

# A Bibliometric Analysis and Visualisation of Research Trends in Nanomedicine

Divya Singhal

Department of BIOTECHNOLOGY, Chandigarh University, Mohali-140413, Punjab, India  
*Email:divya.e9399@cumail.in*

## Abstract

Nanotechnology had been a breakthrough in material engineering and it opened Nanotechnology into the pharmaceutical and medical sectors. The bibliometric analysis had been conducted to understand the active authors, organizations, journals, and countries involved in the research domain of “Nanomedicine”. All published articles related to “Nanomedicine” from “Scopus”, were analyzed using the VOS viewer to develop analysis tables and visualization maps. This article had set the objective to consolidate the scientific literature regarding “Nanomedicine” and also to find out the trends related to the same. The most active journal in this research domain was the International Journal of Nanomedicine. The most active country was the United States of America. The leading organizations engaged in the research regarding Nanomedicine was Brigham and Women's Hospital of the United States of America. The most active authors who had made valuable contributions related to pacemaker batteries were Wang Y and Serhan C N.

**Keywords:** Nanomedicine, Material engineering, Bibliometric analysis, VOS viewer,

## INTRODUCTION

Even though discussions regarding Nanotechnology had started in 1970, Nanomedicine is a relatively new branch of science [1]. Nanotechnology had been a breakthrough in material engineering [2]–[6] and it opened Nanotechnology into the pharmaceutical and medical sectors. The innovations of material engineering through Nanotechnology are used in the development of Nanoparticles, Nanozymes, Nanosensors, Nano colloids, Nanoemulsions, Nano Capsules, and Nanopharmaceuticals. The new and smart treatment is possible through the development of Nanostructures and medicines by manipulating atoms and molecules. The major applications of Nanomedicines are in detection, diagnostics, monitoring, and therapeutics [7][8].

Nanomedicine has been defined as the monitoring, repair, construction, and control of human biological systems at the molecular level using engineered Nanodevices and nanostructures [9]. The application of Nanotechnology for screening, diagnosis, and treatment is collectively known as “Nanomedicine”. Nanomedicines are more personalized in nature and a blend of refined concepts of molecular medicine, integrating genomics and proteomics. Generally, the application of Nanomedicine can be classified into three categories of analytical/diagnostic tools, drug delivery, and regenerative medicine [9][10][11]. Nanotechnology is used in, antibacterial treatments, wound treatment, cell repair through Nanorobots, and many more. Similarly, Nanotechnology is used in the treatment of COVID19, by using nanoparticles, Nanofibres, Nanocrystals; Nanotechnology for heart diseases [12]; Nanotechnology for cancer treatment by using Nanoparticles for drug delivery system [13][12]; The developments in Nanomedicine help treat the neurodegenerative diseases like Parkinson's disease and Alzheimer's disease. Similarly, Nanotechnology and Nanomedicines are applied in operative

dentistry, in ophthalmology, in surgery, tissue engineering, antibiotic resistance and immune responses [14].

The major challenges associated with the development of Nanomedicine are related to controlling the manufacturing process by strictly ensuring quality and safety. Biocompatibility and Nano toxicological effects should also be considered while developing Nanomedicines[15]. There is a strong association between Nanotechnology, Nanomedicines, and Nanotoxicology[16].

This bibliometric analysis will be a useful platform for future researchers by realizing the top researchers, organizations, and countries involved in research regarding Nanomedicines. This article is arranged into four sections. The first section is the introduction, followed by the discussion of the methodology by which the research was conducted. The third section deals with results and discussion. The fourth section deals with the conclusion. The following research objectives and research questions were framed for conducting bibliometric analysis systematically.

### 1.1 Research Objectives

- a) To consolidate the literature regarding Nanomedicine
- b) To find out the trends related to research in Nanomedicine

### 1.2 Research Questions

- a) Who are the active researchers working on Nanomedicine?
- b) Which are the main organizations and countries working on Nanomedicine?
- c) Which are the main journals related to Nanomedicine?

## RESEARCH METHODOLOGY

Scopus files had been used for this article. For the article selection, the Boolean used was TITLE (Nanomedicine) on 17/01/2021. All the tables in this paper were created by using Microsoft Excel and VOS Viewer. Grammarly was used for spelling and grammar checks. Mendeley was used for article review and citation. This paper had been inspired by bibliometric analysis in its presentation style, analysis, and methodology from the works [17]–[23].

## RESULTS AND DISCUSSION

### 1.1 Results

This first round of search produced an outcome of 165 documents, in seven languages, out of which 150 documents were in English. The classification of document categories is shown in Figure 1. For improving the quality of the analysis, we had selected only the peer-reviewed articles and all other documents had not been considered. Thus after using filters “Article” and “English” the second round search produced an outcome of 50 English articles (both open access and others) and had been used to conduct bibliometric analysis and visualization using VOS Viewer. The English research articles in this domain since 2006 had been shown in Figure 2.

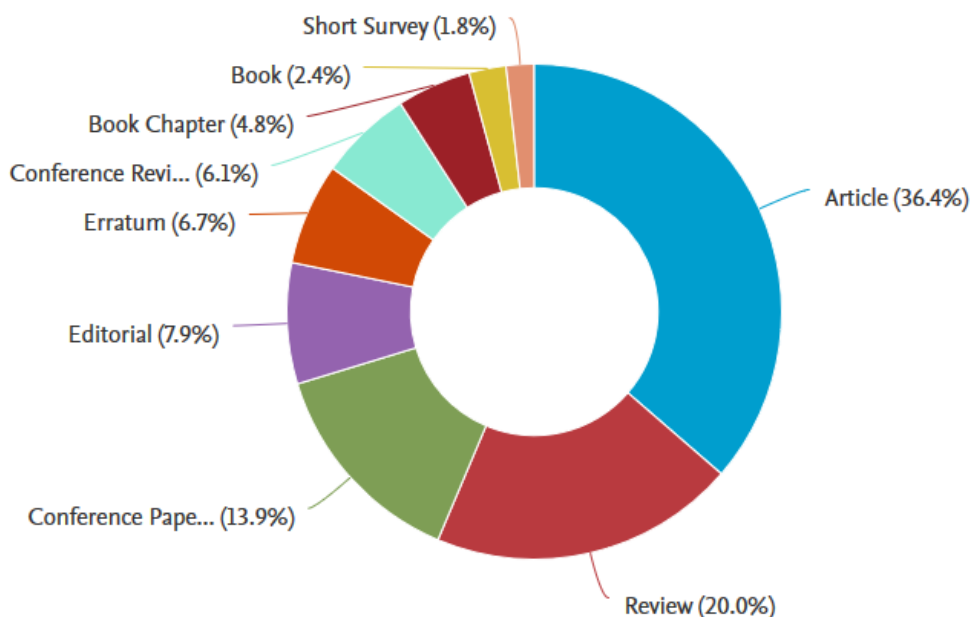


Figure 1: Classification of the documents on “Nanomedicine”, Source: [www.scopus.com](http://www.scopus.com)

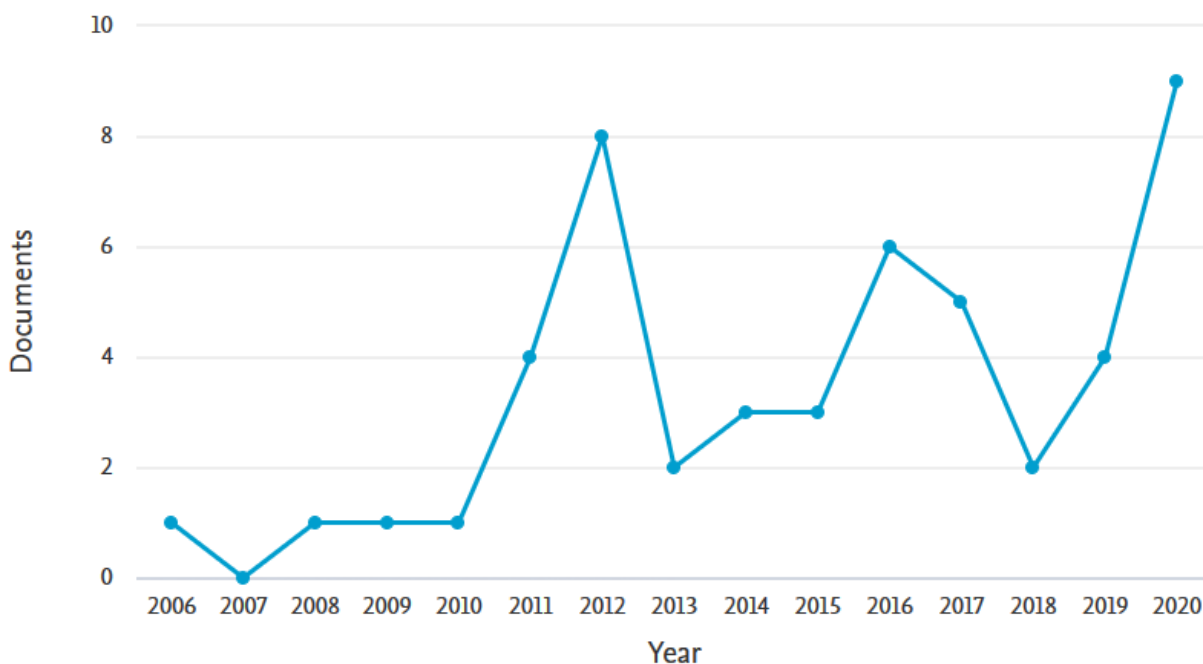


Figure 2: Period wise publication of articles, Source: [WWW.scopus.com](http://WWW.scopus.com)

Co-authorship analysis of top authors had been shown in figure 3. For a better presentation of the analysis, the parameters used were the minimum number of documents of an author as two and the minimum number of citations of authors as one. This combination plotted the map of 10 authors, in four clusters. The overlay visualization map of co-authorship analysis plotted in Figure 3, points out the major researchers with their strong co-authorship linkages and clusters involved.

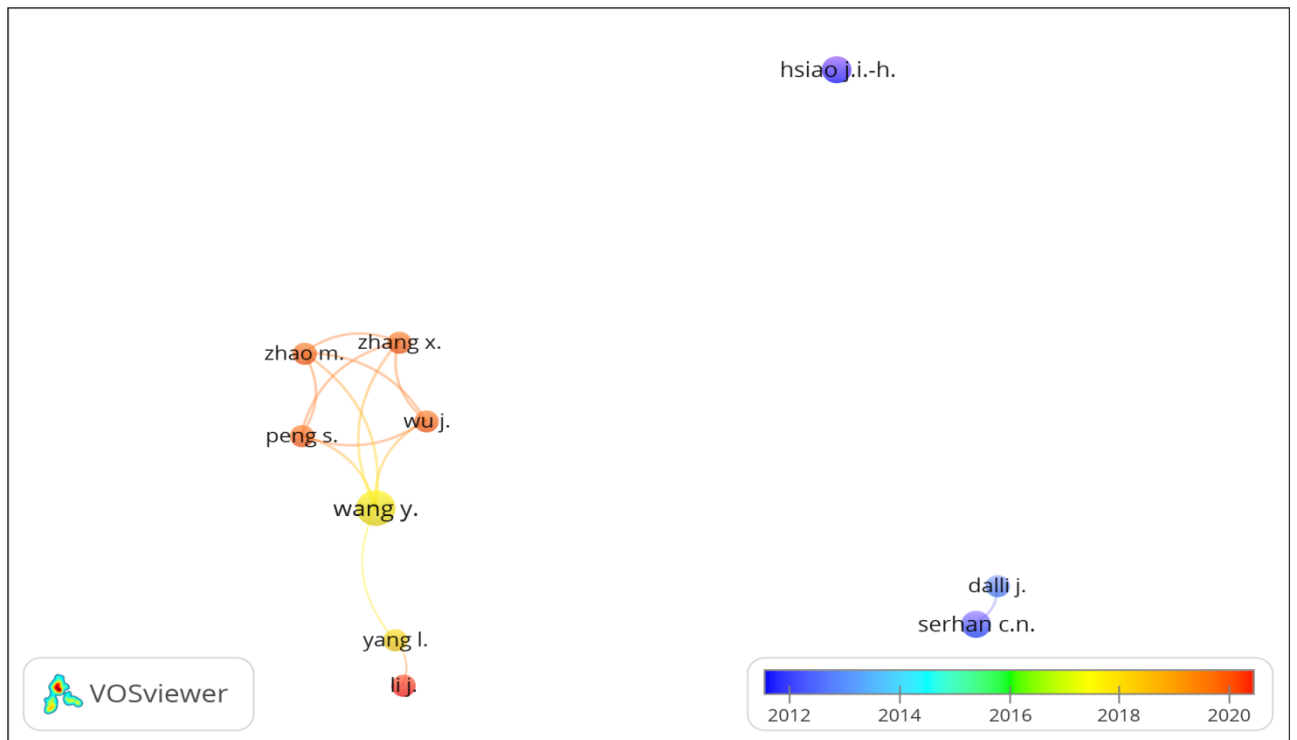


Figure 3: Co-authorship analysis on basis of authors

The citation analysis of top authors had been shown in table 1, along with co-authorship links. For the citation analysis, the parameters used were the minimum number of documents of an author as one and the minimum citations of an author as one.

Table 1: Highlights of most active authors

Description	Authors	Documents	Citations	Average citations per documents	Link strength
Authors with the highest publication and co-authorship links	Wang Y	5	73	14.6	22
Authors with the highest citations	Serhan C.N	3	251	83.6	14

In Co-occurrence analysis, we had used all keyword analyses, by keeping the minimum number of occurrences of a keyword as 5. This combination plotted the map of 28 thresholds, in three clusters. The overlay visualization of co-occurrence analysis of keywords has been shown in Figure 4.

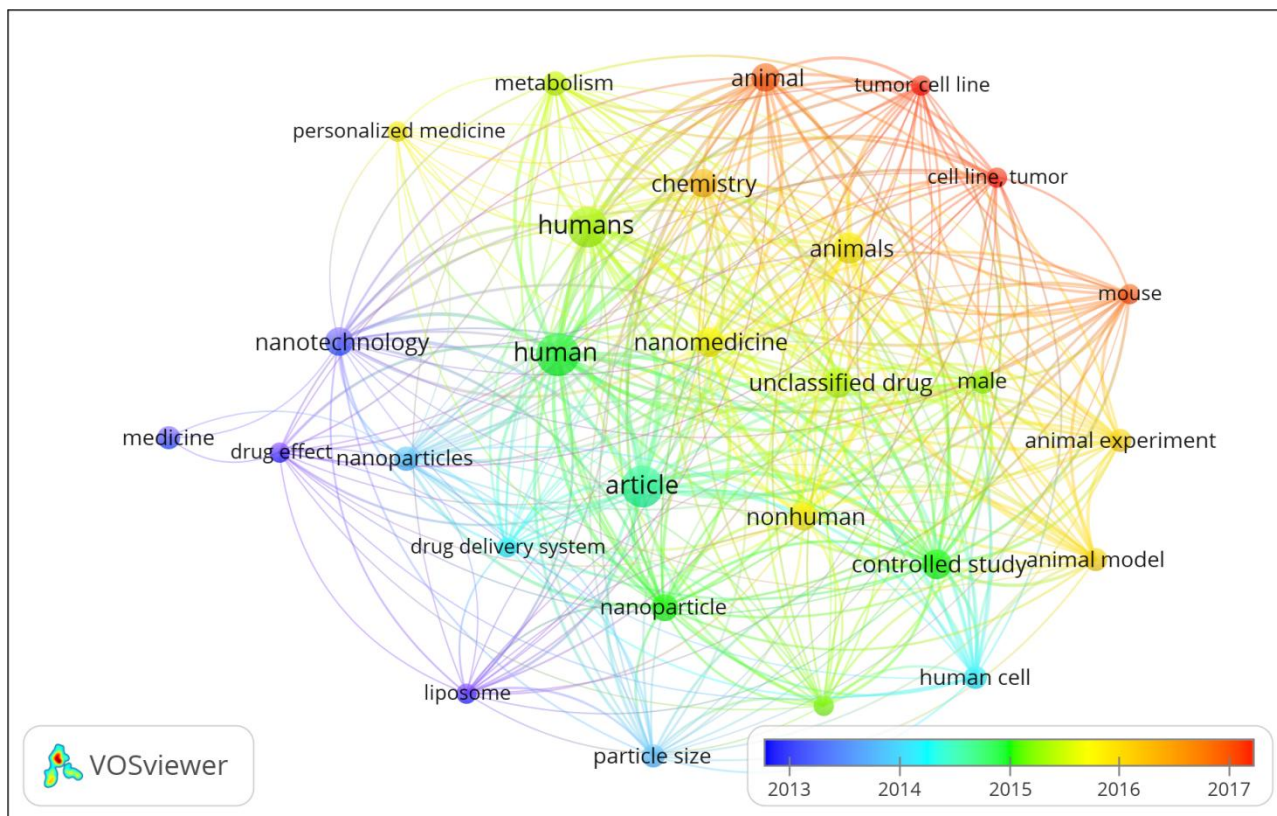


Figure 4: Co-occurrence analysis on basis of all keywords

The leading organizations engaged in research on “Nanomedicine” had been found out by the volume of publications and citation analysis, the parameters used are the minimum number of documents of an organization as one and the minimum number of citations of organizations as one. The leading organization in the research regarding “Nanomedicine”, with the highest number of publications and citations, was the Brigham and Women's Hospital of the United States of America. (Refer to table 2).

Table 2: Highlights of the most active organization

Organizations	Country	Documents	Citations	Average Citations per document
Brigham and Women's Hospital	United States of America	3	251	83.6

Co-authorship analysis of the countries engaged in the research on “Nanomedicine” had been shown in Figure 5. The overlay visualization map of co-authorship analysis plotted in Figure 5, points out the main countries with their strong co-authorship linkages and clusters involved.

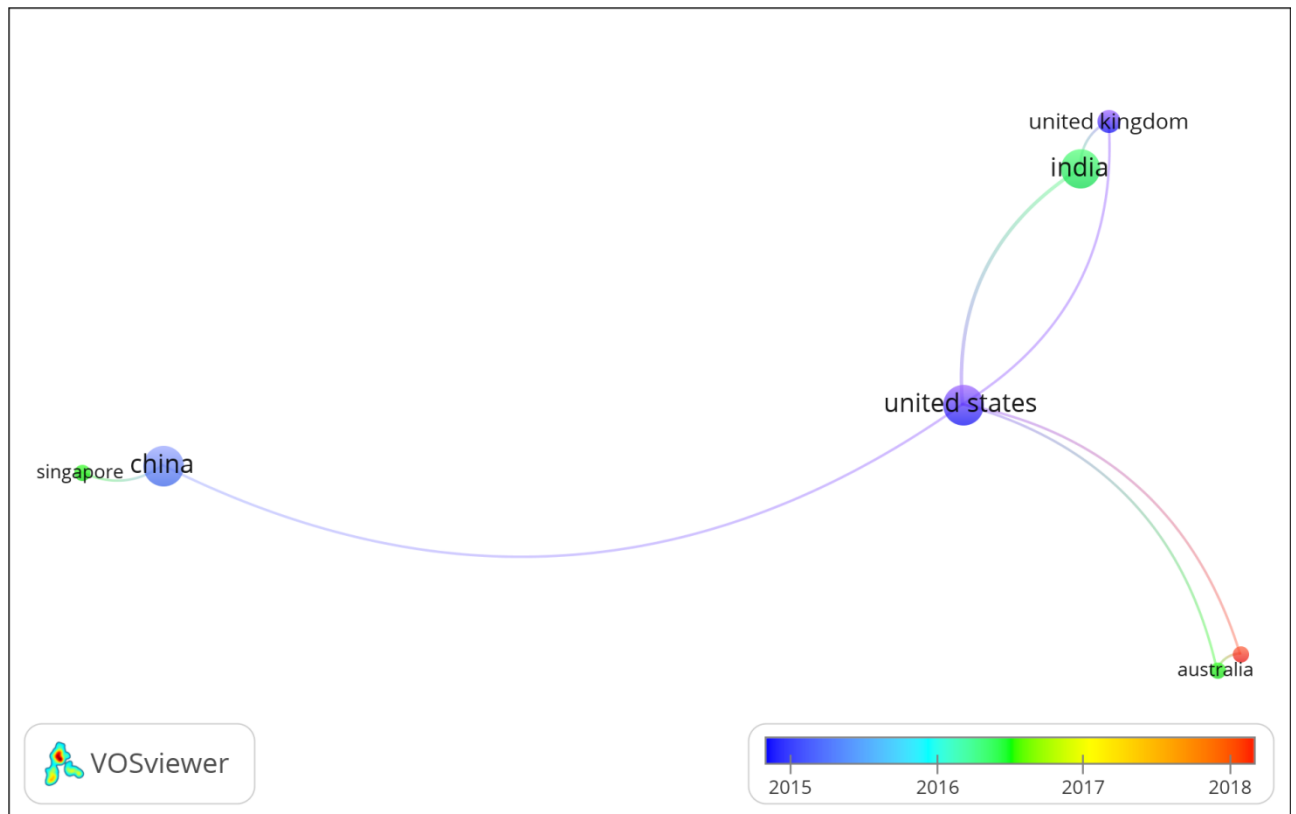


Figure 5: Co-authorship analysis on basis of countries

The citation analysis of top countries had been shown in table 3, along with co-authorship links. For the citation analysis, the parameters used were the minimum number of documents of a country as one and the minimum citations of the country as one.

Table 3: Highlights of Active Countries

Description	Country	Documents	Citations	Link strength
The country with the highest publication, citations, and co-authorship links	United States of America	12	331	9

The most active country in this research domain was the United States of America, with the highest number of publications, and citations.

Link analysis and citation analysis were used to identify the most active journal in this research domain. We have taken the parameters of the minimum number of documents of a journal as one and the minimum number of citations of a journal as one for the link analysis and citation analysis. Highlights of the most active and relevant journals related to “Nanomedicine” are shown in table 4. Table 4 shows the journal activity of this research domain through parameters of publication volume, citations, and co-authorship linkages.

Table 4: Analysis of journal activity

Description	Journal details	Documents	Citations	Average citations per documents
Journal with the highest publications, and co-	International Journal of Nanomedicine	4	25	6.25

authorship links				
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From the above discussion regarding the bibliometric patterns in the research regarding Nanomedicine, this research had observed a gradual increase in research interest regarding Nanomedicine from the starting of the millennium and the momentum is going on positively. This points out the relevance and potential of this research domain (Refer to Figure 2). The most active authors in this research domain were Wang Y and Serhan C N with the highest publication, citation, and co-authorship links (Refer to table 1). The overlay analysis of top countries researching pacemaker battery indicates that the United States of America was the leading countries relating to the highest number of publications, citations, and co-authorship links (Refer to figure 5). The top journal of this research domain was identified as the International Journal of Nanomedicine. From these wide sources of information, researchers can focus on top journals where they can identify the most relevant and highly cited articles regarding Nanomedicine.

## CONCLUSION

Nanomedicine was an interesting research domain and the most active journal related to this research domain was the International Journal of Nanomedicine. The most active country was the United States of America. The leading organizations engaged in the research regarding Nanomedicine was Brigham and Women's Hospital of the United States of America. The most active authors who had made valuable contributions related to pacemaker batteries were Wang Y and Serhan C N. This research domain offers a new avenue for researchers and future research can be on innovations in Nanomedicine.

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