CHAPTER V
FINDINGS AND CONCLUSION

5.0 INTRODUCTION

Gene Therapy forms a significant area of medical and biotechnological research supplemented by genome and stem cells research. Genome projects could be completed by 2003, a few years earlier to the targeted time due to the advances in Information Communications Technology and research tools development. Gene Therapy research is sure to benefit human race in the context of genetic diseases and their treatment which is potentially remains without any alternative. The present study is a bibliometric analysis of Gene Therapy research. The bibliographic records were obtained from PubMed – an international online database, open source published by the National Library of Medicine (USA). After data cleaning process of the captured data, the study arrived at a sum total of 1,28,854 publications authored altogether by 8,03,172 drawn from 78 countries publishing in 8443 journals. The bibliometric analysis, fulfilling the objectives of the study by means of the formulation of a set of appropriate hypotheses and their testing with suitable bibliometric laws and statistical tools, reveals a spectrum of findings.
5.1 WORLD SCIENTIFIC RESEARCH OUTPUT AND SHARE OF GENE THERAPY RESEARCH

The literature output share of Gene Therapy research is compared to the sum total of global literature output in entire Science and Technology fields covered by PubMed. The data for both global research output for the entire S&T fields and Gene Therapy field are obtained on an annual basis for the entire period covered in the present study. There has been an overall growth in the world scientific literature output in Gene Therapy though the trend of growth does not display a continuity and hence lacks uniformity in the growth rate. The share of Gene Therapy research ranges from 0.524 per cent of total world scientific research to a maximum of 0.533 per cent. The correlation coefficient of world scientific output and the Gene Therapy research output is 0.98 showing that there is positive and strong relation between world scientific research and Gene Therapy research.

5.1.1 Annual Output: Growth rate and related facets

It is found that there has been a steady growth in Gene Therapy research in between 2004 and 2013. In 2013, the growth witnessed a depression with a figure lower than that of the previous year i.e 2012. Otherwise the annual output for each of the years covered under the study maintains up. It is noticed that the research output figures for all the years under study, except that of the year 2013, registered a steady growth through out, though not uniformly during the period of
coverage. The overall average annual growth rate for the whole period of 10 years under study is found to be 0.62 per cent which is less than 1.0 per cent. However, it is found that the growth rate has reached a maximum level of 1.14 during the year during 2010. For all the 10 years period covered under the present study, the PubMed was found to have indexed a sum total of 12,8854 publications on Gene Therapy research. A time series analysis is undertaken to study the future projections of the probable growth or decline in the quantum of publications in Gene Therapy research by means of statistical applications.

5.2 AUTHORSHIP PATTERN AND RELATED TRENDS

The authorship pattern in Gene Therapy research ranges from single authored publications to a maximum of 412 authors in a single publication. A majority among the publications are found to be the result of joint authorship. Nearly one third of the papers are found to have been published by two authors (joint authorship). Here it is interesting to note that, when the number of authors per publication exceeds 2, the publication count is found to be on the decline. It can be inferred that, the number of authors and the number of publication counts are in reverse proportion. The graphical representation of the authorship pattern shows an increasing trend upto two authors and then decreasing trend. This is an indication that the optimum number
of authors per paper in the subject Gene Therapy research is found to be 2.

In terms of quantitative output, the trend of authorship pattern in Gene Therapy research shows interesting results. The category of single authored publications are found to have been at its peak during the year 2005 and found to be low in 2013. During the 10 years period covered under the study, it is observed that the category of single authored publications suffered fluctuations with ups and downs quantitatively. Similarly, joint authored publications suffered fluctuations with ups and downs quantitatively. However, joint authored publications reached its peak during 2012 while the category of multiple authorship has increased to nearly two folds. This supports the fact that scientific research is collaborative in nature.

In the context of joint authorship and collaborative publications, the results of the statistical projection for the 2016 and 2020 reveal a probable growth. Regarding the per capita authorship it is found that there is an increase in the per capita authorship from the year 2004 to 2013. The per capita authorship is at its minimum in the year 2004 (5.26) and at a maximum in the year 2011 (7.12). That is, the overall average number of authors per paper is found to be 6.23. Regarding the collaboration index, A dominating trend in the authorship pattern, that has come up is the Collaborative scientific effort in producing scientific papers. Collaboration among scientists leads to the
development of scientific works and the achievement of relevant, accurate results. Collaborative publications symbolize quality. The evidences show the importance of quality and even quantity of scientific papers produced in collaboration. In 1980, Lawani introduced collaboration index (CI) as the average number of authors per article. In the present study, the collaboration index ranges from 5.92 to 7.51 showing that the average number of authors per paper is 7.

Regarding collaborative trend, collaborative trend is becoming the order of the day beyond geographical and subject boundaries. The degree of collaboration in publishing pattern of Gene Therapy varies from 0.87 to 0.94. The Degree of Collaboration is maximum in the year 2011, 2012 and 2013 showing that collaborative research will replace solo research.

Authors who contributed to Gene Therapy research are arranged according to their total publication count. Table 4.24 shows the list of most prolific authors. The author with highest publication count is Zhang, Wei from China. The second leading author is Curiel, David T and the third ranked author is Wang, Wei from China. Here it is interesting to note that the most prolific authors are from China.

Williams, David A has published the highest number of papers followed by Kim.
In the context of author productivity and Lotka’s law, the results obtained in this study do not follow the inverse square power law of Lotka as such.

5.3 GEOGRAPHICAL DISTRIBUTION OF PLACE OF PUBLICATION

Gene Therapy research literature output is found to have been contributed by scholars from 78 countries of the world among which USA takes the lead forming a little less than half (43.05%) of the total output. The second leading country is England (24.67%) followed by Netherlands (8.17%). Germany is in the 4th place while Japan is in the 5th. China has contributed 2.76 per cent of the total world output while India has contributed .32 per cent of the total output. It is noted that nearly 75 per cent of the total research output has been contributed by countries forming .5 per cent of the total of 78 countries involved.

5.4 JOURNALS: PUBLISHING DESTINATION: VARIOUS REGIONS

Undoubtedly, among the universe of publications, USA and England take the lead attracting a heavy number from scholars distributed all over the world. Scholars irrespective of identified 7 regions flock the journals from the above two nations instead a natural trend of choosing journals of their native origin. Scholars from European regions are no exception to this trend running towards USA and England. One striking feature found among the European scholars is that they do not go out to any other region for publishing their
research out other than journals from USA, UK and journals of European region. Seldom they are found to resort to journals of Asian origin unless collaborating with scholars in that region. Native journals in their case rank third or fourth only in the ranked list of journals of preference.

5.4.1 Core Journals in Gene Therapy - Human

The research reports in the subject Gene Therapy are published in 8443 journals of which the core journals are 30 in number. The journals are arranged according to the specified order prescribed in Bradford’s law grouping them into three zones of equal number of publication counts. Publications count though divided into three zones of equal in number, the number of journals which published the papers vary. Bradfords law is applied to the three zones. The three zones are in the ratio which is not in conformity to the Bradford’s formula $1:n:n^2$. In the present study 80% of the total contributions in Gene Therapy i.e 36420 research papers are found to have been published in 224 journals which is nearly 25 per cent of the total journals. Hence the publication pattern of Gene Therapy does not coincide with Pareto’s Principle.

5.4.2 Length of Publications (Number of Pages)

From Single page editorial to a maximum of 7 pages, as the number of pages per article increases the publication count also increases. From 9 paged paper to more than 50 pages report, as the
number of pages per publication increases, the number of publication decreases. This shows that the optimum number of pages in a research paper with respect to the subject Gene Therapy is 8.

5.5 GDP OF NATIONS AND THEIR RESEARCH OUTPUT

The correlation coefficient is 0.916 showing that the research productivity of a country with specific reference to Gene Therapy is proportionate with the GDP of that country.

5.6 HYPOTHESES: TEST RESULTS

H1: Scientists mostly prefer to publish their contributions in journals published from developed countries; The hypothesis proved positive.

H2: Collaborative research output in Gene Therapy is dominant over that of individual (solo) research; The hypothesis proved positive.

H3: The scientific productivity of scientists in Gene Therapy research, is in conformity to the Lotka’s inverse square law of scientific productivity. The hypothesis proved negative.

H4: The results of the present study conforms to Bradford’s Law of scattering. The hypothesis proved negative.

H5: The result of the study is in conformity to Price’s fundamental Law of Science. The hypothesis proved positive.
H6: The results of the study attest that of the Pareto's 80 x 20 principle. i.e., of the total countries participating in Gene Therapy research productivity, 20 per cent produces 80 per cent of the total Gene Therapy research publications during the period of 10 years under observation/study. The hypothesis proved negative.

5.7 CONCLUSION

The work presented in this report is a bibliometric analysis of Gene Therapy research from a global perspective. The objectives of the study were fulfilled through data analysis and testing the formulated set of hypothesis. Among the Asian countries, China leads with a higher rate of contributions while India lags behind. Regarding Journal productivity, USA and UK lead in launching journal articles irrespective of the countries of affiliation of the authors. Review of literature reveals a fact, in the view of the guide as well as the investigator, that biomedical literature is one of the fields that produce highly cited articles known as citation classics. Prolific authors are from China. Multiple authorship is the dominating trend though solo research is not in an appalling status.

Though statistical application based projections show an increasing trend in the research output, there was a fall in the year 2013 when articles focusing ethical issues related to Gene Therapy applications. In all the projections speculating statistically the future
growth, the investigator was cautious in adding a phrase “other things being equal” which indicates the fluctuations in social, political, economic and such other environmental factors. Numbers of the retrospective period is one of the main factors but beyond that are many more factors to be considered for predicting the future. Statistical projections regarding future growth can be suggestive only. Gene Therapy, when progresses beyond many hurdles can bring a happy life to the human race as matching therapy is yet to be found for genetic diseases. Bibliometrically speaking, Gene Therapy research has been on a successful march.

5.8 SUGGESTIONS

As a woman, the present investigator is concerned with the heaviness of the Matilda effect not only in setting aside citations of women’s work but also not giving due recognition by the indexing databases. Studies related to gender bias and disparity in research output have been on the discussion since long. The main hurdle for undertaking such studies with an intention of contributing solutions is remote as databases mostly do not provide an ID to women contributors while indexing the publications. Studies to include women identity universally in databases may be undertaken. Recent work has brought to light so many cases, historical and contemporary, of women scientists who have been ignored, denied credit or otherwise dropped from sight that a sex-linked phenomenon seems to exist, as has been
documented to be the case in fields, such as medicine, art history and literary criticism. Though Matthew and Matilda effect have been proposed and discussed so far as separate issues, a lady author from New York has combined both in a single title of her publication while discussing the gender bias.

According to Margaret W. Rossiter\textsuperscript{162} (1993) from Cornell University, New York expressed her concern in her publication thus: Since this systematic bias in scientific information and recognition practices fits the second half of Matthew 13:12 in the Bible, which refers to the under-recognition accorded to those who have little to start with, it is suggested that sociologists of science and knowledge can add to the 'Matthew Effect', made famous by Robert K. Merton in 1968, the 'Matilda Effect', named for the American suffragist and feminist critic Matilda J. Gage of New York, who in the late nineteenth century both experienced and articulated this phenomenon. Calling attention to her and this age-old tendency may prod future scholars to include other such 'Matildas' and thus to write a better, because more comprehensive, history and sociology of science. More studies may be undertaken not only to highlight the issue but also for suggestions.

\textsuperscript{162} Rossiter, Margaret W. (1993), The Matthew Matilda effect in science. \textit{Social Studies of Science}, 23 (2), pp.325-341
while Gene Therapy addresses many genetic diseases like cancer, Tuberculosis and so an. Literature in Gene Therapy on each of the genetic diseases may be taken up individually for analysis.

The strength of Literature speaking the ethical issues raised against Gene Therapy itself may be taken up and subjected to a bibliometric evaluation. This will help the mapping of the author clusters their religious and regional affiliation and their extent of a check they have introduced as commercialization of Gene Therapy has already been brought to a slowing down the enthusiasm of the researching spirit of the scholar community. This could have been one of the reasons for the fall in the quantum of research literature output in Gene Therapy in the year 2013. This one year data is not sufficient enough to arrive at a conclusion. As such, the hypothetical thinking regarding the gene therapy research decline need to be considered with other environmental factors such as social, political, economic and cultural.

However, the fall in Gene Therapy research output coincides with its failure to produce commercial turn over in the views of certain studies related to technology life cycle. In the view of Ledley et al., 163 (2014), “Biotechnology industry, has a dual mission of developing products from advances in basic sciences and generating capital

growth to provide investors a positive return of their investments. Despite the enormous progress and promise of biomedical science, the biotechnology industry has largely failed to produce either a robust pipeline of new biopharmaceutical product\textsuperscript{164,165} or sustained economic returns.\textsuperscript{166} They all also opine that sufficient bibliometric studies should be undertaken to study the status of the life cycle of the concept of Gene Therapy – a vital component of the field Biomedical Sciences.

