanation of research tools and techniques including short presentation of bibliometric laws and scientometric indicators, selection of database and search strategies, determination of sample size and period of study, selection of software and data analysis pattern, use of reference style.

Chapter Four — **Data Analysis and Interpretation:** This section examines the data gathered from scopus database using various

bibliometric/scientometric laws, indicators and formulas. The result is presented in the form of tabular, graph and chart etc so that a clear picture of the research on that subject can be visualized.

Chapter Five — **Testing of Hypothesis:** This area of the thesis tests the formulated hypothesis pertinent to present research.

Chapter Six — **Findings, Discussions and Conclusion:** This chapter summarizes the essence of facts and findings gathered during data analysis. This section discusses the new and key facts of the present study. This chapter also suggests some propositions based on theories and formulas used in the study. This study also recommends some prospective areas for future study. This chapter concludes with a generalization of the concept conducted.

References — This area lists the bibliographic references used in this thesis arranged according to American Psychological Association (APA) reference style, 6th edition to acknowledge cited publications

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter previously published works on scientometric and allied fields are discussed. Informative literature review has been conducted for the current study and focus on types, main objectives, research methodologies, results and findings of the works under review. There are basically several reasons behind the review process, which is, to identify gaps, to understand contemporary research across the world, and to show important results that are pertinent and helpful to the present study. The reviewed papers are grouped by country of publication and ordered chronologically.

In the case of Bangladesh, the scientometric and allied works are still a new phenomenon. Only one doctoral thesis and a few research articles on such topics were accomplished in the country. Therefore the productions by neighboring India, often treated as the local giant (Mahbuba & Rousseau, 2010) in BIWS (Bibliometric, Informetric, Webometric and Scientometric) research, has been given special importance and priority. The nature, types and quality of research from India is very similar with that of researches conducted by Bangladeshi researchers. The literature review has been classified into three groups according to country wise research productions in BIWS: Scientometric studies conducted by Bangladeshi researchers; Scientometric studies conducted by Indian researchers; Scientometric studies conducted in other parts of the world.

2.2 Scientometric studies conducted by Bangladeshi researchers

This section of literature review focuses on the scientometric and allied works published by Bangladeshi researchers in any format for example, doctoral thesis, journal article, report etc.

Ahmed & Rahman (2008) explored growth and development of nutrition literature of Bangladesh. A total of 636 articles by 998 authors were identified published on nutrition published in 100 local and foreign journals during 1972-2006. The result suggested that Lotka's law could be applicable to the nutrition literature of Bangladesh. In the very next year, **Ahmed and Rahman (2009)** examined the validity of Lotka's law to authorship of same set of data in

the field of nutrition research using K-S goodness-of-fit but a different result was observed. This time the result suggested that author productivity distribution predicted in Lotka's generalized inverse square law was not applicable to nutrition research of Bangladesh.

Ahmed & Shuva (2009) verified the Lotka's law, Price's square root law and Pareto's 80/20 rule in the case of Library and Information Science literature of Bangladesh. The result suggested that although the Lotka's law could be applicable to Library and Information Science literature of Bangladesh, the other two rules could not be applicable to author productivity data.

Mahbuba & Rousseau (2010) compared research indicators related to India, Bangladesh, Pakistan and Sri Lanka using "Web of Science" and "Scopus" data. Collaboration data and evolution of country h-indices were also given. The result of the study indicated that Sri Lanka was the best performer among these four countries.

Mahbuba, Rousseau & Srivastava (2010) compared two health and population research organizations of Bangladesh and India in terms of scientometric indicators during the period of 1979-2008 using "Web of Science" to extract data. The study presented the evolution of publication activities from various aspects including time series of the institutional h- and R-indices, trends in yearly received citation, types of publications, international collaboration, top scientists and most cited articles.

Guns, Liu & Mahbuba (2011) studied Q-measures, as well as betweenness centrality, as indicators of international collaboration in research. The study applied external and internal inter-group geodesics into a collaboration network of 1129 researchers from different countries which is based on BIWS from the period of 1990-2009. The result suggested that average scores for local Q-measures were typically higher, indicating a relatively low degree of international collaboration. The dominating form of international collaboration is bilateral. The study also identified most important global and local actors.

Islam (2011) reported webometric study of all university websites in Bangladesh. The study tried to rank universities websites using webometric indicators. The result of study indicated that though some universities had higher number of web pages than their link pages yet their websites fall behind in terms of web impact factor.

Islam & Alam (2011) carried out another study on impact of website and the web impact factor. The study examined Web Impact Factor and Absolute Web Impact Factor of 44 private

university websites of Bangladesh. The result of the study indicated that due to some reasons the websites of these universities did not have much impact factor. The suggestions were made to follow throughout.

Khatun & Ahmed (2011) identified the literature growth, authorship pattern, collaboration and journal distribution on diarrhoeal literature extracted from PubMed, Web of Science and Scopus databases. The result of study suggested the core journals on diarrhoeal research using Bradford-Zipf's distribution. The h-index count indicated that Bangladesh had greater research impact in the region of South Asia

Mahbuba & Rousseau (2012) proposed a new standard and real valued h-index of two different types. For the first type, sources were years and items were either publications, or citations received or average number of citations received. The second type was the diffusion of speed index. The study suggested possible applications of these new types of h-indices.

Mahbuba (2012) carried out a doctoral thesis entitled "An informetric analysis of the scientific production of Bangladesh" to collect information about the current position of scientific research in Bangladesh. The study compared the conditions of Bangladesh with some neighboring countries according to Global Innovation Index and Human Development Index (HDI). It also discussed the growth of Bangladeshi publications by tracing out the collaborated works with its neighboring countries with special focus on ICDDRB of Bangladesh and NICED of India. This study also highlighted types of publication, International collaboration, top scientists, most cited articles and institutional h- and R- indices. As female scientists played a minor role in their corresponding institutes, a new interpretation in the framework of concept symbols and default values was given besides Matthew effect. Finally the study proposed new variations on the standard and the real-valued h-index. This study was the informetric contribution focusing on Bangladeshi research in an international context.

Islam (2013) described some early history of citation indexing techniques along with some modern contributions on this field. Then he tried to find out some inadequacies of Google Scholar and Thompson ISI Web of Science (WoS) in true citation impact.

Rahman, Guns, Rousseau & Engels (2015) explored bibliometric approaches to determine overlap in expertise between expert panels and the units under evaluation using, as a test case, two research evaluations of the Departments of Chemistry and PHYSICS of the university of Antwerp. The results revealed that there is some discrepancy between the panel's and the

groups' publications in both departments. The panels were not as diverse as the groups that were assessed.

Islam (2016) analyzed Library and Information Science literature published in a single journal named "Social Science Journal" published under the faculty of Social Science in Rajshahi University, Bangladesh during the period of 1996-2013. Among 187 articles by 238 authors published in Social Science journal, 21 articles by 28 authors were identified as Library and Information Science Literature, and these were given bibliometric treatment. Solo research dominated above collaborated authors. Systematic review and survey research were the most preferred research techniques by Library and Information Science researchers.

Mahbuba & Rousseau (2016) extended the notion of year based h-indices and the corresponding h-scores by providing real life example of a Bangladeshi scientist. The result of the study also showed the year based h-indices for all Bangladeshi publications.

Rahman *et al.* (2016) outlined two quantitative approaches that determine cognitive distance between evaluators and evaluees based on example data from four research evaluations during the period of 2009-2014. The study determined the Euclidean distance between the barycenter or SAPV profiles of two entities as an indicator of the cognitive distance between them.

Rousseau *et al.* (2017) overviewed five different methods to determine cognitive distances using publication records. The study presented a theoretical comparison as well as a small empirical case study.

2.3 Scientometric studies conducted by Indian researchers

This section of the literature review includes PhD theses, master dissertations, journal articles etc. by Indian researchers on scientometric, bibliometric and informetric study.

Duraisingam (n.d.) conducted a doctoral thesis entitled "Indian contributions to Biomedical research: a scientometric analysis" to apply the empirical laws of bibliometrics and indicators of scientometrics to the biomedicine literature of India covered by PubMed during 2000-2009. The study also tried to identify the trends in biomedicine research. Although there was increased trend in the research productivity of Indian scientists on biomedicine, the growth rate was not uniform. There was a strong and positive correlation observed between world research output and Indian research output on biomedicine. The study forecasted that there would be ten percent increase in single authored publications and twenty percent increase in

joint authored publications by 2015. The leading journal preferred by Indian scientists is Indian Journal of Experimental Biology. The study suggested there was strong positive correlation between GDP and the research productivity.

Paliwal, Bhatnagar & Haldar (1986) applied Zipf's law, a mathematical relationship between size and rank of discrete phenomena for prediction of Lead-Zinc resources in India. The study indicated that 75% of the Lead-Zinc metal was yet to be discovered. In future exploration preference should be in few areas of Rajasthan and Paleozoic strata of the Himalayas.

Garg & Sharma (1991) carried out a study on solar power research using Engineering Index during 1970-1984. The study indicated that the growth of the literature had been vigorous after the energy crisis in 1973-1982. The number of papers at conferences was quite close to the number of references in journals. The area of solar collectors and solar cells had received maximum attention. The publication output of literature by different countries followed the trend in basic sciences with USA being the major producer. Performance of the developed countries was low in some fields of solar power.

Nagpaul (1995) examined quantitatively and qualitatively the contributions of Indian universities to the mainstream scientific literature during the period of 1987-1989 using Science Citation Index. A number of relative indicators were considered for inter-field and inter-institution comparisons, including, publication effectiveness index, relative quality index, activity index and citability index. Inter-field comparisons were made at the level of eight macro fields: Mathematics, Physics, Chemistry, Biology, Earth & Space Science, Agriculture, Medical Sciences and Engineering & Technology. Inter-institution covered thirty three institutions published at least 150 articles in three years. The structure of correlations of these institutions with eight macro fields was analyzed through correspondence analysis of the matrices of activity and citability profiles.

Karki & Garg (1997) attempted to assess alkaloid chemistry research in India using data extracted from chemical abstract in terms of several indicators such as world and Indian output, the research group involved and their channels of communications, citations of Indian work. The paper identified Alkaloid chemistry research to fairly collaborative and part of main stream science.

Gupta & Karisiddippa (1999) explored the possibility of using new variable represented by the number of collaborators per author as a substitute for the number of papers in Lotka's distribution to predict the productivity strata. It was concluded that the number of

collaborators per author had not proved to be a good substitute in the Lotka's distribution, which was in contrast to Qin's results.

Garg (2001) did a PhD thesis entitled "Scientometric study of laser Research in India during 1970-1994" comprising 25 years of laser research output from India, and one year data set of world laser output in the Journal of Current Laser Abstracts. The objective of this study was to undertake a comprehensive study of Indian research efforts in the field of laser Science and Technology to examine the quantum of research activities being undertaken in India using several scientometric indicators such as, activity index, attractivity index, impact factor, normalized impact per paper, proportion of high quality papers, publication effective index, domestic collaborative index, international collaborative index etc. Finally the study suggested a logistic growth model in the study of laser research.

Krishnamoorthy (2003) performed a doctoral thesis entitled "Indian literature on health sciences: a scientometric study" with a view to examine the literary output, degree of transformation major sub-disciplines, prime Indian journals in the field of health sciences. Based on journal articles extracted from MEDLINE CD-ROM version, the study covered 18,833 literatures from 1966 to 2000. The resulting data was that the proportion of Indian output over the three decades has shown highly statistically significant difference. General medicine, Pharmacology and Biochemistry formed the first three clusters based on high frequency of occurrence.

Gopikuttan (2004) conducted a PhD thesis entitled "Scientometric analysis of research productivity of faculty members in the science departments of the University of Kerala". The data was extracted from the annual reports of University of Kerala from 1980-1999 and examined the relative contribution of scientific productivity, year wise growth pattern, authorship pattern, characteristics of inter-publication differences, and factors influencing research productivity. Of the 2,500 total publications, 61.88% were journal articles, 55.7% were two authored papers. In lab oriented departments the influencing factors to productivity were infrastructural facilities of laboratories, library and funding etc. whilst in non-lab oriented departments productivity influencing factors were sex, age, service and position.

Keshava (2004) carried out a doctoral thesis entitled "Scientometric analysis of Social Science research in India" to explore the applicability of selected growth models in the world and Indian publications in six sub-disciplines of Social Science viz., Anthropology, Economics, History, Psychology, Political Science and Sociology. The study was based on the literature

collected from the CD-ROM version of the Wilson Social Science Abstracts of H.W. Wilson Co., Brox of USA during the period of 1983-1998. A declining trend was observed in the case of mean relative growth rate. Psychology stood first in order in the case of exponential growth rate. Power model was fully applicable in the case of growth of Indian Sociology literature. The citation frequency distribution in Social Science journal articles and books followed a negative exponential pattern. The obsolescence factors such as annual ageing, half-life, mean-life, utility and corrected obsolescence for the journals and books varied from one another.

Pillai (2007) analyzed authorship pattern and collaborative research on Physics doctoral theses awarded by Indian Institute of Science of Bangalore during 1999-2003. The study revealed that authorship collaboration dominated solo research and was more in journal articles rather than in books.

Kademani (2008) sketched a scientometric portrait of Dr. Raja Ramanna by analyzing publication productivity, diachronous citation analysis, pattern of Synchronous reference cited through her doctoral thesis entitled "Life and works of Dr. Raja Ramanna: a scientometric study". A total of 278 publications of this scientist was identified during 1949-2002 in which 282 citations were received from 1949-2005 and citation data was retrieved using Science Citation Index. Average number of publications published per year was 5.14. Productivity coefficient was 0.65 means publication productivity increased after his 50 percentile age in 1975. Out of 278 publications only 70 papers were multi-authored papers in which S.S. Kapoor was most prominent collaborator sharing 17 papers with him. Lectures (87), Journals (85), and conferences (80) were the most preferred communication channels by the scientist. His publication density was 1.77, publication concentration was 0.25 and his h-index was 9. A total of 924 synchronous references had been received to 74 publications.

Agadi (2009) accomplished a PhD. thesis entitled "Indicators in the field of marine engineering: a scientometric analysis" where he quantified research and growth of marine engineering literature by focusing subject dispersion, rate of growth, pattern in collaboration, obsolescence of marine engineering literature. For literature searching, he used COMPENDEX engineering database online covering the 31,895 literature published during 1969-2005. A negative exponential pattern on citation frequency distribution was tested using K-S test. The annual ageing factor in the marine engineering literature was 0.93 and utility factor of the journal literature was 14.91. He showed that scientists of marine engineering used current literature for their research.

Amudha (2010) performed a doctoral thesis entitled "Scientometric analysis of stem cell research literature" to look at pattern of publication, authorship patterns, language of literature, country wise contributions and citations on stem cell literature. During the period of 1990-2004 the researcher gathered 16,645 literature covered by Silver Platter's Biological Abstracts. The study shows that number of publication on stem cell research is directly proportional to the GDP of the country. 124 journals contributed 80 percent of the total publications (14784) which confined with Pareto's 80-20 rule.

Savanur & Srikanth (2010) proposed a simple modification of CC which had limitation in the case of all multi-authored papers. The new proposed measure was named as Modified Collaborative Coefficient for measuring degree of collaboration.

Jeyaseeli (2011) carried out a doctoral thesis entitled "Biomedical research in India and China: a scientometric analysis" to measure biomedical research scientific productivity of India and china from PubMed database during the period from 2001 to 2010. Using various scientometric indicators a total of 4, 15,046 records were analyzed out of which 1, 02,942 records for Indian biomedical research production, and 3, 12,104 records for Chinese biomedical research output were taken into account. The mean relative growth rate of Chinese biomedical research output was higher than that of Indian research output. The growth pattern of literature on biomedical research for both India and China was neither exponential nor linear, but was of logistic pattern. The study shows that the scholarly research output was directly proportional to the increase in population.

Karpagam (2011) measured the research productivity of Nanotechnology among G20 countries in his doctoral thesis entitled "Literature in nanotechnology among G20 countries: a scientometric study based on Scopus database". Scopus database was used to extract 9, 16,414 records on nanotechnology during the period of 1981-2010. A linear trend in the growth of literature and a declining trend in relative growth rate were observed in the field of nanotechnology. A maximum of 20.84% publications on nanotechnology were from United States which is followed by China (16.70%). The major emphasis was given on nanostructure materials as subfield of nanotechnology. 'Applied Physics Letter' journal contributed highest number of articles (19078).

Shanthi (2011) used different scientometric indicators (RGR, Dt, CC, AI, CAI, DC, RPI etc.) to examine research output on aerospace through the doctoral thesis entitled "Scientometric analysis of literature on aerospace based on scopus bibliographic database". For this, a total of

102974 records were extracted from Scopus database on Aerospace during 1986-2010. The study indicated that maximum productions on aerospace were produced by USA. Out of 19 sub-fields, aerospace engineering was ranked first in producing maximum number of output (10289). By producing maximum number of articles 'aviation space and environmental medicine' of USA was ranked first among the total journals on aerospace.

Abilash (2012) conducted a PhD. thesis entitled "Evaluation of research performance using scientometric technique from selected higher education institutions in Kerala" where he evaluated the research performance of scientists in the field of "Kerala State Institutions" in terms of their publication research output during the study period from 1981 to 2010 using Web of Science database. A total of 20,637 records were analyzed using Hiscite software. Though this work is limited to the output of Kerala State Institutions research yet growth and development of medicinal literature was analyzed using various parameters and laws like Pareto principles (80/20 rule), price square root law, exponential growth rate, historiography map etc. The study recorded that mean relative growth rate of the literature is 0.19 and with the same growth rate doubling time has been computed as 16.13 years.

Alex (2012) carried out a doctoral thesis entitled "Knowledge management research-a scientometric analysis" to investigate growth and development of literature on knowledge management covered by ISI web of science database during the decade spanning 2000 and 2010. A total of 7968 documents were analyzed and found that higher research publications by country did not necessarily have higher activity index. During that period average 10 percent growth rate was observed and collaborative publications dominate solo research on knowledge management.

Elango & Rajendran (2012) examined authorship trend and collaboration pattern in marine science literature extracted from Indian journal of marine sciences during 2001-2010. The result of the study revealed that co-authored papers dominated; author productivity followed Lotka's law.

Swain, Jena & Mahapatra (2012) evaluated 315 scholarly articles of the journal of Inter-lending & document supply from 2001 to 2010 using different bibliometric indicators to find out various dimensions of publication trends of this journal. The study revealed that the authorship productivity pattern partially complied with Lotka's law and UK leaded in terms of country productivity. The study concluded ILDS could enrich its standard it could fine tune its editorial policy.

Swain & Panda (2012) analyzed 1541 citations of 332 articles contributed by 471 authors during the period of 2002-2010 in Journal of Intellectual Property Rights. The result of the study indicated the domination of solo research and the average number of citations against all published articles was 0.66 per article. The study also listed the top cited journals.

Bagalkoti (2013) performed a doctoral thesis entitled "Scientometric analysis of Indian science publication output as reflected in Scopus database" to describe the broad features of India's Science and Technology, in terms of size and growth of its publications output, type of institutions participating in science & technology research, their pattern of research output, concentration and scattering institutional productivity, performance across institutions, sectors, geographical regions and subjects, type of collaboration, and measurement of publications quality in terms of average impact factor and citations per paper. During the period of 1997-2011 the researchers extracted 7,01,900 Indian research papers using Scopus database, which make the India number 10^{th} in global ranking among 50 most productive countries on Science and Technology.

Das (2013) analyzes 239 articles published in journal of informetrics to examine growth of literature, types of communications, authorship pattern, collaboration trend, predominant research domain, prolific contributors, degree of collaboration, and time lag trend from 199 higher learning institutes of 32 countries across the globe. The study revealed that 30% of the total publications are single authored papers; average authorship accounted 2.28 per communications; Prof. Egghe was the most prolific author.

Kanagavel (2013) examined the research output of Clinical Trials in HIV/AIDS by identifying and determining its nature, types, and trends through his doctoral thesis entitled "Clinical trials in HIV/AIDS: a scientometric analysis". A total of 6572 records on clinical trial in HIV/AIDS were extracted from PubMed database, and analyzed using various bibliometric laws and scientometric indicators such as, Bradford's law, Lotka's Law, Prices Fundamental law, Pareto's Principle. HIV/AIDS research was largely conducted through collaboration, as illustrated by the number of co-authored papers. Journals were the most commonly used sources and channels in publishing and disseminating HIV/AIDS research.

Swain, Rautaray & Swain (2013) examined 361 papers of KIIT university, Odisha, India extracted from Scopus database during the period from 2000 to 2013 to measure authorship pattern, degree of collaboration, year wise distribution articles, corresponding citations, domain wise distribution of articles, ranking of authors, ranking of highly cited papers,

collaborating countries etc. The result of the study showed that collaborated authors dominated solo research and the highest number of publications of KIIT university researchers published in Communications in computer and Information Science.

Alvi (2014) assessed worldwide hepatitis C virus research activity using Scopus database by conducting a doctoral thesis entitled "World literature on Hepatitis C Virus research: a scientometric study". During the period of 1999-2013 he calculated that there were 60,434 literatures on Hepatitis C Virus to investigate growth, implication of bibliometric law, productivity, collaboration trend, and cognitive structure. During that period an exponential growth on Hepatitis C Virus research literature was observed and USA invariably stands at the top producer Hepatitis C Virus related literature.

Arali (2014) assessed a growth of scientific knowledge and its dynamics as reflected through publications on ten branches of genetics using three databases namely, GenBnk, PubMed and SJR (Scimago Journal and Country Rank Indicator). The results of the study reflected in his doctoral thesis entitled "Indian genetics literature: a scientometric study" showed growth and development of genetic literature to examine India's position among selected developed and developing countries. Among the ten branches of genetics Indian researchers gave priority on Microbial genetics as the data shows the highest activity index. There exists the highest degree of correlation between molecular genetics and human genetics. Factor analysis revealed molecular genetics contributed maximum (94%), which had also highest attractivity index. The journal 'Nature Genetics' had the highest impact factor among the journals of ten branches of genetics.

Chitra (2014) conducted a doctoral thesis entitled "Growth of literature on lung cancer: a scientometric analysis" to ascertain the growth of literature, sources of publications, identification of prolific authors, institutions, core journals and their related impact factor, etc. in the field of Lung Cancer during the period 1984 -2013. A total of 2,67,870 research literature related to lung cancer extracted from Scopus database were analyzed in three different levels such as macro level, meso level and micro level. Research productivity on lung cancer was comparatively higher in developed countries. Periodicals were the major sources of publications on lung cancer research.

Eswaran (2014) analyzed the research publications of scientists in the journal of IEEE Transactions on Fuzzy Systems in terms of growth rate, areas of research concentration, author productivity and authorship pattern in his doctoral thesis entitled "A scientometric

study on IEEE transactions on fuzzy systems". This study covered 931 articles during the period 2004-2013 to examine half-life period of journal citations, degree of collaboration, author productivity, authorship pattern, relative growth rate, double time for publications etc.

Kumar (2014) conducted a doctoral thesis entitled "Analysis of global literature output on textile research: a scientometric study" to examine worldwide growth and development, document type, authorship pattern, affiliated institutions, citation data etc. in the field of textile research. From 1983 to 2012, a total of 96,360 records were extracted using Scopus database. There was a negative CAGR trend in solo research whereas in collaborative research this trend was positive.

Leema (2014) aimed to evaluate the research activity of Madurai Kamaraj University scientists from various disciplines using Web of Science database during the period of 1979-2013 through the doctoral thesis entitled "Research Productivity in Madurai Kamaraj University: a scientometric approach". This study covers 3,416 research output produced by 11,554 authors to examine the growth rate and relative growth level, author productivity and collaboration level, areas of research concentration and research performance of the researchers. The study explored historiography analysis of prolific authors that indicated that highest number cited and quoted links earned by "Balamurugan", "Karthikeyan ", "Kumar " and "Indumathi ".

Maharana, Das & Choudhury (2014) analyzed scholarly papers published in Defence Science Journal to examine annual average growth rate, authorship pattern, degree of collaboration, length of papers, distribution of citations, keywords, geographical scatter, length of papers, most prolific authors during 2007-2011. The result of the study revealed that literature of DSJ journal didn't follow Lotka's law of authors' productivity; The Indian Institute of Technology was the most productive institute and H. Shekhar was most prolific author during the period under study.

Maharana & Pati (2014) examined the research productivity of Fakir Mohan University using Scopus database during the period from 2008 to 2012. The result of the study revealed A.N. Mishra as the most prolific author; 'Pollution Research' was the most favored research journal and environmental science was the most favored research area.

Singh & Bebi (2014) sought to apply Bradford's law on journal citations. The study covered 260 PhD theses on the social sciences during the period of 1995-2008. During that period 9,997 references extracted from 934 journals. The result of the study found the journal

entitled "Economic & Political weekly" as most cited journal with 22.8% citations. Bradford's law of scattering fitted to the current study.

Velmurugan (2014) analyzed 546 articles published in Indian journal of pure science and applied physics during 2009-2012 to explore research trends, authorship pattern, author productivity, collaborative pattern etc. The average degree of collaboration was 0.915 and average author productivity was 6.56.

Baskaran (2015) conducted a doctoral thesis entitled "A scientometric study of the research performance in Anna university" to focus publishing trend, impact factor, authorship pattern, types of articles, international collaborations of authors, affiliated institutions of authors, countries of contributing authors, keyword analysis and referencing pattern of Anna university research publications. A strategy for research development of Anna University on the basis of analysis and findings of the study was suggested. Data was collected using Thomson Reuters' Web of Science during the period 1979-2013 and recorded 8084 papers. Ramasamy, P. was identified as active author of Anna university publications with 836 TLCS and 4107 TGCS.

Bhardwaj (2015) accomplished a doctoral thesis entitled "Scientometric profile of global solar cell research with special reference to India" to examine 10905 global research output at five different points of time, *i.e.* for the year, 1991, 1995, 2000, 2005 and 2010 using Thomson Reuters' Web of Science. Several scientometric indicators were used to assess the world-wide growth of solar cell research, as for example, citation per paper, proportion of papers not cited, impact factor, relative citation index, activity index, co-authorship index, domestic collaborative index, international collaborative index, collaborative coefficient, transformative activity index, citation gain, and proportion of high quality papers.

Gajbe & Sonawane (2015) examined the authorship pattern and degree of collaboration in leprosy research literature. Data was extracted from PubMed database during the period of 2003-2012 using various scientometric indicators such as authorship pattern, degree of collaboration, collaboration co-efficient and dominance factor. The result of the study revealed that collaborated authors dominated over single author and the literature of leprosy followed the productivity of Lotka's law.

Hanmantrao (2015) carried out a doctoral thesis entitled "E-journals in library and information science: a scientometric study" to examine citation analysis, form of document, authorship pattern, degree of collaboration, country wise distribution, productivity of journal etc. The study covered 51,132 citations appended to 1,608 articles of five international e-journals

during 2003-2012. The result of the study indicated that solo research dominated collaborated works; USA was the contributor of maximum articles; maximum contributors were from universities; average citation range was 11-20.

Kalita, Shinde & Patel (2015) aimed at describing the public health research output in India, its focus and distribution, and the actors involved in the research system. The study also recommended steps for systematically promoting and strengthening public health research in the country. A total of 7,893 eligible articles were extracted using PubMed and IndMed databases during the period of 2000-2010. The data was analyzed in terms of biomedical focus based on the Global Burden of Disease, location of research, research institutions, and funding agencies.

Kanakaraj (2015) evaluated the research productivities of various countries relating to aquaculture to identify the trends of publications, thematic patterns etc. through his doctoral dissertation entitled "Evaluation of research publications in the field of aquaculture: a scientometric analysis". Scopus bibliographic database had been used to extract 1,06,227 records on aquaculture to examine country wise research output, relative growth rate of research output, collaborative pattern, applicability of bibliometric laws during the period of 1999-2013. The result of the study indicated a declining trend in growth of aquaculture literature. Journal articles predominated over another eight sources of publications and European continent stood first in producing highest number of article (1,368) in which UK produced maximum (219) in 1999. Woodward K N was active author of Individual contribution of single authored articles in aquaculture research output during the sample time span. The collaborative index for universal level is 4.19 which means collaborative research pattern dominated solo research on aquaculture research.

Karuilancheran (2015) conducted a PhD thesis entitled "Research productivity of Diabetes and allied diseases in India: a scientometric analysis" to ascertain the growth of literature, sources of publications, ranking of journals, calculation of activity index, science production index etc. in the field of diabetes and allied diseases in India for period of 19 years spanning between 1995 and 2013. A total of 8,156 records of Indian researchers were extracted from PubMed online database. A steady growth in terms of productivity was observed and average doubling time for total research output was 3.02 years. All India Institute of Medical Sciences ranked top in order of contributing highest number of research output (13.6%). Endocrinology and metabolism was ranked first (15.2%) as sub-field of the subject areas. V. Mohan ranked first in producing highest number publication in the field of diabetes.

Kumar (2015) analyzed the research performances of the biochemistry researchers and institutions in his doctoral thesis "Scientometric dimensions of biochemistry research in India: a study based on Web of Science." During 2004-2013 the researcher extracted 25,132 records from ISI Web of Science database which were further analyzed based on several parameters as research trend, bibliographic form, authorship pattern, citation pattern, research productivity, ranking of journals, communication channels, etc.

Gaikwad (2016) accomplished a PhD thesis entitled "Scientometric study of journal of antimicrobial chemotherapy" to analyze contents of the journals, authorships patterns of articles and productivity patterns of authors during the period 1975-2010. It was found that total numbers of authors per paper were 4.3. Experts on editorial board and advisory board of the journal wrote more papers than others in antimicrobial chemotherapy journal where Richard Wise ranked first in position by writing 47 papers. Neither price's square root law nor Pareto's 80/20 rules fit into the data set of this study.

Grace (2016) attempted to explore the characteristics of the research output in field of infertility through his doctoral thesis entitled "Research output of infertility literature: a scientometric study." The study was designed to measure the scientific productivity, global share of publications, the growth rate of literature, document and author pattern of publications, most productive institutions and countries and core journals, the impact of research and research network in the field of infertility research. Using Scopus database the researcher explored 75,098 records on infertility research during the period of 30 years (1985-2014). It was found that average citation per paper was 16.7 and USA and Canada had the highest PEI of 1.6. The study successfully tested relations between various variables, such as correlation between number of authors and number of contributions, correlation between citedness and publications, correlation between publications and cited papers, relationship between no. of publications and citations, correlation between number of cited papers and citations received, association between author pattern and cited papers, correlation between authorship pattern and citations, association between most productive journal and most cited papers, association between journal productivity and citations obtained, association between papers by productive authors of India and their citations.

Kandpal (2016) evaluated bioinformatics growth in India especially under the leadership of BTISNET in his doctoral dissertation entitled "Impact of Biotechnology Information System Network (BTISNET) on bioinformatics research in India during 2002-2003: a scientometric study" using various indicators like annual growth rate, authorship pattern, degree of

collaboration, subject wise growth, institution wise growth, core journals, prolific Indian authors, research contributions. A total of 5,245 articles were published by Indian authors from 2002 to 2013, were collected from various sources, *i.e.* BTISNET annual report, Coordinators Meet proceeding, other published document through BTISNET, Scopus Database and Web of Science Database. The growth of BTISNET as well as Indian bioinformatics were assessed by applying seven growth models like as Linear Model, Polynomial/ Quadratic Model, Power Model, Exponential Model, Logarithmic Model, Bass Model and Wood Model. The Coefficient of determination (R^2), Mean Square Error (MSE), Mean absolute Error (MAE), Correlation Coefficient, Standard Deviation parameters were considered to test the goodness of fit out of 7 models and to find out the growth and trend for different data set. The highest value of R^2 and lowest values of MSE and MAE indicate the best fitted model in a particular data set. The authorship pattern showed that bioinformatics researchers prefer collaborative research. The Indian bioinformatics authors published their research paper in 1,084 foreign journal out of which 52 foreign journals covered 1,793 papers (40.62%) and rest of 1,032 foreign journals covered 59.38%. It was also found that Mr. Das was on the top of prolific author in bioinformatics with 23 articles.

Krishnan (2016) assessed the 29,682 records on autism in his doctoral thesis entitled "Scientometric studies on autism research publications: a global perspective" to determine growth of literature, source of publication, prolific authors, institution, core journals, and to test applicability of different laws and rules of bibliometrics and indicators of scientometrics using Web of Science (WoS) from 2006 to 2015. The result of the study indicated that 29,682 records were extracted during the period of 10 years. USA, Canada and Mexico produced maximum productions on autism literature from 112 countries. Journals like "Research in autism spectrum disorders", "Journal of intellectual & development disabilities", "PLOS ONE" were identified the most productive journals in the area of autism research output from 4,623 journals. Warson J.L., Baron-Cohen S. and Gillberg C were the most prolific authors among 95,114 authors contributed in autism research. The institute of "University of California System", "University of London" and "Harvard University " were indentified most productive institutions among 6,814 institutions.

Ramasabareswari & Santhi (2016) analyzed 884 articles of IEEE transaction on pattern analysis and machine intelligence during the period of 2011-2015. The result of the study indicated that majority of the articles contributed by three authors (32.13%). The average productivity per author was 0.96.

Swarnamugi & Santhi (2016) analyzed 735 articles of 2,540 authors in IEEE/ACM transactions on networking to explore authorship trend and collaborative pattern. The result of the study revealed that average degree of author collaboration was 4.92 and highest numbers of contributions were contributed by multiple authors (98.5%).

Similar types of **scientometric studies** were also carried out by Indian researchers on different disciplines, journals, research productivities of scientists/academic librarians/universities etc. Some of such doctoral scientometric studies include: Metallurgy and Material Sciences (Sandha, 2001); Materials Science and Engineering (Rao, 2005); Software (Sahoo, 2006); Chemical Sciences (Meera, 2007); Science and Technology of Universities of Jordan (Al-Jaradat, 2008); IEEE transactions on control systems technology (Santhi, 2008); Building materials (Senapati, 2009); Robotics research of India (Ramasamy, 2011); National Institutes of Technology in India (Tamilselvan, 2011); IEE transactions on Power Electronics (Milselvi, 2012); Science and Technology of Indian Universities (Mushtaq, 2012); Agriculture (Ravanan, 2012); Antimicrobial agents and Chemotherapy journal (Udawant, 2012); Physics (Sedam, 2013); Epidemiology (Mahendran, 2014);Fashion Technology (Manimegalal, 2014); Textile Technology (Packiyaraj, 2014); Nano thin films (Prabakar, 2014); Genetic Engineering (Balasubramani, 2015); Brain tumor (Ramesh, 2015); E-journals in Library and Information Science (Machindra, 2015), Wireless communication (Manickaraj, 2015); Malaria research (Meena, 2015); Human DNA (Murugiah, 2015); Mems (Narayanan A L, 2015); Research performance of Banaras Hindu University (Parameswaran, 2015); Journal of current science (Rekha, 2015); Annals of Library and Information Studies (Senthilkumar, 2015); Swine Influenza (Sivakami, 2015); Nuclear power generation (Venkatesan, 2015); Research productivity of academic librarians of Dr. Babasaheb Ambedkar Marathwada University (Sawai, 2016); Biotechnology (Tejashwini, 2016); Rabies (Sachithanantham, 2017).

There are also some doctoral works of **Knowledge mapping** carried out by Indian researchers on different disciplines, include: Mapping CALIBER, NACLIN & IASLIC proceedings (Kulkarni, 2011); Mapping green computing literature (Surulinathi, 2012); Mapping of Social Science literature (Mogali, 2013); Mapping Indian forensic science research (Jeyasekar, 2015); Mapping Leukemia literature (Lakshmi, 2015); Mapping of tourism literature (Sethukumari, 2015); Mapping of seismic literature (Vijaianand, 2016); Mapping of DRTC annual seminar publications (Waghmare, 2015).

Some researchers also carried out their PhD theses on **Informetric study** on different disciplines, include: Fishery Science (Girijakumari, 1997); Toxicology literature (Devi, 2006);

Physics at the University of Kerala and the Indian Institute of Science, Bangalore (Sudhier, 2006); IT literature in Library and Information Science journals (Ahmad, 2012).

PhD researches have also been carried out on **Citation study** conducted by Indian researchers especially for the case of doctoral dissertations submitted to the educational institutes, or, journals or, in the case of different subjects. Some of such citation studies include: Linguistics research (Varma, 1986); Doctoral dissertations on Library and Information Science by universities of Karnataka (Kannappaanavar, 1991); Phd theses on Social Sciences by Gauhati University (Thoidingjam, 1994); PhD thesis by Punjab Rao Krishi Vidyapeeth (Deshmukh, 1998); Doctoral dissertation on Pure Sciences by Shivaji University (Khan, 1999); Doctoral dissertations in Economics of universities of Madhya Pradesh (Bopapurkar, 2003); Doctoral dissertations of Engineering and Technology of the universities in Karnataka (Dhanamjaya, 2010); Doctoral dissertations in Physics of Gauhati University (Mondol, 2011); Doctoral dissertation on Library and Information Science of universities of western India (Phugnar, 2012); PhD thesis on Social Science of Dr. Baba Saheb Ambedkar Marathwada University (Varshil, 2012); doctoral dissertations on Management of the universities of Haryana, Punjab, & Himachal Pradesh (Rani, 2014); Recency patterns of citations (Khan, 2014); Current Science journal (Dongare, 2015); PhD thesis in economics (Padmaja, 2015); PhD thesis on physical science of Dr. Baba Saheb Ambedkar Marathwada University (Sheshrao, 2015); PhD thesis in Pure Sciences by North Maharashtra University (Satpute, 2015); Doctoral theses in the Universities of Karnataka (Somashekara, 2015); PhD thesis on mathematics and statistics of Dr. Baba saheb Ambedkar Marathwada University (Bhagwanrao, 2017).

Numerous numbers of PhD research were carried out by Indian researchers on **Bibliometric studies** also. These studies were mainly conducted on different disciplines, journals, research productivities of scientists/academic librarians/universities etc., include: Biochemical knowledge on other Biological and Medical Sciences (Sengupta, 1983); Physics and Astronomy (Ratnakar, 1990); Indian Library and Information Science periodical (Tripathi, 1991); Economics (Verma, 1993); Citations in Biological Sciences (Vimala, 1997); Biomedical and health science research journals in India (Sahoo, 1998); Oceanographic research (Tapaswi, 1999); Medical literature in India (Kundra, 2002); PhD theses of Amravati University (Khokale, 2005); Space technologists of VSSC (Rajendran, 2006); Scientific performance of India (Anuradha, 2007); Social Science books in Malayalam (Beena, 2007); Herbal research (Chellappandi, 2007); Doctoral research of North Maharashtra University (Gawande, 2007); Children's literature in Malayalam (Ajikumari, 2008); theoretical population genetics (Gupta, 2009); Research

productivity of Physical Research Laboratory (Anilkumar, 2011); Wireless communication (Dhanakar M, 2011); Drug discovery in medicinal plants (Esakkiammal, 2011); Earthquake (Jasmine, 2011); Literature use pattern among the researchers in English language & literature (Murali, 2011); Indian veterinary science (Choudhary, 2012); Public finance (Bai, 2013); Indian Journal of Engineering and Material Sciences (Dhuldhule, 2013); Indian Health Science (Kavitha, 2013); Social Science research (Ramaprasath, 2013); Open access electronics journals of Library and Information Science (Satpute, 2013); Gene therapy (Muthumathi, 2014); Soft skills (Sethuraman, 2014); Anthropology journal (Thendral, 2014); Doctoral dissertations on horticulture in agricultural science (Tunga, 2014); Sciences in the universities of Punjab (Sangeeta, 2015); Open access journals in Social Science (Vimala, 2015); Indian Rice Research Institute (Ezra, 2016); Information sources in women's studies (Sharma, 2016); PhD thesis on botanical science of Dr. Ambedkar University, Agra and Lucknow University (Srivastava, 2016); Research Performance of Bharathidasan University (Lakshmi, n.d.); Gandhian studies (Singh, n.d.)

2.4 Scientometric studies conducted in other parts of the world

Australia

Hood and Wilson (2001) reviewing the literature on bibliometrics, scientometrics and informetrics indicated that these terms are often used synonymously and overlapping methodologies, *i.e.* the study of the dynamics of disciplines as reflected in the production of their literature. The origins and historical survey of the development of each of these terms were presented. The size of the overall literature of these fields was determined and the growth and stabilization of both the dissertation and non-dissertation were shown. A listing of the top journals in the three fields was given, as well as a list of the major reviews and bibliographies that were published over the years.

Belgium

Egghe (1991) discussed discrepancies of collaborative measures given by Ajiferuke, Burrell, & Tague and by Englisch. The study proposed new collaborative measures to distinguish between different collaborative situations. These new proposed collaborative measures were tested by eight principles what the author called good properties of collaboration.

Egghe (2006) introduced g-index as an improvement of the h-index of Hirsch to measure the global citation performance of a set of articles. If this set is ranked in decreasing order of the

number of citations that they received, the g-index is the largest number such that the top g article received at least g^2 citations. The study proved that $g \geq h$.

Egghe, Bormann & Guns (2011) proposed a first-citation-speed-Index (FCSI) for a set of papers, based on their times of publication and of first citation, which was based on the definition of a h-index for increasing sequences. The study presented two case studies which satisfied the intuitive feelings of what values a FCSI should have in these cases.

Rousseau & Rousseau (2014) showed that structural indicators such as the outgrow index, used in the context of diffusion or interdisciplinary studies. The study provided a simple software program to calculate and visualize the results.

Rousseau & Rousseau (2010) presented a computer program named "Lotka" for fitting power law distribution. The study basically followed Nicholl's methodology. This program could be used to test Zipf's law if data were converted from rank-frequency to size-frequency.

Ossenblock (2016) carried out a doctoral thesis entitled "Scientific communication in the social sciences and humanities: Analysis of publication and collaborating patterns in Flanders" to focus on evolutions, policy effects, collaboration measurements and edited books and provides evidence-based results using the Flemish Academic Bibliographic Database of the social sciences and humanities (VABB-SHW). The study showed how the publication output of SSH researchers has steadily grown over the last decade. There existed a wide variation in publication patterns between the social sciences and the humanities, as well as between individual SSH disciplines. The study also presented how internationally, Flanders has a relatively high degree of research collaboration in the SSH, notwithstanding substantial disciplinary variations. The study showed how the edited book has been a neglected form of research collaboration, both between co-editors, as well as between the edited book's editor(s) and the authors of the chapters contained therein. Including the editors and the editor-author-relation, changes the popular image of the lone humanities researcher.

Canada

Ajiferuke, Burell & Tague (1988) suggested a new measure called 'Collaborative Coefficient' or CC in short for measuring degree of collaboration combining the advantages of both mean number of authors per paper and the proportion of multiple-authored papers. He summed up some discrepancies of previous used measures for the degree of collaboration and suggested in using CC in comparative studies of research collaboration.

Tague-Sutcliffe (1992) defined the scope and significance of the field of informetrics and related to the earlier fields of bibliometrics and scientometrics. The study identified the phenomenon studied by informetricians. The study described the major contributions and current emphases related to the contributions of the field.

Chile

Merigo & Nunez (2016) aimed to identify the leading journals over the last 25 years (1990-2014) according to a wide range of bibliometric indicators using Web of Science database. The result of the study indicated a wide dispersion between categories being the American Journal of Epidemiology, Environmental Health Perspectives, American Journal of Public Health, and Social Science & Medicine, the journals that have received the highest number of citations over the last 25 years. According to other indicators such as the h-index and the citations per paper, some other journals such as the 'Annual Review of Public Health' and 'Medical Care' obtained better results which showed the wide diversity and profiles of outlets available in the scientific community.

China

Zhang (2010) presented relationship of the h-index, g-index and e-index by identifying some disadvantages of h- and g-index. If citations for a scientist were ranked by a power law, the study showed that the g-index could be calculated accurately by h-index, the e-index and the power parameter.

Denmark

Bjorneborn (2004) carried out a doctoral thesis entitled "Small-world link structure across an academic web space: a Library and Information Science approach" to develop a conceptual framework and empirical methods concerning the identification and characterization of whether and how small-world phenomena emerge in link structures across an academic web space. The UK academic web space *ac.uk* was chosen as a setting for the empirical investigation because a link data set that covered 109 UK universities was available and had a suitable size and coverage for studying small-world link structures. A five-step methodology was developed in order to sample, identify and characterize small-world properties by 'zooming' stepwise into more and more fine grained web node levels in the investigated UK academic web space.

Larsen & Ins (2010) noted that there was declining coverage by SCI and there was no indication for declining trends of publication. New channels of publication as for example conference proceedings, open archives, home pages etc were growing faster than low growing coverage by SCI. The limited data available for social sciences showed that the growth rate in SSCI was remarkably low and indicated that the coverage by SSCI was declining over time. It was reported that this declining coverage of citation databases problematized the use of SCI, SSCI, and AHCI type of sources.

Finland

Puuska (2014) carried out a doctoral thesis entitled "Scholarly publishing patterns in Finland: a comparison of disciplinary groups" to investigate variation in publishing patterns of different disciplinary groups in Finnish universities. The study provided a comparative analysis of disciplinary groups, that is, natural sciences, engineering, medicine, agriculture and forestry, social sciences and humanities using different types of datasets including all types of publications. The study focused on various publishing types and co-publications in Finland; changes in publishing patterns during the past two decades; the effects of gender and position on publishing patterns; applicability of different kinds of datasets in the assessment of publishing performance.

Ministry of Education and Culture (2015) described the current state of scientific research in Finnish universities particularly in the early 2010s. The report analyzed volume, productivity and scientific impact of university research and provides comparisons between universities by individual disciplines. The data were extracted from two distinct sources: scientific publications between 2011 and 2012 delivered by the universities to the Ministry of Education and Culture; and publications of Finnish university researchers between 2000 and 2012 entered in the Thomson Reuters Web of Science publications and citations database. The results showed that universities produced on average 37,000 publications between 2011 and 2012, generating 51,400 publication scores. Altogether 19,800 authors were involved in producing the publications. The publication productivity rate at level 1 (publications per authors) was 1.9 per author, and the score for productivity at level 2 (publication score per authors) was 2.6 per author. The volume of WoS publications in universities increased from just over 14,000 between 2000 and 2003 to 18,400 between 2009 and 2012. Based on the WoS data, the main academic disciplines in university research were natural sciences, medicine and health care. The report also showed which disciplines are the most productive and effective in each university.

Germany

Donner, P. (n.d.) compared publication behavior between female and male scientists of 14 countries from Asia and Europe during the period of 1980 to 2010 in various sectors like productivity and involvement, cooperation and citation impact. Data was extracted from Science Citation Index (SCI) of Web of Science.

Donner, Chi & Aman (2014) examined the growth and impact of literature published in the field of public health and epidemiology in Germany. For this 156 journals on public health and 76 journals on epidemiology were selected using Scopus database during the period from 2000 to 2012.The result of the study showed the publication by document types; most productive countries of public health; relative share of German publication in public health; publications dynamics; impact assessment through absolute citations, relative share of citations, citations per paper, share of un-cited publications etc.; German institutes in the field of public health and epidemiology.

Greece

Falagas *et al.* (2008) compared content coverage and practical utility of PubMed, Scopus, Web of Science, and Google scholar. The study used the example of a keyword search to evaluate the usefulness of these databases in biomedical information retrieval and a specific published article to evaluate their utility in performing citation analysis. For citation analysis, Scopus offers about 20% more coverage than Web of Science, whereas Google Scholar offers results of inconsistent accuracy. PubMed remained an optimal tool in biomedical electronic research. Scopus covered a wider journal range, of help both in keyword searching and citation analysis. Google scholar could help in the retrieval of even the most obscure information but its use was marred by inadequate, less often updated, citation information.

Hungary

Bujdoso & Braun (1983) suggested indicators of research activity in order to evaluate the relative research efforts within the subfields of physics in a given country and in relation to the world average. The comparison of the internal activity indicators of various countries showed that self-regulating mechanism of scientific research tended to keep an even distribution of efforts in each of the Physics subfield on a world wide scale.

Iran

Mohammadhassanzadeh, H. *et al.* (2011) proposed two new indices entitled "collaboration h-index" (hc-index) and "collaborative researchers h-index" (hcr-idex), to assess extent of collaboration activities focused on the main goals of a research team. These indices were based on the concept of main research theme and assess the degree of collaboration of each institute and its researchers according to this theme.

Heidari & Safavi (2013) analyzed 288 articles of "Iranian Journal of Pathology" from 2006 to 2012 to calculate collaborative co-efficient between the authors. Average collaborative coefficient of authors in research years was 0.69 which concluded the study that collaboration between authors of Iranian pathology was high.

Samadikuchaksaraei, Mohammadhassanzadeh & Shokraneh (2013) analyzed the growth rates of stem cells and tissue engineering and regenerative medicine publications extracted from PubMed using MeSH terms during the period of 2001-2011. The study showed a moderate growth rate on tissue engineering and regenerative medicine publications and a low growth rate on stem cells publications of Iran. The study recommended viewing and managing stem cells research as a part of regenerative medicine not vice versa.

Japan

Yoshikane *et al.* (2009) examined diachronic correlation of properties *i.e.* the correlation between subsequent and precedent activity. The study analyzed the correlation between the productivity of newcomers subsequent to their emergence into a new domain and the precedent activity of their co-authors with the aim to derive knowledge about the effect of collaborators on their collaborating partners. The result of the study indicated that there was very little correlation between the number of papers of newcomers and the past activity of co-authors.

Malaysia

Anyi, Zainab & Anuar (2009) reviewed 82 bibliometric studies on single journals in the field of Arts, Humanities, Social Sciences, Medical & Health Sciences, Science & Technology, Library & Information Science published in United Kingdom, United States and Americana, Europe and Asia (India, Africa and Malaysia) during 1998-2008. The result of the study indicated that bibliometric studies covered journals in various fields, Asian and African contribution was high;

the quality of the journals and their importance either nationally or internationally are inferred from their indexation status.

Yazit & Zainab (2007) analyzed Malaysian Library and Information Science (LIS) research and publications to explore total number and spread of publications, active authors, authorship pattern, the affiliation status of the authors, the main channels used to publish, subject covered by published works. Data was extracted from seven online databases and seven OPACs during the period of 1965-2005.

Mexico

Macias-Chapula *et al.* (2008) identified the production and visibility of public health research work of Mexico in different databases (ARTEMISA, LILACS-SP, MEDLINE, ISI's Web of Science) so as to obtain the main subject content, collaboration patterns and geographical coverage of such production covering the period from 1987 to 2007. The goal was to incorporate these results into the construction of a conceptual model of public health research work as related to knowledge management in the field. The result of the study indicated that national and regional databases covered mainly Spanish language publications, while international databases covered results in English language. LILACS-SP covered books, book chapters, and grey literature in a greater scale. 60% of LILACS-SP's publications were collaborated authored papers. This database were mainly related to female authors and related to health services and epidemiology types of subject content.

The Netherlands

Zahedi, Costas & Wouter (2014) analyzed the presence and possibilities of altmetrics for bibliometric and performance analysis. Metrics for a total of 20,000 random publications were collected from Web of Science using Impact story, a web based tool. The study then analyzed the presence and distribution of altmetrics in the set of publications, across fields, document types and over publication years, as well as the extent to which altmetrics correlate with citation indicators. The result of the study showed that the altmetrics sources that provide the most metrics is Mendeley. A moderate correlation (r=0.49) was found between Mendeley readership counts and citation indicators. The study concluded with the discussion of these indicators.

Zuccala *et al.* (2014) conducted a publisher ranking study based on a citation data in history journals from Scopus database during period of 2007-2011 and matched the metadata from

WorldCat®. The study constructed a ranking of the top 500 publishers and explored descriptive statistics at the level of publishers type (university, commercial, other) and country of origin. The study then identified top 50 university presses and commercial houses based on total citations and mean citations per book. Then a map of directed citations links between journals and book publishers was presented.

Leydesdorff & Milojević (2015) overviewed the field of scientometrics, *i.e.* the study of science, technology, and innovation from a quantitative perspective. The current study covered historical milestone in relationship with sociology of scientific knowledge, the Library and Information Science, and science policy issues. The study also analyzed the disciplinary organization of scientometrics conceptually and empirically.

Nigeria

Udofia (2002) compared author collaboration in the periodical literature of African Trypanosomiasis, extracted from Tropical diseases bulletin and tsetse and trypanosomiasis quarterly during the period of 1990-2000. The result of the study indicated that multiple authorships dominated in Trypanosomiasis literature.

Pakistan

Qayyum & Naseer (2013) analyzed the contributions of Dr. Khalid Mahmood in the field of Library and Information Science to include geographical and year wise distribution of publications, collaborated nature, subject area coverage etc. The result of the study revealed that two-third of Khalid Mahmood's work was collaborated in nature; among the 115 contributions 99 publications were articles, six publications are books, eight publications are conference proceedings, and two papers are newsletters.

Serbia

Kutlaca *et al.* (2014) analyzes South East European countries scientific output and impact by Frascati fields of science in the period of 2005-2010 to determine level of development of certain scientific fields in selected countries and quality of scientific publication production using several indicators including total number of country publications per full time equivalent researcher, revealed publication advantage, the h-index and top cited articles. The result of the study could be especially significant to the planners and policy makers.

Singapore

Ding, Foo & Chowdhury (1999) analyzed the collaborative pattern of the information retrieval research using co-authored articles retrieved from Social Science Citation Index during the period from 1987 to 1997 to examine level of collaboration, journal collaborative distribution, disciplinary collaborative distribution and country collaboration. The result of study revealed a perceptible upward trend of collaborative IR research.

Spain

Moya-Anegon *et al.* (2007) compared the coverage of Scopus database with Ulrich's directory to determine their homogeneity in academic world. The results of the study described a profile of Scopus in terms of its coverage by areas- geographic and thematic – and the significance of peer- review in its publications. The coverage provided by Scopus was balanced in terms of subject areas, languages and editors when compared with Ulrich's core. The result concluded that to avoid the comparison of research results in diverse or at different aggregations levels some considerations were suggested to be taken into account.

Jimenez-Fanjul, Maz-Machado, & Bracho-Lopez (2013) analyzed four mathematics education journals indexed by SSCI of Web of Science (WoS) to identify co-authorship patterns, diachronic production, publication's language and the universities productivity. The study also identified international production of each country and the university so as to know the most important international collaboration networks.

Torres-Salinas *et al.* (2013) explored the possibilities of applying bi-plot analysis in the research policy area. The study compared JK-biplot representation with other multivariate analysis techniques. The study concluded that bi-plot analysis could be a useful technique in scientometrics when studying multivariate data, as well as an easy to read tool for research decision makers.

Navarro & Martin (2013) analyzed the differences in the scientific literature on the sexism in advertising depending on media. The study conducted a systematic review of studies on gender and advertising published in Spanish and English languages during the period of 1988-2010. Data were extracted from seven Spanish and international databases. The results of the study showed that unlike legislative controls, the academy studied mainly sexism in advertising in print media, although interest by analysis of the treatment of gender in the discourse of advertising audiovisual was increasing.

Switzerland

Bornmann, Mutz & Daniel (2008) examined empirical results on the h-index and its most important variants in order to determine whether the variants developed were associated with an incremental contribution for evaluation purposes using data on post-doctoral researchers in biomedicine. The study calculated a logistic regression analysis with the two factors, that is, number of papers and impact of papers.

Kunzli (2015) critically reviewed Leopoldina report by **Donner, Chi & Aman (2014)** in the editorial. This report failed to include the highest ranking journals such as Lancet, NEJM and top ranking epidemiologic journals. It was also noted that the highest ranking institution published 154 articles during the 13-year study period, while the 10^{th} placed institute published 73 papers. The bibliometric study ignored how epidemiology and public health were organized. The report's definition of what constitutes output in public health science and epidemiology is so restrictive that not much was left to evaluate.

Taiwan

Chuang *et al.* (2011) assessed the growth trend and characteristics of public health related research output published by the researchers in African institutions from 1991-2005. Data was extracted from ISI Web of Science: SCI-Expanded using the phrase of 'public health' by African researchers. The study showed a significant increasing rate of research output and international collaboration pattern during 1991-2005. African researchers were more interested to work with the researchers of European and North American countries. Keywords, subject categories and collaboration patterns of articles varied across regions, reflecting differences in needs and collaboration networks.

United Kingdom

Brookes (1968) showed that Bradford distribution is closely related to the Zipf distribution. The study suggested a standard form to ensure comparability of estimates. This modified form of Bradford distribution was required when Bradford-type collections of journals were merged into larger collections, when situation of the most productive journals occurred.

Clarke, *et al.* (2007) overviewed public health research literature in Europe using SCI and SSCI databases during 1995-2004. The study analyzed output for country by population, Gross domestic product, burden of disease using DALYs and language. A total of 2,10,433 publications were extracted out of which 7,000 papers produced per year in Europe and 9400

papers published per year by USA. The result of the study indicated that GDP was a modest predictor of publications (r^2=0.53, p<0.02) for European countries while population size and disability adjusted life years were not significantly related. Smaller countries and lower producers of public health research were more likely to collaborate with other countries.

USA

Hill (1974) derived the Zipf distribution using a Bose-Einstein form of the classical occupancy model with a random number of cells. He showed that an extension of the Bose-Einstein model of allocation within regions yields convergence to a form of Zipf's law.

Breaver & Rosen (1978) presented and developed the first comprehensive theory of scientific collaboration. French scientists conducted maximum joint research in the early 19th century while collaborative research appeared much later in England and Germany. The findings of the study conformed to theoretical expectation.

Price (1981) explained a method for analyzing matrices of statistics where each element was approximately proportional to some column coefficient and also to some row coefficient. The study used US patent data to show how entries were usually proportional to country "size" and patent category "size".

Fedorowicz (1982) examined a number of theoretical derivations of the Zipf's law in order to show the relationship between the many attempts at ascertaining a theoretical justification for the phenomenon. The study then briefly examined some of the ramifications of applying the law to the bibliographic database environment.

Subramanyam (1983) identified and reviewed earlier several types and levels of collaboration. The study proposed a new measure for the degree of collaboration (DC), the value of which always lies between 0 and 1. The result of the study revealed that the degree of collaboration was higher in biochemistry than in chemical engineering; collaboration was affected by various factors including financial support, nature of the research problem, and the research environment.

Pao (1985) presented a step-by-step outline for testing the applicability of Lotka's law. The steps included the computation of the values of the exponent and the constant based on Lotka's method, and the test for significance of the observed frequency distribution against the estimated theoretical distribution derived from Lotka's formula. For testing the compliance of a group of authors to lotka's inverse power law the study suggested in some

steps: data collection, frequency distribution, calculation of n, calculation of C, Kolmogorov Smirnov test of goodness of fit.

Pao (1986) empirically examined author productivity data to determine if there were characteristics that influenced the conformity to Lotka's law. The findings indicated that most of the data did not fit the inverse square function. The result of the study recommended that data should be compiled from a comprehensive source to capture a true representation of the target population. If only a single major primary journal was used to collect data, a longer period of coverage was advised.

Hirsch (2005) proposed *h* index as the number of papers with citation number ≥*h*, which is a useful index to characterize the scientific output of a researcher. The study defined *h* index as a scientist has index *h* if *h* of his or her Np papers have at least *h* citations each and other (Np-*h*) papers have ≤*h* citations each. The proposed *h* index had some advantages over some typical types of indicators to measure impact of works such as total number of papers, total number of citations, citations per paper, number of significant papers, number of citations to each of the q most cited papers. This index gave an estimate of the importance, significance, and broad impact of a scientist's cumulative research contributions.

Garfield (2009) examined the early days of scientometrics and discussed Derek de Solla Price and John Desmond Bernal on the development of the field. The concept of Scientometrics and Bibliometrics were half a century old, it was evolved with the publication entitled "Science of Science" in 1930 and transitioned by J.D. Bernal's "social function of science" in 1939, but the concept got dormant after D. J.D. Price's books "Science Since Babylon " and "Little Science, Big Science" being published in 1961 and 1963. As father of scientometrics, Price used HisCite software to visualize his impact and subsequent impact of the journal scientometrics on the growth of the field. The timeline for the evolution of scientometrics was demonstrated by a HistCite tabulation of the ranked citation index of the 10,00,000 references cited in the 3,000 papers citing Price.

2.5 BIWS research studies

BIWS research studies have been carried out on different subject, country's production, journal/proceedings, works of scientists/researchers, university production, indicators/law/principles to trace out the growth and development, mapping, collaboration pattern, development of theorem etc. across the world. Scientific publishing patterns have been studied extensively around the world at various levels: through comparisons between

countries, between institutions, and within single scientific fields, etc which are shown in the next few tables:

Table 2.1: BIWS research on specific topics

S.N.	Name of topics	Number of times research carried out
1.	Aerospace	1
2.	African Trypanosomiasis	1
3.	Agriculture	1
4.	Alkaloid chemistry research	1
5.	Antimicrobial chemotherapy	1
6.	Aquaculture	1
7.	Autism research	1
8.	Biochemical knowledge on other biological and medical sciences	1
9.	Biochemistry research	1
10.	Bioinformatics	1
11.	Biological Sciences	1
12.	Biomedical and health science research journals in India	3
13.	Biomedicine	1
14.	Bi-Plot analysis in the research policy area	1
15.	Brain tumor	1
16.	Building materials	1
17.	Chemical Sciences	1
18.	Children's literature in Malayalam	1
19.	Clinical Trials in HIV/AIDS	1
20.	Cognitive distance between evaluators and evaluees	1
21.	Cognitive distances using publication records	1
22.	Comprehensive theory of scientific collaboration	1
23.	Correlation between the number of papers of newcomers and the past activity of co-authors	1
24.	Coverage and practical utility of PubMed, Scopus, Web of Science, and Google scholar	1
25.	Coverage of Scopus database and Ulrich's directory	1
26.	Diabetes and allied diseases	1
27.	Diarrhoeal	1
28.	Doctoral theses on Physics awarded by Indian Institute of Science of Bangalore	1
29.	DRTC annual seminar publications	1
30.	Drug discovery in medicinal plants	1
31.	Earthquake	1
32.	Economics	1
33.	English language & literature	1
34.	Epidemiology	1
35.	Expert panel and the units under evaluation	1
36.	Fashion technology	1
37.	Fishery Science	1
38.	Gandhian studies	1

S.N.	Name of topics	Number of times research carried out
39.	Gene therapy	1
40.	Genetic engineering	1
41.	Green computing literature	1
42.	Health sciences	1
43.	Hepatitis C Virus	1
44.	Herbal	1
45.	History	1
46.	History of scientometrics	2
47.	Horticulture in agricultural science	1
48.	Human DNA	1
49.	Indian forensic science research	1
50.	Indian health science	1
51.	Indian rice research institute	1
52.	Indian science publication	1
53.	Indian veterinary science	1
54.	Infertility literature	1
55.	Information retrieval	1
56.	Information sources in women's studies	1
57.	IT literature	1
58.	Knowledge management	1
59.	Laser Research	1
60.	Lead-Zinc resources	1
61.	Leprosy research	1
62.	Library and Information Science literature of Bangladesh	1
63.	Lung cancer	1
64.	Malaria research	1
65.	Malaysian LIS research and publications	1
66.	Marine engineering	1
67.	Materials Science and Engineering	1
68.	Mathematics education	1
69.	Medical literature in India	1
70.	Mems	1
71.	Metallurgy and material sciences	1
72.	Nano thin films	1
73.	Nuclear power generation	1
74.	Nutrition literature of Bangladesh	2
75.	Oceanographic research	1
76.	Origin and gradual development on bibliometrics, scientometrics and informetrics	1
77.	Physical Research Laboratory of India	1
78.	Physics	2
79.	Physics and Astronomy	
80.	Presence and possibilities of altmetrics	1
81.	Problems of SCI, SSCI, and AHCI type of sources.	1
82.	Public finance	1
83.	Publication behavior between female and male scientists	1
84.	Rabies	1
85.	Review of bibliometric studies on single journals	1

S.N.	Name of topics	Number of times research carried out
86.	Review of Leopoldina report	1
87.	Robotics research of India	1
88.	Scope and significance of Informetrics	1
89.	Seismic literature	1
90.	Sexism in advertising depending on media	1
91.	Small-world link structure across an academic web space	1
92.	Social Science and humanities	1
93.	Social Science books in Malayalam	1
94.	Social Science literature	3
95.	Soft skills	1
96.	Software	1
97.	Solar cell research	1
98.	Solar power research	1
99.	Space technologists of VSSC	1
100.	Stem cell research	2
101.	Swine influenza	1
102.	Textile technology	2
103.	Theoretical population genetics	1
104.	Tourism literature	1
105.	Toxicology	1
106.	Wireless communication	2

Table 2.2: BIWS research productions on specific country

S.N.	Research productions on specific country
1	India, Bangladesh, Pakistan and Sri Lanka
2	Nanotechnology among G20 countries
3	Private university websites of Bangladesh
4	Publishing patterns in Finland
5	Scientific performance of India
6	Scientific production of Bangladesh
7	South east European countries scientific output and impact
8	University websites in Bangladesh

Table 2.3: BIWS research work on researcher/scientist (Bio-bibliometric study)

Name of scientist/researcher	Specialization
Dr. Khalid Mahmood of Pakistan	Library and Information Science
Dr. Raja Ramanna of India	Physics

Table 2.4: BIWS research on journals/proceedings

S.N.	Name of journals/proceedings
1	Annals of Library and Information Studies
2	Anthropology Journal
3	Antimicrobial Agents and Chemotherapy Journal
4	CALIBER, NACLIN & IASLIC Proceedings
5	Defense Science Journal
6	E-journals in Library and Information Science
7	IEE transactions on Power Electronics
8	IEEE transaction on Pattern Analysis and Machine Intelligence
9	IEEE transactions on Control Systems Technology
10	IEEE/ACM Transactions on Networking
11	Indian Journal of Engineering and Material Sciences
12	Indian journal of Pure Science and Applied Physics
13	Indian Library and Information Science Periodical
14	Iranian Journal of Pathology
15	Journal of Current Science
16	Journal of IEEE Transactions on Fuzzy Systems
17	Journal of Informetrics
18	Journal of Intellectual Property Rights
19	Journal of Inter-lending & Document Supply
20	Library and Information Science literature published in Social Science journal
21	Marine Science in Indian Journal of Marine Sciences
22	Open Access Electronics Journals of Library and Information Science
23	Open access Journals in Social Science

Table 2.5: BIWS research on productions by university/institution

S.N.	Research production by university/institution
1	Anna University, India
2	Botanical science of Dr. Ambedkar University, Agra and Lucknow University, India
3	Indian universities
4	Doctoral research of North Maharashtra University, India
5	Fakir Mohan University, India
6	Health and population research organizations of Bangladesh and India
7	Higher education institutions in Kerala, India
8	KIIT University, Odisha, India
9	Madurai Kamaraj University, India
10	National Institutes of Technology in India
11	PhD theses of Amravati University, India
12	Physics at the University of Kerala and the Indian Institute of Science, Bangalore, India
13	Banaras Hindu University, India
14	Bharathidasan University, India
15	Academic librarians of Dr. Babasaheb Ambedkar Marathwada University, India
16	Faculty members in the science departments of the University of Kerala, India
17	Science and Technology of Indian Universities
18	Science and Technology of Universities of Jordan
19	Sciences in the universities of Punjab, India
20	Scientific research in Finnish universities, Finland

Table 2.6: BIWS research on scientometric indicators, laws and principles

Name of scientometric indicators, laws and principles	Number of time research carried out
hc-index and hcr-idex	1
Collaborative Coefficient (CC)	1
Citation Index	1
Degree of collaboration (DC)	1
First-citation-Speed-Index	1
g-index	1
h-index	2
h-index of two different types	1
Lotka program	1
Lotka's law	2
Modified Collaborative Coefficient (MCC)	1
Modified form of Bradford distribution	1
New measure of collaboration	1
Outgrow index	1
Q-measures	1
Relationship of the h-index, g-index and e-index	1
Zipf distribution	2

Table 2.7: BIWS research on PH

Name of topics	Name of country/continent	Types of sources	Coverage	Period	Database
Public health and epidemiology	Germany	Journal literature	156 journals on public health and 76 journals on epidemiology	2000-2012	Scopus
Public health research literature	Europe	All types	2,10,433 publications	1995-2004	SCI and SSCI databases
Public health research work	Mexico	All types	-	1987-2007	ARTEMISA, LILACS-SP, MEDLINE, ISI's Web of Science
Public health research in Africa	Africa	Journal Article	1,213 publications	1991-2005	SCI-Expanded
Public health research in India	India	Journal Article	7,893 articles	2000-2010	PubMed and IndMed databases

The review of literature has been grouped here by country's output and then by studies on several aspects, such as, specific subject's growth pattern; growth and development of country's/institution's/university's production; development of individual or group of

journals/proceedings; research output of individual scientist/researcher; indicators, laws, principles of BIWS research etc.

2.6 Inferences

The review of related literature has been done from 1960s to 2017 keeping in view few issues which may help to design the current study. Some of such issues behind present literature review are as follows:

- To select source database;
- To know contemporary rules, principles, indicators and laws of BIWS research;
- To help to select topic; and
- To show important data of previously conducted research, which are pertinent to present and future research also.

The current literature review is not a comprehensive review covering concerned field of all country's research output but a selective one focusing on current research trend, growth and development, pattern and result of BIWS research. There are only a few fields or subjective disciplines where repeated research works have been found, e.g. study on stem cell research, genetic engineering, textile technology, Social Science literature, physics etc. although the study period, choice of scientometric indicators for analysis, scope of research were different. There are several reasons behind conducting repetitive research works. Firstly, there is no bibliographic control on BIWS research across the globe. Secondly, there is no individual forum/research group who maintain country-wise statistics, which could also be an important area of further research. Apart from few retrospective literature studies, no single research was found at micro level on scientometric study for analyzing growth and development of BIWS research around the world. The future researchers could take this opportunity although it would be a massive task but importantly it will be a permanent solution for guiding the future researchers to select topic, area and scope of research.

In summary, very few publications were found on scientometric study of public health. Three such works have been found at macro level (country's production on public health) (Kalita, Shinde & Patel, 2015; Donner, Chi & Aman, 2014; Macias-Chapula *et al.*, 2008) and two works on continent's production on public health (Chuang *et al.*, 2011; Clarke, *et al.*, 2007) but no work was found assessing public health literature globally. Therefore, the present thesis contributes to scientometric studies by:

1. Providing analysis of literature of single field (Public health) globally instead of analysis of disciplinary groups (e.g. agriculture, Engineering, Social Sciences, etc.);
2. Using productions of one database (Scopus) instead of different kinds of data set (e.g. Web of Science, Scopus etc.);
3. Including all types of publication instead of analyzing one type of document e.g. only articles in international scientific journals; and
4. Including publications of all countries, institutions, authors across the globe.

The current study applied different bibliometric laws such as Lotka's inverse square law, Zipf's law of word occurrence, Bradford's laws of Scattering and scientometric indicators such as Average Annual Growth Ratio (AAGR), and Compound Annual Growth Ratio (CAGR), Relative Growth Ratio (RGR), Doubling time (Dt), Collaborative Index (CI), Degree of Collaboration (DC), Collaborative Coefficient (CC), Revised Collaborative Coefficient (RCC), AAPP, PPA, Citation Per Paper (CPP), h-index, g-index etc. in the field of public health to trace out growth and development of the field, collaborated features, impact factor analyzing citation globally as well as nationally which was never done before. This research is, therefore, the first attempt to conduct scientometric study on public health literature in Bangladesh.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

Research by definition is a studious inquiry or examination; *specifically*: an investigation or experimentation aimed at the discovery and interpretation of facts, a revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws (Research, 2017). The procedures by which researchers go about their work of describing, explaining and predicting phenomena are called research methodology (Rajasekar, Philominathan, & Chinnathambi, 2013). The overall strategy to integrate the different components of the study in a coherent and logical way is called research design (De Vaus, 2001). This chapter attempts to describe the research design and methodology used in this thesis, consisting of an explanation of Scopus database, literature review pattern, area of study, formulation of hypotheses, defining research methods and framework, research tools and techniques, selection of database and search strategies, determination of sample size, presentation of bibliometric/scientometric laws, indicators and formulas, statistics tools and techniques used, and the selection of software for analysis.

3.2 Scopus database

Scopus as the largest abstract and citation database covering scientific journals, books and conference proceedings in the fields of science, technology, medicine, social sciences, and arts humanities. This comprehensive bibliographic database covers more than 66 million records from over 5,000 publishers, of which over 22,748 peer-reviewed journals, 34,000 individual books, 1,38,000 non-serial books, 7.7 million conference papers, 28 million patents received from five patent offices all over the world. For tracking, analyzing and visualizing research Scopus offers author profiles which cover affiliation, number of publications and their bibliographic data, references and details on the number of citations each publication has received (Elsevier, 2017; Wikipedia, n.d.).

The Scopus database was developed by Elsevier in 2004, combining the characteristics of both PubMed and Web of Science databases. Scopus includes a more expanded spectrum of journals than PubMed and Web of Science, and its citation analysis is faster and includes more

articles than the citation analysis of Web of Science (Falagas, *et al.* 2008). The factors like degree of data coverage, various search strategies available, existence of data saving & exporting options were considered before selecting the Scopus database as source of data (Grace, 2016) for this research.

3.3 Research methodology

For the purpose of measuring the research output on public health the following methodologies have been adopted.

3.3.1 Literature review

Related rules and laws of Bibliometric/Scientometric technique and pertinent literature on public health were retrieved by browsing Internet and various primary and secondary pieces of literature including journal articles, PhD thesis, conference proceedings, reports, websites and related text-books. Each publication was reviewed by keeping the following questions in mind:

a) What type of study was it?
b) What were the main objectives behind the study?
c) What methodologies had been used?
d) What types of Scientometric indicators and Bibliometric laws were used?
e) What were the main findings?

Basically, the literature reviews were carried out in relation to current study, to explore the following:

i) To identify the research gaps and unexplored areas;
ii) To investigate the different aspects of the same problem;
iii) To avoid duplication of research;
iv) To determine the area of study;

To retrieve theses on Bibliometric, Informetric, Webometric and Scientometric (BIWS) research, *"Shodhganga"* which is a popular reservoir of Indian theses and 'E-LIS repository' were accessed. The reviewed research output has been presented chronologically country-wise.

3.3.2 Area of the study

The present study is entitled **"Scientometric Analysis of Literature on Public Health Using Scopus Database"** and is based on public health related scholarly output extracted from Scopus database during the period of 2000-2015.

3.3.3 Research method and framework

The current study is primarily exploratory in nature reviewing secondary literature extracted from a bibliographic database and also analytical with the application of appropriate statistical and scientometric tools to strengthen the empirical validity. It can also be considered a scientometric research which helps to take decisions based on scholarly communication. There are basically two types of indicators used in scientometric study. They are **qualitative indicators** used for measuring the performance of publication, author or institution etc. and **quantitative indicators** used for counting scientific publication from various points of view. Both qualitative and quantitative indicators were utilized to assess the research output in public health field. Glänzel (2002) prescribed three levels of aggregation of measurement of research output in the methodology of scientometric research: at the individual research group or **micro level**, at institutions and studies of scientific journal or **meso level**, and at region and country level or **macro level**.

3.3.4 Research tools and techniques

Bibliometric/Scientomeric techniques have been used to quantify data from various stand points to explore the growth and development of public health literature. Various **statistical tools** such as arithmetic mean, percentage, cumulative percentage, average, time series analysis, simple linear regression, correlation coefficient analysis, 'f' test, 't' test, ANOVA etc. as well as various **scientometric indices** and a number of **bibliometric laws** have been used for this study.

There are two types of indicators used in scientometric study: **qualitative indicators** used for measuring the performance of publications, authors or institutions etc and **quantitative indicators** used to count scientific publications from various stand points. The following is the list of scientometric indicators and bibliometrics laws which have been employed in the analysis of public health literature in this study:

A. To analyse growth and development of literature:

- **Annual Growth Ratio (AGR):** comparison between two values.
- **Average Annual Growth Ratio (AAGR):** comparison between values of specific period of interval.
- **Rate of Growth (RoG):** Growth rate compared to previous year.
- **Compound Annual Growth Rate (CAGR):** Exact amount of growth than previous year.
- **Relative Growth Rate (RGR):** Mean growth rate over a specific period of time.
- **Doubling time (Dt):** Calculation of time for a measurement to get doubled.

B. To analyse the collaborative pattern and author productivity of literature:

- **Collaborative Index (CI):** Mean number of authors per paper.
- **Degree of Collaboration (DC):** The proportion of multi-authored papers.
- **Collaborative Coefficient (CC):** Measurement of collaboration
- **Revised Collaborative Coefficient (RCC):** Revised version of collaborative coefficient
- **Average Author Per Paper (AAPP):** Calculation of number of author per paper.
- **Productivity Per Author (PPA):** Calculation of number of paper per author.
- **Activity Index (AI):** Compare one country's research output with world's average research output.

C. To analyse the citation of literature:

- **Citation Per Paper (CPP) for Cited Publication(CP):** proportional number of citations per cited publication
- **Citation Per Paper (CPP) for Total Publication (TP):** proportional number of citation per publication
- **Average Citation Per Paper (ACPP) :** proportional number of citations per published paper of an author
- **Average Citation Per Cited Paper (ACPCP):** proportional number of citations per cited paper of an author

D. To analyse the index score of authors of literature:

- **h-index:** measure the productivity of an author.
- **g-index:** modified measure of h-index.
- **hI,norm:** normalized version of h-index.
- **hI,annual:** measure of h-index at different career stage.

E. To analyse the literature using fundamental laws of Bibliometric:

- **Bradford's law of Scattering:** measures of relationship between number of articles and number of journals.
- **Zipf's Law of word occurrence:** Relationship between the frequency of words and their ranks.
- **Lotka's Inverse Square Law:** Relationship authors of papers to the number of papers written by each authors.

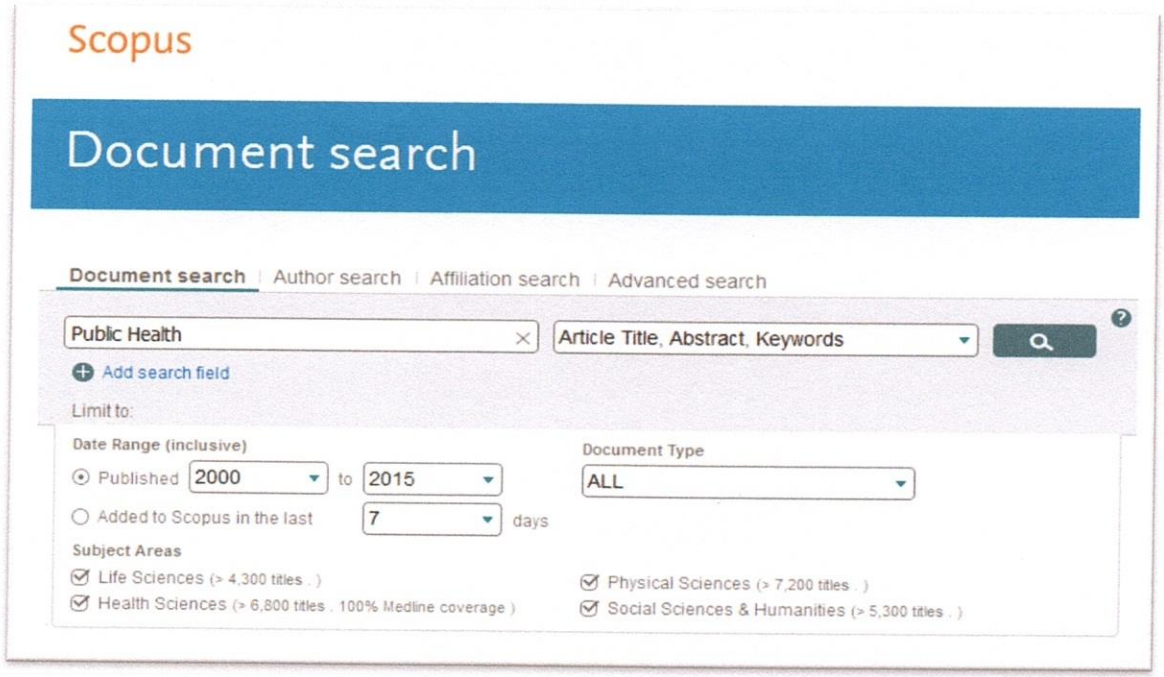
3.3.5 Selection of database and search strategy

For the purpose of the study, Scopus citation database was used to extract bibliographic information on Public health literature during the period of 2000-2015. There were basically three reasons for selecting Scopus database for the current study. Firstly it's an enormous bibliographic database with citation analysis facility, globally only ISI Web of Science is larger. Secondly, access to Scopus database is free for least developed countries through HINARI, and thirdly Scopus database has user-intuitive feature, with simple and flexible search procedures and data extraction policies.

To extract data from the Scopus database the search terms "public health" and period "2000-2015" were used : "(TITLE-ABS-KEY(Public Health) AND PUBYEAR > 1999 AND PUBYEAR < 2016)" and "((TITLE-ABS-KEY(Public health) AND TITLE-ABS-KEY(Bangladesh)) AND PUBYEAR > 1999 AND PUBYEAR < 2016)". To identify Bangladeshi authors' publications, the search terms "Public health AND Bangladesh" and period "2000-2015" were used by employing the following search strategy: *(TITLE-ABS-KEY (Public health) AND PUBYEAR > 1999 AND PUBYEAR < 2016 AND (LIMIT-TO (AFFILCOUNTRY, "Bangladesh").* During the search period, all types of documents relating to public health literature, including research articles, reviews, books, conference proceedings, editorials, notes, short surveys, letters, erratum, books etc. were identified.

The search results were downloaded from the Scopus database in two ways: **Year wise search results** containing subfields including year, number of result, author name, subject area, document type, source title, keyword, affiliation, country, source type, language; and **Detailed search result** with citation information containing subfields including author, title, year, source title, volume, issue, pagination, citation information etc.

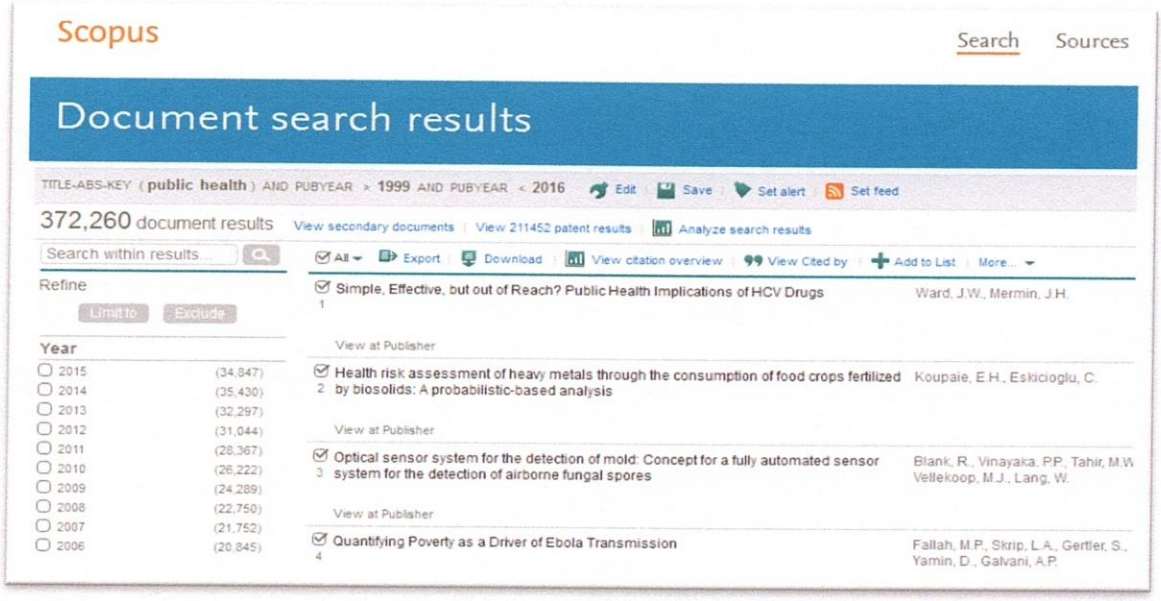
Figure 3.1: Document search interface (Source: Scopus)



3.3.6 Sample size and period of study

Records for the scientometric research were downloaded from the Scopus database on 23 November 2016. A total of 3,72,260 documents related to public health literature were extracted from Scopus database during the study period 2000-2015.

Figure 3.2: Document search results (Source: Scopus)



3.3.7 Selection of software and data analysis

The data on public health literature extracted from Scopus database was analysed using MS-Excel and SPSS (version-24.0). Harzing's Publish or Perish software was used for citation data analysis including calculation of number of citations and impact metrics such as h-index, g-index etc.

3.3.8 Research hypotheses

In accordance with the objectives of the study, the following null hypotheses have been formulated based on literature reviewed and to be tested using statistical tools later on:

Hypothesis 1 (*H1*): There is no relationship between progress of year and growth of literature on public health.

Hypothesis 2 (*H2*): There is no mean-relationship between existing growth of literature and expected future growth of literature on public health.

Hypothesis 3 (*H3*): There is no association between the collaboration of author and research productivity.

Hypothesis 4 (*H4*): Research productivity of public health in Bangladesh does not conform to Lotka's inverse law of author productivity.

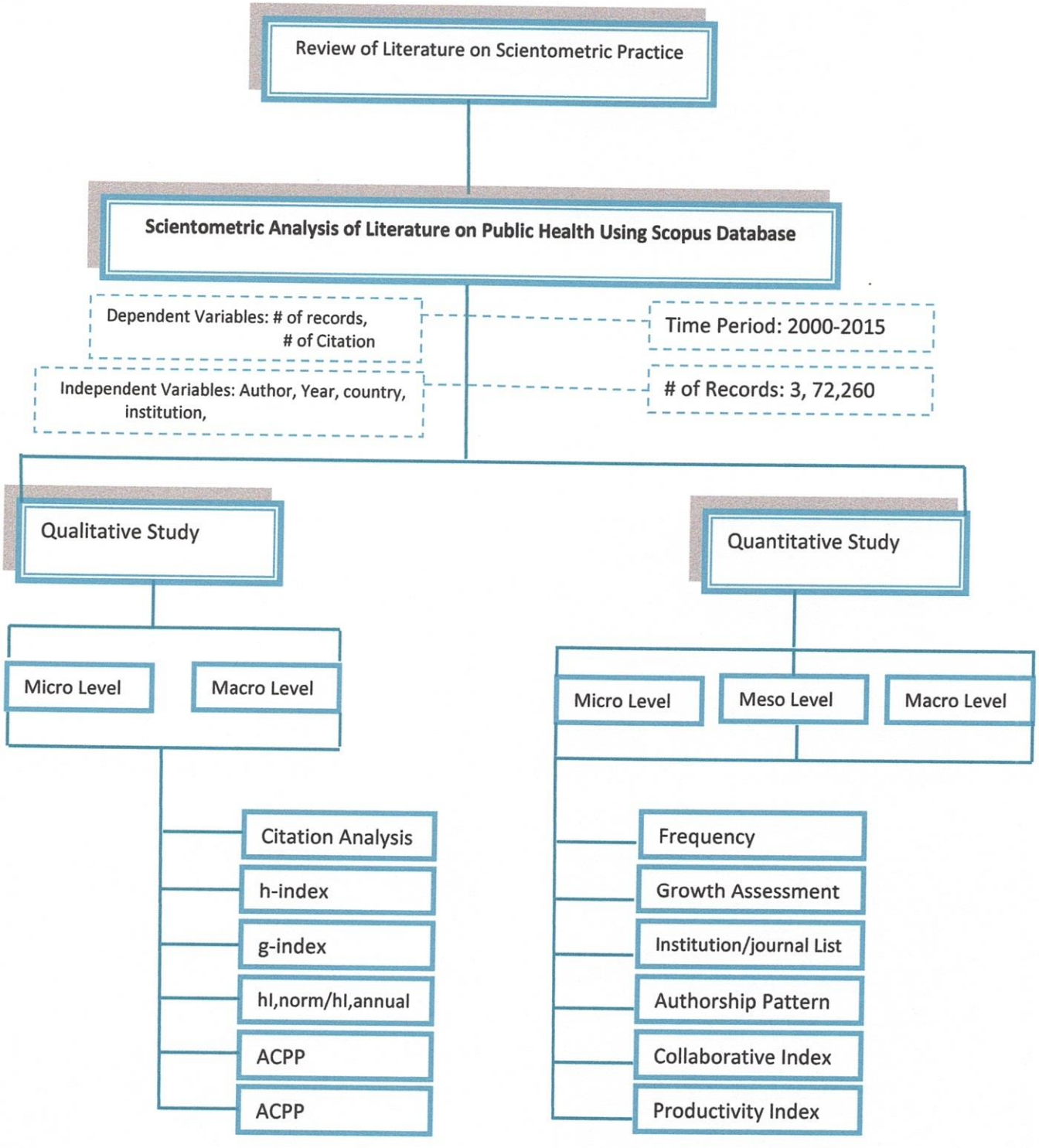
Hypothesis 5 (*H5*): There is no mean-relationship between public health research performances of Bangladeshi researchers and the researchers of other countries.

Hypothesis 6 (*H6*): There is no significant level of relationship between research productivity of developing and developed countries.

3.3.9 Schematic flow of research

The present research was conducted to assess the growth and development of public health literature extracted from Scopus globally using scientometric research approach. A total of 3,72,260 records were retrieved during the period from 2000 to 2015. The dependent variables of the study were number of records, number of citation, etc. whilst the independent variables were author, year, country, institution etc. The literature were analysed quantitatively and qualitatively at micro, meso and macro level of aggregation. Figure 3.3 illuminates a schematic flow of the research.

Figure 3.3: Schematic flow of research at macro/meso/micro level



CHAPTER FOUR

DATA ANALYSIS AND INTERPRETATION

4.1 Assessment of growth of literature

The quantum of Public Health (PH) literature can be analyzed differently to measure the growth of literature using different scientometric indicators and techniques. The most popular measurements in this regard include Annual Growth Ratio (AGR), Average Annual Growth Rate (AAGR), Rate of Growth (RoG), Compound Annual Growth Rate (CAGR), Relative Growth Rate (RGR), Doubling time (Dt), Future Growth Rate (FGR) etc.

4.1.1 Annual Growth Ratio (AGR) and Average Annual Growth Ratio (AAGR) of PH literature

During the current study period from 2000 to 2015 there were 3,72,260 publications on public health enlisted in Scopus database. Table 4.1 shows year wise growth of public health literature.

Table 4.1: Annual Growth Ratio of public health literature in Scopus

Year	Publications	AGR
2000	11,594	1 : 1.06
2001	13,325	1 : 1.15
2002	14,683	1 : 1.10
2003	16,818	1 : 1.15
2004	18,329	1 : 1.09
2005	19,668	1 : 1.07
2006	20,845	1 : 1.06
2007	21,752	1 : 1.04
2008	22,750	1 : 1.05
2009	24,289	1 : 1.07
2010	26,222	1 : 1.08
2011	28,367	1 : 1.08
2012	31,044	1 : 1.09
2013	32,297	1 : 1.04
2014	35,430	1 : 1.10
2015	34,847	1 : 0.98
Total	3,72,260	

Note: There were 10918 publications in 1999 (Source: Scopus); Cells in highlighted font shows highest and lowest values.

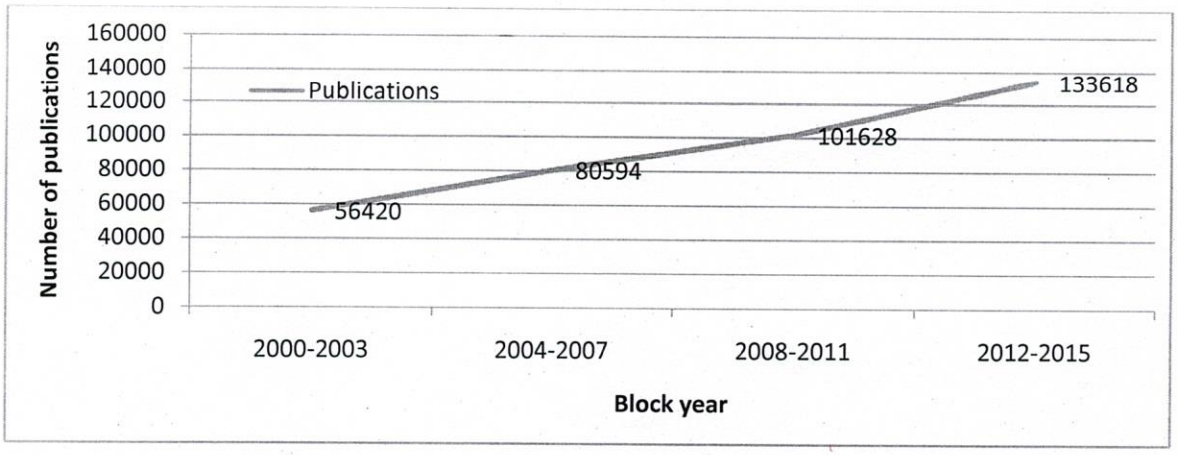
Annual Growth Ratio (AGR) is calculated as present number of publications divided by previous number of publications. The ratio of growth of PH literature annually varies from 0.98 to 1.15. The most productive years recorded were 2001 and 2003 (1: 1.15), and the year 2015 had the lowest AGR (1:0.98) of PH literature.

Average Annual Growth Rate (AAGR) is calculated as summation of the values of specific period of interval divided by number of period interval. For the study period in question 2000-2015 was grouped into 4 class intervals each representing a 4 years. The AAGR has been calculated for each four-year block and shown in Table 4.2 and Figure 4.1 below. It has been observed that the period of 2000-2003 had the highest AAGR and the lowest AAGR was observed during 2012-2015. The totally different scenario was observed if we analyzed percentage at each block years. The highest number research was conducted during the period from 2012 to 2015 (35.89%) followed by period of 2008 to 2011 (27.30%).

Table 4.2: Average Annual Growth Ratio (AAGR)

Four Year Grouping	Publications	%	Cum %	AAGR
2000-2003	56,420	15.16%	15.16%	1.11
2004-2007	80,594	21.65%	36.81%	1.07
2008-2011	1,01,628	27.30%	64.11%	1.07
2012-2015	1,33,618	35.89%	100.00%	1.05
Total	3,72,260	100%		

Figure 4.1: Block year wise publications



4. 1.2 Rate of Growth (RoG) and Compound Annual Growth Rate (CAGR) of PH literature

Rate of Growth (RoG) is calculated as the number of publications of present year divided by the number publication previous year. The formula of RoG is:

$$RoG = \frac{Present\ year\ Value}{Previous\ year\ Value} \quad \textbf{[Eq. 1]}$$

Compound Annual Growth Rate (CAGR) is calculated as the number of publications of present year divided by the number publication previous year to the power of one divided by the period length, and subtracts one from the subsequent result ("Compound Annual Growth Rate", n.d.).The formula of CAGR is:

$$CAGR = \left(\frac{Ending\ Value}{Beginning\ Value}\right)^{\left(\frac{1}{Number\ of\ years}\right)} - 1 \quad \textbf{[Eq. 2]}$$

Table 4.3: RoG and CAGR of PH literature

Year	Publications	Difference between two year	%	Cum	Cum %	RoG	CAGR
2000	11,594	676	3.11%	11,594	3.11%	1.06	0.06
2001	13,325	1731	3.58%	24,919	6.69%	1.15	0.15
2002	14,683	1358	3.94%	39,602	10.64%	1.10	0.10
2003	16,818	2135	4.52%	56,420	15.16%	1.15	0.15
2004	18,329	1511	4.92%	74,749	20.08%	1.09	0.09
2005	19,668	1339	5.28%	94,417	25.36%	1.07	0.07
2006	20,845	1177	5.60%	1,15,262	30.96%	1.06	0.06
2007	21,752	907	5.84%	1,37,014	36.81%	1.04	0.04
2008	22,750	998	6.11%	1,59,764	42.92%	1.05	0.05
2009	24,289	1539	6.52%	1,84,053	49.44%	1.07	0.07
2010	26,222	1933	7.04%	2,10,275	56.49%	1.08	0.08
2011	28,367	2145	7.62%	2,38,642	64.11%	1.08	0.08
2012	31,044	2677	8.34%	2,69,686	72.45%	1.09	0.09
2013	32,297	1253	8.68%	3,01,983	81.12%	1.04	0.04
2014	35,430	3133	9.52%	3,37,413	90.64%	1.10	0.10
2015	34,847	-583	9.36%	3,72,260	100%	0.98	-0.02
Total	3,72,260		100%	Average RoG and CAGR=		1.08	0.08

Note: There were 10918 publications in 1999 (Source: Scopus); Cells in highlighted font shows highest and lowest values.

Table 4.3 depicts the chronological growth of literature on public health by year. During the current study years between 2000 to 2015 there were 3,72,260 literature listed in Scopus database. There is steady growth of literature from 2000 to 2014, the differences in number of publications listed in each year remains 676 to 3,133 during this period. The most productive year in terms of increasing publication than previous year is 2014 (3,133 publication this year, 9.52% in total). Only in the year of 2015 the number of publications decreased if we compare

with the literature published in previous year (-583). There is obvious variation on growth of literature during the study period (2000-2015). During that period RoG varies from 0.98 to 1.15 and average RoG is 1.08.

The cumulative growth of literature shows an increasing number of publications on public health every year during study period until 2015. The percentage of growth of literature varies from 3.11% to 9.52%. From Figure 4.2, cumulative growth of PH literature is observed graphically from 2000-2015.

In Figure 4.3, it is seen that there is upward trend of growth from the year of 2000 to 2003. From 2004 the growth of literature decreases and there is a steady downward trend observed until 2007. Figure 4.4 depicts that CAGR values also varies during the study period (-0.02 to 0.15). The lowest CAGR was during 2015 (-0.02) and the highest CAGR during 2001and 2003.

Figure 4.2: Cumulative growth of literature

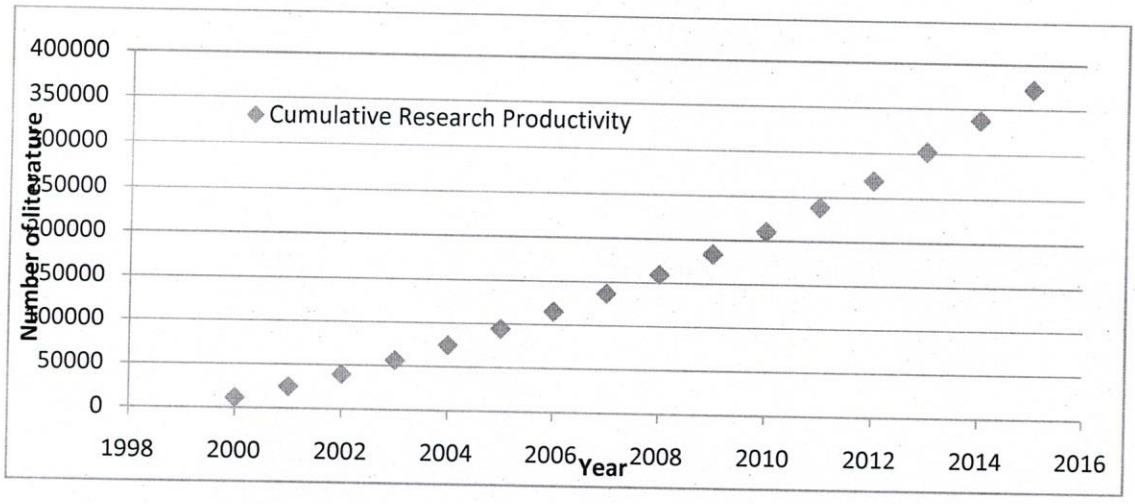


Figure 4.3: Rate of Growth (RoG) of PH literature

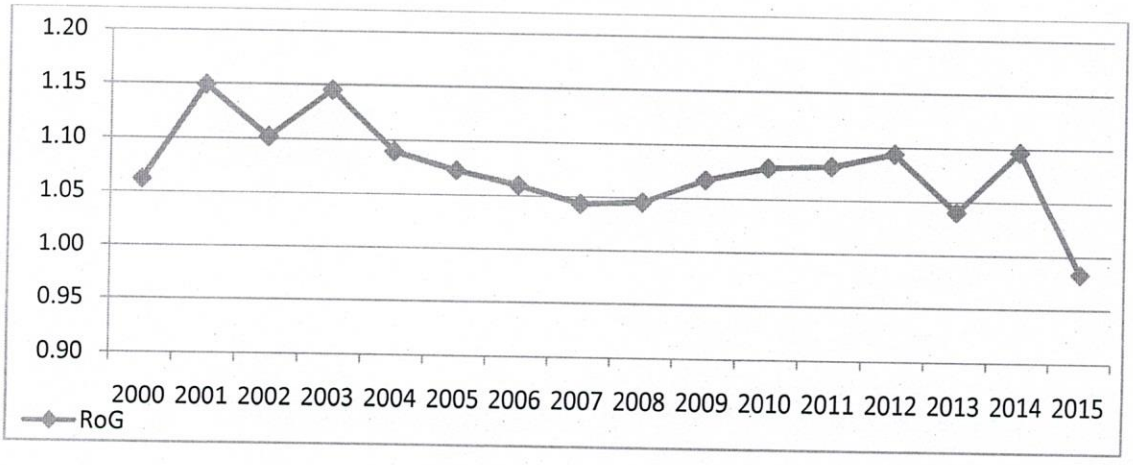
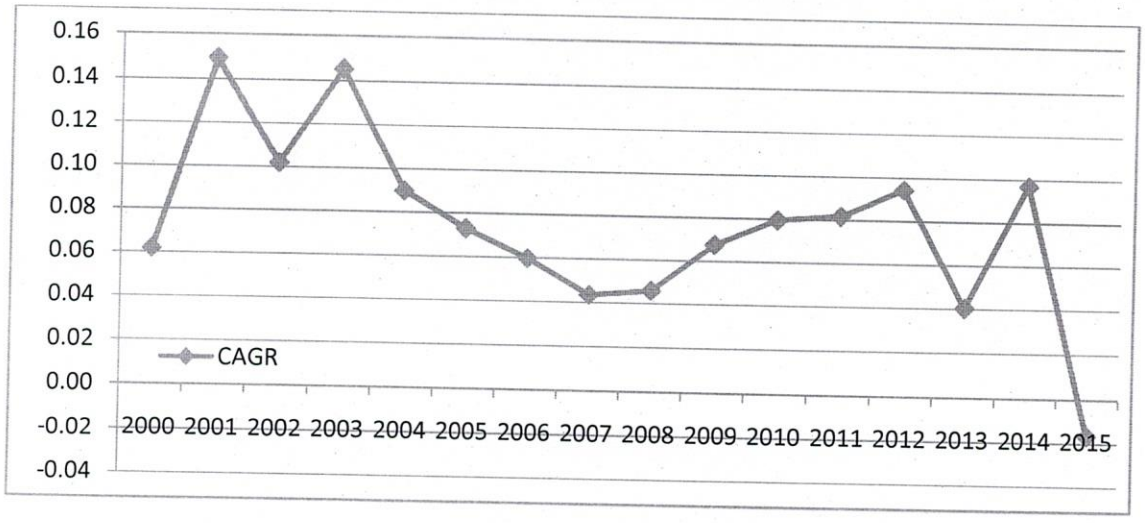


Figure 4.4: Compound Annual Growth Rate (CAGR) of PH literature



4.1.3 Relative Growth Rate (RGR) and Doubling time (Dt)

The concept of Relative Growth Rate (RGR) has been derived from botany to express growth in terms of a rate of increase in size per unit of size. V.H. Blackman called it 'efficiency index' (Hunt, 1990) which is in later used to measure relative growth of literature for a specific period of time. RGR can be used to measure relative growth of both articles and pages of the articles. It shows the increase in number of articles/pages over specific period of interval. RGR can be calculated through the following equation:

$$\text{RGR or R} = \frac{Log_e W_2 - Log_e W_1}{T_2 - T_1} \qquad \textbf{[Eq. 3]}$$

Whereas,

RGR or R = mean relative growth rate over the specific period of interval

$Log_e W_1$ = log of initial number of articles/pages

$Log_e W_2$ = log of final number of articles/pages after specific period of interval

T_2-T_1 = Unit difference between initial time and final time.

Dt (Doubling time) is directly related to RGR and is defined as the time required for the articles to become two-fold of the existing amount. If the number of articles in subject doubles during a given period, then the difference between logarithms of numbers at the beginning and at the end of this period must be the logarithm of the number 2. We used Napier logarithm, and the taken value of loge2 is 0.693. Hence, as per this (0.693) an average growth rate we calculated by what time interval does the Napier logarithm of numbers increases by 0.693 (Keshava, 2004).

Doubling time (Dt) means calculation of time for a particular number of literature get double. Thus the corresponding doubling time for each specific period of interval and for articles can be calculated by the following equation:

$$Dt(a^1) = \frac{\ln(2)}{RGR} \text{ or } \frac{0.693}{RGR} \quad \text{[Eq. 4]}$$

Table 4.4: RGR and Dt of PH literature

Year	Publications	Cum	W_1	W_2	RGR	Dt(a)
2000	11,594	11,594	-	9.36	-	-
2001	13,325	24,919	9.36	10.12	0.76	0.91
2002	14,683	39,602	10.12	10.59	0.47	1.47
2003	16,818	56,420	10.59	10.94	0.35	1.98
2004	18,329	74,749	10.94	11.22	0.28	2.47
2005	19,668	94,417	11.22	11.46	0.24	2.89
2006	20,845	1,15,262	11.46	11.65	0.19	3.65
2007	21,752	1,37,014	11.65	11.83	0.18	3.85
2008	22,750	1,59,764	11.83	11.98	0.15	4.62
2009	24,289	1,84,053	11.98	12.12	0.14	4.95
2010	26,222	2,10,275	12.12	12.26	0.14	4.95
2011	28,367	2,38,642	12.26	12.38	0.12	5.77
2012	31,044	2,69,686	12.38	12.51	0.13	5.33
2013	32,297	3,01,983	12.51	12.62	0.11	6.30
2014	35,430	3,37,413	12.62	12.73	0.11	6.30
2015	34,847	3,72,260	12.73	12.83	0.10	6.93
Total	3,72,260	Average RGR & Dt(a) =			0.23	4.16

Note: Cells in highlighted font shows highest and lowest values.

The RGR values in the field of public health during the period 2000-2015 shown in Table 4.4 lies between 0.10 and 0.76. A downward trend for RGR values has been observed during the period 2000-2015 (Figure 4.5). The Dt(a) values ranges between 0.91 to 6.93 and average Dt(a) value is 4.16. This means that the literature published in public health doubles in every 4.16 year in the period of the study. An upward trend for Dt(a) values has been observed during the period 2000-2015(Figure 4.6).

[1] Here Doubling time (Dt) has been calculated on the basis of articles.

Figure 4.5: RGR of PH literature

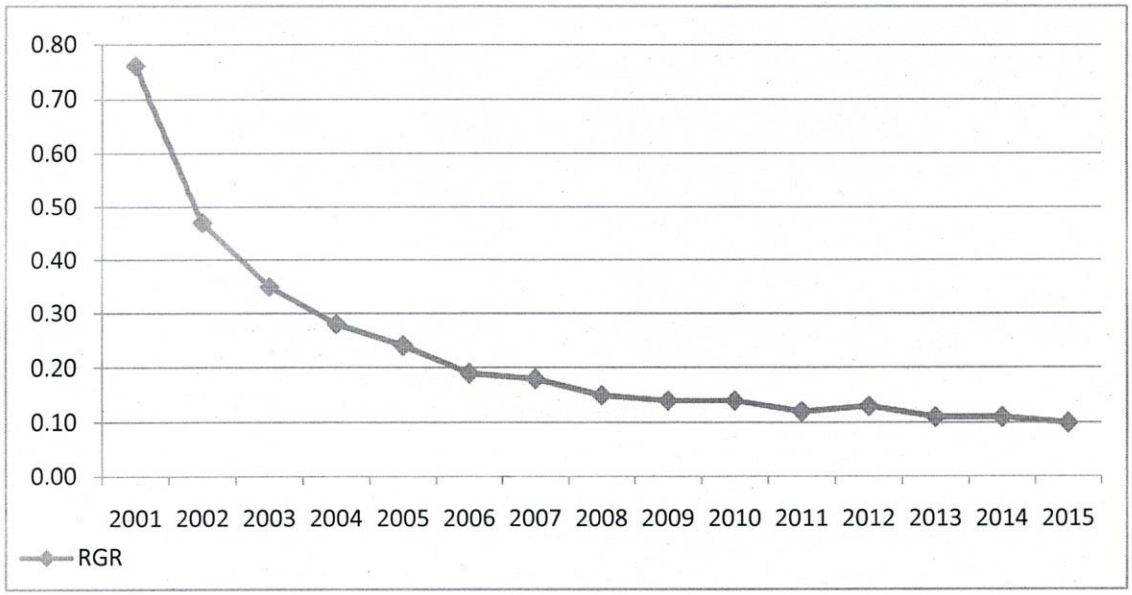
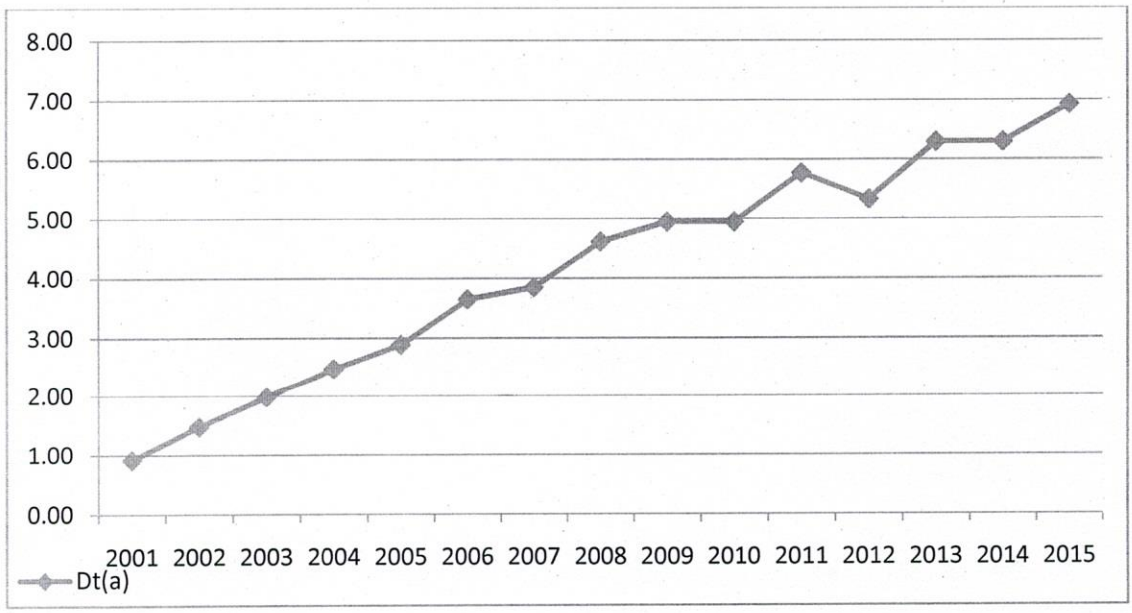


Figure 4.6: Doubling time (Dt) of PH literature



4.1.4 Future growth of PH literature

Using simple linear trends method of the period under study (Table 4.5), future growth of expected literature on public health can be estimated (Table 4.6).

Table 4.5: Simple linear method for future growth of PH literature

Year (x)	Publications (y)	X	X^2	Xy
2000	11,594	-7.5	56.25	-86955
2001	13,325	-6.5	42.25	-86612.5
2002	14,683	-5.5	30.25	-80756.5
2003	16,818	-4.5	20.25	-75681
2004	18,329	-3.5	12.25	-64151.5
2005	19,668	-2.5	6.25	-49170
2006	20,845	-1.5	2.25	-31267.5
2007	21,752	-0.5	0.25	-10876
2008	22,750	0.5	0.25	11375
2009	24,289	1.5	2.25	36433.5
2010	26,222	2.5	6.25	65555
2011	28,367	3.5	12.25	99284.5
2012	31,044	4.5	20.25	139698
2013	32,297	5.5	30.25	177633.5
2014	35,430	6.5	42.25	230295
2015	34,847	7.5	56.25	261352.5
32120	3,72,260		340	536157
2007.5	23,266.25			

Straight line equation is applied to arrive at projections for future growth under time series analysis. Straight line equation: $Y_e=a+bX$

Since $\Sigma x=0$ $a= \Sigma Y/N= 372260/16 = 23266.25$ $b= \Sigma XY/\Sigma x2 = 536157/340= 1576.93235$

As per straight line equation: $Y_e=a+bX$. Estimated literature in 2017 will be 38247.10733.

Where X= 2017-2007.5 = 9.5 a = 23266.25 b = 1576.93235

So $Y_e=a+bX$ = 23266.25 + 1576.93235* 9.5= 38247.10733

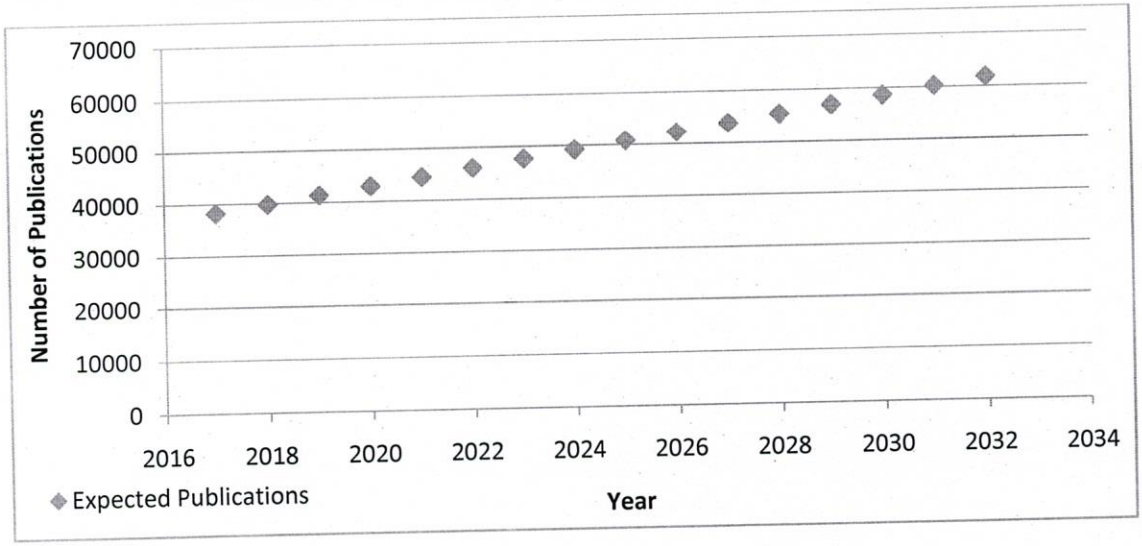
The future growth of literature on public health can be predicted using linear trends method. The future growth of literature on public health from the period of 2017-2032 has been calculated using base year 2015 and shown in Table 4.6 and Figure 4.7 next page:

Table 4.6: Expected publications

Year	Expected publications
2017	38,247.11
2018	39,824.04
2019	41,400.97
2020	42,977.9
2021	44,554.84
2022	46,131.77
2023	47,708.7
2024	49,285.63
2025	50,862.57
2026	52,439.5
2027	54,016.43
2028	55,593.36
2029	57,170.3
2030	58,747.23
2031	60,324.16
2032	61,901.09

The result shows expected positive increase of literature each year. That means an increasing trend of literature on public health might be observed from the year of 2017 to 2032 based on 2000-2015 rates.

Figure 4.7: Forecasting of growth of PH literature



4.2 Identification of authorship pattern, author collaboration and author productivity

The present era of information explosion demands more research and development not only in natural science subject but also other subject fields. To get expected expertise in their field of specialization and fulfill the knowledge gap, the researchers of today's world are increasingly interested to work in collaboration. According to Aristotle's metaphysics theory, the whole is more than some of its parts. This means that combining forces produces not only better product but also maximum product. The main logic behind this theory is that successful integration normally produces a synergistic effect and greater total impact than if each author works separately.

Communication and collaboration between researchers are of great importance in the development of subject areas and in the dissemination of research results. As the new results and investigations filter through the network of interested parties, new insights are obtained and people are inspired to work on the same or related research fields. People cooperate to investigate problems that are almost impossible to solve by an individual working alone. The investigation of authorship pattern, author collaboration and author productivity on public health publications can reflect the nature, dynamism and other characteristics of the discipline (Ding, Foo & Chowdhury, 1999).

4.2.1 Measures for authors' productivity, pattern and collaboration

Several attempts have been made all over the world to measure authors' productivity, authorship patterns and author collaboration (Hemala & Kavitha, 2016; Gajbe & Sonawane, 2015; Kumar& Naqvi, 2014; Rakhi, 2014; Jimenez-Fanjul, Maz-Machado & Bracho-Lopez, 2013; Heidari and Safavi, 2013; Thilakar and Ponnudurai, 2013; Arya & Sharma, 2012; Elango & Rajendran, 2012; Pillai, 2007; Yazit & Zainab, 2007; Udofia, 2002; Ding, Foo & Chowdhury, 1999). Several formulas and indicators have been devised to study mean number of authors per paper, collaborative pattern of authorship on a subject, proportion of single and multi-authored papers etc. Some important formulas in this regard are Collaborative Index (CI) devised by Lawani in 1980, Degree of Collaboration (DC) by Subramanyam in 1983, Collaborative Coefficient (CC) by Ajiferuke, Burrell & Tague in 1988, etc.

4.2.1.1 Authorship pattern

Table 4.7: Authorship pattern on public health literature

Authorship Pattern	Frequency	Percentage
Anon. (Anonymous)	9,715	2.61%
Single Author	16,3972	44.05%
Two Authors	79,242	21.29%
Three Authors	38,969	10.47%
More Than Three Authors	80,362	21.59%
Total	3,72,260	100%

It can be observed from Table 4.7 that majority of publications under survey were published by collaborative authorship (53.34%). While a mentionable number of literature published in public health subject was by single authorship (44.05%). Number of authors by year is shown in Table 4.8 and Figure 4.8, 4.9, 4.10 and 4.11 below and next pages.

Table 4.8: Year wise authorship pattern on PH literature

Year	Anon	Single Authors	Two Authors	Three Authors	Three + Authors	Total
2000	518	4,766	1,980	1,011	3,319	11,594
2001	684	5,319	2,613	1,703	3,006	13,325
2002	828	6,745	2,829	1,900	2,381	14,683
2003	960	7,889	3,001	1,598	3,370	16,818
2004	1003	8,025	2,875	1,922	4,504	18,329
2005	968	8,596	3,568	1,836	4,700	19,668
2006	674	9,149	3,478	2,565	4,979	20,845
2007	498	11,578	4,571	1,989	3,116	21,752
2008	425	10,583	4,002	2,205	5,535	22,750
2009	420	12,421	3,181	2,969	5,298	24,289
2010	455	12,898	5,735	2,627	4,507	26,222
2011	396	11,556	7,895	3,005	5,515	28,367
2012	469	10,527	8,698	3,102	8,248	31,044
2013	445	13,526	7,485	3,589	7,252	32,297
2014	517	15,520	8,756	3,901	6,736	35,430
2015	455	14,874	8,575	3,047	7,896	34,847
Total	9715	1,63,972	79,242	38,969	80,362	3,72,260

Figure 4.8: Year wise authorship pattern

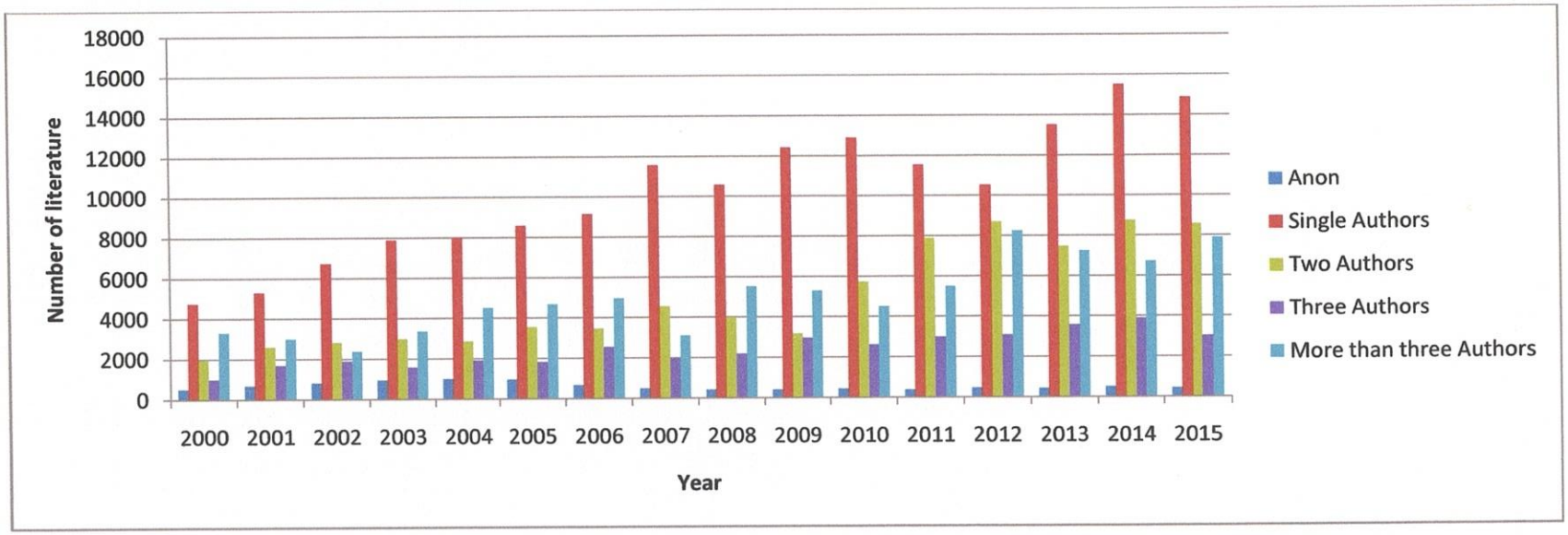


Figure 4.9: Year wise distribution for single author and collaborated authors

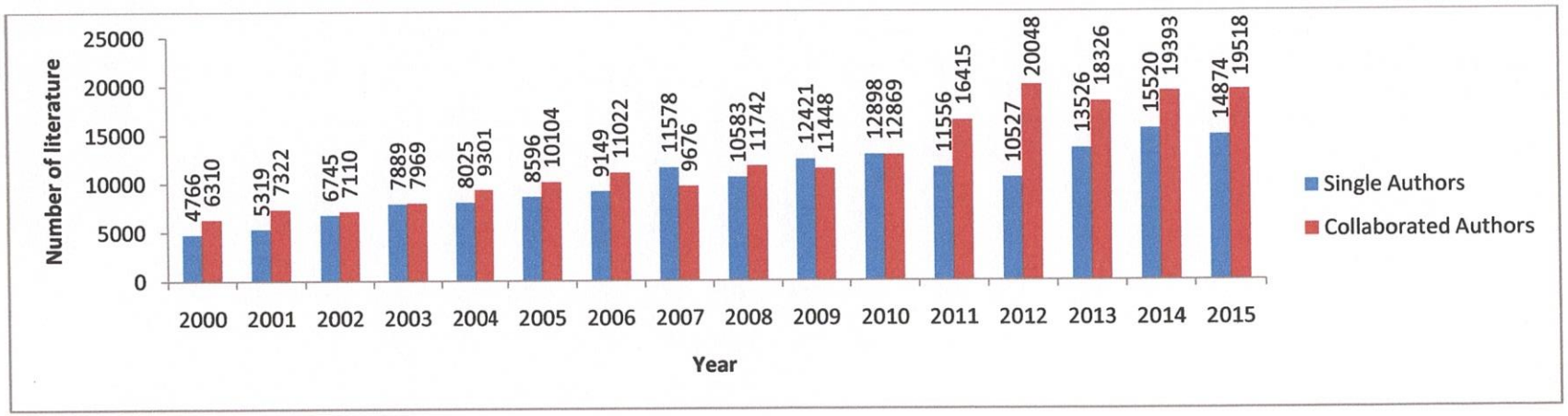


Figure 4.10: Single, collaborated and anonymous authors

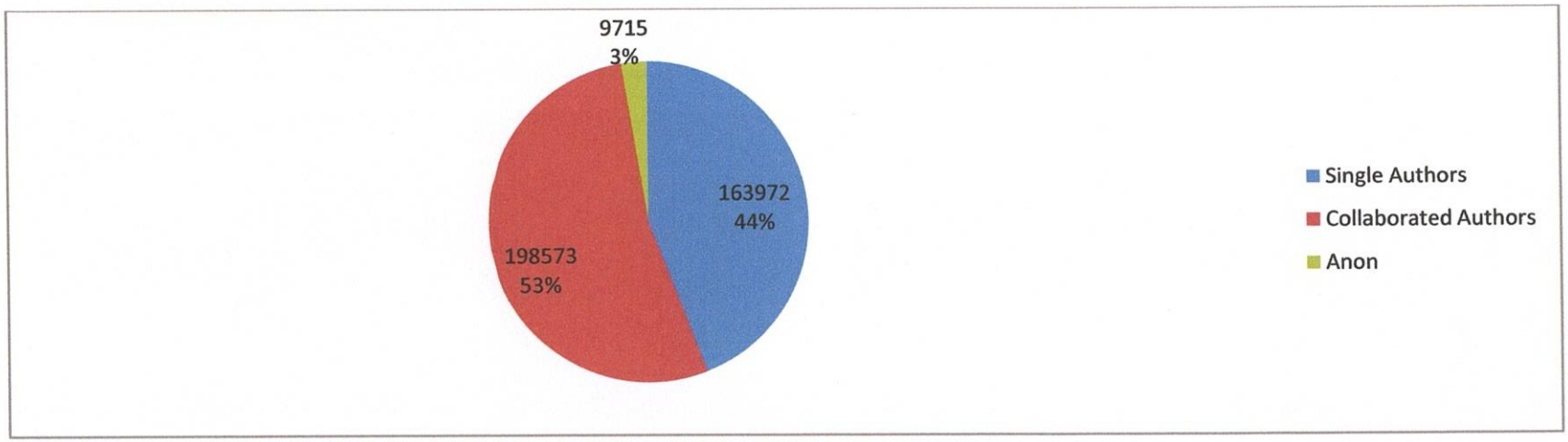
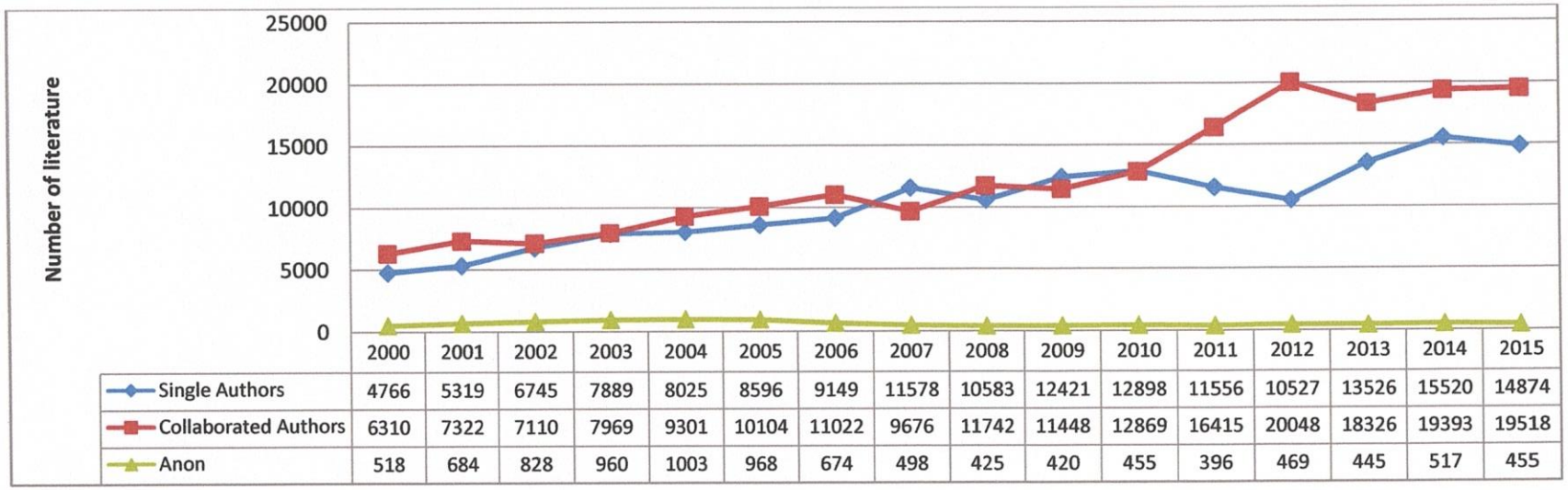


Figure 4.11: Year wise Line chart for single, collaborated and anonymous authors



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Single Authors	4766	5319	6745	7889	8025	8596	9149	11578	10583	12421	12898	11556	10527	13526	15520	14874
Collaborated Authors	6310	7322	7110	7969	9301	10104	11022	9676	11742	11448	12869	16415	20048	18326	19393	19518
Anon	518	684	828	960	1003	968	674	498	425	420	455	396	469	445	517	455

4.2.1.2 Author collaboration

As research has become interdisciplinary in nature, researchers and scientists in one area are eager to collaborate with the researchers and scientists of other areas in order to fulfill the desired goals of research. In making research useful for mankind the researchers of the modern arena realize the necessity of collaboration in research (Arya & Sharma, 2012). In fact scientific collaboration represents a response to the professionalization of science (Beaver & Rosen, 1978).

4.2.1.2.1 Collaborative Index (CI)

Lawani (1980) devised the collaborative Index (CI) to measure mean number of authors per paper. The formula of CI is:

$$CI = \frac{\sum_{j=1}^{k} jfj}{N} \qquad \textbf{[Eq. 5]}$$

Where,

j = types of joint or collaborated author *i.e.* single author, two authors, three authors etc.

fj = frequency of joint or collaborated author *i.e.* under joint/collaborated authors how many number of research paper published on a subject during a certain period

N= Total number of research paper published on a subject during a certain period

K= Greatest number of authors per paper on a subject.

Collaborative Index (CI) can be calculated as the total number of authors divided by the total number of research articles published during a certain period on a certain subject. It has some advantages and disadvantages. Although there are many advantages to using this CI, at the same time this formula of collaboration has disadvantages too, such as single authored paper has actually no collaboration, but it gives non-zero weight (of 1) to them, and it has no upper limit *i.e.* the value of CI neither lies between 0 and 1 and it is not expressible in terms of percentage.

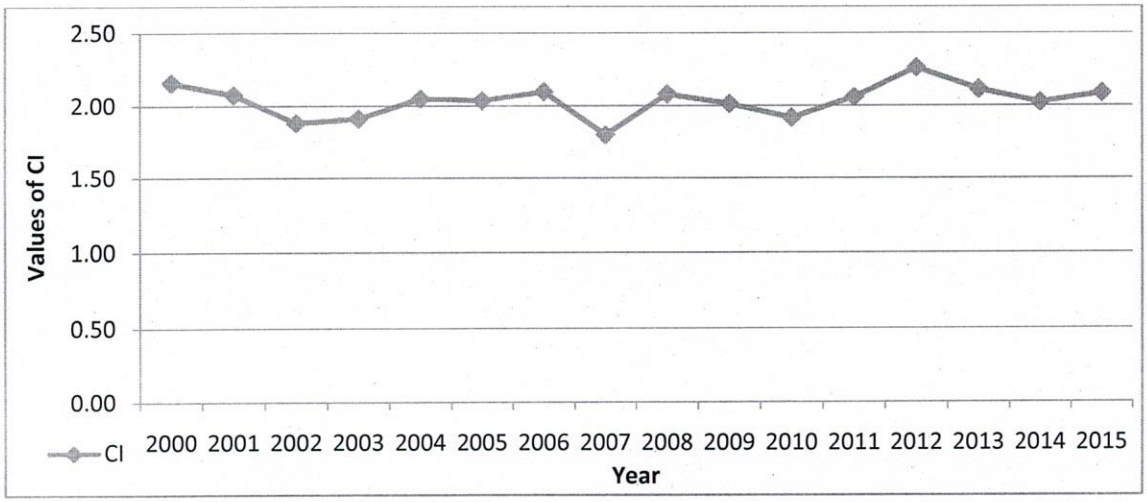
Table 4.9: Collaborative Index (CI) of public health authors according to year

Year	Anon	Single Authors	Two Authors	Three authors	Three + Authors	Total Authors	Total Records	CI
2000	518	4,766	1,980	1,011	3,319	25,035	11,594	2.16
2001	684	5,319	2,613	1,703	3,006	27,678	13,325	2.08
2002	828	6,745	2,829	1,900	2,381	27,627	14,683	1.88
2003	960	7,889	3,001	1,598	3,370	32,165	16,818	1.91
2004	1,003	8,025	2,875	1,922	4,504	37,557	18,329	2.05
2005	968	8,596	3,568	1,836	4,700	40,040	19,668	2.04
2006	674	9,149	3,478	2,565	4,979	43,716	20,845	2.10
2007	498	11,578	4,571	1,989	3,116	39,151	21,752	**1.80**
2008	425	10,583	4,002	2,205	5,535	47,342	22,750	2.08
2009	420	12,421	3,181	2,969	5,298	48,882	24,289	2.01
2010	455	12,898	5,735	2,627	4,507	50,277	26,222	1.92
2011	396	11,556	7,895	3,005	5,515	58,421	28,367	2.06
2012	469	10,527	8,698	3,102	8,248	70,221	31,044	**2.26**
2013	445	13,526	7,485	3,589	7,252	68,271	32,297	2.11
2014	517	15,520	8,756	3,901	6,736	71,679	35,430	2.02
2015	455	14,874	8,575	3,047	7,896	72,749	34,847	2.09
Total	9,715	1,63,972	79,242	38,969	80,362	7,60,811	3,72,260	2.04

Note: Cells in highlighted font shows highest and lowest values.

Table 4.9 shows the number of authors per publication and CI by year wise. The CI is illustrated in Figure 4.12 below, ranging from 2.26 (2012) to 1.80 (2007) with an average of 2.04 per paper which implies that research team of just above two is typical in the field of public health.

Figure 4.12: CI line for the authors during 2000-2015



4.2.1.2.2 Degree of Collaboration (DC)

Subramanyam (1983) proposed Degree of Collaboration (DC) to measure the proportion of multi-authored papers. The degree of collaboration in a discipline was defined as the ratio of the number of collaborative research papers to the total number of research papers published in the discipline during a certain time period.

He devised the following formula to define the degree of collaboration:

$$DC = 1 - \frac{fi}{N} \qquad \textbf{[Eq. 6]}$$

Where, DC means Degree of Collaboration

fi = single authored papers;

N= Total number of publication.

DC can be interpreted as a degree, *i.e.*, it lies between 0 and 1. A value of 1 means maximum collaboration. It always ranks higher in a discipline with a higher number of multi-authored papers though DC does not differentiate among levels of multiple authorships (Kumar & Naqvi, 2014; Ajiferuke, Burell & Tague, 1988)

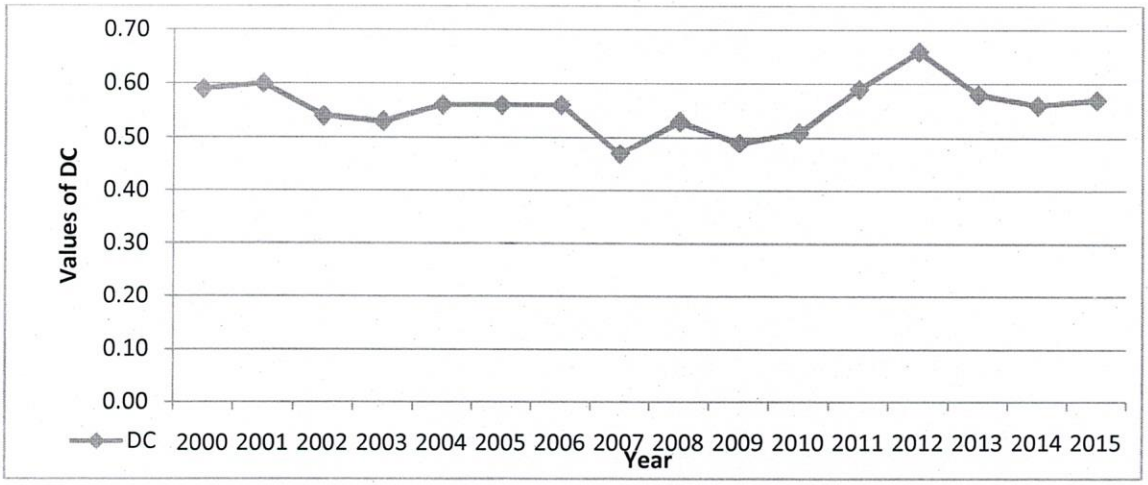
Table 4.10: Degree of Collaboration (DC) of PH authors according to year

Year	Literature of Single Author (SA)	Total Literature (TL)	SA/TL	DC
2000	4,766	11,594	0.41	0.59
2001	5,319	13,325	0.40	0.60
2002	6,745	14,683	0.46	0.54
2003	7,889	16,818	0.47	0.53
2004	8,025	18,329	0.44	0.56
2005	8,596	19,668	0.44	0.56
2006	9,149	20,845	0.44	0.56
2007	11,578	21,752	0.53	**0.47**
2008	10,583	22,750	0.47	0.53
2009	12,421	24,289	0.51	0.49
2010	12,898	26,222	0.49	0.51
2011	11,556	28,367	0.41	0.59
2012	10,527	31,044	0.34	**0.66**
2013	13,526	32,297	0.42	0.58
2014	15,520	35,430	0.44	0.56
2015	14,874	34,847	0.43	0.57
Total	1,63,972	3,72,260	Average	0.56

Note: Cells in highlighted font shows highest and lowest values.

Degree of Collaboration has been calculated on public health published literature during the study period. The DC values vary from 0.47 to 0.66 with an average of 0.56 which indicates that there exists moderate degree of collaboration among authors in the field of public health (Table 4.10).

Figure 4.13: DC line for the authors during 2000-2015



The trend line of DC indicates that there is an increasing tendency of collaboration among authors from 2009 to 2012 which indicates authors of that period prefer collaboration in their research work.

4.2.1.2.3 Collaborative Coefficient (CC)

Researchers in this area noted that the two collaborative measures *i.e.* both CI and DC had some inadequacies which were removed by incorporating the merits of both, and devised a new measure by Ajiferuke and his team in 1988 called Collaborative Coefficient (CC). The value of CC can be calculated by the following formula (Ajiferuke, Burell & Tague, 1988):

$$CC = 1 - \frac{\sum_{j=1}^{k}(\frac{1}{j})fj}{N} \qquad \textbf{[Eq. 7]}$$

Where, CC = Collaborative Coefficient

Fj = Number of authored papers in a subject during certain period of time

N = Total number of research published in a subject during certain period of time

K = the greatest number of authors per papers

The value of CC lies between 0 and 1. The value 0 is corresponding to single authorship and whatever number is closer to 1 indicates more collaboration between authors.

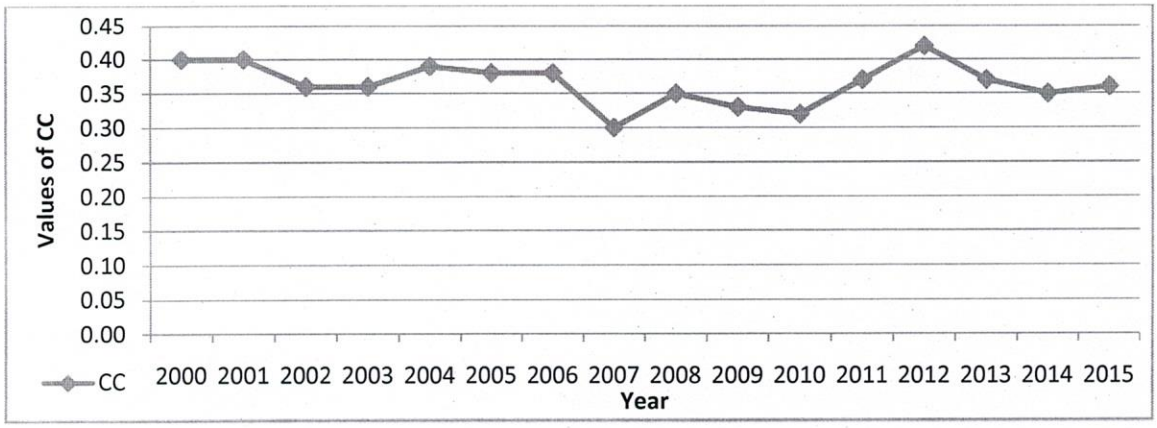
Table 4.11: Collaborative Coefficient (CC) of public health authors according to year

Year	Anon	Single Authors	Two Authors	Three authors	Three + Authors	Total Literature	CC
2000	518	4,766	1,980	1,011	3,319	11,594	0.40
2001	684	5,319	2,613	1,703	3,006	13,325	0.40
2002	828	6,745	2,829	1,900	2,381	14,683	0.36
2003	960	7,889	3,001	1,598	3,370	16,818	0.36
2004	1,003	8,025	2,875	1,922	4,504	18,329	0.39
2005	968	8,596	3,568	1,836	4,700	19,668	0.38
2006	674	9,149	3,478	2,565	4,979	20,845	0.38
2007	498	11,578	4,571	1,989	3,116	21,752	0.30
2008	425	10,583	4,002	2,205	5,535	22,750	0.35
2009	420	12,421	3,181	2,969	5,298	24,289	0.33
2010	455	12,898	5,735	2,627	4,507	26,222	0.32
2011	396	11,556	7,895	3,005	5,515	28,367	0.37
2012	469	10,527	8,698	3,102	8,248	31,044	0.42
2013	445	13,526	7,485	3,589	7,252	32,297	0.37
2014	517	15,520	8,756	3,901	6,736	35,430	0.35
2015	455	14,874	8,575	3,047	7,896	34,847	0.36
Total	9,715	1,63,972	79,242	38,969	80,362	3,72,260	0.37

Note: Cells in highlighted font shows highest and lowest values.

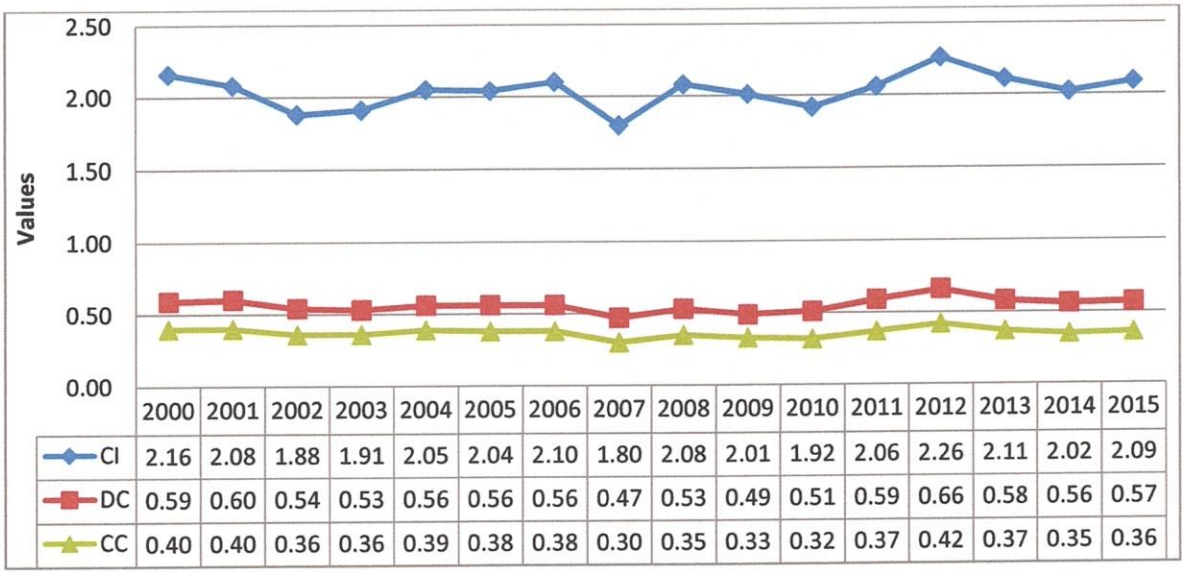
The value of CC doesn't represent high collaboration among authors of public health during the period of 2000-2015. The highest CC has been observed in 2012 (0.42) and the lowest one is 0.30 in 2007.

Figure 4.14: CC line for the authors during 2000-2015



The CC for public health authors lies between 0.30 and 0.42 with an average of 0.37 which means there is no significant magnitude of collaboration among the authors during the study period.

Figure 4.15: CI, DC and CC: comparative analysis



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CI	2.16	2.08	1.88	1.91	2.05	2.04	2.10	1.80	2.08	2.01	1.92	2.06	2.26	2.11	2.02	2.09
DC	0.59	0.60	0.54	0.53	0.56	0.56	0.56	0.47	0.53	0.49	0.51	0.59	0.66	0.58	0.56	0.57
CC	0.40	0.40	0.36	0.36	0.39	0.38	0.38	0.30	0.35	0.33	0.32	0.37	0.42	0.37	0.35	0.36

As there is no upper limit, the line for CI values lies at the top of the chart whereas lines for DC and CC remain underneath it. The most collaborative research year is 2012 (CI: 2.26, DC: 0.66, CC: 0.42) which means researcher under survey prefer more collaborative work in their research than any other years under survey. In contrast, 2007 is the lowest collaborative research year in the field of public health (CI: 1.80, DC: 0.47 CC: 0.30).

4.2.1.2.4 Revised Collaborative Coefficient (RCC)

The value of CC can exactly lay "o" if all the frequencies remain under single authorship. But for maximal collaboration CC fails to yield exactly 1. That means the value of CC does not produce 1 in the case of all authors who are as co-authors in the collection. To overcome from this situation some modifications has been done on CC called "Revised Collaborative Coefficient (RCC)" by Egghe and also called "Modified Collaborative Coefficient (MCC)" by Savanur and Srikanth. It is the normalized version of CC and is defined as following formula (Todeschini & Baccini, 2016; Savanur & Srikanth, 2010; Egghe, 1991):

$$RCC= \quad \frac{N}{N-1} \cdot \left(1 - \frac{\Sigma_{j=1}^{k}(\frac{1}{j})fj}{N}\right) \qquad \textbf{[Eq. 8]}$$

Table 4.12: Revised Collaborative Coefficient (RCC)

Year	CC	$\frac{N}{N-1}$	RCC
2000	0.40	1.00009	0.40
2001	0.40	1.00008	0.40
2002	0.36	1.00007	0.36
2003	0.36	1.00006	0.36
2004	0.39	1.00005	0.39
2005	0.38	1.00005	0.38
2006	0.38	1.00005	0.38
2007	0.30	1.00005	0.30
2008	0.35	1.00004	0.35
2009	0.33	1.00004	0.33
2010	0.32	1.00004	0.32
2011	0.37	1.00004	0.37
2012	0.42	1.00003	0.42
2013	0.37	1.00003	0.37
2014	0.35	1.00003	0.35
2015	0.36	1.00003	0.36

As there is existence of frequencies in the case of single authorship under present study, the values of RCC is equivalent with the values of CC.

4.2.1.3 Authors' productivity

Yoshikane et al (2009) revealed diachronic correlation of properties to measure author's productivity by devising formulas which had been slightly modified by Mamdapur et al (2014) in their work.

$$AAPP = \frac{TA}{TP} \quad \textbf{[Eq. 9]}$$

$$PPA = \frac{TP}{TA} \quad \textbf{[Eq. 10]}$$

Where, AAPP = Average Author Per Paper

PPA = Productivity Per Author

TA = Total number of Authors

TP = Total number of Publication

Table 4.13: AAPP and PPA

Year	Total Authors	Total Publications	AAPP	PPA
2000	25,035	11594	2.16	0.46
2001	27,678	13325	2.08	0.48
2002	27,627	14683	1.88	0.53
2003	32,165	16818	1.91	0.52
2004	37,557	18329	2.05	0.49
2005	40,040	19668	2.04	0.49
2006	43,716	20845	2.10	0.48
2007	39,151	21752	**1.80**	**0.56**
2008	47,342	22750	2.08	0.48
2009	48,882	24289	2.01	0.50
2010	50,277	26222	1.92	0.52
2011	58,421	28367	2.06	0.49
2012	70,221	31044	**2.26**	**0.44**
2013	68,271	32297	2.11	0.47
2014	71,679	35430	2.02	0.49
2015	72,749	34847	2.09	0.48
Total	7,60,811	372260	**2.04**	0.49

Note: Cells in highlighted font shows highest and lowest values.

The average author per paper is the value equivalent to CI (Collaborative Index). It is noted that average author per publication is 2.04 means there are more than two authors per paper during the period 2000-2015. The average productivity per author (PPA) is 0.49 which means every author produces less than half of a publication each year during the study period. The average production rate per author ranges between 0.44 and 0.56. In 2007 authors had high production rate (0.56) whilst the year 2012 was the lowest productive year from PPA point of view (0.44).

4.3 Citation analysis of publications on public health

In the present age of "Information Explosion" the indexing system plays an important linking role between the producer of information and the consumer. Citation indexing as a significant type of indexing system bridges the research literature between so-called later and earlier works of research and allows the information seeker and researcher to trace out the more potential area of research. The citation technique is being increasingly used as a scientometric tool to trace out the impact factor of journal as well as individual author. Citation indexing is the mechanism of

conceptual accord of related literature. With the help of citation index database it is possible to go deeper into the specialized subject fields. Using citation index the chronological development of any branch of human knowledge can easily be traced out. As a result it may constantly help to create new dimensions of any subject field. By means of citation index anyone can count the number of times when an individual article has been cited. Therefore, an invisible linking can be set up among the homogeneous group of works or uniform group of authors of related works (Islam, 2013).

4.3.1 Cited publication and citation of public health literature

Eugene Garfield, the inventor of citation indexing, defined a citation index as 'an ordered list of cited articles each of which is accompanied by a list of citing articles. The citing article is identified by a source index, the cited article by a reference citation. The reference is arranged by reference citations (as cited in Chandler & Roper 1991). It may perhaps be said that cited articles are ancestors and the citing articles are descendants and this descending relationship is reflected through the index. A Citation index links cited articles with citing articles (Chakrabortty & Chakrabarti, 1984). The year wise distribution of cited publication together with total number of citation of publication on public health is presented in Table 4.14 next page:

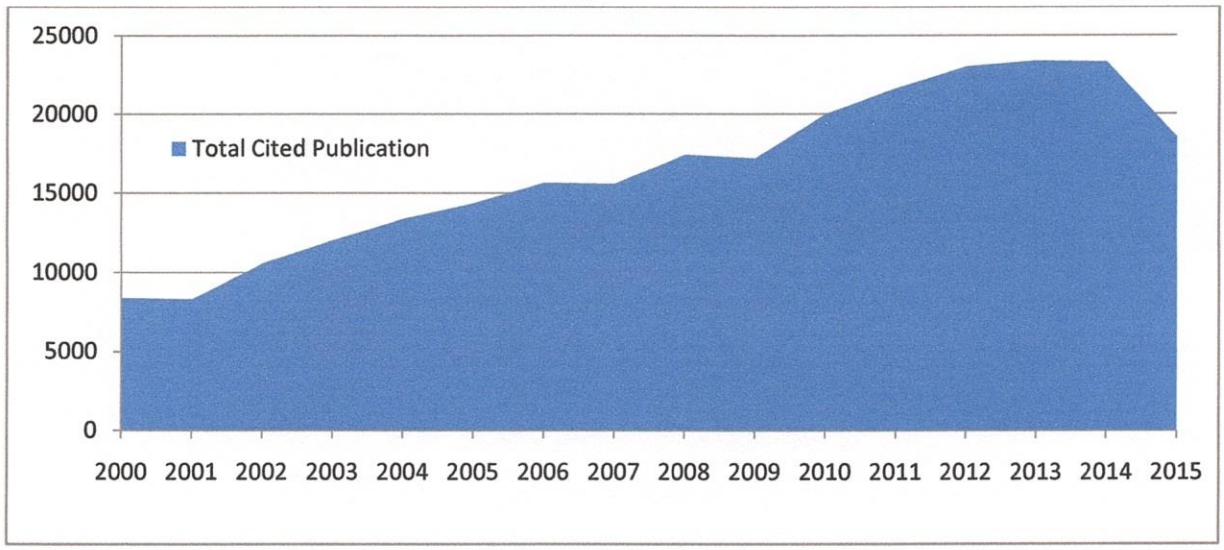
Table 4.14: Cited publication and citation on PH literature

Year	Total Publications	Total Cited Publications	Percentage	Cumulative	Cum %	Total Citations	Percentage	Cumulative	Cum %
2000	11,594	8,408	3.20%	8,408	3.20%	2,85,225	5.39%	2,85,225	5.39%
2001	13,325	8,318	3.16%	16,726	6.36%	2,48,376	4.69%	5,33,601	10.08%
2002	14,683	10,594	4.03%	27,320	10.39%	3,47,433	6.56%	8,81,034	16.64%
2003	16,818	12,031	4.57%	39,351	14.96%	3,76,969	7.12%	12,58,003	23.77%
2004	18,329	13,381	5.09%	52,732	20.05%	4,12,230	7.79%	16,70,233	31.55%
2005	19,668	14,376	5.46%	67,108	25.51%	4,18,067	7.90%	20,88,300	39.45%
2006	20,845	15,666	5.96%	82,774	31.47%	4,33,391	8.19%	25,21,691	47.64%
2007	21,752	15,595	5.93%	98,369	37.39%	4,32,004	8.16%	29,53,695	55.80%
2008	22,750	17,444	6.63%	1,15,813	44.02%	4,12,830	7.80%	33,66,525	63.60%
2009	24,289	17,214	6.54%	1,33,027	50.57%	3,75,577	7.10%	37,42,102	70.70%
2010	26,222	20,012	7.61%	1,53,039	58.18%	3,74,267	7.07%	41,16,369	77.77%
2011	28,367	21,673	8.24%	1,74,712	66.41%	3,78,642	7.15%	44,95,011	84.92%
2012	31,044	23,050	8.76%	1,97,762	75.18%	3,06,997	5.80%	48,02,008	90.72%
2013	32,297	23,419	8.90%	2,21,181	84.08%	2,44,596	4.62%	50,46,604	95.34%
2014	35,430	23,349	8.88%	2,44,530	92.95%	1,61,726	3.06%	52,08,330	98.40%
2015	34,847	18,534	7.05%	2,63,064	100.00%	84,894	1.60%	52,93,224	100.00%
Total	3,72,260	2,63,064	100%			52,93,224	100%		

Note: Cells in highlighted font shows highest and lowest values.

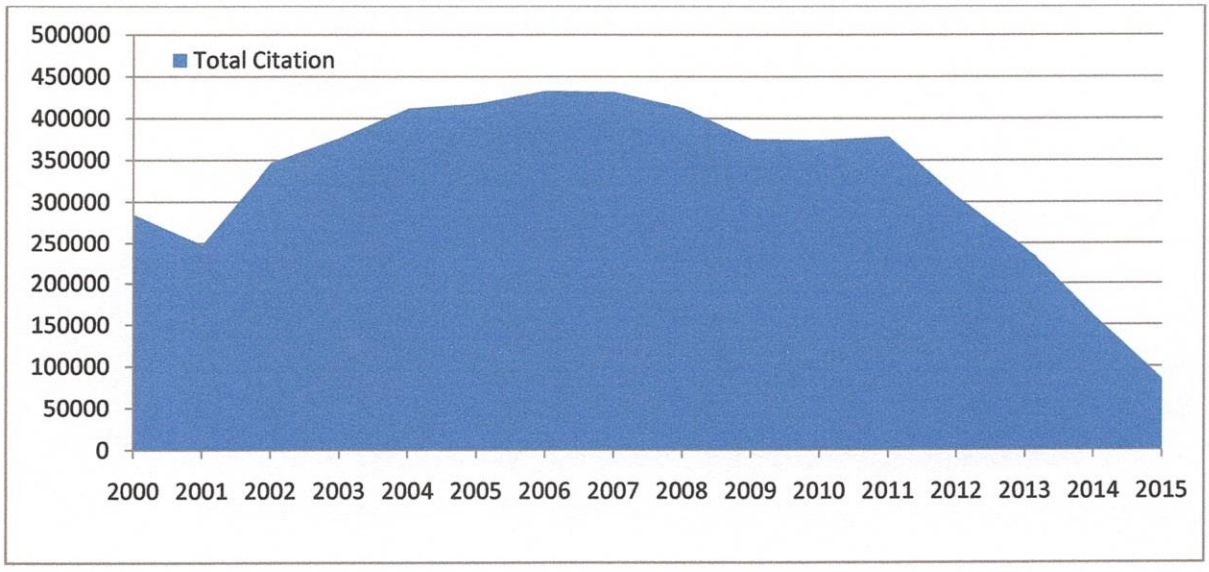
It is evident from Table 4.14 that out of 3,72,260 publications on PH 2,63,064 publications were cited by other authors. That means 70.66% of total publications were cited publications. The number of cited publications was the maximum in 2013 (8.90%) and the lowest in 2001 (3.16%). During the study period of 2000-2015 the total citation of 2,63,064 cited publications is 52,93,224. In the year of 2006, the maximum number of citation was achieved (8.19%) whereas the lowest number of citation was received in 2015 (1.60%).

Figure 4.16: Total cited publication vs. years



From Figure 4.16, an increasing trend of cited publication on public health has been observed during the study period. The number of cited publication varies from 8,318 to 23,419 with an average of 16,442 cited publications per year.

Figure 4.17: Total citation vs. years



It is seen from Figure 4.17 that the distribution of the citation is symmetrical. In 2001 the total citation received was 2,48,376 and this gradually increased to 4,33,391 in 2006 and then it decreased to 84,894 in 2015.

4.3.2 Un-cited publications on PH

The year wise distribution of cited and un-cited publication is presented in Table 4.15:

Table 4.15: Year wise un-cited publications

Year	Un-cited publications	Percentage
2000	3186	2.92%
2001	5007	4.59%
2002	4089	3.74%
2003	4787	4.38%
2004	4948	4.53%
2005	5292	4.85%
2006	5179	4.74%
2007	6157	5.64%
2008	5306	4.86%
2009	7075	6.48%
2010	6210	5.69%
2011	6694	6.13%
2012	7994	7.32%
2013	8878	8.13%
2014	12081	11.06%
2015	16313	14.94%
Total	109196	100.00%

Note: Cells in highlighted font shows highest and lowest values.

About 30% of the total publication on public health is un-cited. The number of un-cited publication was lowest in 2002 (2.92%) but it has been gradually increased as the year progress. The highest number of un-cited publication has been observed in 2015 (14.94%). An increasing trend of un-cited publications has been observed from 2002 to 2007 and from 2010 to 2015, which is presented in Figure 4.18 below:

Figure 4.18: Un-cited publications on PH

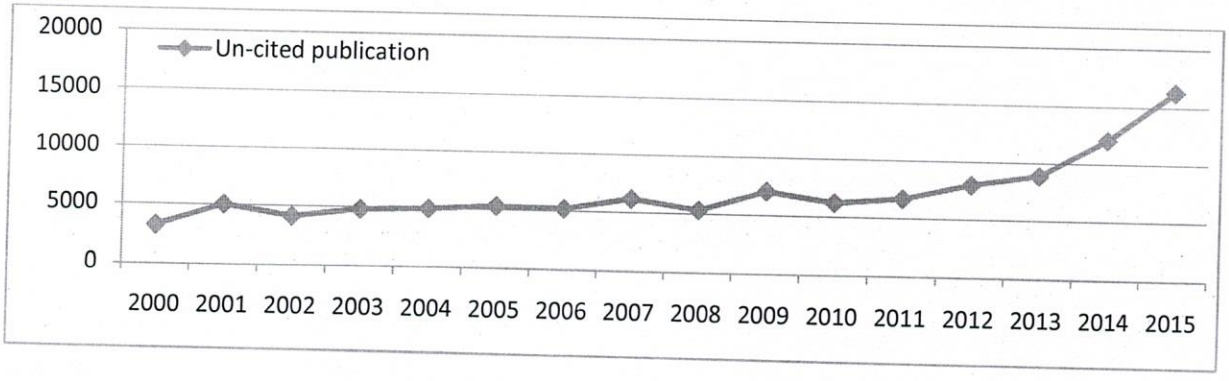


Figure 4.19: Comparative view of cited and un-cited publication

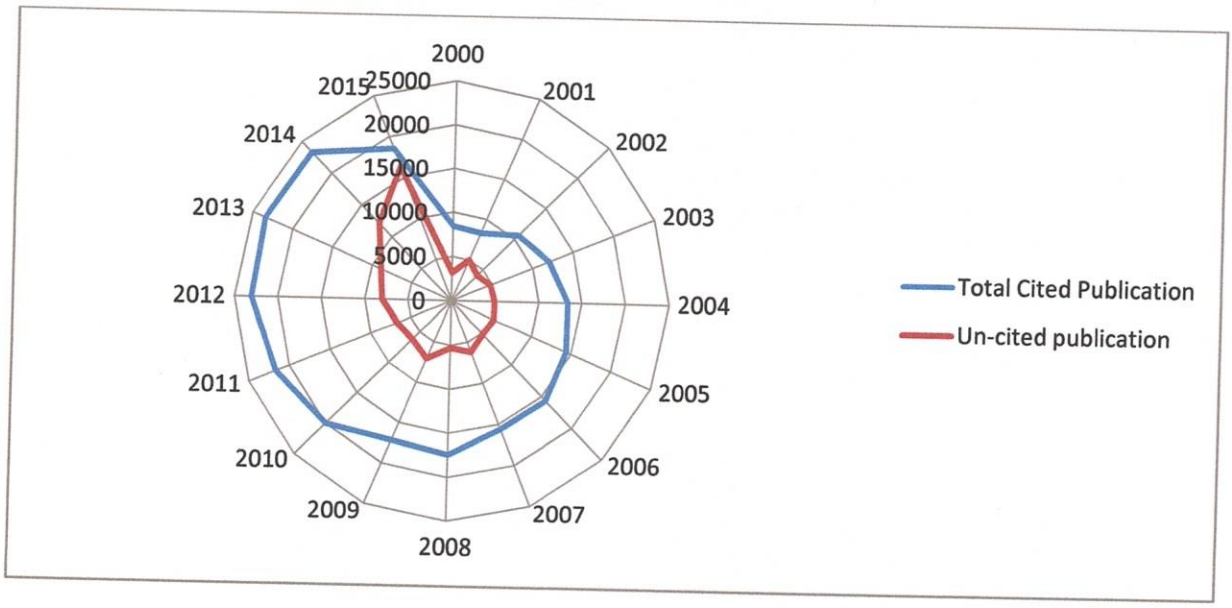


Figure 4.19 shows a year-wise comparative picture of cited and un-cited publications. More than 70% of total publication has been cited by other documents. The number un-cited document is smaller than cited publication.

4.3.3 CPP (TP) and CPP (CP) of PH literature

Citation Per Paper (CPP) can be calculated in two ways, firstly the CPP Total Publications [CPP(TP)] based on total number publication of particular year and secondly the CPP Cited Publications [CPP(CP)] based on total number of cited publication of a particular year. CPP (TP) and CPP (CP) can be calculated by using the following formulas:

$$\mathrm{CPP(TP)} = \frac{Total\ number\ of\ citations\ for\ a\ year/\ country}{Total\ number\ of\ publications\ of\ that\ year/country} \qquad \textbf{[Eq. 11]}$$

$$\mathrm{CPP(CP)} = \frac{Total\ number\ of\ citations\ for\ a\ year/\ country}{Total\ number\ of\ cited\ publications\ of\ that\ year/country} \qquad \textbf{[Eq. 12]}$$

CPP (TP) represents proportional number of citations per publication from total publications (including cited and un-cited) over a specific period of interval or in a geographical area e.g. country. The average number of citations per publication including both cited and un-cited publication was 16.21 during the study period 2000-2015. On the other hand, CPP (CP) represents proportional number of citation per

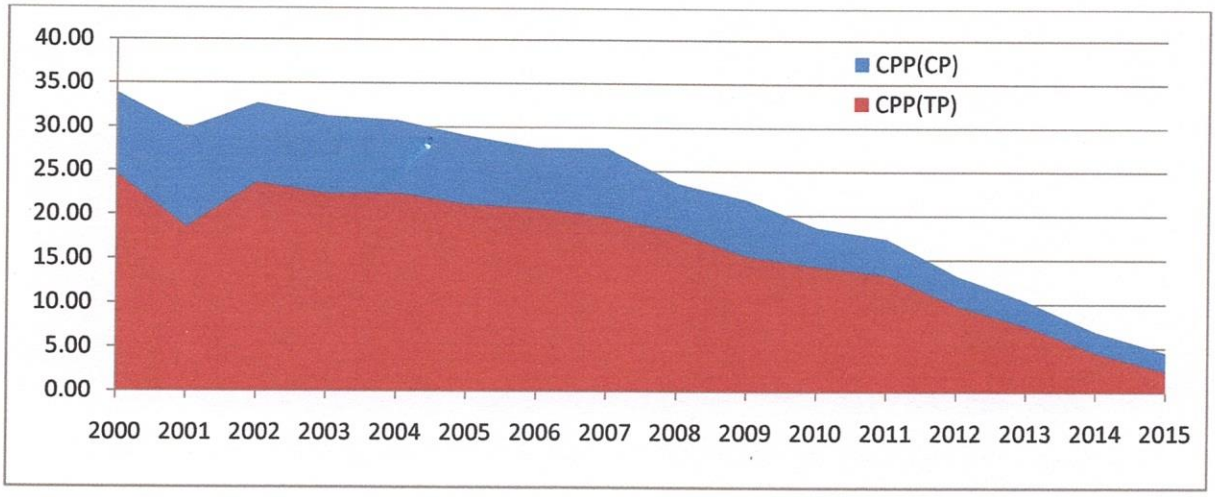
cited publication over a specific period of interval or geographical area. The average number of citation per cited publication was 22.51 during the study period 2000-2015. The value of CPP (CP) is certainly bigger than the value of CPP (TP) on during the study period.

Table 4.16: CPP (TP) and CPP (CP) of PH literature

Year	Total Citations	Total Publications	CPP(TP)	Total Cited Publications	CPP(CP)
2000	2,85,225	11,594	24.60	8,408	33.92
2001	2,48,376	13,325	18.64	8,318	29.86
2002	3,47,433	14,683	23.66	10,594	32.80
2003	3,76,969	16,818	22.41	12,031	31.33
2004	4,12,230	18,329	22.49	13,381	30.81
2005	4,18,067	19,668	21.26	14,376	29.08
2006	4,33,391	20,845	20.79	15,666	27.66
2007	4,32,004	21,752	19.86	15,595	27.70
2008	4,12,830	22,750	18.15	17,444	23.67
2009	3,75,577	24,289	15.46	17,214	21.82
2010	3,74,267	26,222	14.27	20,012	18.70
2011	3,78,642	28,367	13.35	21,673	17.47
2012	3,06,997	31,044	9.89	23,050	13.32
2013	2,44,596	32,297	7.57	23,419	10.44
2014	1,61,726	35,430	4.56	23,349	6.93
2015	84,894	34,847	2.44	18,534	4.58
Total	52,93,224	3,72,260	16.21	2,63,064	22.51

Note: Cells in highlighted font shows highest and lowest values.

Figure 4.20: CPP (TP) vs. CPP (CP)



The highest number of citation per publication CPP (TP) was 24.60 in 2000 and the lowest was 2.44 in 2015. At the same time the highest number of citation per cited publication CPP (CP) was 33.92 in 2000 and the lowest was 4.58 in 2015. As the ratio of CPP (CP) has been calculated on the basis of total cited publication the proportional value of CPP (CP) is slightly bigger than CPP (TP).

4.3.4 RoG and CAGR of cited publications and citations

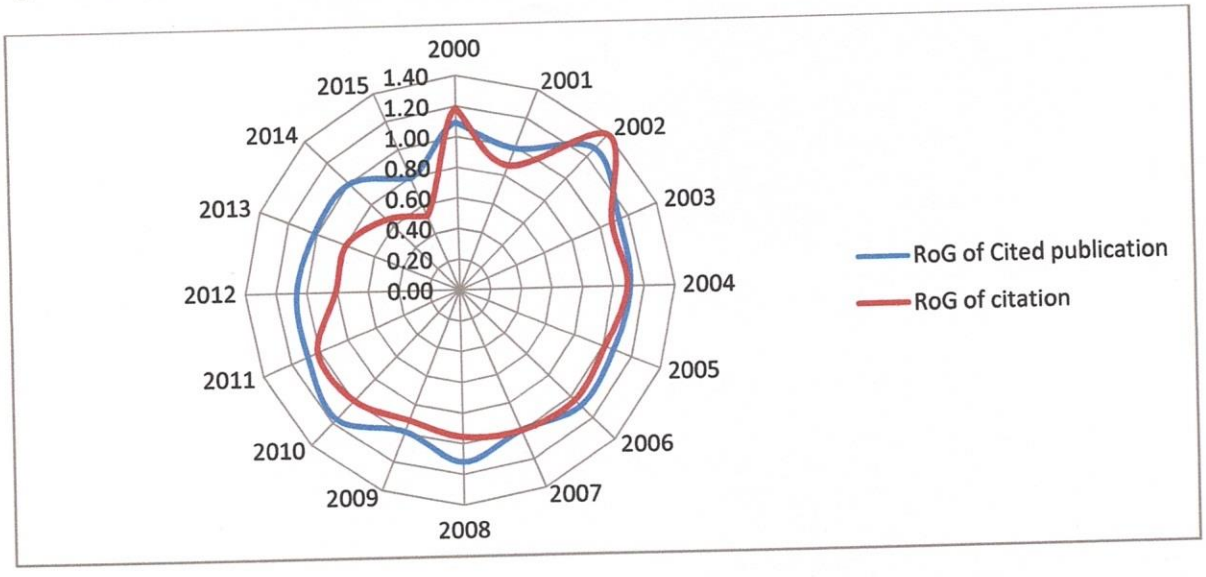
Table 4.17: RoG and CAGR of cited publications and citations

Year	Total Cited Publications	RoG	CAGR	Total Citations	RoG	CAGR
1999	7,695			2,40,301		
2000	8,408	1.09	0.09	2,85,225	1.19	0.19
2001	8,318	0.99	**-0.01**	2,48,376	0.87	-0.13
2002	10,594	**1.27**	0.27	3,47,433	**1.40**	**0.40**
2003	12,031	1.14	0.14	3,76,969	1.09	0.09
2004	13,381	1.11	0.11	4,12,230	1.09	0.09
2005	14,376	1.07	0.07	4,18,067	1.01	0.01
2006	15,666	1.09	0.09	4,33,391	1.04	0.04
2007	15,595	1.00	0.00	4,32,004	1.00	0.00
2008	17,444	1.12	0.12	4,12,830	0.96	-0.04
2009	17,214	0.99	**-0.01**	3,75,577	0.91	**-0.09**
2010	20,012	1.16	0.16	3,74,267	1.00	0.00
2011	21,673	1.08	0.08	3,78,642	1.01	0.01
2012	23,050	1.06	0.06	3,06,997	0.81	-0.19
2013	23,419	1.02	0.02	2,44,596	0.80	-0.20
2014	23,349	1.00	0.00	1,61,726	0.66	-0.34
2015	18,534	**0.79**	-0.21	8,48,94	**0.52**	-0.48
Total	2,63,064	1.06	0.06	52,93,224	0.96	-0.04

Note: There were 7,695 cited publications which receive 2,40,301 citations in 1999 (Source: Scopus); Cells in highlighted font shows highest and lowest values.

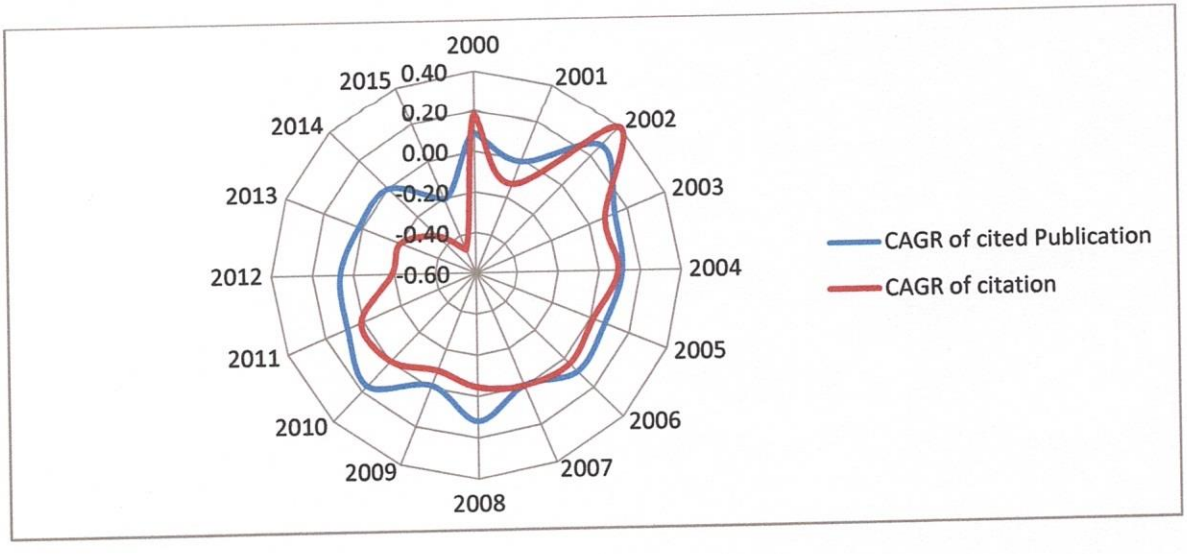
Usually RoG value shows proportional growth rate of present year based on previous year. So anything less than 1 indicates less growth rate than previous year. Therefore, the average growth rate of cited publication (1.06) is better than the RoG of citation (0.96). The Rate of Growth (RoG) of citation in 2000 is 1.19 means positive growth rate than previous year. As RoG value is positive CAGR shows positive deviation of proportional growth. More specifically, the CAGR of citation is 0.19 (1.19-1) in 2000, and -0.13 (0.87-1) in 2001 and so forth.

Figure 4.21: RoG of citation and cited publication



The rate of growth (RoG) for cited publication varies from 0.79 to 1.27 with an average of 1.06 and for citation RoG varies from 0.52 to 1.40 with an average of 0.96 during the study period 2000-2015. Figure 4.22 shows that CAGR of cited publication is greater than CAGR of citation. The average CAGR of cited publication is 0.06 which means positive proportional growth rate has been emphasized during the whole study period. On the other hand the average CAGR of citation is -0.04 means negative proportional growth rate has been emphasized during that period.

Figure 4.22: CAGR of citation and cited publication



4.3.5 RGR and Dt(cp)/Dt(c) of cited publications and citations

The Relative Growth Rate (RGR) and Double time for both cited publications Dt(cp) and citations Dt(c) has been calculated and the result is presented in Table 4.18.

Table 4.18: RGR and Dt(cp)/Dt(c) of cited publications and citations

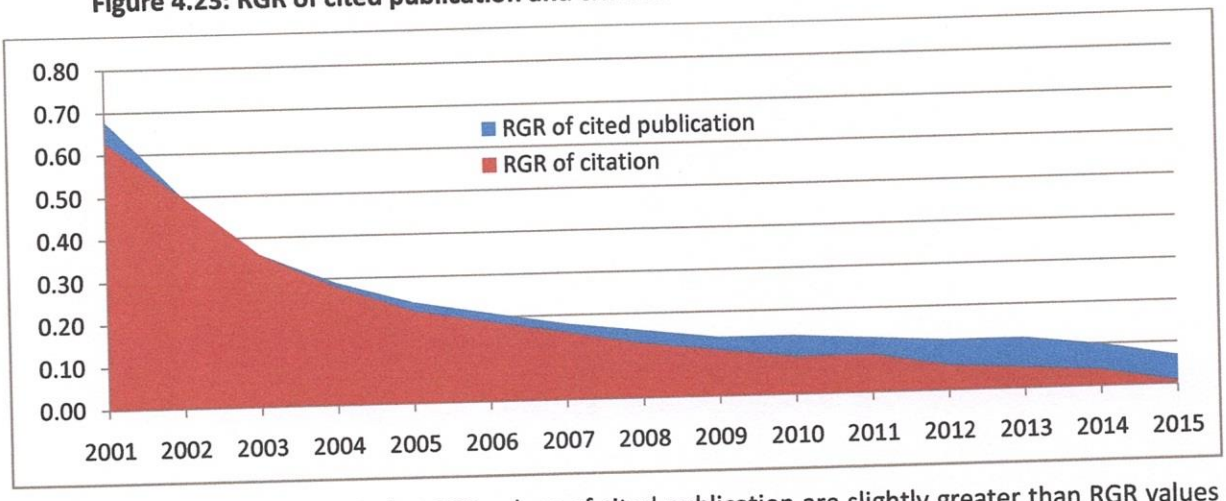
Year	Total Cited Publications	Cum	W_1	W_2	RGR	Dt(cp)	Total Citations	Cum	W_1	W_2	RGR	Dt(c)
2000	8408	8408	0.00	9.04			285225	285225	0.00	12.56		
2001	8318	16726	9.04	9.72	0.68	1.02	248376	533601	12.56	13.19	0.63	1.10
2002	10594	27320	9.72	10.22	0.50	1.39	347433	881034	13.19	13.69	0.50	1.39
2003	12031	39351	10.22	10.58	0.36	1.93	376969	1258003	13.69	14.05	0.36	1.92
2004	13381	52732	10.58	10.87	0.29	2.39	412230	1670233	14.05	14.33	0.28	2.48
2005	14376	67108	10.87	11.11	0.24	2.89	418067	2088300	14.33	14.55	0.22	3.15
2006	15666	82774	11.11	11.32	0.21	3.30	433391	2521691	14.55	14.74	0.19	3.65
2007	15595	98369	11.32	11.50	0.18	3.85	432004	2953695	14.74	14.90	0.16	4.33
2008	17444	115813	11.50	11.66	0.16	4.33	412830	3366525	14.90	15.03	0.13	5.33
2009	17214	133027	11.66	11.80	0.14	4.95	375577	3742102	15.03	15.14	0.11	6.30
2010	20012	153039	11.80	11.94	0.14	4.95	374267	4116369	15.14	15.23	0.09	7.70
2011	21673	174712	11.94	12.07	0.13	5.33	378642	4495011	15.23	15.32	0.09	7.70
2012	23050	197762	12.07	12.19	0.12	5.78	306997	4802008	15.32	15.38	0.06	11.55
2013	23419	221181	12.19	12.31	0.12	5.77	244596	5046604	15.38	15.43	0.05	13.86
2014	23349	244530	12.31	12.41	0.10	6.93	161726	5208330	15.43	15.47	0.04	17.32
2015	18534	263064	12.41	12.48	0.07	9.90	84894	5293224	15.47	15.48	0.01	69.30
Total	263064	Average RGR & Dt(cp)			0.23	4.31	5293224	Average RGR & Dt(c)			0.19	10.47

Note: Dt(cp)= Double time (cited publication), Dt(c)= Double time (citation); Cells in highlighted font shows highest and lowest values.

A trade off relation between RGR and Dt values has always been observed. The highest mean relative growth rate of cited publication was 0.68 in 2001 and it will take minimum time to get those cited publication doubled (1.02 year). The lowest RGR value for cited publications being observed was 0.07 in 2015 and at the same growth rate the cited publication will get doubled within 9.90 years.

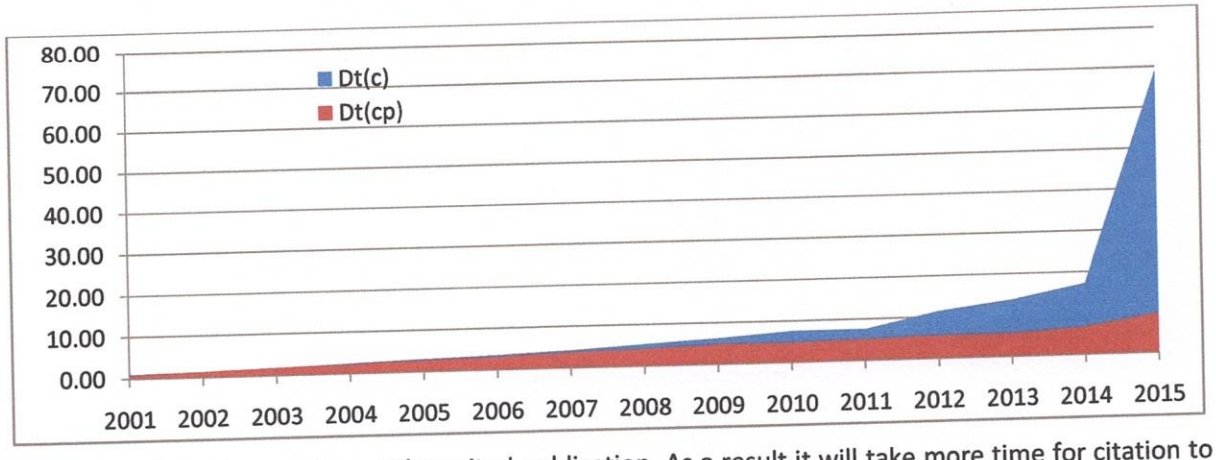
RGR values of citation, on the other hand, lie between 0.01 and 0.63. The lowest possible double time value for citation is 1.10 and highest one is 69.30.

Figure 4.23: RGR of cited publication and citation



It is observed from Figure 4.23 that RGR values of cited publication are slightly greater than RGR values of citation. RGR values for both cited publication and citation were higher in 2001 and decreased gradually every year.

Figure 4.24: Double time of cited publication Dt(cp) and citation Dt(c)



The extent of citation was bigger than cited publication. As a result it will take more time for citation to double its size than cited publications. The Dt (cp) and Dt (c) is increasing as the year by year.

4.3.6 Highly cited publications

The publications which were cited by more than 2000 times are presented in Table 4.19 together with name of authors, title of publications, year, source title and document type.

Table 4.19: Top 50 highly cited publications on PH

S.N.	Cited by	Authors	Title	Year	Source title	Document Type
1.	18,405	Jemal, A., Bray, F., Center, M.M., Ferlay, J., Ward, E., Forman, D.	Global cancer statistics	2011	CA Cancer Journal for Clinicians	Article
2.	8,280	Jemal, A., Siegel, R., Ward, E., Hao, Y., Xu, J., Thun, M.J.	Cancer statistics, 2009	2009	CA Cancer Journal for Clinicians	Article
3.	7,546	Levey, A.S., Coresh, J., Bolton, K., Culleton, B., Harvey, K.S., Ikizler, T.A., Johnson, *et al.*	K/DOQI clinical practice guidelines for chronic kidney disease	2002	American Journal of Kidney Diseases	Review
4.	7,377	Siegel, R., Naishadham, D., Jemal, A.	Cancer statistics, 2013	2013	CA Cancer Journal for Clinicians	Article
5.	6,536	Abra moff, M.D., Magalhaes, P.J., Ram, S.J.	Image processing with imageJ	2004	Biophotonics International	Review
6.	6,474	Ogden, C.L., Carroll, M.D., Curtin, L.R., McDowell, M.A., Tabak, C.J., Flegal, K.M.	Prevalence of overweight and obesity in the United States, 1999-2004	2006	Journal of the American Medical Association	Article
7.	6,360	Stroup, D.F., Berlin, J.A., Morton, S.C., Olkin, I., Williamson, G.D., Rennie, D., Moher, D., Becker, B.J., Sipe, T.A., Thacker, S.B.	Meta-analysis of observational studies in epidemiology: A proposal for reporting	2000	Journal of the American Medical Association	Article

S.N.	Cited by	Authors	Title	Year	Source title	Document Type
8.	5,529	Go, A.S., Chertow, G.M., Fan, D., McCulloch, C.E., Hsu, C.-Y.	Chronic kidney disease and the risks of death, cardiovascular events, and hospitalization	2004	New England Journal of Medicine	Article
9.	5,371	Eriksson, H., Engellau, P., *et al.*	Solution of current health problem: "a health check money" makes free choice possible for the patients	2000	Lakartidningen	Article
10.	4,772	Flegal, K.M., Carroll, M.D., Ogden, C.L., Johnson, C.L.	Prevalence and trends in obesity among US adults, 1999-2000	2002	Journal of the American Medical Association	Article
11.	4,318	Kolpin, D.W., Furlong, E.T., Meyer, M.T., Thurman, E.M., Zaugg, S.D., Barber, L.B., Buxton, H.T.	Pharmaceuticals, hormones, and other organic wastewater contaminants in U.S. streams, 1999-2000	2002	Environmental Science and Technology	Article
12.	3,824	Selkoe, D.J.	Alzheimer's disease: Genes, proteins, and therapy	2001	Physiological Reviews	Review
13.	3,700	Alberti, K.G.M.M., Zimmet, P., Shaw, J.	The metabolic syndrome - A new worldwide definition	2005	Lancet	Note
14.	3,697	Klein, G.	A denial with catastrophic consequences	2005	Läkartidningen	Article
15.	3,622	Pearson, T.A., Mensah, G.A., Alexander, R.W., Anderson, J.L., *et al.*	Markers of inflammation and cardiovascular disease:	2003	Circulation	Review

S.N.	Cited by	Authors	Title	Year	Source title	Document Type
16.	3,611	Siegel, R.L., Miller, K.D., Jemal, A.	Cancer statistics, 2015	2015	CA Cancer Journal for Clinicians	Article
17.	3,376	Rabe, K.F., Hurd, S., Anzueto, A., Barnes, P.J., Buist, S.A., Calverley, P., Fukuchi, Y., Jenkins, C., Rodriguez-Roisin, R., Van Weel, C., Zielinski, J.	Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary	2007	American Journal of Respiratory and Critical Care Medicine	Review
18.	3,360	Hotamisligil, G.S.	Inflammation and metabolic disorders	2006	Nature	Review
19.	3,352	Kearney, P.M., Whelton, M., *et al.*	Global burden of hypertension:	2005	Lancet	Article
20.	3,313	Mathers, C.D., Loncar, D.	Projections of global mortality and burden of disease from 2002 to 2030	2006	PLoS Medicine	Article
21.	3,259	Barba, C., Cavalli-Sforza, T., Cutter, J., Darnton-Hill, I., Deurenberg, P., Deurenberg-Yap, M., Gill, T., James, P., Ko, G., Nishida, C.	Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies	2004	Lancet	Review
22.	3,122	Hedley, A.A., Ogden, C.L., Johnson, C.L., Carroll, M.D., Curtin, L.R., Flegal, K.M.	Prevalence of overweight and obesity among US children, adolescents, and adults, 1999-2002	2004	Journal of the American Medical Association	Article
23.	3,078	Mokdad, A.H., Marks, J.S., Stroup, D.F., Gerberding, J.L.	Actual Causes of Death in the United States, 2000	2004	Journal of the American Medical Association	Review

S.N.	Cited by	Authors	Title	Year	Source title	Document Type
24.	3,033	Roger, V.L., Go, A.S., Lloyd-Jones, D.M., Benjamin, E.J., Berry, J.D., *et al.*	Heart disease and stroke statistics-2012 update	2012	Circulation	Article
25.	2,998	McGlynn, E.A., Asch, S.M., Adams, J., Keesey, J., Hicks, J., DeCristofaro, A., Kerr, E.A.	The quality of health care delivered to adults in the United States	2003	New England Journal of Medicine	Article
26.	2,970	Roger, V.L., Go, A.S., Lloyd-Jones, D.M., Adams, R.J., Berry, J.D., *et al.*	Heart disease and stroke statistics-2011 update	2011	Circulation	Article
27.	2,947	Lloyd-Jones, D., Adams, R.J., Brown, T.M., Carnethon, M., Dai, S., *et al.*	Executive summary: Heart disease and stroke statistics-2010 update:	2010	Circulation	Review
28.	2,904	Cohen, M.S., Chen, Y.Q., McCauley, M., Gamble, T., Hosseinipour, M.C., *et al.*	Prevention of HIV-1 infection with early antiretroviral therapy	2011	New England Journal of Medicine	Article
29.	2,826	Goldberger, A.L., Amaral, L.A., Glass, L., Hausdorff, J.M., Ivanov, P.C., *et al.*	PhysioBank, PhysioToolkit, and PhysioNet:	2000	Circulation	Article
30.	2,821	Go, A.S., Mozaffarian, D., Roger, V.L., Benjamin, E.J., Berry, J.D., *et al.*	Heart disease and stroke statistics-2013 update	2013	Circulation	Review
31.	2,611	Levey, A.S., Coresh, J., Balk, E., Kausz, A.T., Levin, A., Steffes, M.W., *et al.*	National Kidney Foundation Practice Guidelines for Chronic Kidney Disease	2003	Annals of Internal Medicine	Review
32.	2,582	Donlan, R.M., Costerton, J.W.	Biofilms: Survival mechanisms of clinically relevant microorganisms	2002	Clinical Microbiology Reviews	Review
33.	2,532	Troiano, R.P., Berrigan, D., Dodd, K.W.,	Physical activity in the United	2008	Medicine and Science in Sports	Article

S.N.	Cited by	Authors	Title	Year	Source title	Document Type
		MÃ¢sse, L.C., Tilert, T., Mcdowell, M.	States measured by accelerometer		and Exercise	
34.	2,509	Sacks, F.M., Svetkey, L.P., Vollmer, W.M., Appel, L.J., Bray, G.A., Harsha, D., Obarzanek, E., Conlin, P.R., *et al.*	Effects on blood pressure of reduced dietary sodium and the dietary approaches to stop hypertension (dash) diet	2001	New England Journal of Medicine	Article
35.	2,491	Shaw, J.E., Sicree, R.A., Zimmet, P.Z.	Global estimates of the prevalence of diabetes for 2010 and 2030	2010	Diabetes Research and Clinical Practice	Review
36.	2,411	Alberti, K.G.M.M., Zimmet, P., Shaw, J.	Metabolic syndrome - A new world-wide definition	2006	Diabetic Medicine	Review
37.	2,315	Haskell, W.L., Lee, I.-M., Pate, R.R., Powell, K.E., Blair, S.N., Franklin, B.A., MacEra, C.A., Heath, G.W., Thompson, P.D., Bauman, A.	Physical activity and public health: Updated recommendation for adults from the American College of Sports Medicine and the American Heart Association	2007	Medicine and Science in Sports and Exercise	Review
38.	2,300	Go, A.S., Mozaffarian, D., Roger, V.L., Benjamin, E.J., Berry, J.D., Blaha, M.J., Dai, S., Ford, E.S., Fox, C.S., Franco, S., Fullerton, H.J., Gillespie, C., Hailpern, S.M., Heit, J.A., Howard, V.J., *et al.*	Heart Disease and Stroke Statistics - 2014 Update: A report from the American Heart Association	2014	Circulation	Review
39.	2,286	Pope III, C.A., Dockery, D.W.	Health effects of fine particulate air pollution: Lines that connect	2006	Journal of the Air and Waste Management Association	Review

S.N.	Cited by	Authors	Title	Year	Source title	Document Type
40.	2,242	Sherry, S.T., Ward, M.-H., Kholodov, M., Baker, J., Phan, L., Smigielski, E.M., Sirotkin, K.	DbSNP: The NCBI database of genetic variation	2001	Nucleic Acids Research	Article
41.	2,225	Young, T., Peppard, P.E., Gottlieb, D.J.	Epidemiology of obstructive sleep apnea: A population health perspective	2002	American Journal of Respiratory and Critical Care Medicine	Review
42.	2,180	Young, D.	Experts warn drug industry, government about weaknesses in drug supply chain.	2003	American journal of health-system pharmacy : AJHP	Article
43.	2,111	Kuczmarski, R.J., Ogden, C.L., Grummer-Strawn, L.M., Flegal, K.M., Guo, S.S., Wei, R., Mei, Z., Curtin *et al.*	CDC growth charts: United States.	2000	Advance data	Article
44.	2,101	Greenhalgh, T., Robert, G., Macfarlane, F., Bate, P., Kyriakidou, O.	Diffusion of innovations in service organizations: Systematic review and recommendations	2004	Milbank Quarterly	Review
45.	2,099	Klibanski, A., Adams-Campbell, L., Bassford, T., Blair, S.N., Boden, S.D., Dickersin, K., Gifford, D.R., *et al.*	Osteoporosis prevention, diagnosis, and therapy	2001	Journal of the American Medical Association	Conference Paper
46.	2,069	Ezzati, M., Lopez, A.D., Rodgers, A., Vander Hoorn, S., Murray, C.J.L.	Selected major risk factors and global and regional burden of disease	2002	Lancet	Article

S.N.	Cited by	Authors	Title	Year	Source title	Document Type
47.	2,058	Sallis, J.F., Prochaska, J.J., Taylor, W.C.	A review of correlates of physical activity of children and adolescents	2000	Medicine and Science in Sports and Exercise	Article
48.	2,056	Lobstein, T., Baur, L., Uauy, R.	Obesity in children and young people: A crisis in public health	2004	Obesity Reviews, Supplement	Review
49.	2,040	De Pauw, B., Walsh, T.J., Donnelly, J.P., Stevens, D.A., Edwards, J.E., Calandra, T., Pappas, P.G., *et al.*	Revised definitions of invasive fungal disease from the European Organization for Research and Treatment of Cancer/Invasive Fungal Infections Cooperative Group and the National Institute of Allergy and Infectious Diseases Mycoses Study Group (EORTC/MSG) Consensus Group	2008	Clinical Infectious Diseases	Article
50.	2,024	Tilman, D., Cassman, K.G., Matson, P.A., Naylor, R., Polasky, S.	Agricultural sustainability and intensive production practices	2002	Nature	Review

Table 4.19 has been prepared by ranking high impact publication on the basis of highest number of citation received. The publication with highest number of citations (18,405) from total publications on public health during 2000-2015 was Jemal, A. *et al.* entitled 'Global cancer statistics' published on 'CA Cancer Journal for Clinicians' in 2011. The next most highly cited paper (8,280) was also by Jemal, A. *et al.* entitled 'Cancer statistics, 2009'published on 'CA Cancer Journal for Clinicians' in also in 2011.

4.3.6.1 Citation range of highly cited articles

There are 589 publications which have received 500 or more citations each. Only one article has received more than 10,000 citations (0.17%) whereas 417 articles each belongs to the citation range of 500-999 (70.80%). This is shown in Table 4.20 below.

Table 4.20: Number and percentage of highly cited articles

Citation Range	Numbers of publication	Percentage
Above 10,000	1	0.17%
8,000 and less than 10,000	1	0.17%
6,000 and less than 8,000	5	0.85%
4,000 and less than 6,000	4	0.68%
2,000 and less than 4,000	39	6.62%
1,000 and less than 2,000	122	20.71%
500 and less than 1,000	417	70.80%
Total	589	100.00%

Note: Calculation has been done on publications which equal and more than 500 citation.

4.3.6.2 Publication types of highly cited publications

Table 4.21: Document types of highly cited publications

Document Type	Numbers	Percentage
Article	27	54%
Review	21	42%
Note	1	2%
Conference Paper	1	2%
Total	50	100%

Table 4.21 shows that majority percent (54%) of highly cited publications are 'articles' whereas 42% of highly cited document's type was 'review'.

4.3.6.3 Global top ten authors

McKee of United Kingdom who was affiliated with London School of Hygiene & Tropical Medicine contributed the largest number of document on public health (292), which is followed by the publications (226) contributed by Mr. Bateman of South Africa. Among the top ten authors, four authors

were represented from United Kingdom and two authors were represented each from United States of America and Japan.

Table 4.22: Top 10 authors on public health with affiliation

Authors	Affiliated country	Affiliated Institution	Total publications	Publications on public health	Rank
McKee, M.	United Kingdom	London School of Hygiene & Tropical Medicine	1041	292	1
Bateman, C.	South Africa	Health and Medical Publishing Group	712	226	2
Gostin, L.O.	United States of America	Georgetown University Law Center	535	190	3
Tsugane, S.	Japan	National Cancer Center Tokyo	654	186	4
Brownson, R.C.	United states of America	Washington University in St. Louis, Prevention Research Center in St. Louis	496	172	5
Horton, R.	United Kingdom	The Lancet	967	165	6
Mackie, P.	United Kingdom	Scottish Mental Health Research Network	191	163	7
Wilson, N.	New Zealand	University of Otago	471	160	8
Inoue, M.	Japan	University of Tokyo	382	156	9
Sim, F.	United Kingdom	Royal Society for Public Health	174	155	10

Average Citation Per Paper (ACPP) and Average Citation Per Cited Paper (ACPCP) can be calculated in the following ways:

$$\text{ACPP} = \frac{Total\ number\ of\ citations\ received\ by\ a\ researcher}{Total\ number\ of\ publications\ by\ the\ author} \quad \textbf{[Eq. 13]}$$

$$\text{ACPCP} = \frac{Total\ number\ of\ citations\ received\ by\ a\ researcher}{Total\ number\ of\ cited\ publications\ acknowledge\ to\ the\ source\ author} \quad \textbf{[Eq. 14]}$$

The total number of citation, cited document, ACPCP, ACPP along with rank were calculated and presented in Table 4.23:

Table 4.23: Top 10 authors on public health with ranking across 4 criteria

Authors	Number of Citations	Cited Documents	ACPCP	ACPP	Rank			
					1	2	3	4
McKee, M.	25895	18024	1.44	24.88	1	1	2	4
Bateman, C.	513	436	1.18	0.72	8	8	7	8
Gostin, L.O.	7642	6046	1.26	14.28	6	6	5	5
Tsugane, S.	19733	14908	1.32	30.17	3	3	4	3
Brownson, R.C.	23469	15994	1.47	47.32	2	2	1	1
Horton, R.	12730	11225	1.13	13.16	5	5	8	6
Mackie, P.	127	117	1.09	0.66	9	9	10	10
Wilson, N.	4035	2818	1.43	8.57	7	7	3	7
Inoue, M.	14893	12049	1.24	38.99	4	4	6	2
Sim, F.	123	110	1.12	0.71	10	10	9	9

Note:

ACPCP : Average Citation Per Cited Paper

ACPP : Average Citation Per Paper

1 : Based on citations

2 : Based on cited document

3 : Based on ACPCP

4 : Base on ACPP

It is observed from Table 4.23 that McKee has been placed as 1st rank based on citations and cited documents. Mr. Brownson is placed 2nd rank based on citations and cited documents and first rank based on ACPP and ACPCP. Sim is placed 10th rank based on citations and cited documents and 9th rank based on ACPP and ACPCP.

4.3.6.4 Global top ten authors with various indices

Various citation indices have been devised throughout the world to measure the productivity and impact of published work. To measure and characterize scientific output of a researcher, Hirsch (2015) proposed h-index, Egghe (2006) proposed g-index.

The h-index is defined as: *"A scientist has index h if h of his/her Np papers have at least h citations each, and the other (Np-h) papers have no more than h citations each".* A h-index of 20 means that an academic has published at least 20 papers that have received at least 20 citations each. The h-index thus combines an assessment of both quantity (number of papers) and an approximation of quality (impact, or citations to these papers). The g-index based on modification of h-index is defined as "given a set of articles ranked in decreasing order of the number of citations that they received, the g-index is the

unique largest number such that the top g articles received together at least g^2 citations." A g-index of 20 means that and academic has published at least 20 articles that combined have received at least 400 citations. However, unlike the h-index these citations could be generated by only a small number of articles. For instance an academic with 20 papers, 15 of which have no citations with the remaining five having respectively 350, 35, 10, 3 and 2 citations would have a g-index of 20, but a h-index of 3 (three papers with at least 3 citations each) (Harzing, 2016).

Due to some differences remaining in calculating h-index between senior and junior academics across disciplines and career stages, hI,norm and hIa (hI,annual) were introduced. hI normalize the number of citations for each paper by dividing the number of citations by the number of co-authors for that paper, and then calculate the h-index of the normalized citation counts. To compare different academics at different career stages hI,annual was devised. hI,annual is defined as hI,norm/academic age, where academic age means number of years elapsed since first publication(Harzing, 2017).

In this section the research outputs of top ten authors on public health globally were assessed by some such citation indices using Publish or Perish, version 5.

Table 4.24: Top ten authors with various indices

Authors	h-index	g-index	hI,norm	hI,annual	Publication years	Citation Years
McKee, M.	75	132	33	1.14	1988-2017	29 (1988-2017)
Bateman, C.	7	10	7	0.41	2000-2016	17 (2000-2017)
Gostin, L.O.	44	67	31	0.7	1973-2017	44 (1973-2017)
Tsugane, S.	66	103	20	0.63	1985-2017	32 (1985-2017)
Brownson, R.C.	72	141	32	1.07	1987-2017	30 (1987-2017)
Horton, R.	46	100	31	0.97	1985-2017	32 (1985-2017)
Mackie, P.	4	6	3	0.18	2000-2017	17 (2000-2017)
Wilson, N.	33	47	14	0.52	1990-2017	27(1990-2017)
Inoue, M.	58	104	17	0.68	1992-2016	25 (1992-2017)
Sim, F.	4	6	3	0.11	1990-2017	27 (1990-2017)

Table 4.24 indicates h-index of McKee, M. (75) is greater than others but lower hI,norm (33) means most of his articles were co-authored with at least three other academics. The g-index of Brownson (141) is superior to other authors of public health but have lower hI,norm (32) in comparison with his h-index (72). Gosting has comparatively better hI,norm (31) in relation to his h-index (44). Mackie, P and Sim have single digit index of all three indexes (h-index, g-index, hI,norm). A hIa of 1.0 means an academic has consistently published one article per year. Accordingly, Mckee, M, And Brownson have more than

1.0 hla which means that more than one article each year was published by them. Gosting is most senior academic in terms of article publishing tenure (44 years) followed by Horton (32 years) and Tsugane (32 years). A comparative view of ranks based on these citation indexes among ten authors on public health is presented in Table 4.25 below.

Table 4.25: Rank of indices among top ten authors of PH

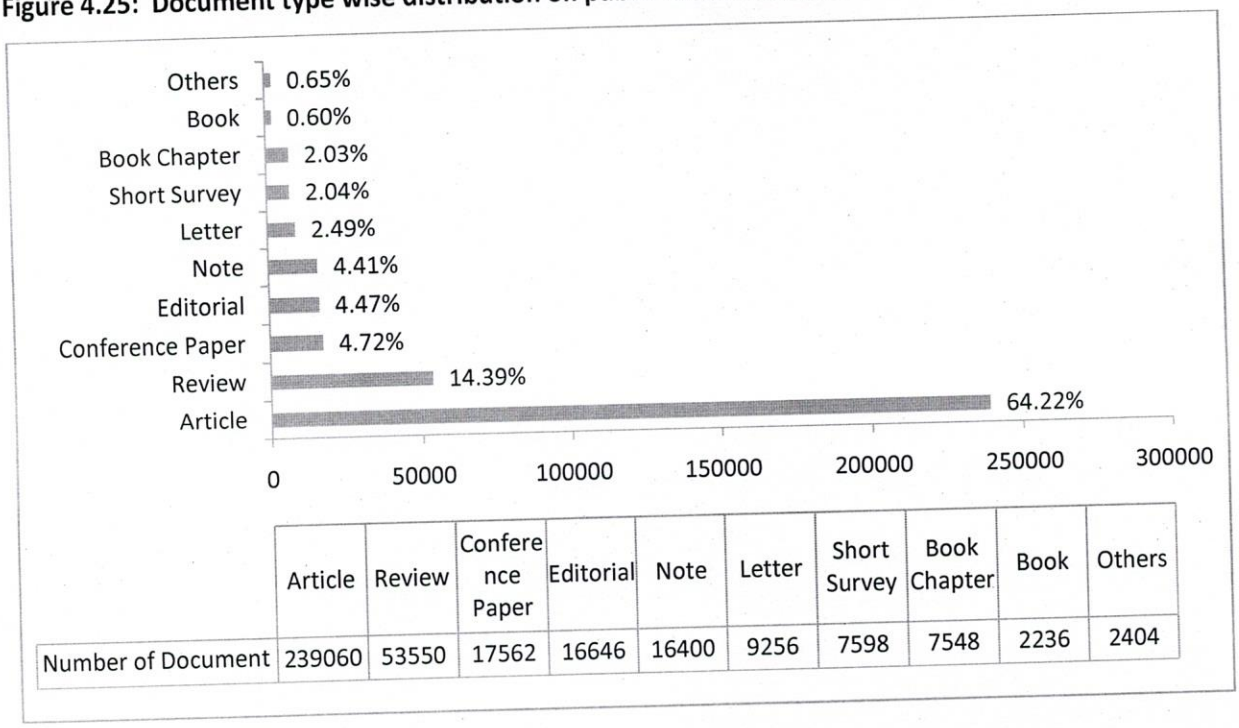
Authors	h-rank	Authors	g-rank	Authors	hI,n rank	Authors	hI,a rank
McKee, M.	1	Brownson	1	McKee, M.	1	McKee, M.	1
Brownson	2	McKee, M.	2	Brownson	2	Brownson	2
Tsugane	3	Inoue	3	Gostin	3	Horton	3
Inoue	4	Tsugane	4	Horton	3	Gostin	4
Horton	5	Horton	5	Tsugane	4	Inoue	5
Gostin	6	Gostin	6	Inoue	5	Tsugane	6
Wilson	7	Wilson	7	Wilson	6	Wilson	7
Bateman	8	Bateman	8	Bateman	7	Bateman	8
Mackie, P.	9	Mackie, P.	9	Mackie, P.	8	Mackie, P.	9
Sim	9	Sim	9	Sim	8	Sim	10

4.4 Assessment of literature using various parameters and laws

4.4.1 Document type

Research output normally appears in different formats for example: articles, book chapters, conference proceedings etc. Scopus database also covers a variety of publication formats of research output. During conducting this search on public health, all types of documents supported by Scopus database were included.

Figure 4.25: Document type wise distribution on public health literature



	Article	Review	Conference Paper	Editorial	Note	Letter	Short Survey	Book Chapter	Book	Others
Number of Document	239060	53550	17562	16646	16400	9256	7598	7548	2236	2404

Figure 4.25 shows the types of document together with rate of percent covered under the present study. The largest percentage of the research output is published in form of article (64.22%), next review (14.39%) and then in the form of conference paper (4.72%). 'Book' and 'Book chapter' types of document were very small in quantity (2.63%) for the years in question

4.4.2 Major subject areas of PH

Although the total number of research outputs of 3,72,260 which were published in different subject areas of public health during 2000-2015, yet there are also good number of same research outputs covering different subject areas of public health. Therefore, the subject area-wise research output was greater than document type wise research output. The number wise distribution of major subject areas covered under the present research is presented in Table 4.26:

Table 4.26: Subject area-wise distribution

Subject Areas	Numbers	Percentage
Medicine	2,65,526	49.08%
Social Sciences	43,400	8.02%
Nursing	30,549	5.65%
Biochemistry, Genetics and Molecular Biology	24,576	4.54%
Environmental Science	23,267	4.30%
Immunology and Microbiology	18,908	3.50%
Pharmacology, Toxicology and Pharmaceutics	16,816	3.11%
Agricultural and Biological Sciences	16,803	3.11%
Health Professions	10,945	2.02%
Psychology	10,708	1.98%
Engineering	9,848	1.82%
Arts and Humanities	7,204	1.33%
Veterinary	5,506	1.02%
Computer Science	4,968	0.92%
Neuroscience	4,909	0.91%
Business, Management and Accounting	4,557	0.84%
Economics, Econometrics and Finance	4,354	0.80%
Dentistry	4,170	0.77%
Chemistry	3,418	0.63%
Earth and Planetary Sciences	3,392	0.63%
Multidisciplinary	3,091	0.57%
Chemical Engineering	2,796	0.52%
Mathematics	2,121	0.39%
Energy	1,827	0.34%
Physics and Astronomy	1,689	0.31%
Materials Science	1,118	0.21%
Decision Sciences	962	0.18%
Others	13,566	2.51%
Total	5,40,994	100%

Medicine, Social Sciences, Nursing, Biochemistry, Genetics and Molecular Biology, Environmental Science, Immunology and Microbiology, Pharmacology, Toxicology and Pharmaceutics, Agricultural and Biological Sciences, and Health Professions are the top 10 subject fields covering 83.33% of total publication.

4.4.3 Country-wise research output on public health

The countries which produced more than 800 publications on public health are presented in Table 4.27.

Table 4.27: Country-wise publications on public health

S.N.	Country	Publications	Percentage	Rank
1	United States	1,16,418	31.27%	1
2	United Kingdom	38,313	10.29%	2
3	Canada	18,692	5.02%	3
4	Australia	18,002	4.84%	4
5	Brazil	12,953	3.48%	5
6	France	12,431	3.34%	6
7	Germany	11,466	3.08%	7
8	India	9,159	2.46%	8
9	China	8,586	2.31%	9
10	Italy	8,305	2.23%	10
11	Spain	8,217	2.21%	11
12	Netherlands	7,229	1.94%	12
13	Switzerland	6,889	1.85%	13
14	Sweden	6,122	1.64%	14
15	Japan	4,921	1.32%	15
16	South Africa	4,637	1.25%	16
17	Belgium	3,859	1.04%	17
18	Denmark	3,589	0.96%	18
19	Norway	3,324	0.89%	19
20	New Zealand	3,280	0.88%	20
21	Mexico	3,024	0.81%	21
22	Turkey	2,801	0.75%	22
23	Iran	2,726	0.73%	23
24	South Korea	2,707	0.73%	24
25	Taiwan	2,690	0.72%	25
26	Finland	2,575	0.69%	26
27	Greece	2,260	0.61%	27
28	Thailand	2,167	0.58%	28
29	Nigeria	2,059	0.55%	29
30	Israel	1,983	0.53%	30
31	Hong Kong	1,977	0.53%	31
32	Ireland	1,941	0.52%	32
33	Portugal	1,897	0.51%	33
34	Malaysia	1,869	0.50%	34
35	Poland	1,814	0.49%	35
36	Austria	1,679	0.45%	36
37	Pakistan	1,664	0.45%	37
38	Argentina	1,463	0.39%	38
39	Colombia	1,448	0.39%	39
40	Singapore	1,400	0.38%	40
41	Chile	1,307	0.35%	41
42	Kenya	1,291	0.35%	42
43	Saudi Arabia	1,,186	0.32%	43
44	Croatia	1,172	0.31%	44
45	Egypt	1,154	0.31%	45
46	Czech Republic	1,018	0.27%	46
47	Tanzania	923	0.25%	47
48	Uganda	895	0.24%	48
49	Bangladesh	871	0.23%	49
50	Hungary	808	0.22%	50
51	Ethiopia	802	0.22%	51

It is observed from Table 4.27 that about one-third of the total publications were produced from United States. In fact more than half of the total publications were produced by top four countries. Among the SAARC countries India ranked top position with a total of 9159 publication (8^{th} in world ranking) which is followed by Pakistan with a total of 1664 documents (37^{th} in world ranking). Bangladesh occupies 49^{th} place with a total of 871 publications (49^{th} in world ranking).

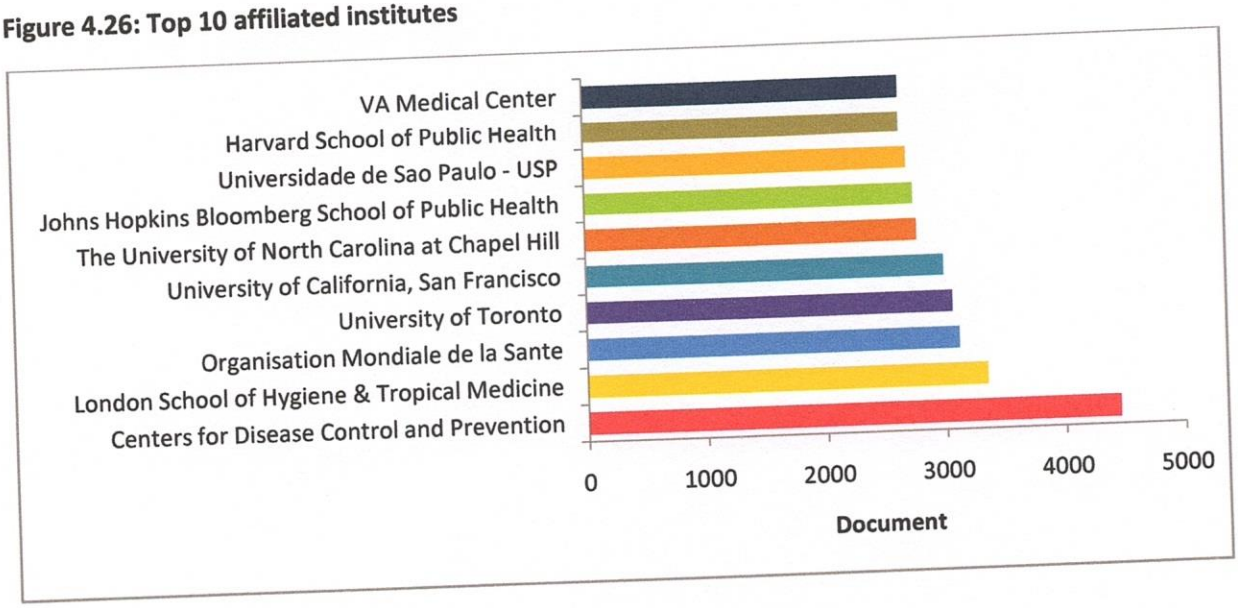
4.4.4 Top 10 affiliated institutions on public health

Table 4.28 shows the list of top ten institutions the authors on public health affiliated most.

Table 4.28: Top 10 affiliated institutions

Affiliated Institutes	Country	Records	Percentage	Rank
Centers for Disease Control and Prevention	USA	4,457	1.20%	1
London School of Hygiene & Tropical Medicine	UK	3,349	0.90%	2
Organisation Mondiale de la Sante	Switzerland	3,115	0.84%	3
University of Toronto	Canada	3,063	0.82%	4
University of California, San Francisco	USA	2,994	0.80%	5
The University of North Carolina at Chapel Hill	USA	2,776	0.75%	6
Johns Hopkins Bloomberg School of Public Health	USA	2,752	0.74%	7
Universidade de Sao Paulo - USP	Brazil	2,701	0.73%	8
Harvard School of Public Health	USA	2,644	0.71%	9
VA Medical Center	USA	2,641	0.71%	10

Figure 4.26: Top 10 affiliated institutes



The authors affiliated with 'Centers for Disease Control and Prevention' of USA produced maximum papers on public health. The researchers of this institutions published 1.20% of the total publication (1st in world ranking). London School of Hygiene & Tropical Medicine was placed 2nd rank by producing 3,349 records (0.90%). Organisation Mondiale de la Sante or World Health Organization held 3rd place in world ranking in producing public health related literature (3,115, 0.84%).

4.4.5 Top 10 publication languages

The language of research output is also interesting part to notice under the present study. Table 4.29 depicts language wise distribution of the records.

Table 4.29: Language-wise distribution

Language	Records	Percentage	Ranking
English	3,32,134	89.22%	1
French	9,872	2.65%	2
Spanish	8,709	2.34%	3
German	7,551	2.03%	4
Portuguese	7,147	1.92%	5
Italian	1,903	0.51%	6
Russian	1,716	0.46%	7
Chinese	1,691	0.45%	8
Japanese	1,352	0.36%	9
Polish	1,117	0.30%	10

Without any doubt English is the world recognized language which is also preferred language in scholarly communication. The language of 89.22% of the total research output is English which is followed by French (2.65%), Spanish (2.34%) and German (2.03%).

4.4.6 Source type of publication

It is obvious from Table 4.30 that 93.91% of the total publications on public health were journal articles. Only 2.66% and 1.83% of the total publications were books and conference proceedings gradually.

Table 4.30: Source type of publication

Source Type	Numbers	Percentage
Journals	3,49,584	93.91%
Books	9,917	2.66%
Conference Proceedings	6,808	1.83%
Book Series	3,697	0.99%
Trade Publications	1,988	0.53%
Others	266	0.07%
Total	3,72,260	100%

4.4.7 Journal productivity

4.4.7.1 Core journals' titles

The journal which has the highest percentage of articles pertaining to the subject is called a core journal. The top 50 most such core journals' titles on public health literature together with number of articles are presented in Table 4.31.

Table 4.31: Top 50 journals

S.N.	Name of Journals	Articles	%	Rank
1	Lancet	3264	0.88%	1
2	American Journal of Public Health	3234	0.87%	2
3	PLOS ONE	3117	0.84%	3
4	Health Service Journal	2713	0.73%	4
5	BMC Public Health	2535	0.68%	5
6	American Journal of Epidemiology	2128	0.57%	6
7	Public Health	2117	0.57%	7
8	Social Science And Medicine	2000	0.54%	8
9	Pharmaceutical Journal	1799	0.48%	9
10	European Journal of Public Health	1568	0.42%	10
11	Public Health Reports	1566	0.42%	11
12	Environmental Health Perspectives	1423	0.38%	12
13	Medical Journal of Australia	1324	0.36%	13
14	Canadian Journal of Public Health	1300	0.35%	14
15	American Journal of Preventive Medicine	1261	0.34%	15
16	Scandinavian Journal of Public Health	1222	0.33%	16
17	Bulletin of The World Health Organization	1182	0.32%	17
18	BMJ Clinical Research Ed	1146	0.31%	18
19	Vaccine	1129	0.30%	19

S.N.	Name of Journals	Articles	%	Rank
20	Australian And New Zealand Journal of Public Health	1099	0.30%	20
21	Health Affairs	1093	0.29%	21
22	Journal of Epidemiology And Community Health	1059	0.28%	22
23	BMJ Online	1043	0.28%	23
24	Journal of Public Health Management And Practice	1042	0.28%	24
25	Science	1036	0.28%	25
26	Nature	1030	0.28%	26
27	Pediatrics	1030	0.28%	26
28	International Journal of Environmental Research And Public Health	1017	0.27%	27
29	Ciencia E Saude Coletiva	981	0.26%	28
30	Cadernos De Saude Publica	970	0.26%	29
31	South African Medical Journal	964	0.26%	30
32	BMC Health Services Research	954	0.26%	31
33	New England Journal of Medicine	905	0.24%	32
34	Health Policy	880	0.24%	33
35	Health Promotion Practice	876	0.24%	34
36	Public Health Nutrition	867	0.23%	35
37	International Journal of Epidemiology	847	0.23%	36
38	New Zealand Medical Journal	834	0.22%	37
39	British Medical Journal	815	0.22%	38
40	Emerging Infectious Diseases	780	0.21%	39
41	Preventing Chronic Disease	771	0.21%	40
42	Environmental Science And Technology	769	0.21%	41
43	JAMA Journal of The American Medical Association	767	0.21%	42
44	Revista Panamericana De Salud Publica Pan	758	0.20%	43
45	Journal of The American Medical Association	752	0.20%	44
46	Journal of Public Health	727	0.20%	45
47	MMW Fortschritte Der Medizin	718	0.19%	46
48	Clinical Infectious Diseases	715	0.19%	47
49	Nursing Times	706	0.19%	48
50	Science of The Total Environment	695	0.19%	49

The UK based journal named 'Lancet' is ranked top of the list in producing 3,264 articles which is 0.88% of total publications on public health during the period 2000-2015. 'American Journal of Public Health' placed 2nd in ranking by contributing 3,234 records during study period. Another US based journal named 'PLOS ONE' is the third of journal ranking by publishing 3,117 articles with a rate of 0.81%.

4.4.7.2 Bradford's law of scattering

Bradford's Law of Scattering describes a quantitative relationship between journals and the papers they publish. Journals arranged in order of their decreasing productivity of articles on a given field can be divided into three zones, containing the same number of articles. Zone-1 or core zone contains one third of the total articles, which is most productive zone treated as nuclear zone or core. Zone-2 contains the same number of articles but a greater number of journals than zone-1, which is moderately productive zone. Zone-3 contains same number of articles but greater number of journals than zone-2, which is low productive zone treated as peripheral zone. The mathematical relationship of the number of journals in the zone-1 to zone-2 is constant n and to the second zone the relationship is n^2 (as cited in Singh & Bebi, 2014). Bradford expressed relationship among the zones as

$$1:n:n^2 \qquad \textbf{[Eq. 15]}$$

Based on Bradford's observations, Brookes suggested the following linear relation to describe the scattering phenomenon as: $F(x) = a + b \log x$, where $F(x)$ is the cumulative number of references contained in the first x most productive journals, and 'a' and 'b' are constants. This is the most widely used formulation of Bradford's Law (as cited in Sudhier, 2010).

The statement of Bradford's conclusion is called a verbal formulation. As Bradford didn't give mathematical formulation of his law, Brookes, Vickery and Leimkuhler, later on, suggested different models of Bradford's law called graphical formulation.

4.4.7.2.1 Application of Bradford's law of scattering into the journals of PH

Bradford law of scattering describes how the literature on a particular subject is scattered or distributed in the journals (Wardikar & Gudadhe, 2013). Bradford's law of scattering can be applied in library and information centers. On a given subject field the Bradford's law of scattering helps the librarian to select core journals.

A number of studies have already been conducted around the world to test the applicability of Bradford's law of scattering (Singh & Bebi, 2014; Sudhier, 2010; Nicolaisen & Hjorland, 2007 Vickery, 1948). In the present study for calculating the algebraic interpretations of Bradford's law, 160 journal titles were divided into three zones. The total number of journals together with corresponding number of articles in descending order is presented in Table 4.32:

Table 4.32: Distribution of journals and corresponding articles according to Bradford's law

Number of articles	Total Number of journal	Total number of articles	Cumulative articles
3,264	1	3,264	3,264
3,234	1	3,234	6,498
3,117	1	3,117	9,615
2,713	1	2,713	12,328
2,535	1	2,535	14,863
2,128	1	2,128	16,991
2,117	1	2,117	19,108
2,000	1	2,000	21,108
1,799	1	1,799	22,907
1,568	1	1,568	24,475
1,566	1	1,566	26,041
1,423	1	1,423	27,464
1,324	1	1,324	28,788
1,300	1	1,300	30,088
1,261	1	1,261	31,349
1,222	1	1,222	32,571
1,182	1	1,182	33,753
1,146	1	1,146	34,899
1,129	1	1,129	36,028
1,099	1	1,099	37,127
1,093	1	1,093	38,220
1,059	1	1,059	39,279
1,043	1	1,043	40,322
1,042	1	1,042	41,364
1,036	1	1,036	42,400
1,030	2	2,060	44,460
1,017	1	1,017	45,477
981	1	981	46,458
970	1	970	47,428
964	1	964	48,392
954	1	954	49,346
905	1	905	50,251
880	1	880	51,131
876	1	876	52,007
867	1	867	52,874
847	1	847	53,721
834	1	834	54,555
815	1	815	55,370

Number of articles	Total Number of journal	Total number of articles	Cumulative articles
780	1	780	56,150
771	1	771	56,921
769	1	769	57,690
767	1	767	58,457
758	1	758	59,215
752	1	752	59,967
727	1	727	60,694
718	1	718	61,412
715	1	715	62,127
706	1	706	62,833
695	1	695	63,528
670	1	670	64,198
658	1	658	64,856
655	1	655	65,511
650	1	650	66,161
645	1	645	66,806
629	1	629	67,435
624	1	624	68,059
622	1	622	68,681
621	1	621	69,302
600	1	600	69,902
585	1	585	70,487
573	1	573	71,060
566	1	566	71,626
553	1	553	72,179
551	1	551	72,730
541	1	541	73,271
533	2	1066	74,337
530	1	530	74,867
524	1	524	75,391
522	2	1044	76,435
519	1	519	76,954
517	1	517	77,471
495	1	495	77,966
482	2	964	78,930
480	1	480	79,410
465	2	930	80,340
463	1	463	80,803
454	1	454	81,257
453	1	453	81,710

Number of articles	Total Number of journal	Total number of articles	Cumulative articles
448	1	448	82,158
443	1	443	82,601
428	2	856	83,457
427	1	427	83,884
424	1	424	84,308
421	1	421	84,729
419	1	419	85,148
409	1	409	85,557
407	1	407	85,964
405	1	405	86,369
404	1	404	86,773
403	1	403	87,176
402	2	804	87,980
399	1	399	88,379
398	2	796	89,175
395	1	395	89,570
387	1	387	89,957
384	1	384	90,341
382	1	382	90,723
380	1	380	91,103
378	1	378	91,481
376	2	752	92,233
374	1	374	92,607
367	2	734	93,341
365	1	365	93,706
360	1	360	94,066
359	1	359	94,425
357	1	357	94,782
356	1	356	95,138
349	2	698	95,836
348	3	1044	96,880
346	1	346	97,226
342	2	684	97,910
340	1	340	98,250
338	1	338	98,588
337	1	337	98,925
335	1	335	99,260
334	1	334	99,594
331	1	331	99,925
328	1	328	1,00,253

Number of articles	Total Number of journal	Total number of articles	Cumulative articles
327	1	327	1,00,580
324	1	324	1,00,904
323	1	323	1,01,227
322	2	644	1,01,871
320	1	320	1,02,191
317	1	317	1,02,508
314	1	314	1,02,822
312	1	312	1,03,134
311	2	622	1,03,756
306	1	306	1,04,062
302	1	302	1,04,364
301	1	301	1,04,665
300	2	600	1,05,265
299	1	299	1,05,564
296	1	296	1,05,860
294	1	294	1,06,154
290	1	290	1,06,444
289	2	578	1,07,022
288	2	576	1,07,598
287	3	861	1,08,459
286	1	286	1,08,745
	160	108745	

Note: The journals which have at least 286 number of articles considered for the current study.

The distributions of journals and corresponding number of articles in three zones along with values of Bradford's multipliers are presented in Table 4.33:

Table 4.33: Bradford's zone wise distribution of journals of public health

Zone	Articles	%	Number of Journal	%	n
1	36028	33.13%	19	11.88%	--
2	36151	33.24%	45	28.13%	2.37
3	36566	33.63%	96	60.00%	2.13
	108745	100%	160	100%	2.25

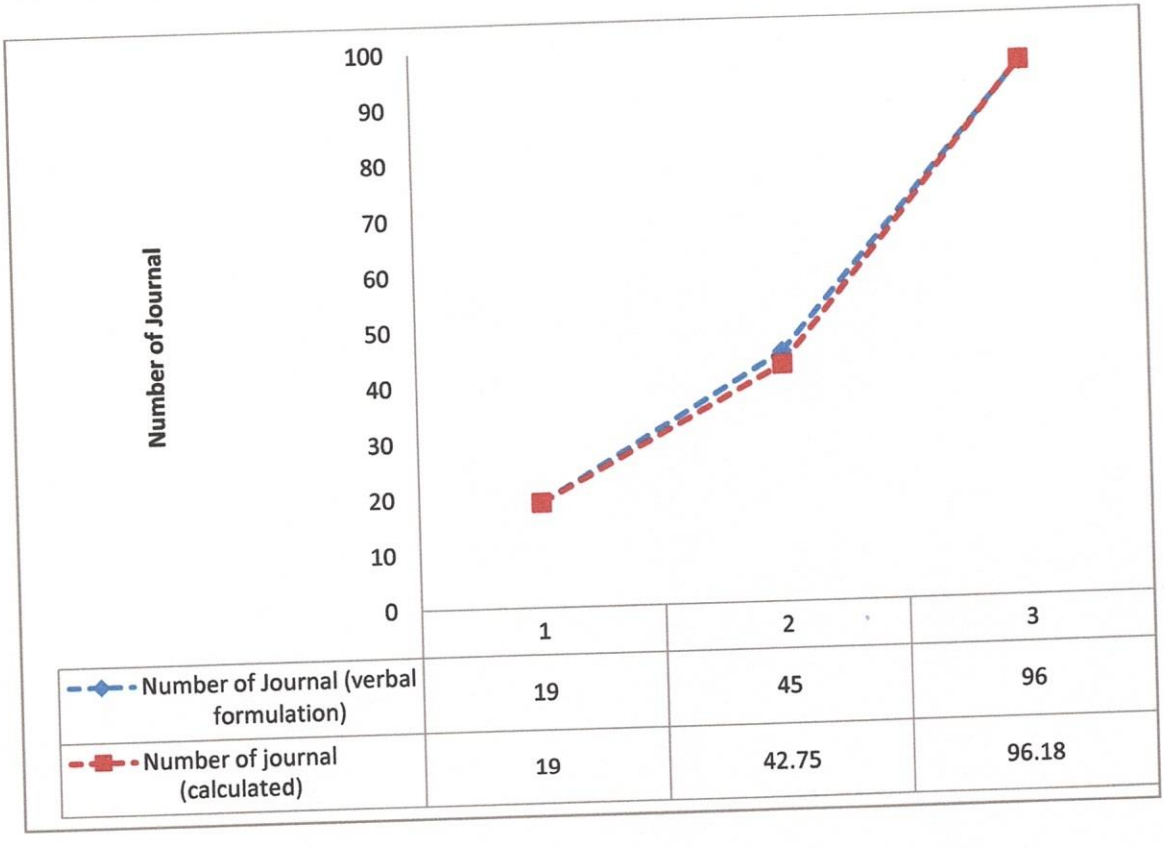
Table 4.33 reveals one third of total articles has been covered by each group of journals (108745/3= approximately 36248.33 articles in each zone). As a result, 19 journals covered 36,028 articles, and the next 45 journals covered 36,151 articles and last 96 journals covered 36,566 articles . Bradford's multiplier is the proportion of journal of any group to the number of journal of

preceding zone. The multiplier 'n' has been calculated as number of journal of a zone (45) divided by number of journal of preceding zone (19).

The number of journal in nucleus zone is 19 and the mean value of multiplier is 2.25. With this value Bradford's verbal formulation can be expressed as follows:

$$1: n: n^2 = 19: 19 \times 2.25: 19 \times 2.25^2 = 19: 42.75: 96.18$$

Figure 4.27: Zone wise journal distribution according to Bradford's law of scattering



	1	2	3
Number of Journal (verbal formulation)	19	45	96
Number of journal (calculated)	19	42.75	96.18

Calculation of percentage of errors: Sum of 19, 42.75, 96.18= 157.93 $= \frac{157.93-160}{160} \times 100 = 1.29\%$

Since, the percentage error is very nominal the data will fit well the Bradford's law. The three zones are exactly 1/3 of the total articles as proved by the Bradford. The difference of articles between any of two zones is below 0.5%. The Bradford's verbal calculation of number of journal of Zone-2 is 42.75 which is 2.25 less than actual number. Therefore, in the present study Bradford's law of scattering was found to be fit to data set.

4.4.7.3 Zipf's law of word occurrence

Zipf's law of word occurrence shows relationship between frequency of words and their ranks through the following relationship:

$$rf=c \qquad \textbf{[Eq. 16]}$$

Where, f = frequency of a word

r= rank of a word based upon frequency

c= constant depend on subject

If words are arranged in their decreasing order of frequency, then the rank of any given word of the text will be inversely proportional to the frequency of occurrence of the word (Wyllys, 1981).

4.4.7.3.1 Application of Zipf's law on keywords of PH literature

The law is probably most familiar in the graphic representation of a mathematically equivalent form (Rajneesh & Rana, 2015). If we apply f * r value then it comes not to constant as what Zipf suggested and if we multiply the value of f with the value of r the curve shows a hyperbolic curve. Vickery and brooks converted this hyperbolic curve into straight line graph. They suggested converting the value of f and r into log f and logging r. As the relation between r and f is inversely proportional (r a 1/f)

Then r*f= a constant >>> Log r = a constant - log f >>> log r + log f = a constant

For applying Zipf's law on keywords of public health literature a total of 164 keywords occurred 32, 41,857 times. The keywords has been selected which occurred >6768 times. The values of logr, logf and log c have been calculated and presented in Table 4.34 together with frequency of keywords and their ranks.

Table 4.34: Highly used keywords on public health

Keywords	Frequency (f)	Rank (r)	Log of f	Log of r	C (log f+ log r)
Human	2,57,256	1	12.46	0.00	12.46
Humans	2,33,479	2	12.36	0.69	13.05
Article	1,92,641	3	12.17	1.10	13.27
Public Health	1,07,418	4	11.58	1.39	12.97
Female	1,04,434	5	11.56	1.61	13.17
Male	89,739	6	11.40	1.79	13.19
Adult	76,464	7	11.24	1.95	13.19
Priority Journal	74,043	8	11.21	2.08	13.29
United States	67,069	9	11.11	2.20	13.31
Review	47,398	10	10.77	2.30	13.07
Middle Aged	45,771	11	10.73	2.40	13.13
Adolescent	41,927	12	10.64	2.48	13.12
Controlled Study	40,538	13	10.61	2.56	13.17
Aged	37,899	14	10.54	2.64	13.18
Organization And Management	36,660	15	10.51	2.71	13.22
Major Clinical Study	36,600	15	10.51	2.71	13.22
Public Health Service	35,538	16	10.48	2.77	13.25
Health Care Policy	34,184	17	10.44	2.83	13.27
Child	33,232	18	10.41	2.89	13.30
Prevalence	26,224	19	10.17	2.94	13.11
Risk Factor	25,953	20	10.16	3.00	13.16
Risk Assessment	24,042	21	10.09	3.04	13.13
Health Survey	23,500	22	10.06	3.09	13.15
Nonhuman	23,336	23	10.06	3.14	13.20
Methodology	23,323	24	10.06	3.18	13.24
Risk Factors	22,620	25	10.03	3.22	13.25
Health Care Quality	21,915	26	9.99	3.26	13.25
Questionnaire	21,872	27	9.99	3.30	13.29
United Kingdom	21,375	28	9.97	3.33	13.30
Animals	20,664	29	9.94	3.37	13.31
Young Adult	20,504	30	9.93	3.40	13.33
Health Care Delivery	20,495	31	9.93	3.43	13.36
Health Promotion	20,305	32	9.92	3.47	13.39
Economics	19,987	33	9.90	3.50	13.40
Public Relations	19,800	34	9.89	3.53	13.42
Statistics	18,755	35	9.84	3.56	13.4
Questionnaires	18,168	36	9.81	3.58	13.39
Mortality	17,673	37	9.78	3.61	13.39

Keywords	Frequency (f)	Rank (r)	Log of f	Log of r	C (log f+ log r)
Health Service	17,243	38	9.76	3.64	13.4
Education	17,024	39	9.74	3.66	13.4
Standard	17,014	40	9.74	3.69	13.43
Health Program	17,002	41	9.74	3.71	13.45
Psychological Aspect	16,990	42	9.74	3.74	13.48
Government	16,851	43	9.73	3.76	13.49
Note	16,313	44	9.70	3.78	13.48
Health Policy	16,082	45	9.69	3.81	13.4
Editorial	15,771	46	9.67	3.83	13.4
Health Care Cost	15,512	47	9.65	3.85	13.50
Cross-Sectional Studies	15,481	48	9.65	3.87	13.52
Practice Guideline	15,411	49	9.64	3.89	13.53
Child, Preschool	14,982	50	9.61	3.91	13.52
Epidemiology	14,869	51	9.61	3.93	13.54
Attitude To Health	14,609	52	9.59	3.95	13.54
Infant	14,552	53	9.59	3.97	13.56
Legal Aspect	14,411	54	9.58	3.99	13.57
Health	13,974	55	9.54	4.01	13.55
Cross-sectional Study	13,820	56	9.53	4.03	13.56
Socioeconomics	13,774	57	9.53	4.04	13.57
Health Care	13,707	58	9.53	4.06	13.59
Health Education	13,540	59	9.51	4.08	13.59
National Health Programs	13,480	60	9.51	4.09	13.60
Health Care Planning	13,346	61	9.50	4.11	13.61
Incidence	13,087	62	9.48	4.13	13.61
Obesity	13,013	63	9.47	4.14	13.61
Medical Research	12,992	64	9.47	4.16	13.63
Great Britain	12,835	65	9.46	4.17	13.63
Socioeconomic Factors	12,732	66	9.45	4.19	13.64
Patient Care	12,695	67	9.45	4.20	13.65
Health Care Personnel	12,650	68	9.45	4.22	13.67
Human Immunodeficiency Virus	12,412	69	9.43	4.23	13.66
Health Care Organization	11,894	70	9.38	4.25	13.63
Health Care System	11,852	71	9.38	4.26	13.64
Pregnancy	11,783	72	9.37	4.28	13.65
Public Hospital	11,572	73	9.36	4.29	13.65
Preschool Child	11,556	74	9.35	4.30	13.65
Smoking	11,527	75	9.35	4.32	13.67
Inter professional Relations	11,501	76	9.35	4.33	13.68
Aged, 80 And Over	11,225	77	9.33	4.34	13.67

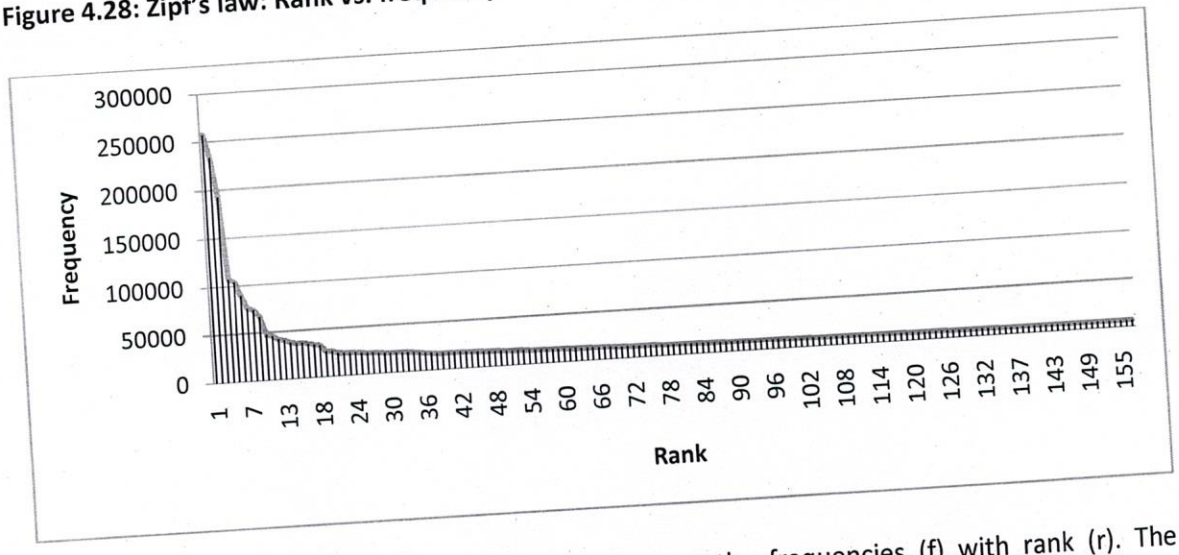
Keywords	Frequency (f)	Rank (r)	Log of f	Log of r	C (log f+ log r)
Health Knowledge, Attitudes, Practice	11,091	78	9.31	4.36	13.67
Decision Making	11,070	79	9.31	4.37	13.68
Health Status	10,887	80	9.30	4.38	13.68
Canada	10,871	81	9.29	4.39	13.68
Epidemic	10,846	82	9.29	4.41	13.70
Policy	10,719	83	9.28	4.42	13.70
Financial Management	10,531	84	9.26	4.43	13.69
Australia	10,476	85	9.26	4.44	13.70
Public Policy	10,376	86	9.25	4.45	13.70
Comparative Study	10,333	87	9.24	4.47	13.71
Health Services Accessibility	10,207	88	9.23	4.48	13.71
Animal	10,179	89	9.23	4.49	13.72
Clinical Trial	10,148	90	9.23	4.50	13.73
Demography	10,125	91	9.22	4.51	13.73
Attitude Of Health Personnel	9,991	92	9.21	4.52	13.73
World Health Organization	9,650	93	9.17	4.53	13.70
Information Processing	9,620	94	9.17	4.54	13.71
Sex Difference	9,596	95	9.17	4.55	13.72
Interview	9,543	96	9.16	4.56	13.72
Health Insurance	9,521	97	9.16	4.57	13.73
Treatment Outcome	9,517	98	9.16	4.58	13.75
Medical Education	9,312	99	9.14	4.60	13.74
Infant, Newborn	9,090	100	9.11	4.61	13.72
Infection Control	8,963	101	9.10	4.62	13.72
Letter	8,904	102	9.09	4.62	13.71
Follow Up	8,900	103	9.09	4.63	13.72
HIV Infections	8,853	104	9.09	4.64	13.73
Conference Paper	8,812	105	9.08	4.65	13.73
Organization	8,788	106	9.08	4.66	13.74
Health Personnel Attitude	8,739	107	9.08	4.67	13.75
Health Care Access	8,735	108	9.08	4.68	13.76
Health Behavior	8,702	109	9.07	4.69	13.76
Europe	8,672	110	9.07	4.70	13.77
Delivery Of Health Care	8,622	111	9.06	4.71	13.77
Outcome Assessment	8,573	112	9.06	4.72	13.78
Quality Of Life	8,496	113	9.05	4.73	13.78
Age	8252	114	9.02	4.74	13.76
Politics	8,201	115	9.01	4.74	13.75

Keywords	Frequency (f)	Rank (r)	Log of f	Log of r	C (log f+ log r)
Environmental Exposure	8,148	116	9.01	4.75	13.76
National Health Service	8,111	117	9.00	4.76	13.76
Age Distribution	8,092	118	9.00	4.77	13.77
Disease Transmission	8,064	119	9.00	4.78	13.78
Ethics	7,894	120	8.97	4.79	13.76
Clinical Practice	7,847	121	8.97	4.80	13.77
Primary Health Care	7,837	122	8.97	4.80	13.77
Community Care	7,801	123	8.96	4.81	13.77
Vaccination	7,666	124	8.94	4.82	13.76
Statistics And Numerical Data	7,646	125	8.94	4.83	13.77
Program Evaluation	7,619	126	8.94	4.84	13.80
Public Opinion	7,560	127	8.93	4.84	13.77
Physician	7,509	128	8.92	4.85	13.77
Brazil	7,492	129	8.92	4.86	13.78
Morbidity	7,456	130	8.92	4.87	13.79
Interpersonal Communication	7,447	131	8.92	4.88	13.80
Health Hazard	7,434	132	8.91	4.88	13.79
Procedures	7,365	133	8.90	4.89	13.79
Time Factors	7,362	134	8.90	4.90	13.80
Disease Outbreaks	7,280	135	8.89	4.91	13.80
Germany	7,240	136	8.89	4.91	13.80
Mental Health	7,195	137	8.88	4.92	13.80
Population Surveillance	7,195	137	8.88	4.92	13.80
History	7,189	138	8.88	4.93	13.81
Retrospective Studies	7,155	139	8.88	4.93	13.81
Poverty	7,141	140	8.87	4.94	13.81
International Cooperation	7,102	141	8.87	4.95	13.82
Cooperative Behavior	7,055	142	8.86	4.96	13.82
Cooperation	6,979	143	8.85	4.96	13.81
Age Factors	6,966	144	8.85	4.97	13.82
Internet	6,942	145	8.85	4.98	13.83
Diabetes Mellitus	6,929	146	8.84	4.98	13.82
Cohort Analysis	6,917	147	8.84	4.99	13.83
Retrospective Study	6,915	148	8.84	5.00	13.84
Health Services Research	6,908	149	8.84	5.00	13.84
Disease Association	6,898	150	8.84	5.01	13.85
Hospitalization	6,858	151	8.83	5.02	13.85
Cardiovascular Disease	6,838	152	8.83	5.02	13.85
Hospitals, Public	6,816	153	8.83	5.03	13.86

Keywords	Frequency (f)	Rank (r)	Log of f	Log of r	C (log f+ log r)
Short Survey	6,813	154	8.83	5.04	13.87
Safety	6,810	155	8.83	5.04	13.87
Developing Country	6,801	156	8.82	5.05	13.87
Developing Countries	6,769	157	8.82	5.06	13.88

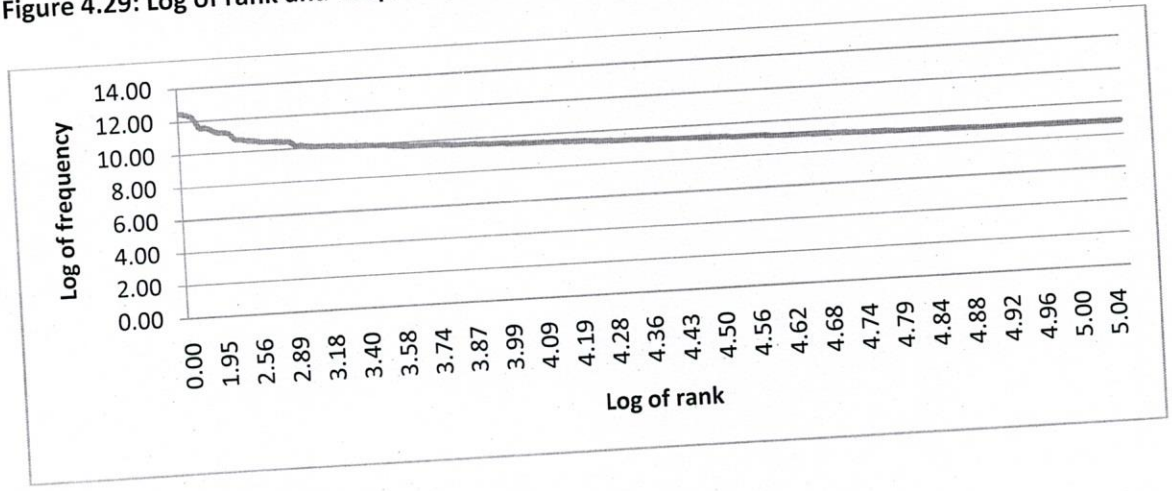
Table 4.34 demonstrates the word "Human" had the highest frequencies of 2,57,256 times which is 1st in ranking on public health literature during period 2000-2015. The other top most occurrence keywords are Humans (2,33,479), Article (1,92,641), Public Health (1,07,418) etc. On the basis of these values, the following graphs have been plotted to display the Zipf's Law.

Figure 4.28: Zipf's law: Rank vs. frequency



A hyperbolic curve has been observed if we compare the frequencies (f) with rank (r). The relationship between frequency and rank is proportionally inverse.

Figure 4.29: Log of rank and frequency chart on keywords



During the entire data set the log values of rank and frequency looked like approximately constant. It has been observed that Zipf's Law approximates the relationship between rank 'r' and frequency 'f' for the public health.

4.5 Extent of research on public health in Bangladesh

The literatures on public health were published by a number of different authors from various countries. The Bangladeshi authors also played important role in publishing articles on public health. To extract public health literature by Bangladeshi authors from Scopus database the following search strategy has been used: *(TITLE-ABS-KEY (Public health) AND PUBYEAR > 1999 AND PUBYEAR < 2016 AND (LIMIT-TO (AFFILCOUNTRY, "Bangladesh")*

4.5.1 Growth of public health literature by Bangladeshi authors

The search was carried out due to separate literature of Bangladeshi authors from the literature of other countries. The year wise result of Bangladeshi literature during the period from 2000 to 2015 has been shown in Table 4.35.

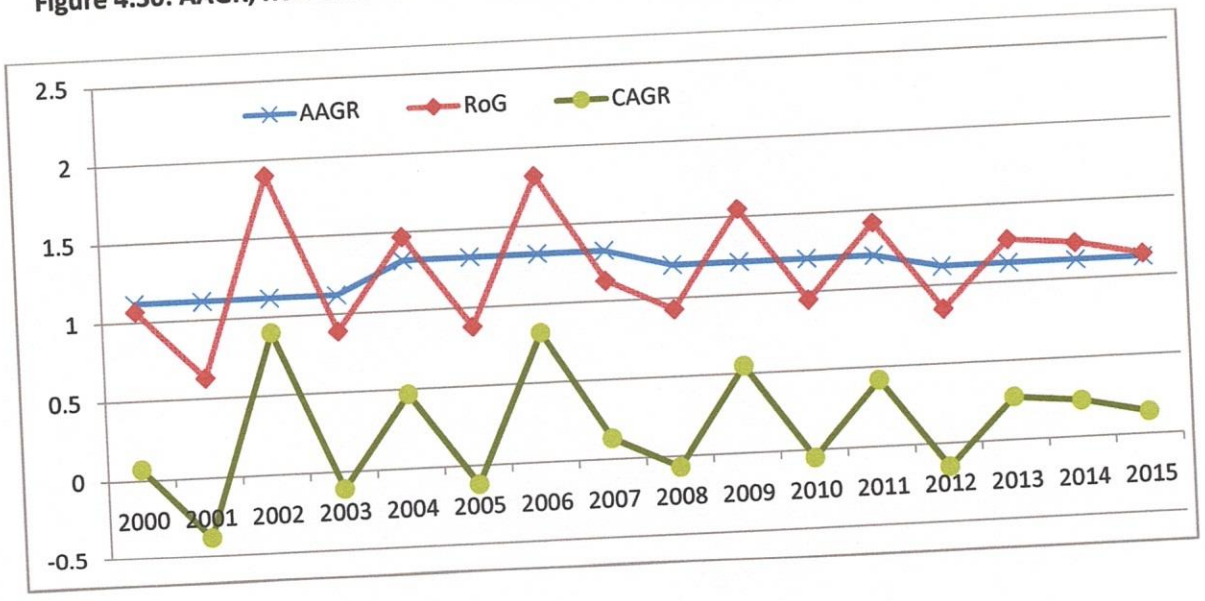
Table 4.35: Growth of literature by Bangladeshi authors

Four Yr. Block	Year	Records	Percentage	Difference between years	Growth ratio	AAGR	RoG	CAGR
2000-2003	2000	16	1.84	1	1 : 1.07	1.12	1.07	0.07
	2001	10	1.15	-6	1 : 0.63		0.63	-0.38
	2002	19	2.18	9	1 : 1.90		1.9	0.90
	2003	17	1.95	-2	1 : 0.89		0.89	-0.11
2004-2007	2004	25	2.87	8	1 : 1.47	1.32	1.47	0.47
	2005	22	2.53	-3	1 : 0.88		0.88	-0.12
	2006	40	4.59	18	1 : 1.82		1.82	0.82
	2007	45	5.17	5	1 : 1.13		1.13	0.13
2008-2011	2008	42	4.82	-3	1 : 0.93	1.21	0.93	-0.07
	2009	65	7.46	23	1 : 1.55		1.55	0.55
	2010	62	7.12	-3	1 : 0.95		0.95	-0.05
	2011	88	10.10	26	1 : 1.42		1.42	0.42
2012-2015	2012	75	8.61	-13	1 : 0.85	1.12	0.85	-0.15
	2013	95	10.91	20	1 : 1.27		1.27	0.27
	2014	117	13.43	22	1 : 1.23		1.23	0.23
	2015	133	15.27	16	1 : 1.14		1.14	0.14
Total		871	Average	7.375	1 : 1.2	1.2	1.20	0.20

Note: There were 15 publications of Bangladeshi authors in 1999 (Source: Scopus). Cells in highlighted font show highest and lowest values.

A total of 871 publications have been published by Bangladeshi authors during the period of 2000-2015. Highest growth in terms of number of publication has been observed in the year of 2015 (133, 15.27%) and the lowest in 2001 (10, 1.15%). The average increasing rate of publications between two years is above 7. The AGR varies from 0.63 to 1.90. The highest AAGR has been observed in block period 2004-2007 and the lowest in 2000-2003 and 2012-2015. The RoG (Rate of Growth) shows that 2001 was the deep decreasing year whereas the following year was the most increasing year during the study period of 2000-2015. The Compound Annual Growth Rate (CAGR) varies from -0.05 to 0.90 with an average of 0.20 during the study period. A comparative view among AAGR, RoG and CAGR on the growth of literature by Bangladeshi authors has been graphed in Figure 4.30 below.

Figure 4.30: AAGR, RoG and CAGR of PH literature by Bangladeshi authors



4.5.1.1 RGR and Dt(a) of Bangladeshi contributions

The growth of PH literature by Bangladeshi contributions can be analyzed on the basis of Relative Growth Rate (RGR) and Doubling time (Dt). RGR in terms of literature means growth in number of literature (article/pages) per unit of time.

Doubling time (Dt) is the amount of time it takes for a given quantity to double in size if relative growth rate remains constant. Doubling time can be calculated directly from RGR and the larger the RGR, the faster the doubling time (Boucher, 2017).

Table 4.36: RGR and Dt(a) of Bangladeshi contributions

Year	Records	Cum	W_1	W_2	RGR	Dt(a)
2000	16			2.77		
2001	10	26	2.77	3.26	0.49	1.41
2002	19	45	3.26	3.81	0.55	1.26
2003	17	62	3.81	4.13	0.32	2.17
2004	25	87	4.13	4.47	0.34	2.04
2005	22	109	4.47	4.69	0.22	3.15
2006	40	149	4.69	5.00	0.31	2.24
2007	45	194	5.00	5.27	0.27	2.57
2008	42	236	5.27	5.46	0.19	3.65
2009	65	301	5.46	5.71	0.25	2.77
2010	62	363	5.71	5.89	0.18	3.85
2011	88	451	5.89	6.11	0.22	3.15
2012	75	526	6.11	6.27	0.16	4.33
2013	95	621	6.27	6.43	0.16	4.33
2014	117	738	6.43	6.60	0.17	4.08
2015	133	871	6.60	6.77	0.17	4.08
Total	871	Average RGR & Dt(a)=			0.27	3.00

Table 4.36 represents a chronological distribution of RGR and Dt(a). During the period 2001-2015, RGR values of Bangladeshi contributions on PH literature varies from 0.16 to 0.55 with an average RGR value of 0.27. Dt(a) values, on the other hand, also varies from 1.26 to 4.33 with an average Dt(a) values of 3.00. That means the literature of public health by Bangladeshi authors with 0.27 growth rate would have a doubling time of 3 years.

Figure 4.31: RGR of Bangladeshi contributions

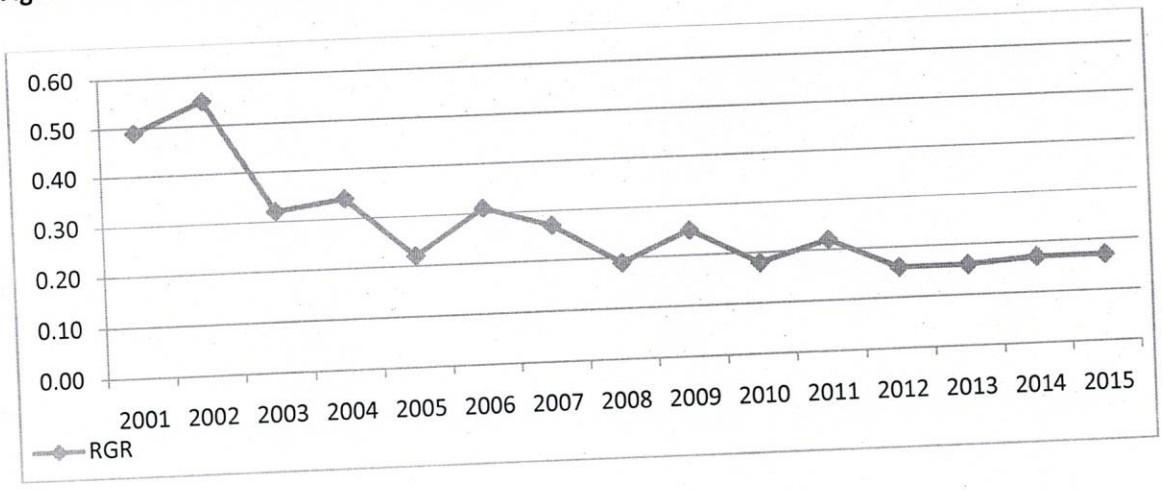
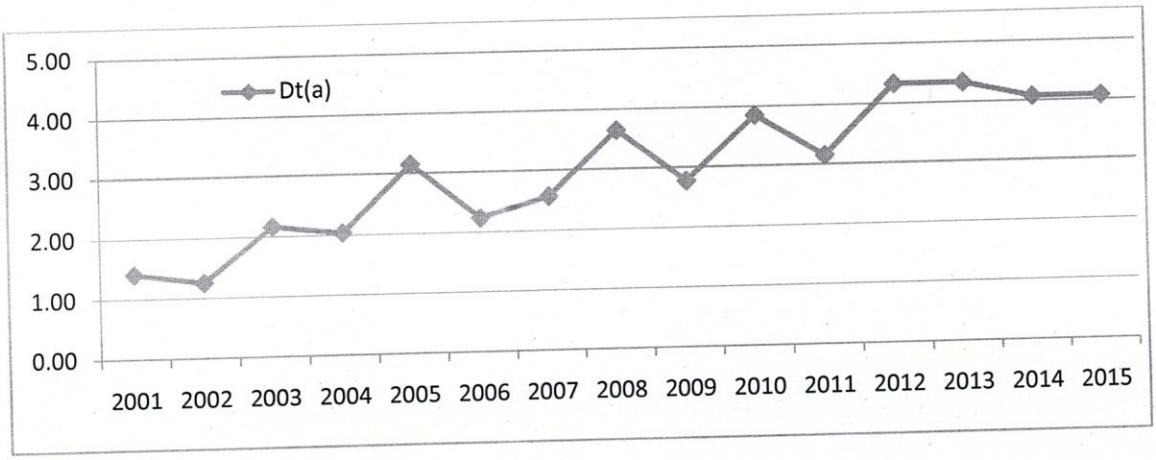


Figure 4.31 shows a downwards trends of RGR for Bangladeshi contributions. The year 2002 was the peak year of the period under survey if we consider the RGR values of Bangladeshi authors whereas the years 2012 and 2013 had the lowest RGR values. Figure 4.32 shows upward trends with some fluctuation at some points for Dt(a) values of Bangladeshi contributors on public health. 2002 has the lowest doubling time values whereas 2012 and 2013 have the highest Dt(a) value for the public health literature published by Bangladeshi authors.

Figure 4.32: Dt(a) of Bangladeshi contributions



4.5.2 Measures for pattern, collaboration and productivity of Bangladeshi contributions

To assess the research contributions on any subject field it is necessary to examine authorship pattern and productivity. Thus assessment of authorship pattern and research productivity is important aspects of scientometric studies. Therefore, productivity, pattern and collaboration by Bangladeshi authors have also been examined here.

4.5.2.1 Authorship pattern by Bangladeshi contributors

The distribution of the literature based on Bangladeshi contributors has been displayed in Table 4.37 below.

Table 4.37: Authorship pattern of Bangladeshi contributors on PH

Authorship Pattern	Quantum of Contributions	%
Single author	68	7.81%
Two authors	96	11.02%
Three authors	112	12.86%
More than three authors	595	68.31%
Total	871	100%

Figure 4.33: Authorship pattern of Bangladeshi contributors

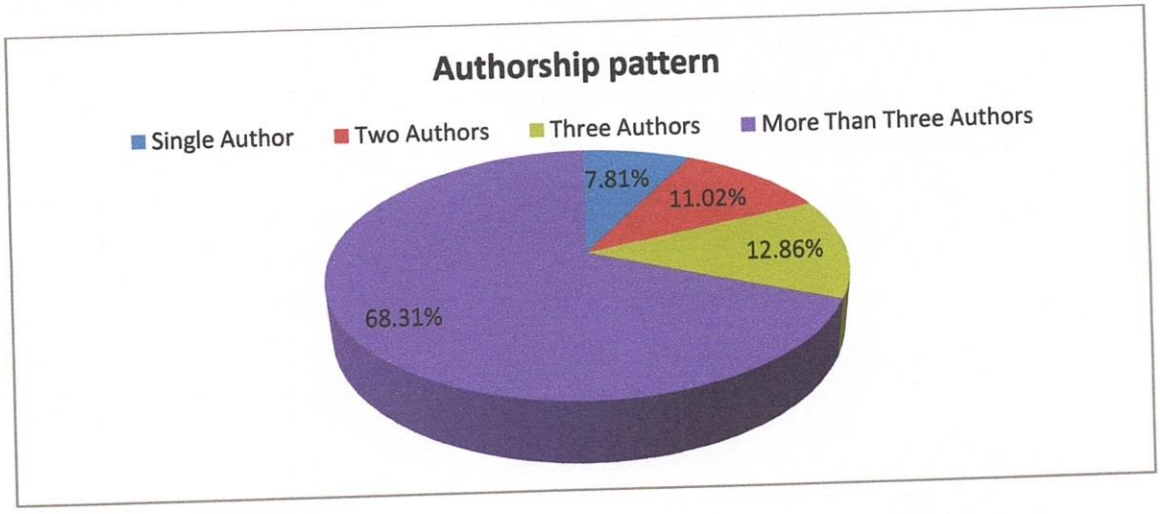


Table 4.38 and Figure 4.34 shows year wise authorship pattern of Bangladeshi authors on public health literature.

Table 4.38: Year wise authorship pattern of Bangladeshi authors on public health literature

Year	Single Authors	Two Authors	Three Authors	Three + Authors	Total
2000	5	2	3	6	16
2001	1	0	3	6	10
2002	4	1	1	13	19
2003	5	3	3	6	17
2004	4	4	3	14	25
2005	5	3	1	13	22
2006	3	2	4	31	40
2007	4	9	3	29	45
2008	4	9	4	25	42
2009	8	6	10	41	65
2010	2	7	6	47	62
2011	6	10	11	61	88
2012	4	4	11	56	75
2013	2	11	16	66	95
2014	7	14	15	81	117
2015	4	11	18	100	133
Total	68	96	112	595	871

Figure 4.34: Year wise authorship pattern of Bangladeshi contributors

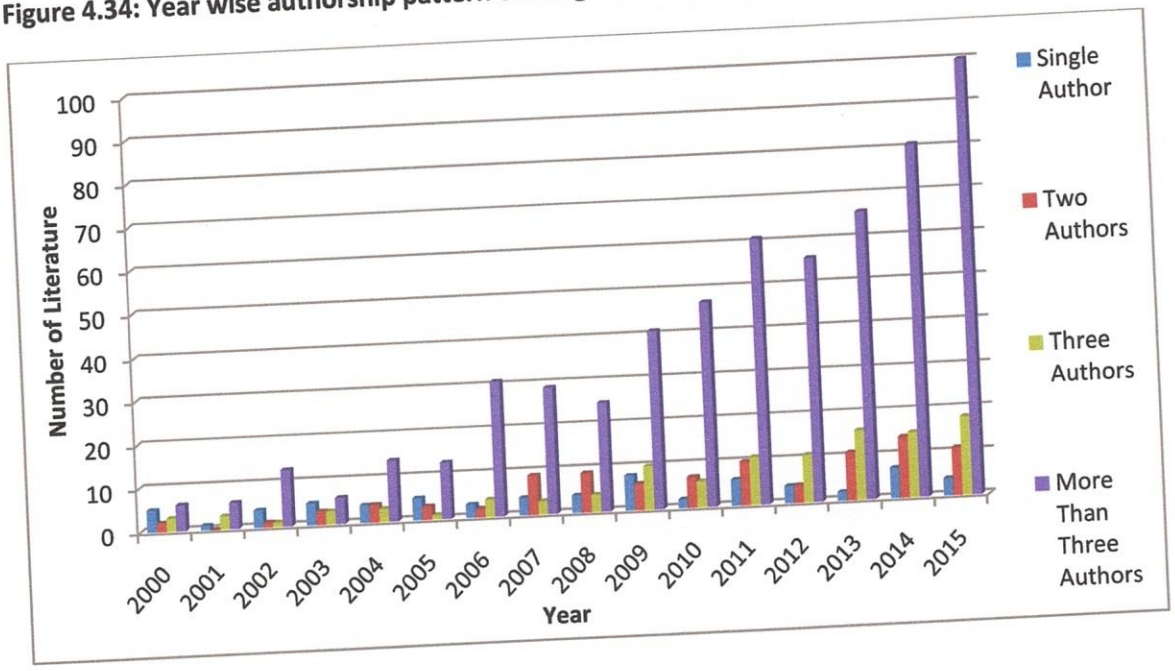
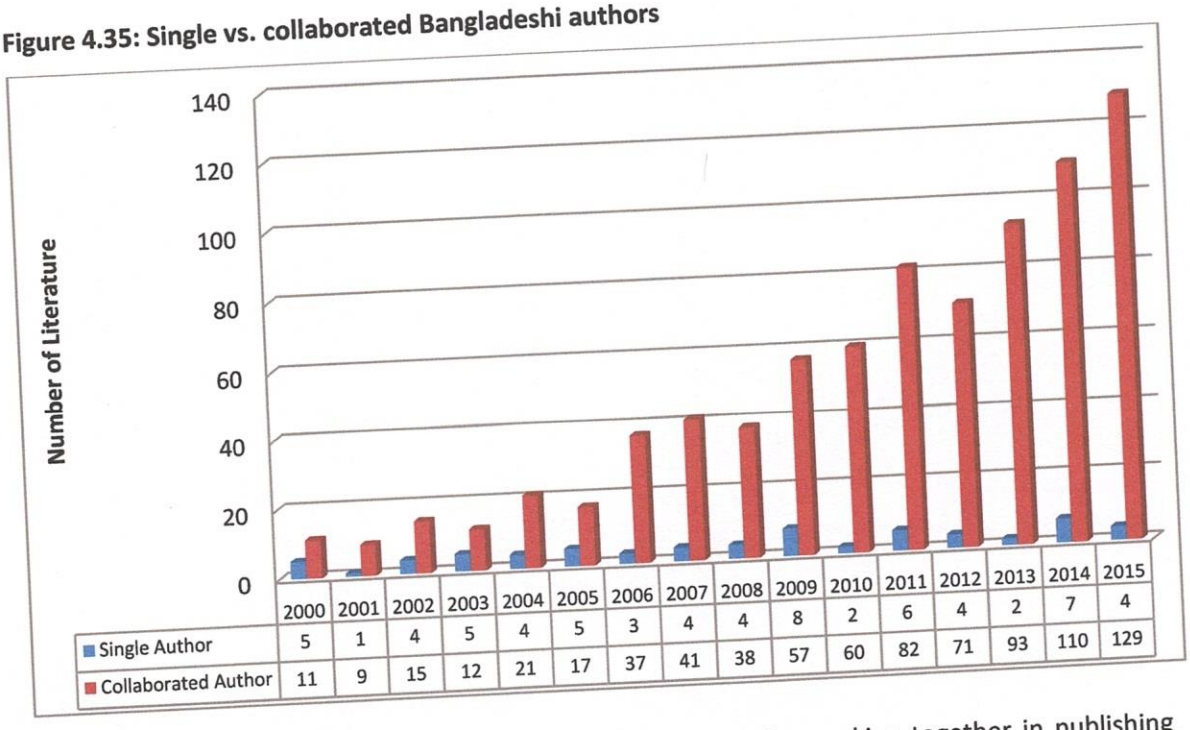


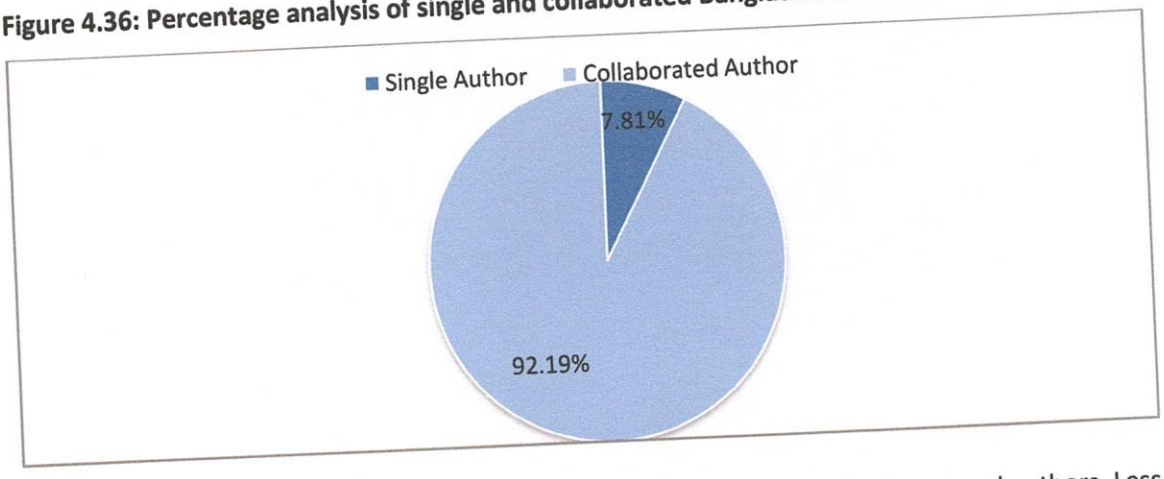
Figure 4.35: Single vs. collaborated Bangladeshi authors



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Single Author	5	1	4	5	4	5	3	4	4	8	2	6	4	2	7	4
Collaborated Author	11	9	15	12	21	17	37	41	38	57	60	82	71	93	110	129

It is evident from Figure 4.35 researchers of Bangladesh prefer working together in publishing public health literature. An increasing trend has been observed in the case of multi authored papers. In 2000 there were only 11 multi-authored papers which increased dramatically in the following years and by 2015 the figure turned 129.

Figure 4.36: Percentage analysis of single and collaborated Bangladeshi authors



It is clear from Figure 4.36 that more than 92% of total contributors are collaborated authors. Less than 8% literature have single authored. That means Bangladeshi authors prefer collaborated works in publishing research papers on public health.

4.5.2.2 Collaborated works by Bangladeshi authors

Collaborated works means working together to conduct research by a number of researchers and to bring out their team work as research publication. Various indices have been used throughout the world to calculate degree of collaboration as for example Collaborative Index (CI) by Lawani (1980), Degree of Collaboration (DC) by Subramanyam (1983), Collaborative Coefficient (CC) by Ajiferuke, Burell & Tague (1988), Revised Collaborative Coefficient (RCC) by Eagghe (1990)or Modified Collaborative Coefficient (MCC) by Savanur & Srikanth (2010) etc.

4.5.2.2.1 Collaborative Index (CI) of Bangladeshi contributors

To measure mean number of authors per paper Lawani devised collaborative Index (CI). To calculate CI value for Bangladeshi authors, the entire data was classified into total authors of single authored papers, total authors of two authored papers, total authors of three authored papers and total authors of more than three authored papers. The year wise distribution of public health literature by Bangladeshi contributors together with the value of Collaborative Index is shown in Table 4.39 and Figure 4.37.

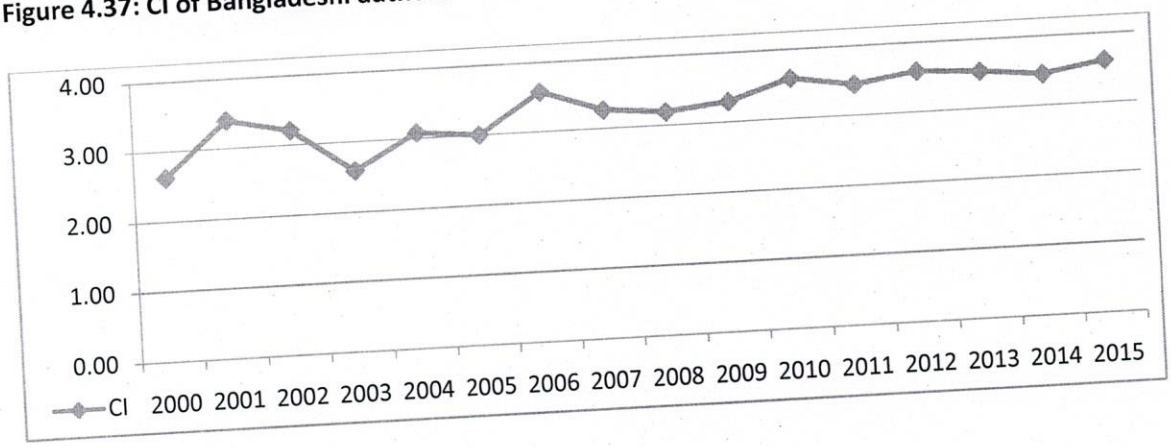
Table 4.39: Collaborative Index (CI) of Bangladeshi authors

Year	1	2	3	3+	TA	TP	CI
2000	5	4	9	24	42	16	2.63
2001	1	0	9	24	34	10	3.40
2002	4	2	3	52	61	19	3.21
2003	5	6	9	24	44	17	**2.59**
2004	4	8	9	56	77	25	3.08
2005	5	6	3	52	66	22	3.00
2006	3	4	12	124	143	40	3.58
2007	4	18	9	116	147	45	3.27
2008	4	18	12	100	134	42	3.19
2009	8	12	30	164	214	65	3.29
2010	2	14	18	188	222	62	3.58
2011	6	20	33	244	303	88	3.44
2012	4	8	33	224	269	75	3.59
2013	2	22	48	264	336	95	3.54
2014	7	28	45	324	404	117	3.45
2015	4	22	54	400	480	133	**3.61**
Total	68	192	336	2,380	2,976	871	3.28

Note: 1= total authors as single authored papers; 2= total authors as two authored papers; 3= total authors as three authored papers; 3+= total authors as four authored papers TA=Total Authors; TP=Total Publication. Cells in highlighted font show highest and lowest values.

It is evident that the CI for all the years were more than 2.5 that means there are 2.5 Bangladeshi authors per paper although the average CI value was 3.28. Under the period 2000-2015 CI ranges from 2.59 to 3.61 which imply Bangladeshi researchers have positive awareness towards collaborated works.

Figure 4.37: CI of Bangladeshi authors



A fluctuation trend of CI value has been observed under period 2000-2015. The year 2015 has the highest CI value whereas 2003 has the lowest CI value.

4.5.2.2.2 Degree of Collaboration (DC) of Bangladeshi contributors

The Degree of Collaboration (DC) indicates the proportion of multi-authored papers. The value of DC always remains ranges from 0.01 to 0.99. The higher DC value means maximum collaboration. The extent of DC has been calculated and presented year wise in Table 4.40 and Figure 4.38.

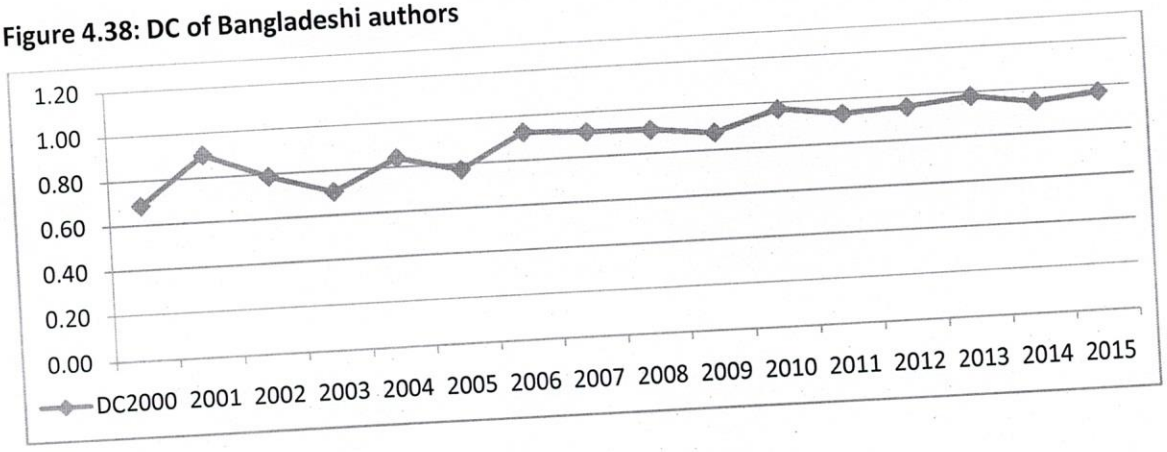
Table 4.40: Degree of Collaboration (DC) of Bangladeshi authors

Year	Literature of Single Author (SA)	Total Literature (TL)	SA/TL	DC
2000	5	16	0.31	**0.69**
2001	1	10	0.10	0.90
2002	4	19	0.21	0.79
2003	5	17	0.29	0.71
2004	4	25	0.16	0.84
2005	5	22	0.23	0.77
2006	3	40	0.08	0.93
2007	4	45	0.09	0.91
2008	4	42	0.10	0.90
2009	8	65	0.12	0.88
2010	2	62	0.03	0.97
2011	6	88	0.07	0.93
2012	4	75	0.05	0.95
2013	2	95	0.02	**0.98**
2014	7	117	0.06	0.94
2015	4	133	0.03	0.97
Total	68	871	Average	0.88

Note: Cells in highlighted font shows highest and lowest values.

The year-wise DC lies between 0.69 and 0.98, which indicates a high degree of author collaboration among Bangladeshi authors during the period 2000-2015. The average DC value is 0.88 which indicates that the proportion of multi authored paper is greater than single authored paper.

Figure 4.38: DC of Bangladeshi authors



4.5.2.2.3 Collaborative Coefficient (CC) of Bangladeshi contributors

The value CC devised by Ajiferuke and his team always lies between '0' means single authorship and '1' means multi authorship. Therefore the value of CC, which is greater than 0.5, means better probability of collaboration and lesser than half indicates that the authors doesn't enjoy multiple authorship pattern.

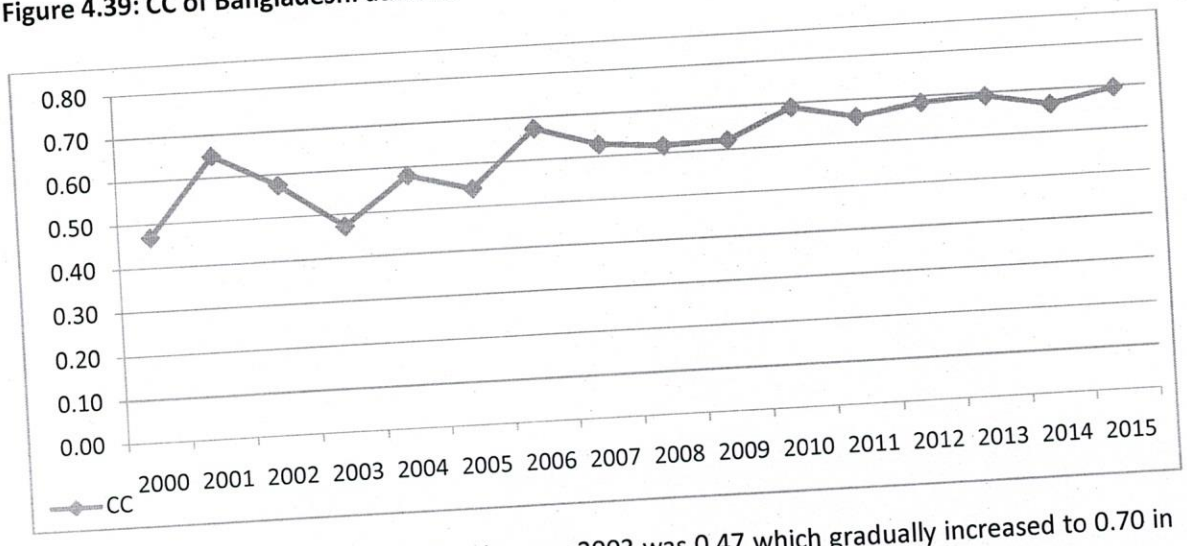
Table 4.41: Collaborative Coefficient (CC) of Bangladeshi authors

Year	1	2	3	3+	Total	CC
2000	5	1	1.00	1.5	16	**0.47**
2001	1	0	1.00	1.5	10	0.65
2002	4	0.5	0.33	3.25	19	0.57
2003	5	1.5	1.00	1.5	17	**0.47**
2004	4	2	1.00	3.5	25	0.58
2005	5	1.5	0.33	3.25	22	0.54
2006	3	1	1.33	7.75	40	0.67
2007	4	4.5	1.00	7.25	45	0.63
2008	4	4.5	1.33	6.25	42	0.62
2009	8	3	3.33	10.25	65	0.62
2010	2	3.5	2.00	11.75	62	0.69
2011	6	5	3.67	15.25	88	0.66
2012	4	2	3.67	14	75	0.68
2013	2	5.5	5.33	16.5	95	0.69
2014	7	7	5.00	20.25	117	0.66
2015	4	5.5	6.00	25	133	**0.70**
Total					871	0.62

Note: 1= credit point is shared by single authored papers; 2= credit point is shared by two authored papers; 3= credit point is shared by three authored papers; 3+= credit point is shared by four authored papers. Cells in highlighted font show highest and lowest values.

The value of CC represents highly collaboration among Bangladeshi authors of public health during the period of 2000-2015. The highest CC has been observed in 2015 (0.70) and the lowest one is 0.47 in 2000 and 2003. The CC for public health authors lies between 0.47 and 0.70 with an average of 0.62 which means there is significant magnitude of collaboration among the authors during the study period.

Figure 4.39: CC of Bangladeshi authors



The Collaborative Coefficient (CC) for the year 2003 was 0.47 which gradually increased to 0.70 in 2015. The mean value of CC is 0.62 which indicates the significant collaboration among Bangladeshi authors.

4.5.2.2.4 Revised Collaborative Coefficient (RCC) of Bangladeshi contributors

A normalized version of CC is called Revised Collaborative Coefficient (RCC) which is devised by Egghe. Later on Savanur and Srikanth also made same modification of CC rename as Modified Collaborative Coefficient (MCC), which was actually similar to what was devised by Egghe.

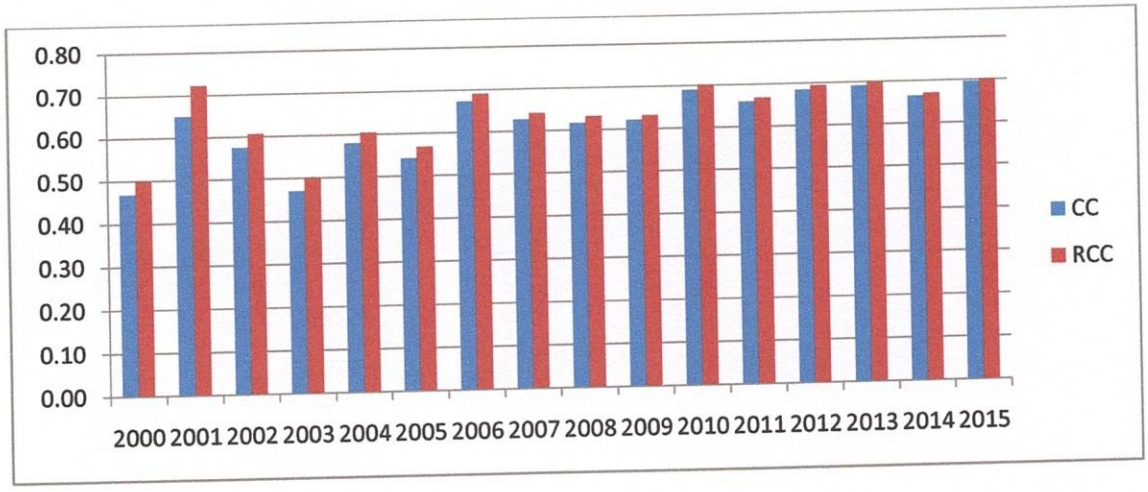
Table 4.42: Revised Collaborative Coefficient (RCC) of Bangladeshi authors

Year	CC	$\frac{N}{N-1}$	RCC
2000	0.47	1.07	0.50
2001	0.65	1.11	0.72
2002	0.57	1.06	0.61
2003	0.47	1.06	0.50
2004	0.58	1.04	0.60
2005	0.54	1.05	0.57
2006	0.67	1.03	0.69
2007	0.63	1.02	0.64
2008	0.62	1.02	0.63
2009	0.62	1.02	0.63
2010	0.69	1.02	0.70
2011	0.66	1.01	0.67
2012	0.68	1.01	0.69
2013	0.69	1.01	0.70
2014	0.66	1.01	0.67
2015	0.70	1.01	0.70

Note: Cells in highlighted font shows highest and lowest values.

Some differences have been observed between the values of CC and RCC in Table 4.42. It is clear that greater the amount of literature, the smaller the differences between the values of CC and RCC. In Figure 4.40 some variations of CC and RCC has been noticed in some years as the year wise total literature by Bangladeshi authors is relatively small compared to year wise amount of world's total PH literature.

Figure 4.40: Comparative view of CC and RCC values



4.5.2.3 Productivity by Bangladeshi authors

4.5.2.3.1 AAPP and PPA of Bangladeshi authors

Yoshikane et al. (2009) and Mamdapur et al. (2014) have devised Average Author Per Paper (AAPP) and Productivity Per Author (PPA) to measure author's productivity. The value of AAPP is equivalent to Collaborative Index (CI). The year wise distribution of public health literature by Bangladeshi contributors together with the value of AAPP and PPA is shown in Table 4.43 below.

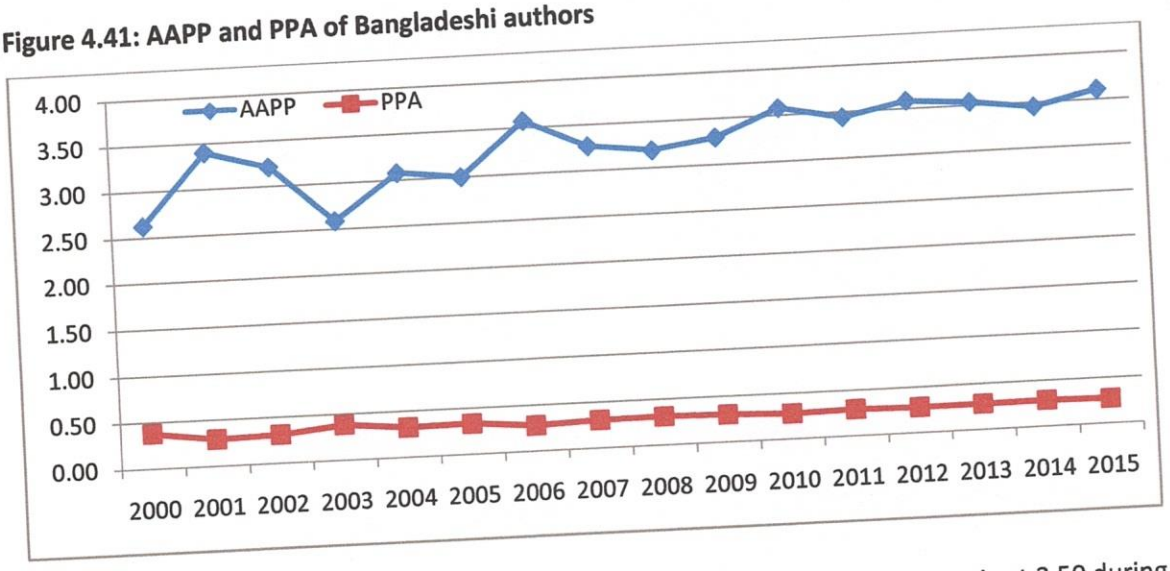
Table 4.43: AAPP and PPA of Bangladeshi Authors

Year	Total Authors	Total Publications	AAPP	PPA
2000	42	16	2.63	0.38
2001	34	10	3.40	0.29
2002	61	19	3.21	0.31
2003	44	17	**2.59**	**0.39**
2004	77	25	3.08	0.32
2005	66	22	3.00	0.33
2006	143	40	3.58	**0.28**
2007	147	45	3.27	0.31
2008	134	42	3.19	0.31
2009	214	65	3.29	0.30
2010	222	62	3.58	**0.28**
2011	303	88	3.44	0.29
2012	269	75	3.59	**0.28**
2013	336	95	3.54	**0.28**
2014	404	117	3.45	0.29
2015	480	133	**3.61**	**0.28**
Total	2976	871	3.28	0.31

Note: Cells in highlighted font shows highest and lowest values.

The AAPP values ranges from 2.59 to 3.61 with an average of 3.28, which means there are more than three authors per paper during the period 2000-2015. The PPA values ranges from 0.28 to 0.39 with an average of 0.31, which means every author produces less than half of a publication each year during the study period.

Figure 4.41: AAPP and PPA of Bangladeshi authors



It is evident from Figure 4.41 that AAPP values for Bangladeshi author remain static at 2.50 during the study period while PPA of Bangladeshi authors remain less than half a publication each year. The year 2015 had the highest value (3.61) of Average Author Per Paper (AAPP) whilst the year 2003 had lowest AAPP value (2.59) for Bangladeshi authors. In 2003 Bangladeshi authors had high production rate (0.39) whilst the years 2006, 2010, 2012, 2013, and 2015 were the lowest productive years from PPA point of view.

4.5.2.3.2 Activity Index (AI) of Bangladeshi contributions

The Activity Index (AI) characterizes the relative research efforts of a country to a given subject field (Karki & Garg, 1997). Frame (1977) suggested Activity Index (AI) first as:

$$\mathrm{AI} = \frac{Country's\ publication\ output\ on\ a\ given\ field\ in\ particular\ year}{World's\ publication\ output\ on\ a\ given\ field\ in\ particular\ year} \times 100$$

To compare Bangladeshi research output with world's output on public health during the period 2000-2015, AI can be defined mathematically in the following way:

$$\mathrm{AI} = \frac{\frac{B_i}{B_o}}{\frac{W_i}{W_o}} \times 100 \qquad \textbf{[Eq. 17]}$$

Where,

B_i = Bangladeshi research output in the year i

B_o = Total Bangladeshi output

W_i = World's research output in the year i

W_o = Total world's output

AI = 100 indicates that the country's research effort in the given field corresponds precisely to the world's average. AI > 100 reflects higher activity than the world's average, and AI < 100 indicates lower than average effort dedicated to the field under study (Karki & Garg, 1997).

Table 4.44: World output vs. Bangladeshi output on public health

Year	World Output	Bangladeshi Output	AI
2000	34847	16	19.62
2001	35430	10	**12.06**
2002	32297	19	25.14
2003	31044	17	23.40
2004	28367	25	37.67
2005	26222	22	35.86
2006	24289	40	70.38
2007	22750	45	84.54
2008	21752	42	82.52
2009	20845	65	133.27
2010	19668	62	134.73
2011	18329	88	205.20
2012	16818	75	190.60
2013	14683	95	276.53
2014	13325	117	375.27
2015	11594	133	**490.28**
Total	372260	871	137.32

Note: Cells in highlighted font shows highest and lowest values.

The result of AI indicates that Bangladeshi researchers' efforts on PH publications is lower than when compared with world average output during the years 2001 to 2008. During the next seven years, from 2009 to 2015 the research efforts from Bangladesh were higher than world's average research efforts. The Activity Index (AI) was maximum in 2015 and the lowest in 2001. The average Activity Index (AI) during 2000-2015 was 137.32 which reflect higher activity than the world's average on PH literature.

Figure 4.42: AI for Bangladeshi output

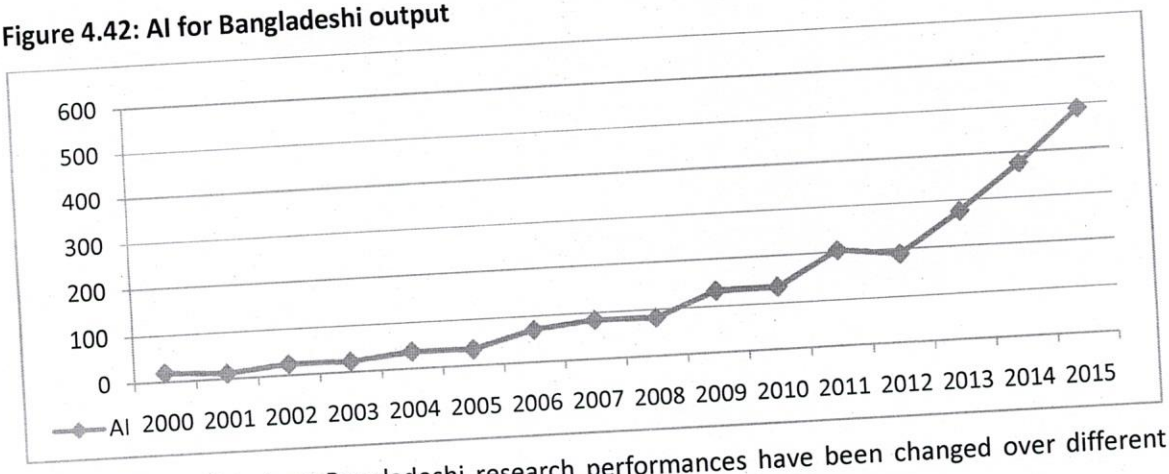


Figure 4.42 depicts how Bangladeshi research performances have been changed over different years. During study period Activity Index (AI) has reflected an increasing trend.

4.5.2.3.3 Applicability of Lotka's law into production of Bangladeshi authors

The number of publication produced by Bangladeshi authors as one author each, two authors each and so forth is presented in Table 4.45 below:

Table 4.45: Distribution of author productivity

Number of Papers	Number of Authors	Percentage
1	408	62.01
2	123	18.69
3	48	7.29
4	23	3.50
5	14	2.13
6	11	1.67
7	3	0.46
8	8	1.22
9	2	0.30
10	3	0.46
11	2	0.30
12	1	0.15
13	5	0.76
14	1	0.15
18	3	0.46
20	1	0.15
23	1	0.15
31	1	0.15
Total	658	100

Of the 658 unique Bangladeshi authors' names, 408 (62.01%) produced one article, 123 (18.69%) produced two articles and so forth. The number of authors who produced more than 10 articles each is quite small (2.74%).

Alfred J Lotka proposed an Inverse-Square Law relating to the authors of scientific papers to the number of papers written by each author (Lotka, 1926). He describes the frequency of publication by authors in any given field and in any given period of literature. According to his Inverse-square law, the number of authors publishing a certain number of articles is a fixed ratio to the number of authors publishing a single article. As the number of articles published increases, authors producing that many publications become less frequent. Out of all the authors in a given field, 60% will just have one publication, and 15% will have two publications each (¼), 7% authors will have three publications each (1/9), and so on (Potter, 1988; Wikipedia, n.d.). This has been calculated through the following formula:

$$Y = \frac{C}{X^n} \qquad \textbf{[Eq. 18]}$$

Where, Y = relative frequency of authors with 'X' publications.

C = Constants depending on the specific field

X = Number of publications/papers

n = Constants depending on the specific field

Generally author productivity is determined on the basis of number of papers contributed by the authors in a specific field. It's quite relevant to study the impact of Lotka's law in examining the author productivity on public health. Table 4.46 presents the results of productivity of Bangladeshi author based on Lotka's law:

Standardized has been calculated in the following way:

$$\text{Standardized} = \frac{Value\ of\ Y * Total\ number\ of\ actual\ unique\ author}{Total\ number\ of\ calculated\ unique\ author}$$

Table 4.46: Calculation of authors' productivity based on Lotka's law

Number of Papers	Number of Authors	Percentage	Expected (n=2)	Standardized	Percentage
1	408	62.01	408	415.269488	63.11
2	123	18.69	102	103.817372	15.78
3	48	7.29	45.33333	46.14105423	7.01
4	23	3.50	25.5	25.954343	3.94
5	14	2.13	16.32	16.61077952	2.52
6	11	1.67	11.33333	11.53526356	1.75
7	3	0.46	8.326531	8.474887511	1.29
8	8	1.22	6.375	6.48858575	0.99
9	2	0.30	5.037037	5.126783803	0.78
10	3	0.46	4.08	4.15269488	0.63
11	2	0.30	3.371901	3.43197924	0.52
12	1	0.15	2.833333	2.883815889	0.44
13	5	0.76	2.414201	2.457215906	0.37
14	1	0.15	2.081633	2.118721878	0.32
18	3	0.46	1.259259	1.281695951	0.19
20	1	0.15	1.02	1.03817372	0.16
23	1	0.15	0.771267	0.785008484	0.12
31	1	0.15	0.424558	0.432122256	0.07
Total	658	100	646.4814	657.9999856	100.00

4.5.3 Citation analysis of Bangladeshi research output

There is close relation between citation and reference though they are distinct from each other. According to Small, S. G. "Citations symbolize the *conceptual* association of scientific ideas as recognized by publishing research authors" (as cited in Garfield, n.d.). Francis Narin, *et al.* stated a 'reference' is the acknowledgment that one document gives to another; a citation is the acknowledgment that one document receives from another (as cited in Smith, 1981). Garfield, E. (1963) defines reference as "any item cited in the bibliography or text of a source document or publication". Merton R. K. pointed out that by the references they cite in their papers, authors make explicit linkages between their current research and prior work in the archive of scientific literature (as cited in Garfield, n.d.).

The preparation of citation index entries usually depends upon the analysis of particular parts of an article or research paper viz. reference, bibliography, end note, footnote etc. These parts of an article can be viewed as sources for preparing citation index entries. Reference or bibliography

section of a paper often reflects the exact subject content. Authors of a work may cite another's work previously published on the same or related topic. So there is an invisible relation seemingly between references of a work with the main text of that work itself. Citation index points out this relationship of subject content of one work with others indicating who cite whose works.

4.5.3.1 Cited publications and numbers of citation of Bangladeshi contributors

The year wise distribution of cited publication together with total number of citation of publication produced by Bangladeshi researchers is presented in Table 4.47.

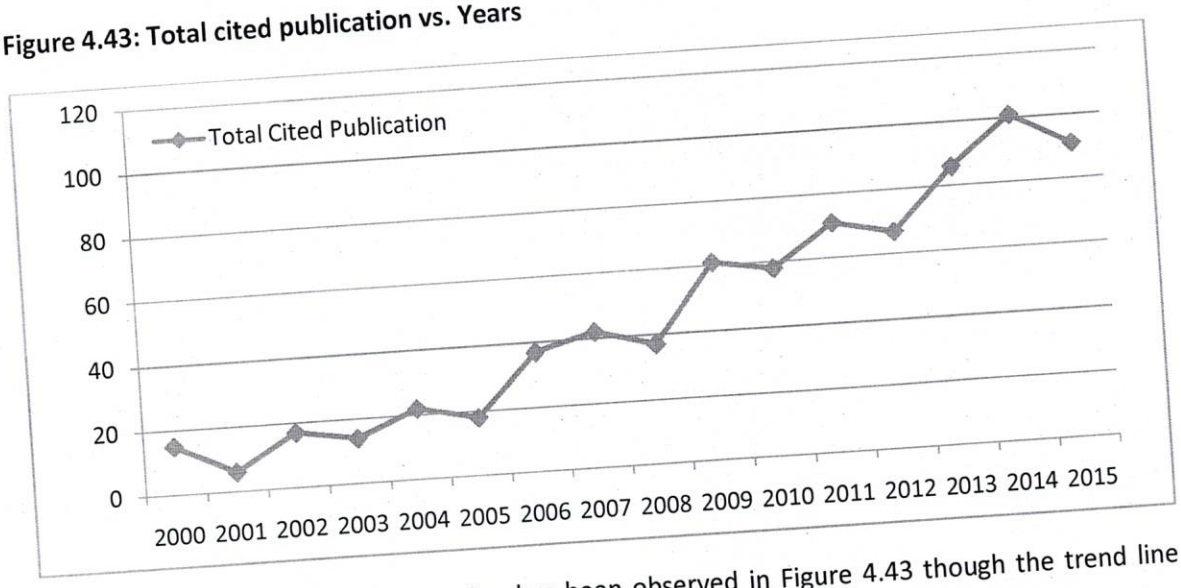
Table 4.47: Cited publications of Bangladeshi contributors

Year	Total Publication	Total Cited Publications	Percentage	Cumulative %
2000	16	15	2.02%	2.02%
2001	10	6	0.81%	2.83%
2002	19	17	2.29%	5.11%
2003	17	14	1.88%	7.00%
2004	25	22	2.96%	9.96%
2005	22	18	2.42%	12.38%
2006	40	37	4.98%	17.36%
2007	45	42	5.65%	23.01%
2008	42	37	4.98%	27.99%
2009	65	61	8.21%	36.20%
2010	62	58	7.81%	44.01%
2011	88	71	9.56%	53.57%
2012	75	67	9.02%	62.58%
2013	95	86	11.57%	74.16%
2014	117	101	13.59%	87.75%
2015	133	91	12.25%	100.00%
Total	871	743	100.00%	

Note: Cells in highlighted form indicate highest and lowest values

It is observed from Table 4.47 that the year 2014 was the most fruitful year in term of cited publication, which had the highest number citation (13.59%) whilst the year 2001 had the lowest number of total cited publication (0.81%). The period 2010 to 2015 belongs to the more 60% of total cited publication. During the period 2000-2015 out of 871 publications 743 publications received citation, which was 85.30% of total publication.

Figure 4.43: Total cited publication vs. Years



A fluctuation trend of cited publication has been observed in Figure 4.43 though the trend line was upward. The cited publication varies from 6 to 101 with an average of more than 46 cited publications per year.

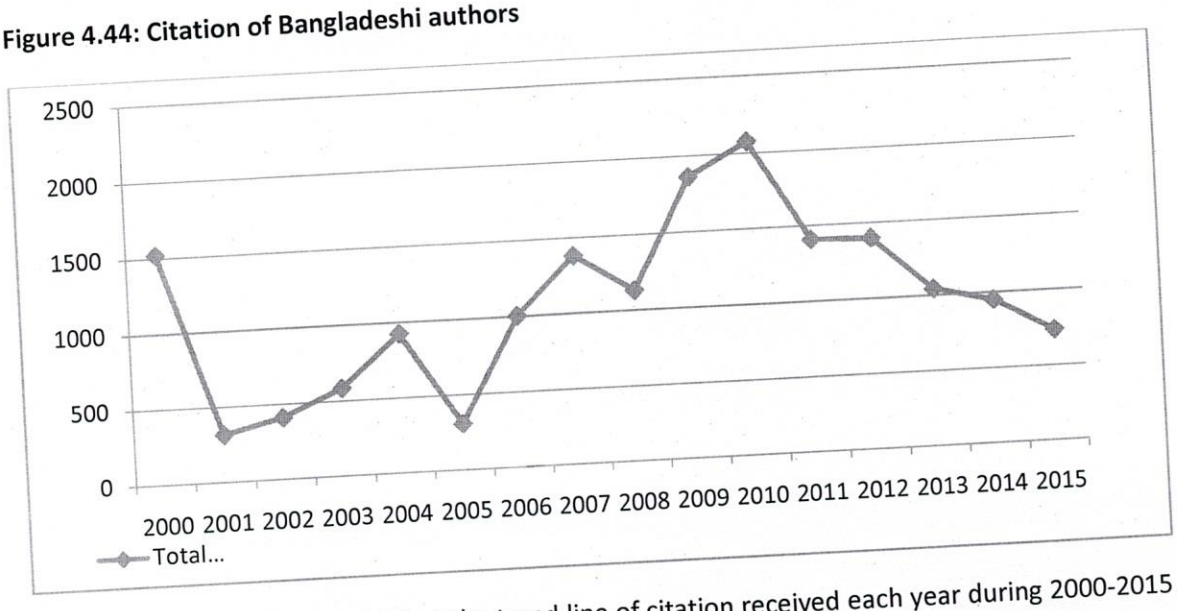
Table 4.48: Total cited publications and citations of Bangladeshi production

Year	Total Cited Publication	Total Citation	Cumulative	Percentage	Cumulative %
2000	15	1521	1521	8.91%	8.91%
2001	**6**	317	1838	1.86%	10.77%
2002	17	410	2248	2.40%	13.17%
2003	14	584	2832	3.42%	16.60%
2004	22	926	3758	5.43%	22.02%
2005	18	**307**	4065	1.80%	23.82%
2006	37	1004	5069	5.88%	29.71%
2007	42	1381	6450	8.09%	37.80%
2008	37	1133	7583	6.64%	44.44%
2009	61	1861	9444	10.91%	55.35%
2010	58	**2079**	11523	12.18%	67.53%
2011	71	1410	12933	8.26%	75.80%
2012	67	1400	14333	8.20%	84.00%
2013	86	1042	15375	6.11%	90.11%
2014	**101**	951	16326	5.57%	95.68%
2015	91	737	17063	4.32%	100.00%
Total	743	17063		100%	

Note: Cells in highlighted form indicate highest and lowest values.

It is evident from Table 4.48 that 743 cited publications achieved 17063 citations during 2000 to 2015 with an average of more than 1066 citation per year. The highest number of citation received in the year of 2010 (12.18%) whilst the year 2005 had the lowest number of citation (1.80%) received during the period 2000-2015.

Figure 4.44: Citation of Bangladeshi authors



It is observed from Figure 4.44 that the trend line of citation received each year during 2000-2015 is up and down. 2010 is the peak year in terms of highest number of citation received a year whilst the year 2005 had the lowest. There is an increasing trend being observed from 2005 to 2010. After that the trend line decreased dramatically till 2015.

4.5.3.2 CPP (TP) and CPP (CP) of Bangladeshi authors

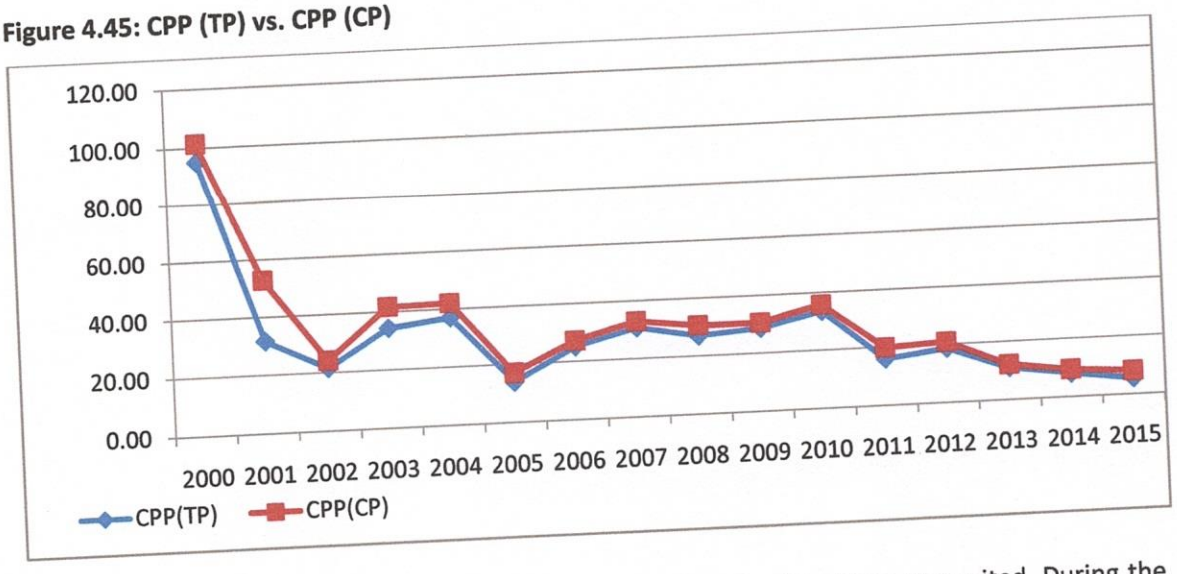
It is evident from Table 4.48, the number of publications increased in 2015 but the number of cited publications has not increased accordingly and for this reason the CPP (CP) is the lowest in the year 2015. By contrast the year 2000 had lowest number of publication but received greater number of citation so the result CPP (CP) was highest in 2000.

Table 4.49: CPP (TP) and CPP (CP) of Bangladeshi authors

Year	Total Citation	Total Publications	CPP(TP)	Total Cited Publications	CPP(CP)
2000	1521	16	95.06	15	101.40
2001	317	10	31.70	6	52.83
2002	410	19	21.58	17	24.12
2003	584	17	34.35	14	41.71
2004	926	25	37.04	22	42.09
2005	307	22	13.95	18	17.06
2006	1004	40	25.10	37	27.14
2007	1381	45	30.69	42	32.88
2008	1133	42	26.98	37	30.62
2009	1861	65	28.63	61	30.51
2010	2079	62	33.53	58	35.84
2011	1410	88	16.02	71	19.86
2012	1400	75	18.67	67	20.90
2013	1042	95	10.97	86	12.12
2014	951	117	8.13	101	9.42
2015	737	133	5.54	91	8.10
Total	17063	871	27.37	743	31.66

Note: Cells in highlighted form indicate highest and lowest values.

Figure 4.45: CPP (TP) vs. CPP (CP)



The CPP (CP) value is slightly greater than CPP (TP) as not all publications were cited. During the period 2000-2015 CPP (CP) ranges between 101.40 and 8.10 with average of 31.66 whilst CPP (TP) ranges between 95.06 and 5.54 with average of 27.37.

4.5.3.3 RoG and CAGR of cited publications and citations of Bangladeshi authors

Table 4.50: RoG and CAGR of cited publications and citations

Year	Total Publication	Total Cited Publication	RoG	CAGR	Total Citation	RoG	CAGR
2000	16	15	1.07	0.07	1,521	3.05	2.05
2001	10	6	**0.40**	-0.60	317	**0.21**	-0.79
2002	19	17	**2.83**	**1.83**	410	1.29	0.29
2003	17	14	0.82	-0.18	584	1.42	0.42
2004	25	22	1.57	0.57	926	1.59	0.59
2005	22	18	0.82	-0.18	307	0.33	-0.67
2006	40	37	2.06	1.06	1,004	**3.27**	**2.27**
2007	45	42	1.14	0.14	1,381	1.38	0.38
2008	42	37	0.88	-0.12	1,133	0.82	-0.18
2009	65	61	1.65	0.65	1,861	1.64	0.64
2010	62	58	0.95	-0.05	2,079	1.12	0.12
2011	88	71	1.22	0.22	1,410	0.68	-0.32
2012	75	67	0.94	**-0.06**	1,400	0.99	**-0.01**
2013	95	86	1.28	0.28	1,042	0.74	-0.26
2014	117	101	1.17	0.17	951	0.91	-0.09
2015	133	91	0.90	-0.10	737	0.77	-0.23
Total	871	743	1.23	0.23	17,063	1.26	0.26

Note: There are 15 publication in 1999 in which 14 was cited publication received 499 citations (Source: Scopus); Cells in highlighted form indicate highest and lowest values.

Table 4.50 reveals that RoG of total cited publication ranges between 0.40 and 2.83 with an average of 1.23. CAGR of cited publication varies from -0.06 to 1.83 with an average of 0.23 although minus trend of CAGR value has been observed in few years viz., 2001, 2003, 2005, 2008, 2010, 2012 and 2015.

On the other hand RoG of total citation ranges between 0.21 and 3.27 with an average of 1.26. CAGR of total citation varies from -.01 to 2.27 with an average of 0.26 during the study period 2000-2015.

Figure 4.46: RoG of cited publication and citation

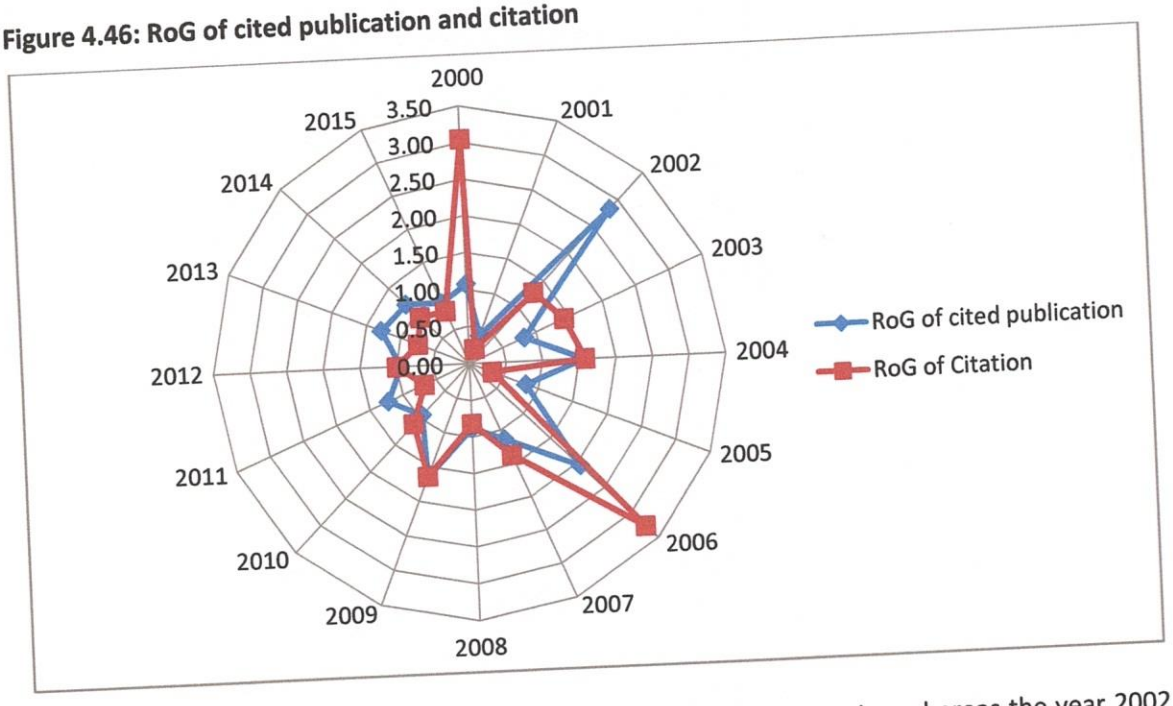


Figure 4.46 depicts that the year 2006 had optimal RoG value for citation whereas the year 2002 had highest RoG value for cited publication.

Figure 4.47: CAGR of Cited publication and citation

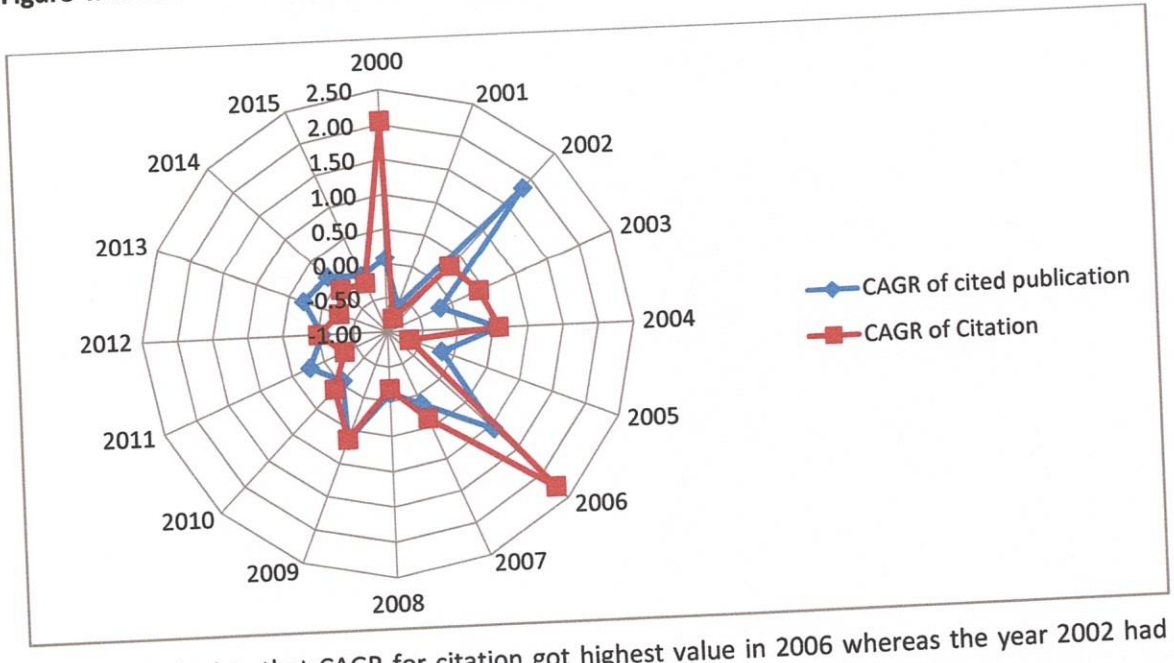


Figure 4.47 depicts that CAGR for citation got highest value in 2006 whereas the year 2002 had the maximum CAGR value for cited publication.

4.5.3.4 RGR and Dt(cp)/Dt(c) of cited publications and citations of Bangladeshi authors

Table 4.51: RGR and Dt(cp)/Dt(c) of cited publications and citations

Year	Total Cited Publications	Cum	W_1	W_2	RGR	Dt(cp)	Total Citations	Cum	W_1	W_2	RGR	Dt(c)
2000	15	15	0.00	2.71	-	-	1521	1521	0.00	7.33	-	-
2001	6	21	2.71	3.04	0.33	2.10	317	1838	7.33	7.52	0.19	3.65
2002	17	38	3.04	3.64	0.60	1.16	410	2248	7.52	7.72	0.20	3.47
2003	14	52	3.64	3.95	0.31	2.24	584	2832	7.72	7.95	0.23	3.01
2004	22	74	3.95	4.30	0.35	1.98	926	3758	7.95	8.23	0.28	2.48
2005	18	92	4.30	4.52	0.22	3.15	307	4065	8.23	8.31	0.08	8.66
2006	37	129	4.52	4.86	0.34	2.04	1004	5069	8.31	8.53	0.22	3.15
2007	42	171	4.86	5.14	0.28	2.48	1381	6450	8.53	8.77	0.24	2.89
2008	37	208	5.14	5.34	0.20	3.47	1133	7583	8.77	8.93	0.16	4.33
2009	61	269	5.34	5.59	0.25	2.77	1861	9444	8.93	9.15	0.22	3.15
2010	58	327	5.59	5.79	0.20	3.47	2079	11523	9.15	9.35	0.20	3.47
2011	71	398	5.79	5.99	0.20	3.47	1410	12933	9.35	9.47	0.12	5.77
2012	67	465	5.99	6.14	0.15	4.62	1400	14333	9.47	9.57	0.10	6.93
2013	86	551	6.14	6.31	0.17	4.08	1042	15375	9.57	9.64	0.07	9.90
2014	101	652	6.31	6.48	0.17	4.08	951	16326	9.64	9.70	0.06	11.55
2015	91	743	6.48	6.61	0.13	5.33	737	17063	9.70	9.74	0.04	17.32
Total	743	Average RGR & Dt(cp)			0.26	3.09	17063	Average RGR & Dt(c)			0.16	5.98

Note: Dt(cp)= Double time (cited publication), Dt(c)= Double time (citation); Cells in highlighted form indicate highest and lowest values.

The relative growth rate of cited publication lies between 0.13 and 0.60 with an average of 0.26. On the other hand, RGR value of citation ranges from 0.04 to 0.28 with an average of 0.16 during the study period 2000-2015. The cited publications double after every 3.09 years time period whilst citation received by cited publication would double after every 5.98 years. A comparative picture of RGR and Dt between cited publication and citation is shown in the area chart 4.48 and 4.49 next page.

Figure 4.48: RGR of cited publication and citation of Bangladeshi authors

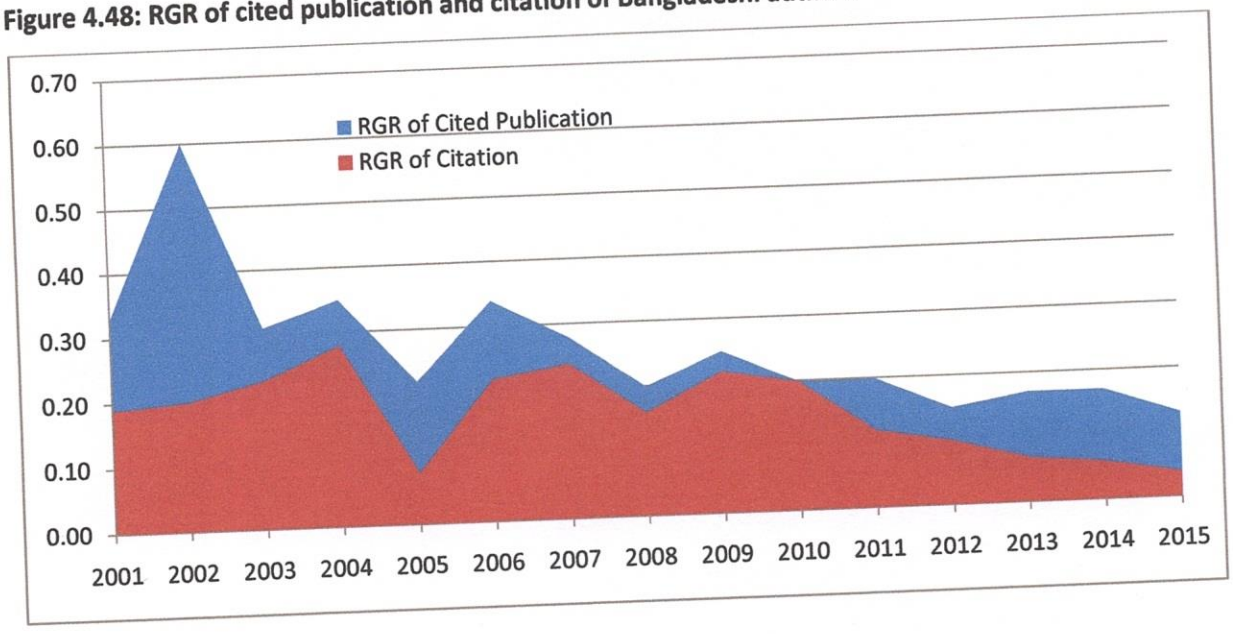
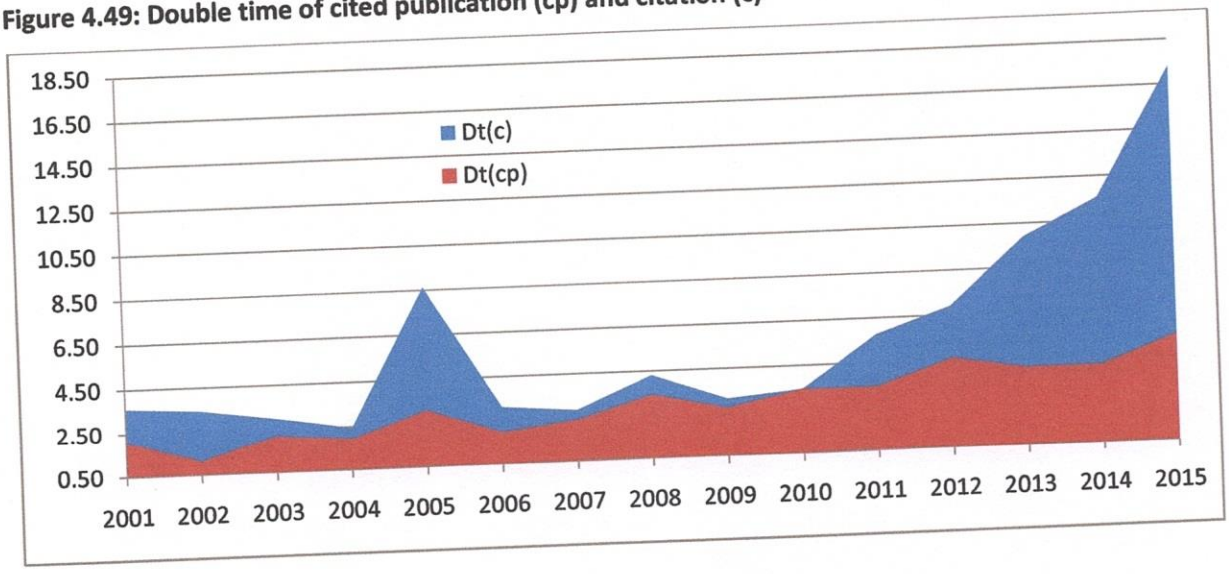


Figure 4.49: Double time of cited publication (cp) and citation (c)



4.5.3.5 Un-cited publications of Bangladeshi authors

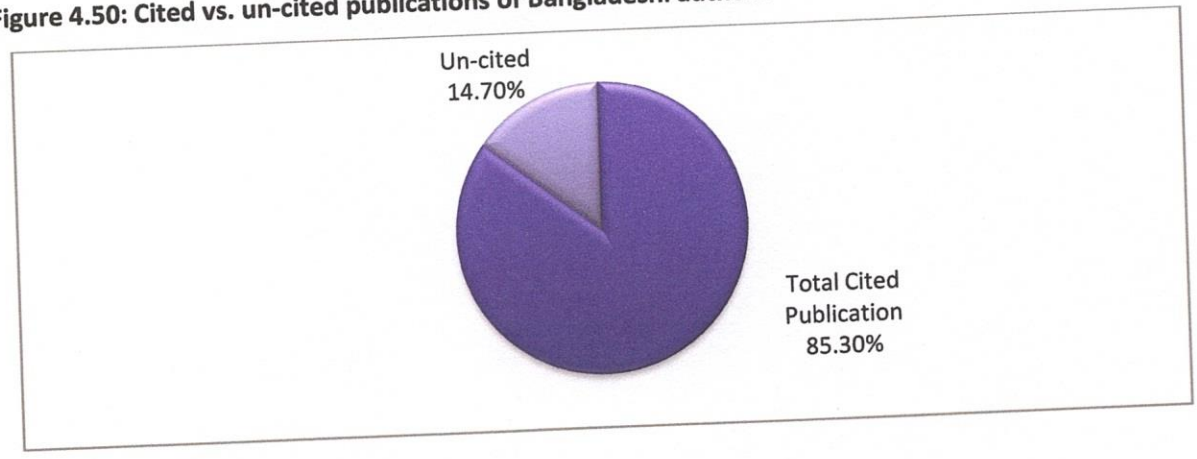
The year wise distribution of cited and un-cited publications of Bangladeshi authors is presented in Table 4.52 below.

Table 4.52: Year wise un-cited publications

Year	Un-cited Publications	Percentage
2000	1	0.78%
2001	4	3.13%
2002	2	1.56%
2003	3	2.34%
2004	3	2.34%
2005	4	3.13%
2006	3	2.34%
2007	3	2.34%
2008	5	3.91%
2009	4	3.13%
2010	4	3.13%
2011	17	13.28%
2012	8	6.25%
2013	9	7.03%
2014	16	12.50%
2015	42	32.81%
Total	128	100.00%

Of 871 publications 743 publications (85.30%) by Bangladeshi authors received citations from other publications and 128 publications (14.70%) were un-cited. In the year 2011 there were the highest number of un-cited publication (13.28%) whilst the year 2000 had the lowest number of un-cited publication (0.78%) for Bangladeshi authors.

Figure 4.50: Cited vs. un-cited publications of Bangladeshi authors



4.5.3.6 Highly cited Bangladeshi papers

The publications on public health by Bangladeshi authors which were cited by more than 100 times are presented in Table 4.53 together with names of authors, titles of publications, years, source titles and document types.

Table 4.53: Top 18 highly cited Bangladeshi papers

Cited by	Authors	Year	Source title	Document Type	Title
1019	Smith, A.H., Lingas, E.O., Rahman, M.	2000	Bulletin of the World Health Organization	Article	Contamination of drinking-water by arsenic in Bangladesh: A public health emergency
436	Salomon, J.A., Vos, T., Hogan, D.R., Gagnon, M., Naghavi, M., Mokdad, A., Begum, N., Shah, R., Karyana, M., Kosen, S., Farje, M.R., Moncada, *et al.*	2012	The Lancet	Review	Common values in assessing health outcomes from disease and injury: Disability weights measurement study for the Global Burden of Disease Study 2010
326	Ahmed, K.M., Bhattacharya, P., Hasan, M.A., Akhter, S.H., Alam, S.M.M., Bhuyian, M.A.H., Imam, M.B., Khan, A.A., Sracek, O.	2004	Applied Geochemistry	Review	Arsenic enrichment in groundwater of the alluvial aquifers in Bangladesh: An overview
251	Nair, H., Brooks, W.A., Katz, M., Roca, A., Berkley, J.A., Madhi, S.A., Simmerman, C., Goswami, D., *et al.*	2011	The Lancet	Article	Global burden of respiratory infections due to seasonal influenza in young children: A systematic review and meta-analysis

Cited by	Authors	Year	Source title	Document Type	Title
233	Bryce, J., El Arifeen, S., Pariyo, G., Lanata, C.F., Gwatkin, D., Habicht, J.-P.	2003	Lancet	Review	Reducing child mortality: Can public health deliver?
214	Das, H.K., Mitra, A.K., Sengupta, P.K., Hossain, A., Islam, F., Rabbani, G.H.	2004	Environment International	Article	Arsenic concentrations in rice, vegetables, and fish in Bangladesh:
192	Chun, J., Grim, C.J., Hasan, N.A., , Huq, A., Nair, G.B., Colwell, R.R. *et al.*	2009	Proceedings of the National Academy of Sciences of the United States of America	Article	Comparative genomics reveals mechanism for short-term and long-term clonal transitions in pandemic Vibrio cholerae
182	Muthuri, S.G., Venkatesan, S., Myles, P.R., Leonardi-Bee, J., Al Khuwaitir, T.S.A., Al Mamun, A., Anovadiya, A.P., *et al.*	2014	The Lancet Respiratory Medicine	Article	Effectiveness of neuraminidase inhibitors in reducing mortality in patients admitted to hospital with influenza A H1N1pdm09 virus infection: A meta-analysis of individual participant data
158	Ahsan, H., Chen, Y., Parvez, F., Zablotska, L., Argos, M., Hussain, I., Momotaj, H.,*et al.*	2006	American Journal of Epidemiology	Article	Arsenic exposure from drinking water and risk of premalignant skin lesions in Bangladesh: Baseline results from the health effects of arsenic longitudinal study
138	Anawar, H.M., Akai, J., Mostofa, K.M.G., Safiullah, S., Tareq, S.M.	2001	Environment International	Article	Arsenic poisoning in groundwater: Health risk and geochemical sources in Bangladesh

Cited by	Authors	Year	Source title	Document Type	Title
133	De Magny, G.C., Murtugudde, R., Sapiano, M.R.P., Nizam, A., Brown, Huq, A., Sack, R.B., Colwell, R.R. *et al.*	2008	Proceedings of the National Academy of Sciences of the United States of America	Article	Environmental signatures associated with cholera epidemics
132	Rahman, A., Vahter, M., Smith, A.H., Nermell, B., Yunus, M., El Arifeen, S., Persson, *et al.*	2009	American Journal of Epidemiology	Article	Arsenic exposure during pregnancy and size at birth: A prospective cohort study in Bangladesh
128	Hussam, A., Munir, A.K.M.	2007	Journal of Environmental Science and Health	Article	A simple and effective arsenic filter based on composite iron matrix
127	Rahman, A., Vahter, M., EkstrÃm, E.-C., Rahman, M., Golam Mustafa, A.H.M., Wahed, M.A., Yunus, M., Persson, L.-Ã....	2007	American Journal of Epidemiology	Article	Association of arsenic exposure during pregnancy with fetal loss and infant death: A cohort study in Bangladesh
124	Kim, K.-H., Kabir, E., Kabir, S.	2015	Environment International	Review	A review on the human health impact of airborne particulate matter
124	Chen, Y., Parvez, F., Gamble, M., Islam, T., Ahmed, A., Argos, M., Graziano, J.H., Ahsan, H.	2009	Toxicology and Applied Pharmacology	Article	Arsenic exposure at low-to-moderate levels and skin lesions, arsenic metabolism, neurological functions, and biomarkers for respiratory and cardiovascular diseases

Cited by	Authors	Year	Source title	Document Type	Title
123	Arifeen, S.E., Hoque, D.E., Akter, T., Rahman, M., Hoque, M.E., Begum, *et al.*	2009	The Lancet	Article	Effect of the Integrated Management of Childhood Illness strategy on childhood mortality and nutrition in a rural area in Bangladesh
108	Dittmar, J., Voegelin, A., Roberts, L.C., Hug, S.J., Saha, G.C., Ali, M.A., Badruzzaman, A.B.M., Kretzschmar, R.	2007	Environmental Science and Technology	Article	Spatial distribution and temporal variability of arsenic in irrigated rice fields in Bangladesh.

Table 4.53 indicates that the paper of Rahman et.al entitled "Contamination of drinking-water by arsenic in Bangladesh: A public health emergency" published in 'Bulletin of the World Health Organization' in 2000 received the highest number of citation (1019) among the top cited Bangladeshi authors on public health. The largest percentage of the highly cited publication by Bangladeshi author was articles (78%) which were followed by review (22%).

4.5.3.6.1 Top ten Bangladeshi authors

The only authors who are either affiliated with or originated from Bangladesh are selected for the current analysis. Rank is made based on the highest number of publication on public health and is arranged in ascending order of rank.

Table 4.54: Top ten Bangladeshi authors with affiliations

Authors	Affiliated Institution	Total Publications by Author	Publications on Public health	Rank
Yunus, M.	ICDDRB	283	21	1
Ahsan, H.	University of Chicago	267	18	2
Noor, R.	Stamford University Bangladesh	47	16	3
Parvez, F.	Columbia University Medical Center	119	16	3
Rahman, M.	Bangladesh Rural Advancement Committee	74	16	3
El Arifeen, S.	ICDDRB	119	15	4
Islam, T.	UChicago Research Bangladesh	79	15	4
Haque, R.	ICDDRB	243	14	5
Nahar, N.	ICDDRB	82	14	5
Ahmed, S.M.	Mymensingh Medical College	81	13	6

Table 4.54 shows that among the Bangladeshi authors Mr. Yunus of ICCDDRB placed 1st position which means he had maximum number of publications on public health in the list. Actually he had 21 publications on public health out of his total 283 publications. Mr. Ahsan had the 2nd highest number of publications (18) which placed him in 2nd position of the list. Mr. Parvez and Mr. Rahman had the equal number of publications on public health (16), which placed them as third in rank. Interesting to note that out of top 10 authors, four authors were affiliated with ICDDRB and two authors were affiliated with foreign institutions.

The top ten Bangladeshi authors together with citation number, cited document, ACPCP, ACPP and rank of the authors are presented in Table 4.55 below.

Table 4.55: Top ten Bangladeshi authors with ranking across four criteria

Authors	Citation Number	Cited Document	ACPCP	ACPP	Rank			
					1	2	3	4
Yunus, M.	9548	6972	1.37	33.74	2	2	7	4
Ahsan, H.	12110	8498	1.43	45.36	1	1	6	2
Noor, R.	222	102	2.18	4.72	10	10	1	10
Parvez, F.	5009	2751	1.82	42.09	4	5	2	3
Rahman, M.	3731	2527	1.48	50.42	6	6	5	1
El Arifeen, S.	3778	2939	1.29	31.75	5	4	8	5
Islam, T.	1575	1058	1.49	19.94	7	8	4	7
Haque, R.	7559	4584	1.65	31.11	3	3	3	6
Nahar, N.	764	600	1.27	9.32	9	9	9	9
Ahmed, S.M.	1371	1136	1.21	16.93	8	7	10	8

Note:

ACPCP : Average Citation Per Cited Paper
ACPP : Average Citation Per Paper
1 : Based on citations
2 : Based on cited document
3 : Based on ACPCP
4 : Base on ACPP

The top ten Bangladeshi authors are analyzed based on citation number, cited document, Average Citation Per Cited Paper (ACPCP), Average Citation Per Paper (ACPP) in Table 4.55. It is obvious that Mr. Ahsan placed 1st rank based on citation and cited document. He has received 12,110 citations from 8,498 cited documents. Mr. Noor got the first place based on ACPCP (2.18) and Mr. Rahman placed first in position based on ACPP (50.42).

4.5.3.6.2 Top ten Bangladeshi authors with various indices

Table 4.56 indicates Mr. Ahsan had the maximum h-index (62) and g-index (101) scores than others. All of the top most Bangladesh authors had low hI,norm index value means most of their articles were co-authored with at least three other academics. All of the authors listed failed to produced at least one article per year as all of their hI,a values are below 1.0. Anyway, Mr. Yunus was the most experienced author as he had maximum year of experience in publication (47 years).

Table 4.56: Top ten Bangladeshi authors with various indices

Authors	h-index	g-index	hI,norm	hI,annual	Tenure	Citation Years
Yunus, M.	52	86	17	0.36	1970-2016	47 (1970-2016)
Ahsan, H.	62	101	16	0.7	1994-2017	23 (1994-2017)
Noor, R.	9	11	4	0.29	2003-2017	14 (2003-2017)
Parvez, F.	39	69	11	0.65	2000-2017	17 (2000-2017)
Rahman, M.	28	61	14	0.64	1995-2017	22 (1995-2017)
El Arifeen, S.	35	58	10	0.53	1998-2017	19 (1998-2017)
Islam, T.	20	38	8	0.38	2000-2017	17 (2000-2017)
Haque, R.	49	76	16	0.59	2004-2017	13 (2004-2017)
Nahar, N.	14	25	6	0.18	1984-2017	33 (1984-2017)
Ahmed, S.M.	23	34	12	0.57	1996-2017	21 (1996-2017)

Table 4.57: Rank of indices among top ten Bangladeshi authors of PH

Authors	h-rank	g-rank	hI,n-rank	hI,a-rank
Yunus, M.	2	2	1	8
Ahsan, H.	1	1	2	1
Noor, R.	10	10	9	10
Parvez, F.	4	4	5	2
Rahman, M.	6	5	3	3
El Arifeen, S.	5	6	6	6
Islam, T.	8	7	7	7
Haque, R.	3	3	2	4
Nahar, N.	9	9	8	9
Ahmed, S.M.	7	8	4	5

4.5.4 Assessment of literature by Bangladeshi author using various parameters

4.5.4.1 Top 10 Bangladeshi affiliated institutions

Various institutes where Bangladeshi researchers affiliated with were also ranked on the basis of highly published number of research output in the field of public health. The top 10 highly productive Bangladeshi institutes are listed in Table 4.58.

Table 4.58: Top 10 institutions affiliated by Bangladeshi authors

Affiliated Institutes	Records	Rank
International Centre for Diarrhoeal Disease Research Bangladesh (ICDDRB)	362	1
University of Dhaka	82	2
BRAC	42	3
BRAC University	39	4
Rajshahi University	34	5
Jahangirnagar University	31	6
Bangabandhu Sheikh Mujib Medical University	28	7
National Institute of Preventive and Social Medicine (NIPSOM)	21	8
Stamford University Bangladesh	20	9
Bangladesh University of Engineering and Technology	19	10

International Centre for Diarrhoeal Disease Research Bangladesh (ICDDRB) produced the maximum research output (362) on public health placed 1st in rank which is followed by University of Dhaka with 82 contributions placed 2nd in ranking. The parent and sister organization of BRAC produced 81 research outputs which placed themselves as 3rd and 4th gradually in ranking. University of Rajshahi or Rajshahi University positioned 5th place in producing public health literature as Bangladeshi institute.

4.5.4.2 Top 10 collaborated countries by Bangladeshi authors

The researchers of Bangladesh worked together with the researchers of various countries around the world. Table 4.59 listed top ten collaborated countries with which Bangladeshi researchers jointly work as a team.

Table 4.59: Top 10 collaborated countries by Bangladeshi authors

Collaborated Countries	Records	Rank
United States of America	310	1
United Kingdom	119	2
Australia	80	3
Japan	78	4
India	71	5
Sweden	59	6
Switzerland	50	7
Canada	42	8
Malaysia	30	9
Thailand	29	10

The researchers of Bangladesh preferred most to work together with the researchers of United States of America. The joint efforts by the researchers of Bangladesh and USA produced 310 records, which is top in collaboration ranking. The second most preferred country, with which the researchers of Bangladesh working together, is United Kingdom. Australia, Japan and India are the third, fourth and fifth most collaborated countries gradually preferred by Bangladeshi researchers.

Table 5.1: Year wise publications

Year	Publications
2000	11,594
2001	13,325
2002	14,683
2003	16,818
2004	18,329
2005	19,668
2006	20,845
2007	21,752
2008	22,750
2009	24,289
2010	26,222
2011	28,367
2012	31,044
2013	32,297
2014	35,430
2015	34,847

To test the variance of year and publication variables, and check significance of regression coefficient "F" test and "t" test were sequentially carried out.

Table 5.2: Summary output

Regression Statistics	
Multiple R	0.993846053
R Square	0.987729977
Adjusted R Square	0.986853547
Standard Error	866.1479354
Observations	16

Table 5.3: ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	845483319.6	8.45E+08	1126.992	8.81839E-15
Residual	14	10502971.44	750212.2		
Total	15	855986291			

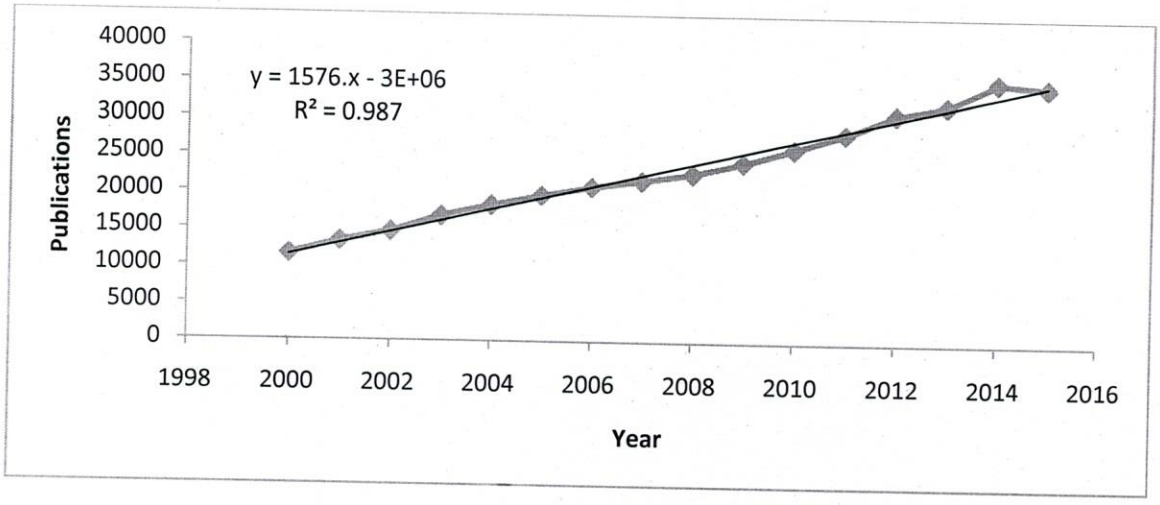
Table 5.4: Regression Coefficients

	Coefficients	*Standard Error*	*t Stat*	*P-value**	*Lower 95%*	*Upper 95%*
Intercept	-3142425.449	94299.4837	-33.3239	9.77E-15	-3344677.725	-2940173.172
Year	1576.932353	46.97346704	33.5707	8.82E-15	1476.184286	1677.680419

Note: *Significant at p<0.01

From table 5.2, the value of R square is 0.9877. That means 98% of the variability in publication is explained by the regression line or by the regression of year on publication. The result of the "t-test" showed that there is a significant relationship between progressing years' and the growth of literature (p<0.01). The null hypothesis (*H1*) was therefore rejected during the study period.

Figure 5.1: Linear trend of year and literature



It is evident from Figure 5.1 that from 2000 to 2007 the observed line coincide with the fitted line. After 2007 the observed values are falls below the fitted values until 2011. From 2011 to 2014 the observed line is above of the fitted line and in 2015 the two lines once again coincide.

5.3 Relationship between existing growth of literature and future growth of literature

In order to analyze the relationship between existing growth of literature and future growth of literature the following null hypothesis was tested using 't'test.

Hypothesis 2 (*H2*): There is no mean-relationship between existing growth of literature and expected future growth of literature on public health.

This test was carried out due to the quantitative nature of these two dependent variables (existing and future growth of literature) and the qualitative nature of independent variable (year). In our data analysis chapter future growths of literature from 2017 to 2032 has been calculated. In this section the mean difference of two dependent variables (existing and future growth of literature) has been tested for significance.

Table 5.5: Existing vs. future growth of literature

Year	Existing Growth of Literature (2000-2015)	Future Growth of Literature (2017-2032)
Year-1	11,594	38,247
Year-2	13,325	39,824
Year-3	14,683	41,400
Year-4	16,818	42,977
Year-5	18,329	44,554
Year-6	19,668	46,131
Year-7	20,845	47,708
Year-8	21,752	49,285
Year-9	22,750	50,862
Year-10	24,289	52,439
Year-11	26,222	54,016
Year-12	28,367	55,593
Year-13	31,044	57,170
Year-14	32,297	58,747
Year-15	35,430	60,324
Year-16	34,847	61,901

Table 5.6: t-Test: Paired Two Sample for Means

	Variable 1	*Variable 2*
Mean	50074.09995	23266.25
Variance	56365554.43	57065752.73
Observations	16	16
Pearson Correlation	0.993846053	
Hypothesized Mean Difference	0	
df	15	
t Stat	128.1479056	
P(T<=t) one-tail	1.61378E-24	
t Critical one-tail	1.753050325	
P(T<=t) two-tail	3.22756E-24*	
t Critical two-tail	2.131449536	

Note: *significant at p<0.01

The mean of the two dependent variables are 50074.09 for the variables of future growth (2017-2032) and 23266.25 for the variables of existing growth. Table 5.6 depicts that p-value is much lower than 0.01 which indicates there is strong positive mean relationship between the existing and future growth of literature, therefore, the null hypothesis (*H2*) is rejected.

5.4 Relationship between collaboration and productivity

Studies by Price and Beaver (1966), Zuckerman (1968), and Pao (1981) have shown a strong association between collaboration and productivity (Cited in Ding, Foo & Chowdhury, 1999).In order to analyse the relationship between collaborative authors and their productivity the following stated null hypothesis was tested using parametric test.

Hypothesis 3 (*H3*): There is no association between the collaboration of author and research productivity.

Table 5.7: Collaborative authors and their productions

Collaborative authors (X)	Productions by collaborative authors (Y)
20,269	6,310
22,359	7,322
20,882	7,110
24,276	7,969
29,532	9,301
31,444	10,104
34,567	11,022
27,573	9,676
36,759	11,742
36,461	11,448
37,379	12,869
46,865	16,415
59,694	20,048
54,745	18,326
56,159	19,393
57,875	19,518

Note: Excluding anonymous and single authors and their productions

Table 5.8: Summary Output

Regression Statistics	
Multiple R	0.996197823
R Square	0.992410103
Adjusted R Square	0.991867968
Standard Error	432.8166858
Observations	16

The squared R value reflects the similarity in the distribution overall which is equivalent of Pearson's r for two set of values. The value of R Square indicates that productivity is related with collaborative authors.

Table 5.9: ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	342918834.5	342918834.5	1830.557388	3.04948E-16
Residual	14	2622623.969	187330.2835		
Total	15	345541458.4			

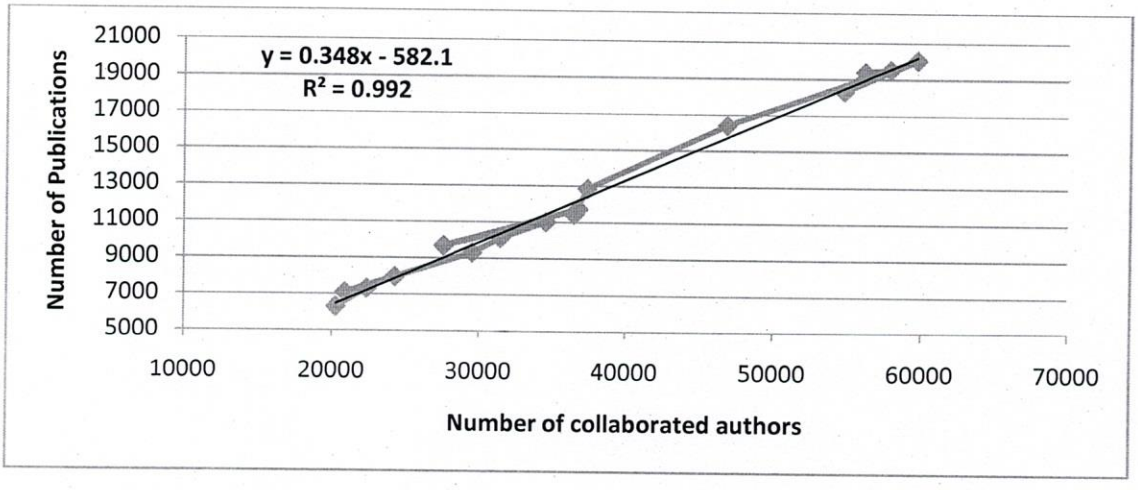
Table 5.10: Regression coefficient

	Coefficients	*Standard Error*	*t Stat*	*P-value**	*Lower 95%*	*Upper 95%*
Intercept	-582.1885122	322.3823316	-1.805894602	0.092475209	-1273.629843	109.2528
Collaborated Author	0.348315067	0.008141053	42.78501359	**3.04948E-16**	0.330854245	0.365776

Note: *significant at p<0.01

In this case p-value is significantly less than 0.01 meaning the regression coefficient is statistically significant. Our null hypothesis (*H3*) is therefore rejected during this present study. In summary, author productivity is influenced by the collaboration of authors and there is strong positive correlation between authors' collaboration and authors' productivity.

Figure 5.2: Collaborated author against Publications



5.5 Conformation of public health literature to Lotka's inverse law

Hypothesis 4 (*H4*): Research productivity of public health in Bangladesh does not conform to Lotka's inverse law of author productivity.

Table 5.11: Distribution of authors and papers based on Lotka's law

Number of papers (x)	Number of Authors (y)	X=Log of x	Y= Log of y
1	408	0	6.011267
2	123	0.693147	4.812184
3	48	1.098612	3.871201
4	23	1.386294	3.135494
5	14	1.609438	2.639057
6	11	1.791759	2.397895
7	3	1.94591	1.098612
8	8	2.079442	2.079442
9	2	2.197225	0.693147
10	3	2.302585	1.098612
11	2	2.397895	0.693147
12	1	2.484907	0
13	5	2.564949	1.609438
14	1	2.639057	0
18	3	2.890372	1.098612
20	1	2.995732	0
23	1	3.135494	0
31	1	3.433987	0
Total	658		

Table 5.12: Summary output

Regression Statistics	
Multiple R	0.944737754
R Square	0.892529424
Adjusted R Square	0.885812513
Standard Error	0.602861062
Observations	18

Table 5.13: ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	48.29335947	48.29336	132.878	3.67486E-09
Residual	16	5.815063355	0.363441		
Total	17	54.10842282			

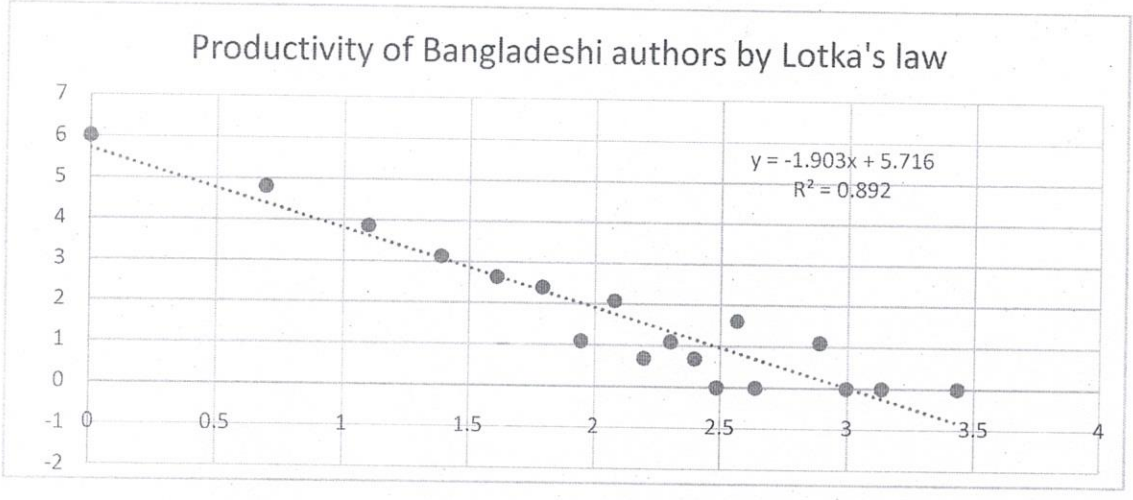
Table 5.14: Regression Coefficient

	Coefficients	*Standard Error*	*t Stat*	*P-value**	*Lower 95%*	*Upper 95%*
Intercept	5.71595	0.373405073	15.3076	5.6E-11	4.924368	6.507535
Log of X	-1.9032	0.165103253	-11.527	3.7E-09	-2.25319	-1.553187

Note: *significant at p<0.01

As the p-value is less than 0.01 in the present study, the regression coefficient is statistically significant. Null hypothesis (*H4*) is therefore rejected. So we can comment that the research productivity of public health in Bangladesh conforms to Lotka's inverse law of author productivity.

Figure 5.3: Productivity of Bangladeshi authors by Lotka's law



5.6 Relationship between public health research performances of Bangladeshi researchers and the researchers of other countries

In order to analyse the relationship between existing public health research performances of Bangladeshi researchers and the researchers of other countries the following null hypothesis was tested using "t-test".

Hypothesis 5 (*H5*): There is no mean-relationship between public health research performances of Bangladeshi researchers and the researchers of other countries.

This test was carried out due to quantitative nature of the two dependent variables (values of Bangladeshi Researchers and Researchers of other parts of the world) and qualitative nature of the independent variable (year). Therefore, the mean difference of two dependent variables (Bangladeshi Researchers and Researchers of other parts of the world) was tested for

significance. The research output of Bangladeshi authors and rest of the world is presented in table 5.15.

Table 5.15: Research output of Bangladesh and rest of the world

Year	Research output of Bangladeshi authors	Research output of rest of the world
2000	16	11,578
2001	10	13,315
2002	19	14,664
2003	17	16,801
2004	25	18,304
2005	22	19,646
2006	40	20,805
2007	45	21,707
2008	42	22,708
2009	65	24,224
2010	62	26,160
2011	88	28,279
2012	75	30,969
2013	95	32,202
2014	117	35,313
2015	133	34,714

Table 5.16: t-Test: Paired Two Sample for Means

	Variable-1	*Variable-2*
Mean	54.4375	23211.8125
Variance	1461.995833	56513199.36
Observations	16	16
Pearson Correlation	0.958618053	
Hypothesized Mean Difference	0	
df	15	
t Stat	-12.38216578	
P(T<=t) one-tail	1.40649E-09	
t Critical one-tail	1.753050325	
P(T<=t) two-tail	2.81298E-09*	
t Critical two-tail	2.131449536	

Note: *significant at p<0.01

The mean of the two dependent variables are 54.43 for Bangladeshi researchers and 23211.81 for researchers of the rest of the world. Table 5.16 depicts that p-value is much lower than 0.01 which indicates that strong positive mean relation between the public health research performances of Bangladeshi researchers and the researchers of other countries. So our null hypothesis (*H5*) is rejected.

5.7 Relationship between research productivity of developing countries and the research productivity of developed countries

In order to test the significant level of relation of research productivity between developing countries and developed countries the country-wise research productions for each category of countries were arranged in order of decreasing productivity on public health literature during 2000-2015. The first ten countries were then selected from each category of the list. The research output of top ten developed and developing countries on public health is presented in Table 5.17.

Table 5.17: Publication number of top 10 developed and developing countries

Developed countries		Developing countries	
United States	116418	Brazil	12953
United Kingdom	38313	India	9159
Canada	18692	China	8586
Australia	18002	South Africa	4637
France	12431	Mexico	3024
Germany	11466	Turkey	2801
Italy	8305	Iran	2726
Spain	8217	Taiwan	2690
Netherlands	7229	Thailand	2167
Switzerland	6889	Nigeria	2059
Total Output	245962	Total output	50802

Note: Cut-off country-wise research production was set on the basis of top ten highest number of literature producer countries.

Hypothesis 6 (*H6*): There is no significant level of relationship between research productivity of developing and developed countries.

In the present study there are two set variables each *i.e.* two independent variables (developing and developed countries) and two dependent variables (production of public health literature of developing and developed countries). The correlation coefficient was used to measure the degree of relationship between two variables, which always varies between -1 and +1. Table 5.18 shows the result of the correlation coefficient between developing countries and developed countries.

Table 5.18: Correlation coefficient of developing and developed countries

	Developed countries	*Developing countries*
Developed Countries	1	
Developing Countries	0.869757973	1

The result of Pearson's correlation is 0.87 which is near to +1 indicating a positive relationship of production of public health literature between developing countries and developed countries. Therefore, the production of developing countries in terms of public health literature is correlated with the production of developed countries.

Table 5.19: Correlation test for significance of correlation

Correlations			
		Developed	Developing
Developed	Pearson Correlation	1	.870**
	Sig. (2-tailed)		.001
	N	10	10
Developing	Pearson Correlation	.870**	1
	Sig. (2-tailed)	.001	
	N	10	10
**. Correlation is significant at the 0.01 level (2-tailed).			

The correlation test was carried out with the help of SPSS, version-24.0 and the correlation is significant at the 0.01 level. Thus our null hypothesis is rejected and there is a significant level of relationship between research productivity of developing countries and the research productivity of developed countries.

CHAPTER SIX

FINDINGS, DISCUSSIONS AND CONCLUSION

6.1 Introduction

The present study was designed with the intention to assess the growth pattern and development of literature on public health in the period 2000-2015. Some special objectives and hypothesis were initially determined to measure this general objective. In the previous chapters an analysis of data on published public health literature identified using Scopus database and the testing of several hypotheses has been presented. This chapter highlights some major findings of this data analysis in relation to the special objectives and the result of the hypotheses testing, together with the suggestions of emerging areas where further research can be done, and concluding remarks.

6.2 Major findings in relation to objectives of the study

6.2.1 Assessment of growth of literature

During the study time period in question (2000-2015), using Scopus database, 3,72,260 documents were identified, 2014 being the most productive year and the year 2000 the least productive.

6.2.1.1 GR and AAGR

The **Growth Ratio (GR) or Rate of Growth (RoG)** meaning the proportional growth of number of volumes in a year compared to the previous year, a value of 1 or more meaning increased growth. During the study period, it was found that growth rate of public health literature was most productive in the years 2001 and 2003 (1.15) and 2015 was the least productive year (0.98).The **AAGR (Average Annual Growth Rate)** meaning the average rate of growth or growth ratio during specific period interval, this study found that the period 2000-2003 had the highest AAGR values (1.11) whereas the period 2012-2015 had the lowest AAGR values (1.05).

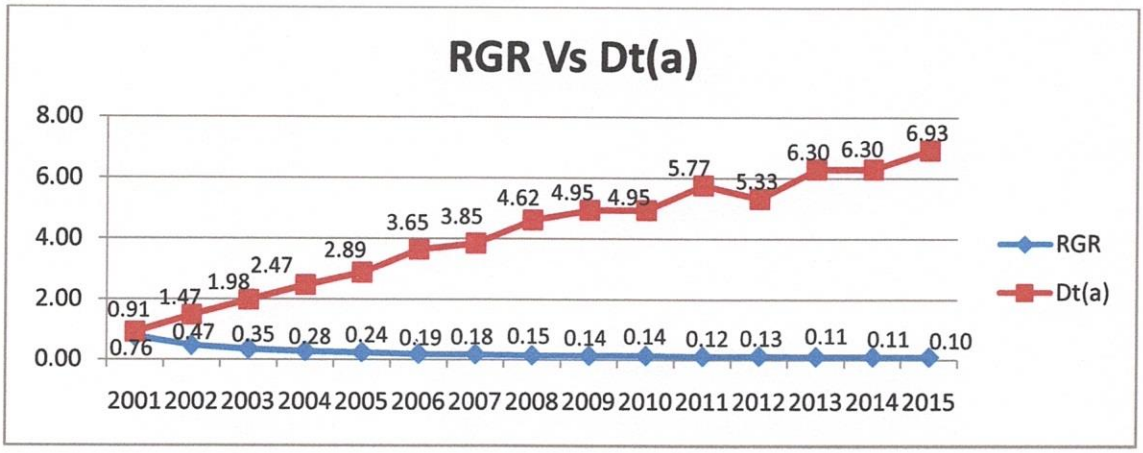
6.2.1.2 RoG and CAGR

There is slight difference between **RoG (Rate of Growth)** and **CAGR (Compound Annual Growth Rate)**. Both is calculated between two values and shows proportional growth rate. The proportion between two equal values is 1. CAGR shows that deviation of value compared with previous year/value based on one either positively or negatively. Anything greater than 1 is treated as a positive value and shows better growth rate than previous value/year and vice versa. As this study found that in 2001 and 2003 RoG values (1.15) were highest, so their CAGR values showed a positive deviation of proportional growth (0.15). On the other hand, as 2015 had the lowest RoG values (0.98), the CAGR value showed negative deviation of proportional growth (-0.02).

6.2.1.3 RGR and Dt

Relative Growth Rate (RGR) usually indicates differences of present year cumulative growth of publication with previous year cumulative growth. It's also called exponential or continuous growth rate. On the other hand doubling time (Dt) means amount of time the number of publication gets double. There is trade-off relation between RGR and Dt(a) values. If RGR value increases Dt(a) value goes down. That means if the RGR of a particular literature for a specific period of time increases, it will definitely take less time to double. Otherwise it will take more time to be doubled. For example 0.10 is the lowest RGR values in 2015 which indicates if the literature increases at the same rate it will take near about 7 years to get doubled. Whereas 0.76 is the highest RGR values represented in 2001, which indicates if it continues at the same rate it will double in less than a year only.

Figure 6.1: Trade-off relationship between RGR and Dt (a)



6.2.1.4 Forecasting

The future growths of literature on public health were predicted using time series analysis. The number of publications in the literature on public health was 11,594 in 2000, which is predicted to grow to 61,902 in 2032.

6.2.2 Identification of authorship pattern, author collaboration and author productivity

Authorship pattern means distribution of publication by single authored paper, two authored paper, three authored paper and so forth. More than half of total authors identified in this survey were collaborative authors (53.35%) although a good number of authors were single authors (44.05%). Only 2.61% of total publications were anonymously written. Author collaboration means combined efforts to bring out publication on a given subject. Author productivity means publication production rate of authors on a given period of time.

6.2.2.1 Collaborative measures

6.2.2.1.1 CI, DC, CC and RCC

Average number of author per paper is called **Collaborative Index or CI.** It can be calculated as total authors on a given subject field/period divided by the total number of publications. As there must be at least one author each on a publication, this means if the result of CI is 1, there is no collaboration of authors on that subject or given period, a result of 2 indicates that there are 2 authors per paper. CI on public health literature ranges from 2.26 (2012) to 1.80 (2007) with an average of 2.04 per paper which implies that research team remains slightly above than 2 in the field of public health.

Degree of collaboration (DC) is the proportional measurement of multi-authored in respect of total publication. The result of DC always lies between 0 and 1, indicating minimum to maximum collaboration. The DC values on public health literature vary from 0.47 to 0.66 with an average of 0.56. There is a moderate degree of collaboration among authors on that subject field.

In **Collaborative Coefficient (CC)** a credit point is shared by the number of authors contributing a single paper. As for example, the author receives a credit point if a paper has single author, authors receive 0.5 credit point if the paper has two authors, and credit point is divided by three for three authors and so on. CC values also lies between 0 and 1, and 0

corresponds to single authorship. CC values on public health literature lie between 0.30 and 0.42 with an average of 0.37 which means there is no significant magnitude of collaboration among the authors during the study period. Normalized version of CC is called **RCC (Revised Collaborative Coefficient)** or **MCC (Modified Collaborative Coefficient)** which can produce exactly 1 if all the authors are co-authors in the collection. In the present study the values of RCC is similar to the values of CC.

6.2.2.1.2 The value of CC and forecasting level of collaboration

The value of CC indicates whether the collaboration between authors on a particular subject in a specified period of time is high or low. CC as a number lies between 0 and 1. After calculating Collaborative Coefficient it can be said that if the value of CC is closer to '1' it means there is high collaboration of authors and when it is closer to '0' indicating a weaker collaboration of authors.

When all the publications of a database are published by a single author then the level of collaboration definitely remains on the single author. If otherwise *i.e.* publications are published by single author, two authors, three authors etc. at the same time, the value of CC doesn't indicate the level of collaboration directly. In simple words, it is not possible to trace out the level of collaborations with the value of CC *i.e.* two authors level of collaboration or three authors level of collaboration and so on. If we find out degree of CC at different levels of collaboration then it is possible to refer to the magnitude of collaboration with CC values. Here are some imaginary instances in finding out values at the levels of different collaboration:

Table 6.1: Degree of collaborative coefficient for level of collaboration: a new proposition

Year	Number of authors										CC values for different levels of collaboration
	2	3	4	5	6	7	8	9	10	100	
1961	15	-	-	-	-	-	-	-	-	-	0.50 (Two Authors)
1962	-	15	-	-	-	-	-	-	-	-	0.67 (Three Authors)
1963	-	-	15	-	-	-	-	-	-	-	0.75 (Four Authors)
1964	-	-	-	15	-	-	-	-	-	-	0.80 (Five Authors)
1965	-	-	-	-	15	-	-	-	-	-	0.83 (Six Authors)
1966	-	-	-	-	-	15	-	-	-	-	0.86 (Seven Authors)
1967	-	-	-	-	-	-	15	-	-	-	0.88 (Eight Authors)
1968	-	-	-	-	-	-	-	15	-	-	0.89 (Nine Authors)
1969	-	-	-	-	-	-	-	-	15	-	0.90 (Ten Authors)
1970	-	-	-	-	-	-	-	-	-	15	0.99 (Hundred Authors)

Note: The value of each cell indicates the frequency of authors under each level of collaboration. All the data in this table is imaginary to find out CC values at different level of collaboration

If the CC value stays between 0< and <0.50, we can assume that during that period maximum authors have two author level of collaboration. Similarly CC values ranges from 0.51 to 0.67 is for three authors collaboration, 0.68-0.75 ranges for four authors collaboration and so forth. This might be interesting area for future researchers. The precondition in finding out CC values for a particular level of collaboration (as for example CC values for two-author level of collaboration) is that all the levels of collaboration (as for example for three-author level, four-author level etc.) should be nil. In the present study the average CC value was 0.36 indicating two-author level of collaboration.

6.2.2.1.3 Inequality of CI, DC and CC

In measuring collaboration, we have used Collaborative Index (CI), Degree of Collaboration (DC), Collaborative Coefficient (CC) and Revised Collaborative Coefficient (RCC). RCC is the modification of the previously given formula Collaborative Coefficient (CC). In measuring collaboration the inequality of CI, DC and CC states that the value of CI is always greater than DC, which is further greater than CI. So we can say easily for same set of values that:

CI > DC > CC

6.2.2.2 Authors' productivity

The average author per paper is called AAPP which is equivalent to CI value and the productivity per author is called PPA which is calculated as the number of publication is divided by number of total authors. The PPA of public health literature ranges between 0.44 and 0.56 with an average of 0.49 which means that public health authors produce less than half a publication each year during the study period in question.

6.2.3 Citation analysis of publications on public health

Among the 3,72,260 publications on public health identified, 2,63,064 publications (70.66%) were cited by others and 1,09,196 papers (29.33%) were never cited during the study period 2000-2015. The number of total citations is 52,93,224 with an average of 16.21 **citations per publication** (CPPtp) and 22.51 **citations per cited publication** (CPPcp).

6.2.3.1 RoG, CAGR, RGR and Dt of cited publications and citations

The average growth rate **(RoG)** of cited publications (1.06) which is positive deviation of proportional growth (0.06) considering **CAGR** value is better than RoG of citation (0.96) which is negative deviation of proportional growth (-0.04) if we consider CAGR value .

RGR values of cited publications ranges between 0.07 and 0.68 with an average of 0.23. The lowest possible **double time** value for cited publication is 1.02 and highest one is 9.90 with an average of 4.31. That means if RGR values remain constant the number of citation get doubled within 4.31 years. RGR values of citation, on the other hand, lies between 0.01 and 0.63 with an average of 0.19. The lowest possible double time value for citation is 1.10 and highest one is 69.30 with an average of 10.47. That means if RGR values remain constant the number of citations get doubled within 10.47 years.

The average RGR value of cited publication (0.23) is greater than the average RGR value of citation (0.19). Therefore, cited publication will take less time (4.31 years) than citation (10.47 years) to get its volume doubled.

6.2.3.2 Highly cited paper and top author on public health

'Global cancer statistics' produced by Mr. Jemal *et al.* which was published in 2011 was found to have the highest number of citations (18,405). Of total highly cited publications, 70.80% belongs to the citation range of 500 ≥ 1000 and 54% of these were of research articles.

Mr. McKee has the highest number of publications on public health (292). His citations number (25,895) and the number of cited publication (18,024) are also greater than other top authors on public health. Based on **Average Citation Per Cited Paper (ACPCP)** he is 2nd in ranking and 4th in the case of **Average Citation Per Paper (ACPP)**. His h-index is 75 and g-index is 132 which make him number one in index ranking.

6.2.3.2.1 Average Citation Per Cited Paper (ACPCP): A new proposition

For analyzing author's cited publication ACPP (Average Citation Per Paper) is commonly used all over the world. This is important to trace out the number of cited publication out of author's all publications. But the problem arises when a document cites the same author's more than one publication; the conventional indicator doesn't measure that. To overcome from this situation ACPCP (Average Citation Per Cited Paper) has been proposed to assess an author's multiple cited rate by single publication.

More citations received by cited document from more than one publication of an author (source author) is called Average Citation Per Cited Paper (ACPCP). For calculating ACPCP the following formula was proposed by the present researcher:

$$\text{ACPCP} = \frac{Total\ number\ of\ citations\ received\ by\ a\ researcher}{Total\ number\ of\ cited\ publications\ acknowledge\ to\ the\ source\ author}$$

Table 6.2: ACPCP

Authors	Citations	Cited Document	ACPCP
McKee, M.	25895	18024	1.44
Bateman, C.	513	436	1.18
Gostin, L.O.	7642	6046	1.26
Tsugane, S.	19733	14908	1.32

Average Citation Per Cited Publication (ACPCP) means the citations rate for publications of an author from cited publications point of view. The result of ACPCP could be interpreted as follows:

If **ACPCP =1,** the author of cited publication use citation from only one publication of same source author;

If **ACPCP >1,** the author of cited publication use more citation from more than one publication of same source author.

6.2.4 Assessment of literature using various parameters and laws

Of the total publications studied, 64.22% are of the document type research articles and 93.91% of the total publications were written for publications in journals. Approximately 50% of the total publications were written on medicine and the majority (89.22%) was written in English. USA is the country with the single highest production of maximum publications (31.27%). The authors affiliated with 'Centers for Disease Control and Prevention' of USA produced maximum papers on public health (1.20%). The contributions of Bangladeshi authors are only 0.23% to the world's public health literature publications.

Based on major contributions Lancet (0.88%), American Journal of Public Health (0.87%), and Plos One (0.84%) are the top three journals on public health. According to Bradford's law, out of 160 journals, 19 journals on public health are producing one-third of the total articles.

These 19 journals can be treated as core journals of public health subject. According to Zipf's law, the top most occurrence keywords are Human, Article and Public Health etc.

6.2.5 Extent of research on public health in Bangladesh

871 publications (0.23%) counted as publications of Bangladeshi authors out of 3,72,260 documents during the period 2000-2015, 2015 being the most productive year (15.27%) and 2001 the least productive year (1.15%) in terms of number of publications.

6.2.5.1 RoG, CAGR, AAGR, RGR, D(t)

The average Rate of Growth (RoG) of Bangladeshi productions was 1.20 with average CAGR of 0.20. 2004-2007 was the highest block of years in terms of AAGR. During the period 2001-2015, RGR values of Bangladeshi contributions on public health literature varied from 0.16 to 0.55 with an average RGR value of 0.27. Dt(a) values, on the other hand, also varied from 1.26 to 4.33 with an average Dt(a) values of 3.00. That means the literature of public health by Bangladeshi authors with a 0.27 growth rate would have a doubling time of 3 years.

6.2.5.2 Authorship pattern

More than 68% of the total Bangladeshi productions have more than three authors per paper whilst near about 8% papers are single authored papers. In fact more than 92% of total publications produced by Bangladeshi authors are collaborated works dominating single author works.

6.2.5.3 Collaborative index

The CI values were found to range from 2.59 to 3.61 with an average of 3.28 which means there are 3.28 Bangladeshi authors per paper. The average DC value is 0.88 which indicates the proportion of multi authored paper is greater than single authored paper. The mean value of CC is 0.62 which indicates the better collaboration among Bangladeshi authors. Some variations of values have been observed between RCC (normalized version of CC) and CC as the number of literature of Bangladeshi authors is quite smaller than public health literature in general.

6.2.5.4 Productivity Index for Bangladeshi research output

The AAPP which is equivalent to CI values for all the years was more than 2.5 that means there are 2.5 Bangladeshi authors per paper. The PPA values ranges from 0.28 to 0.39 with an average of 0.31, which means every author produce less than half of a publication each year

during the study period. From 2009 to 2015 the research efforts of Bangladeshi authors were higher than world's research efforts. The Activity Index (AI) was maximum in 2015 (490.28) and the lowest in 2001 (12.06).

6.2.5.5 Lotka's law of productivity

Lotka's inverse square law indicates the number of authors publishing a certain number of articles is a fixed ratio to the number of authors publishing a single article. That ratio is out of all the authors in a given field, 60% will just have one publication, and 15% will have two publications each (¼), 7% authors will have three publications each (1/9), and so on. Of the 658 unique Bangladeshi authors' names, 408 (62.01%) had produced one article, 123 (18.69%) had produced two articles, 48 (7.29%) had produced three articles, which is a similar finding to Lotka's law of productivity.

6.2.5.6 Citation analysis

Out of 871 publications produced by Bangladeshi authors, 743 publications received citations and 128 publications (14.70%) did not. 2014 was most productive year in terms of number of citations received (101). 743 cited publications achieved 17063 citations during 2000 to 2015 with an average of more than 1066 citation per year. Citation per Paper (CPP) can be calculated both in terms of Cited Publication and Total publication. The average CPP (CP) is 31.66 all the period round for Bangladeshi authors.

6.2.5.6.1 RoG, CAGR, RGR and Dt of cited publication and citation

The average RoG of total cited publications for Bangladeshi research output is 1.23 with an average CAGR of 0.23. The average RoG of total citation is 1.26 with an average CAGR of 0.26. The average RGR for cited publication is 0.26 which means 3.09 years will be required to get cited publication doubled. It would take 5.98 years for citation to be doubled with a constant growth rate of 0.16.

6.2.5.6.2 Highest citation and top authors

The paper of Rahman et.al entitled "Contamination of drinking-water by arsenic in Bangladesh: A public health emergency" published in 'Bulletin of the World Health Organization' in 2000 received the highest number of citations (1019) among the top cited Bangladeshi authors on public health. On the basis of the highest number of publication on public health Mr. Yunus was placed first in the ranking among Bangladeshi authors. Mr. Ahsan was placed first rank based on citation and cited document, and h-index (62) and g-index (101)

of Ahsan were the highest than others. Mr. Noor was first rank based on ACPCP. Mr. Rahman stood first in ranking based on ACPP.

6.2.5.7 World's contribution vs. Bangladeshi contributions on PH literature

A comparative analysis of contributions between researchers of world and researchers of Bangladesh on public health has nicely been depicted through Table 6.3.

Table 6.3: Comparison between World researchers and Bangladeshi Researchers

Indicators	World's contributions	Bangladeshi contributions
Number of literature on PH	3,71,389	871 (0.23% contributions to the world)
Author's productivity (based on Average PPA)	0.49	0.31
Percentage of cited Document	70.66%	85.30%
Activity Index (Average AI)	100	137.32
Index of top author (h-index & g-index)	75 & 132	62 & 101
World growth (RoG & RGR)	1.08 & 0.23	1.20 & 0.27
Double time (dt)	4.16	3.00
Percentage of collaboration among authors (CC values in bracket)	53.35% (0.37)	92.19% (0.62)

The researchers or authors of Bangladesh made a 0.23% contribution to the world on public health literature. Author's productivity of world's researchers based on Productivity Per Author (PPA) is slightly greater than the productivity of Bangladeshi authors (0.31). The number of cited documents acknowledged in the world's literature on public health is lower than cited documents of Bangladeshi literature (85.30%). During the period 2000-2015 the average Bangladeshi research output was better than world's average (137.32). The h-index and g-index of Bangladeshi top author on public health (62 & 101) is near the indices of world's top author. The average double time value of world's literature is nearly equal to the double time value of Bangladeshi literature on public health (3.00). The collaborated rate of Bangladeshi researchers (92.19%) is far greater than the collaborative rate of world's researchers.

6.3 Major findings in relation to hypothesis of the study

In accordance with the objectives of the study, the following hypotheses have been formulated and tested later on:

H1: There is no relationship between progress of year and growth of literature on public health.

Result: The result of "t-test" showed that there is significant relationship between the years' progress with the growth of literature ($p<0.01$). The null hypothesis (*H1*) was therefore rejected during this study period.

H2: There is no mean-relationship between existing growth of literature and expected future growth of literature on public health.

Result: The result of "t-test" showed that there is significant relationship of mean between existing growth of literature and expected future growth of literature on public health ($p<0.01$). The null hypothesis (*H2*) was therefore rejected during this study period.

H3: There is no association between the collaboration of author and research productivity.

Result: In this case p-value is significantly less than 0.01 which means the regression coefficient is statistically significant. Therefore author productivity is influenced by the collaboration of authors and there is strong positive correlation between authors' collaboration and authors' productivity and our null hypothesis (h3) is therefore rejected during the present study.

H4: Research productivity of public health in Bangladesh does not conform to Lotka's inverse law of author productivity.

Result: In this case t-test was carried out. The result shows that regression coefficient is statistically significant. Therefore we can conclude that the research productivity of public health in Bangladesh conforms to Lotka's inverse law of author productivity and the null hypothesis (H4) is therefore rejected.

H5: There is no mean-relationship between public health research performances of Bangladeshi researchers and the researchers of other countries.

Result: In this case null hypothesis was tested using t-test. As the p-value is much lower than 0.01 there exists a strong positive mean relation between public health research performances of Bangladeshi researchers and the researchers of other countries and the null hypothesis (H5) is therefore rejected.

H6: There is no significant level of relationship between research productivity of developing and developed countries.

Result: The correlation test showed that correlation is significant at the 0.01 level. Thus our null hypothesis is rejected and there is significant level of relation between the research productivity of developing countries and the research productivity of developed countries.

During the scope of this research, several hypotheses were formulated in relation to the main objectives, and these were tested using appropriate statistical tools. It was interesting to note that all null hypothesis have been rejected, giving compelling evidence to follow throughout and accept alternative hypotheses.

6.4 Research outputs

The present research can potentially contribute in the society to a larger extent. The various sectors of the society that may directly or indirectly benefit through the present research, including:

- To identify core journals on public health field;
- To assist the librarian in subscribing to important journals of public health;
- To assist the researchers in selecting journals for publishing their articles;
- To inform the researchers on contemporary research works on public health;
- To examine the works of researchers on public health;
- To identify important research area and most prominent researchers of the world.

6.5 Directions for future study

The findings of this research have suggested following few areas where further research can be conducted:

- Mapping of scholarly literature in public health
- Qualitative analysis of literature published in public health

- Comparative study on public health literature using different database as for example, Web Of Science (WoS), Scopus etc
- Extent and pattern of collaborative research and productivity of authors among different countries on public health literature
- Public health literature among SAARC countries
- Citation analysis of public health literature
- Value and significance of collaborative measurement score.

6.6 Conclusion

The terms Scientometrics and bibliometrics study have their root in library and information science subject and these techniques are utilized to assess the development of a subject quantitatively and qualitatively. The question remains whether or not scientometrics/bibliometrics techniques, which belong to parent subject "Library and Information Science", are actually being used in library and information centers to facilitate policy making and the making of managerial decisions. The answer is quite depressing as librarians, especially of the Indian subcontinent, irrespective of different types of library in which they work, do not usually include bibliometric/scientometric techniques in their practical work. The reasons for this lack of practice of these techniques amongst library professionals are manifold, including

i) A time consuming processes as effort is needed to update many variables on a day to day basis;
ii) A complex task-work due to ever expanding growth of literature;
iii) Labor intensive as efforts are needed to inform the outcome of the analysis to academic community to which they supposed to serve;
iv) Complicated task as data set is big which is difficult to put together and compare.

To promote the increase in usage of these techniques, the basic objective of the present thesis was to evaluate the growth and development of the global literature on public health has been assessed through this research using various scientometrics indicators and bibliometrics laws. Public health literature were extracted from Scopus database and assessed both qualitatively and quantitatively during the period of 2000-2015. Various popular and tested scientometric indicators and fundamental laws of bibliometric were employed to analyse the result globally and when appropriate for Bangladesh only. The assessment of public health literature with the help of these indicators and laws could be very useful to researchers,

scientists, library and information professionals, policy makers, and government agency relating to the concerned fields. It was observed that there is an increasing trend of public health literature during the period under study. In the case of relative growth rate the increment trend of public health literature is downward and at the same time a reverse trend has been observed in the case of dt(a) values globally. There is a trade-off relation between RGR and Dt values being observed. Future growth of public health literature has also been calculated using simple linear trend.

In the present thesis it was found that a majority of works were published by collaborated authors, which lends force to the power of synergistic efforts. Author's collaboration was assessed using several measurements of collaboration. The forecasting level of collaboration by each CC (Collaborative Coefficient) value is the important findings of the present thesis. The present research sought to determine the level of collaboration by a CC value which was never been calculated previously. More mathematical and statistical formulation is required for its sound establishment. It was observed that inequality remains in the values of different measurements of collaboration. In our present study, the value of CI (Collaborative Index) was greater than DC (Degree of Collaboration) which was further greater than CC (Collaborative Coefficient) values although all of these indicators were used in measuring authors' collaboration from same data set. Across all of these indicators, the collaboration rate for Bangladeshi researchers was greater by comparison to a general global authors' collaborated rate, implying that Bangladeshi authors feels more interested to work together than global authors.

Authors' productivity on public health literature was less than half a publication each year globally. In the case of Bangladeshi authors the average authors' productivity was below the world's average. The Activity Index (AI) for Bangladeshi authors was quite impressive nonetheless. This is actually higher than world's research efforts.

The percentage rate of cited documents and the CPP (Citation Per Paper) for global authors is below the rate of Bangladeshi authors. To assess an author's multiple citations rate by single publication ACPCP (Average Citation Per Cited Paper) has been proposed. This is important in the case of measuring the importance of publications of an author by the single publication of others. The most prolific authors globally from Bangladesh in the field of public health were also examined using different indices including h-index, and g-index, etc.

Public health literature was also assessed using several parameters, including document type-wise distribution, country-wise distribution, subject-wise distribution, most prolific institutions etc. Several bibliometrics laws including Lotka's law of productivity, Bradford's law of scattering and Zipf's law of word occurrence have also been tested across the literature of public health. It was found that research productivity of public health by Bangladeshi authors conformed to Lotka's inverse law and Bradford's law of scattering fitted to the data of public health journals globally. It was also observed that Zipf's law approximated the relationship between rank and frequency of keywords of public health.

The assessment of public health literature with the help of scientometric indicators and bibliometric laws could be very useful to researchers, scientists, library and information professionals, policy makers, and government agency relating to the concerned fields.

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