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Scientific Mapping of Research on Digital Pulmonary Function Test: A Bibliometric Analysis

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Abstract

Digital Pulmonary Function Test (PFT) is a non-invasive test that helps in evaluating the efficiency of a patient's lungs. The test is key to keeping tabs on a patient's health that may be suffering from Chronic Obstructive Pulmonary Disease, Asthma, Restrictive Respiratory Disease, etc, as pollution increases day by day in the world the amount of people getting affected from it and being diagnosed with respiratory diseases the importance of PFT continues to grow. The Scopus database has been used exclusively for this analysis. A key observation of this survey has been that engineering and medicine have gone hand in hand towards the development of the PFT. The survey has also revealed that a majority of the publications in

this subject have been published as articles. The paper discusses the bibliometric analysis of the Digital Pulmonary Function Test from the Scopus database. The 405 archives extricated from this data set in the exploration region have been procured till 15th May 2021. It is the examination of the exploration distributed as articles, meeting papers, surveys, which helps in understanding the effect of the distribution on the specific theme worldwide. The representation is finished with open-source programming like VOS Viewer and Excel. The representation adds to a vastly improved understanding of the perspective in the specific research domain.

Keywords: Digital PFT, Pulmonary Function Test, Bibliometric Analysis

1. Introduction

Pulmonary Function Test (PFT) is a non-invasive test that determines the efficiency of the lungs. The test measures lung capacity, flow rates, and respiration. With the help of this information the treatment and diagnosis of certain lung disorders can be done as quickly as possible (Calthorpe, et al. 2019). PFT can be done using two methods. The two methods can be used together and perform tests and depending on the results of the tests the healthcare provider can take further decisions. The two tests are:

- **Spirometry.** A spirometer is a medical tool with a mouth-piece connected to a small electronic machine.
- **Plethysmography.** It is a medical equipment that measures the change in volume within an organ (Thyagarajan, et al. 2020).

Lung infections such as Asthma and Chronic Obstructive Pulmonary Disease (COPD) can affect a person's breathing. Over 600 million people are affected with COPD and over 300 million are afflicted with Asthma. Also, people having such respiratory diseases are more prone to diseases like Covid-19 (Horowitz and Freeman 2020). Thus, PFT can confirm whether you have asthma or any other lung-related disease. Also, it helps your doctor or the health care provider to decide on your treatment.

PFT measures the following parameters:

- **Forced Expiratory Volume (FEV₁):** Amount of air exhaled in the first second of the test.
- **FVC (Forced Vital Capacity):** The maximum amount of air exhaled forcefully.

- VC (Vital Capacity): The highest amount of air expelled regardless of force.
- The ratio of FEV₁/FVC
- PEF (Peak Expiratory Flow): it is the maximum flow achieved during steady flow. This is obtained by FEV₁ and FVC.
- FEV₂₅₋₇₅, FEV₅₀
- Inspiratory vital capacity (IVC): it is the largest volume of air that can be inspired after full exhalation (Kouri, et al. 2020)
- Total Lung Capacity: Total volume of lungs filled with as much air as possible.

These values of PFT may vary depending on the region of tests conducted and on individual basis. The volume of air breathed in and breathed out in the test outcomes are contrasted with that of a normal individual of a similar tallness, age, sex. The outcomes are likewise contrasted with the past aftereffects of the test (Pawaria and Kalra 2020).

Pulmonary Function tests are regularly done by respiratory patients. These tests are done by sound individuals everyday as a part of their daily routine. These tests can be done regularly in workplaces to guarantee representative well-being. PFTs can be used to check lung conditions before various medical procedures who have lung related infections, are smokers or have other ailments (Khemasuwan, Sorensen and Colt 2020).

Pulmonary function tests have evolved over time into a much more complex set of lung function evaluations using varied devices and techniques. Should the variability of the outcomes be minimized, and the measurement accuracy improve, abnormalities might be detected with greater ease (Mokal, Sheikh and Mokal 2018).

Spirometry tests were the establishment of respiratory work tests and give planned estimations of breathed lung volumes. With automation, beyond 15 distinct estimations can be assessed from spirometry alone (Jagannath, et al. 2019).

Some of the drawbacks of existing Spirometers includes cost to be incurred by patients for such tests, accessibility of clinics, and also when it comes to rural areas the hospitals lack the sophisticated testing equipment like Spirometer thereby requiring the patient to travel large distances to undergo testing [9]. The large electronic equipment situated in doctor's laboratories is massive and quite expensive and not installed at many locations. The calculation process used for detecting lung diseases in this equipment is very complex and time-

consuming. If a patient is found to have a lung disease such as Asthma and COPD, should regularly go through spirometry tests in order to get this disease diagnosed (Williams 1994).

The digital revolution in medication and medical services data has provoked a development of information in components from numerous advanced sources like clinical imaging, electronic wellbeing records and applications for clinical gadgets. Such monstrous development has mixed the improvement of an expanding number of Mobile Applications that can be sent in clinical practice. This makes the way for some pulmonary experts who know about electronics to take advantage of future practice and research opportunities (González 2012).

In recent years there have been many technological advancements in the Digital Pulmonary Function Tests, and these may incorporate peak expiratory stream gadgets, electronic compact spirometers, convenient breathed out nitric oxide estimation, wireless transmission oscillometer gadgets, and novel advanced health instruments, for example, cell phone mouthpiece spirometers and portable health innovations alongside the coordination of Artificial Intelligence draws near (Zhou, Yang and Huang 2019). With the help of various sensors and microcontrollers the testing process is becoming faster and more accurate. Sensors like pressure sensors, barometric sensors and volumetric sensors are now used in many spirometry devices to give accurate lung parameters (Chandrakar 2014). The sensors are factory calibrated and optimized ensuring no degradation in total error band, accuracy, and stability regardless of the sensor selected (Fahad 2019). The selection of some novel methodologies could not simply be replaced yet could enhance the current testing circumstance of the Pulmonary Function Test.

Today convenient Spirometers are used in place of the customary PFTs. As home-based healthcare services are increasing, it also reduces the risk of forceful expiratory measurements and cough in the hospitals (Ali, et al. 2014). The portable Spirometers can well be used for diagnosis of lung related infections like COPD and Asthma. The accuracy of such devices is identical to those which are used in the hospitals. With correct patient information the portable spirometers are a significant alternative to the traditional devices used in the hospitals [16]. With the help of correct information about the chronic lung conditions, through virtual care patients can now get timely advice from the doctors without them coming to the hospitals. This will also reduce the burden of high testing demands on PFT laboratories and focus on new diagnosis and more urgent testing (Augustynek, Adamec and Micanik 2012).

2. Preliminary Data

2.1 Search Procedure

Through various publications like articles, gathering papers, and audits, it helps in understanding the effect of publication in the particular research space all around the world. The factual examination of such publications is called as Bibliometric analysis. Scopus Database, Google Scholar, Web of Science are the most well-known distribution data sets. For the current investigation, the paper considers the Scopus information base. Scopus contains exhaustive audits and decisions on the field of specialized, clinical, sociologies research papers.

2.2 Keywords and publication type

Various keywords have been utilized as search conditions in the Scopus information base. As per analysis ‘Pulmonary Function Test’ is the broad-level keyword and to further narrow it down to specific citations the addition of words like ‘digital’ has been done related to the topic “Digital Pulmonary Function Test”. The main keyword ‘Pulmonary Function Test’ gives us 61,854 document results which contain articles, reviews, conference papers, books, which have been published in various journals. When keywords like ‘digital’ are being used then the document results narrow down to 405.

The results obtained after the search revealed the occurrence of many keywords. Few of the important keywords are given in table 1.

Table 1. Important Keywords

| Keyword | No. of times they appeared |
|--------------------|-----------------------------------|
| Human | 348 |
| Article | 281 |
| Male | 242 |
| Humans | 223 |
| Adult | 222 |
| Female | 212 |
| Lung Function Test | 203 |

| | |
|----------------------------|-----------------------------------|
| Priority Journal | 156 |
| Middle Aged | 121 |
| Respiratory Function Tests | 116 |
| Keyword | No. of times they appeared |
| Aged | 110 |
| Controlled Study | 108 |
| Major Clinical Study | 102 |
| Clinical Article | 95 |

Source - The Scopus database accessed on 15th May 2021

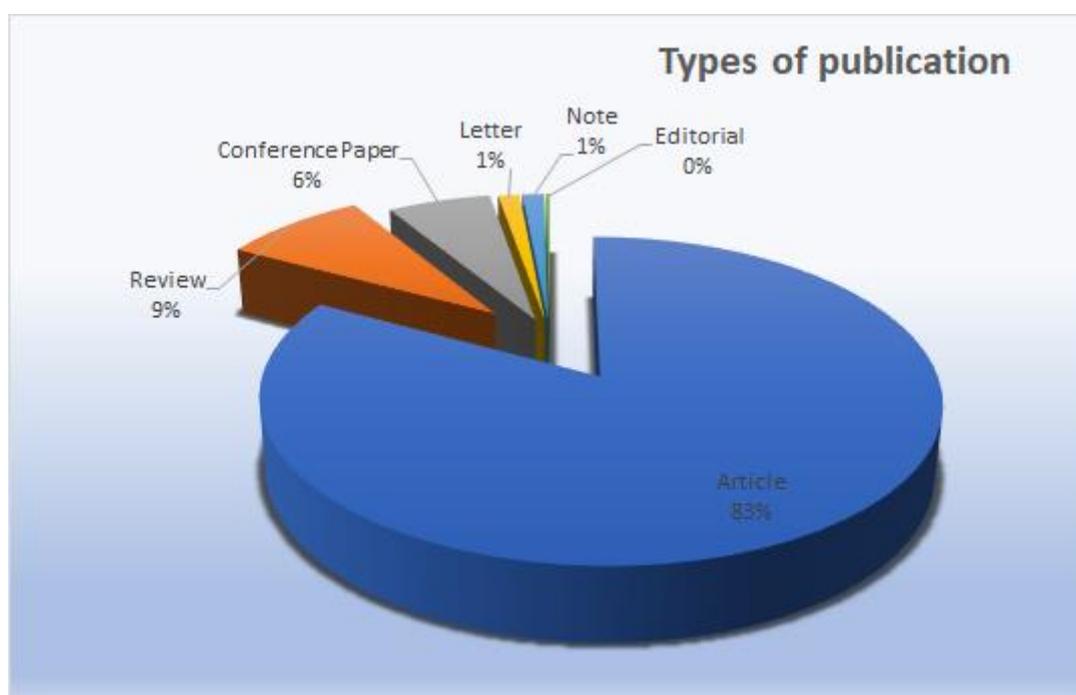


Figure 1. Distribution of type of publications

Source - The Scopus database accessed on 15th May 2021

The above figure (Figure 1) shows the various kinds of publications in the particular research area of Digital PFT Spirometry. The total number of publications are 405 which were taken for analysis out of which 336 were articles, 24 of them were conference papers, 34 audit papers and the rest are letters. The entirety of the distributions is in the English language.

2.3 Analysis of Papers Published Each Year

Figure 2 gives the data about the quantity of archives distributed every year in the specific area of the research region. 37 papers were published in the year of 2020 which were the highest documents published in a year. There are 4 publications as of now in the year 2021.

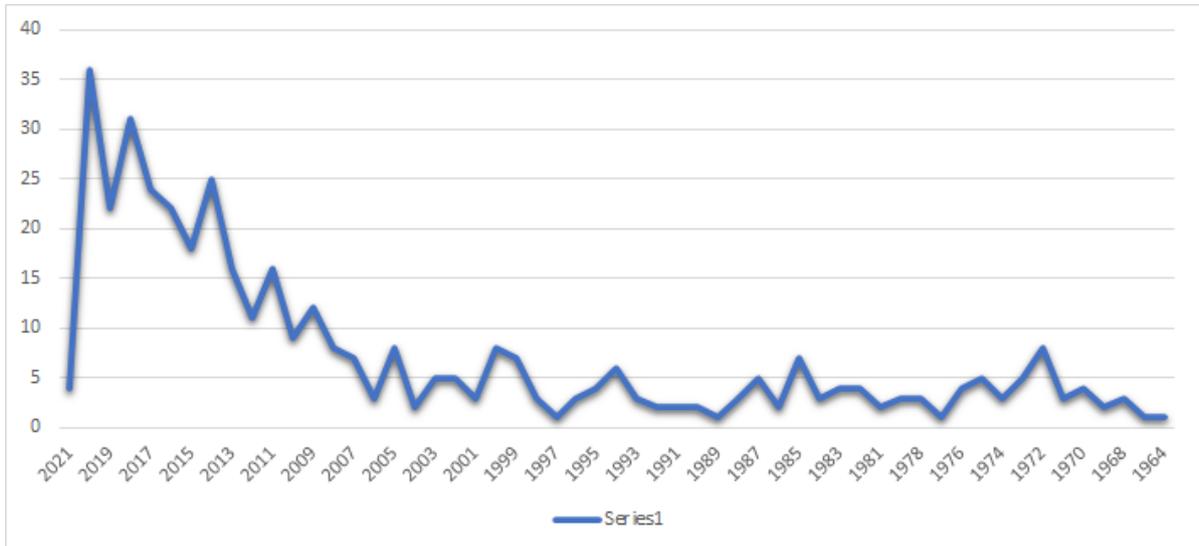


Figure 2. Year wise graph for documents

Source - The Scopus database accessed on 15th May 2021

2.4 Documents by Country

The graph in figure 3 gives information on the contribution of various countries towards Digital PFT research. 120 publications have come from the United States which is the highest number of publications all around the world in this particular research area. The major countries include Germany, Japan, Italy, and many more.

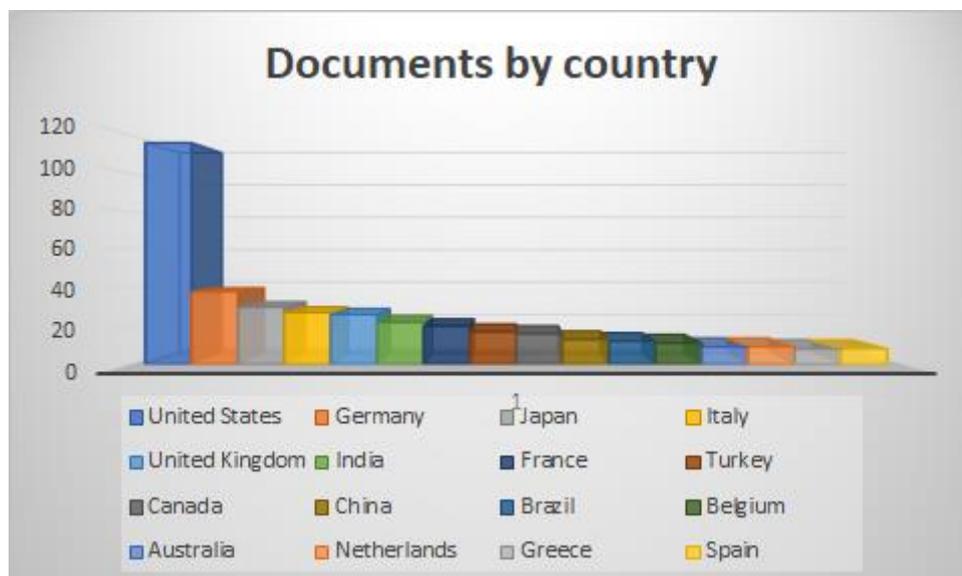


Figure 3. Distribution of documents by country

Source - The Scopus database accessed on 15th May 2021

2.5 Document by Affiliation

The foundation or the public authority office demands that the predefined research project be completed with the characterized destinations and objectives. The Research is carried out more at the University in Roma with 8 papers published under them. VA Medical Center, University of North Carolina, and Xian Jiaotong University, all have published 6 publications. The rest of the affiliations are as shown in Figure 4.

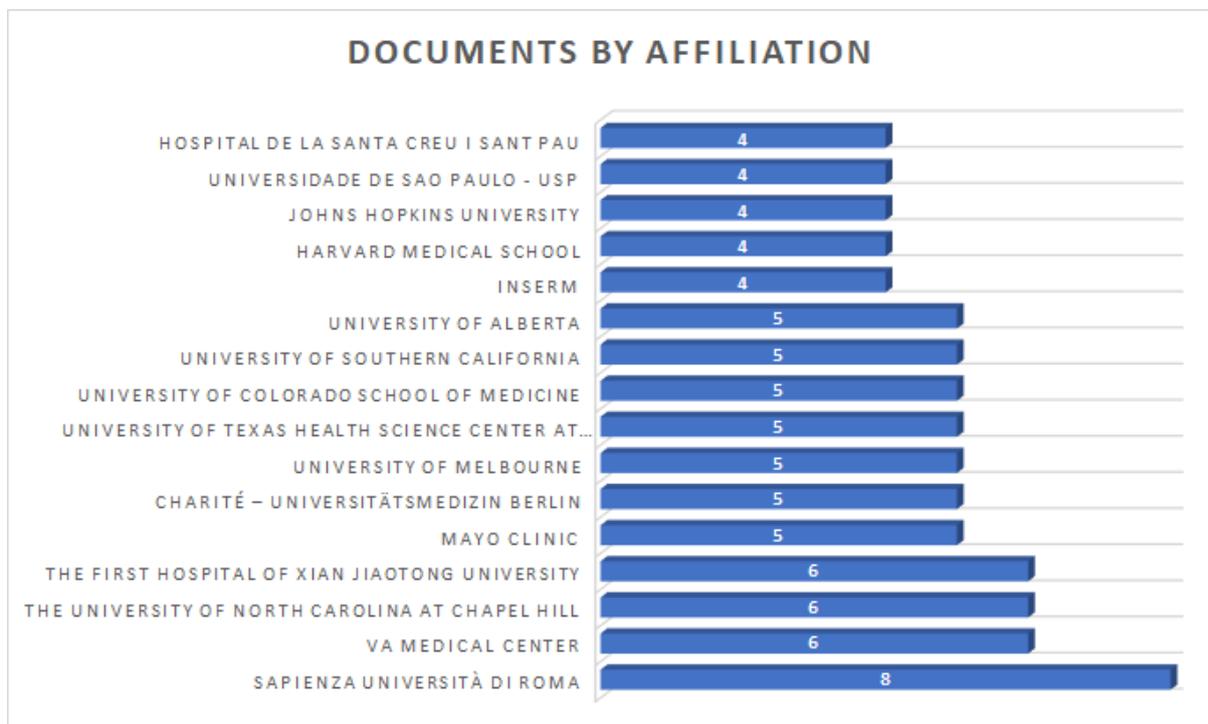


Figure 4. Distribution of documents by affiliation

Source - The Scopus database accessed on 15th May 2021

2.6 Documents by Search Area

The below figure (Figure 5) shows the distribution of the papers related to different domains such as Medicine, Engineering, Computer Science, etc. From the figure it can be noted that the highest research has been carried out in Medicine which is 65%. Biochemistry, Genetics & Molecular Biology, Engineering, and Immunology & Microbiology have contributed the most other than Medicine.

Note:- “Others” includes - Agricultural and Biological Sciences, Chemistry, Decision Sciences, Earth and Planetary Sciences, Energy, Mathematics, Multidisciplinary, Psychology, Social Sciences, Veterinary, Decision Sciences.

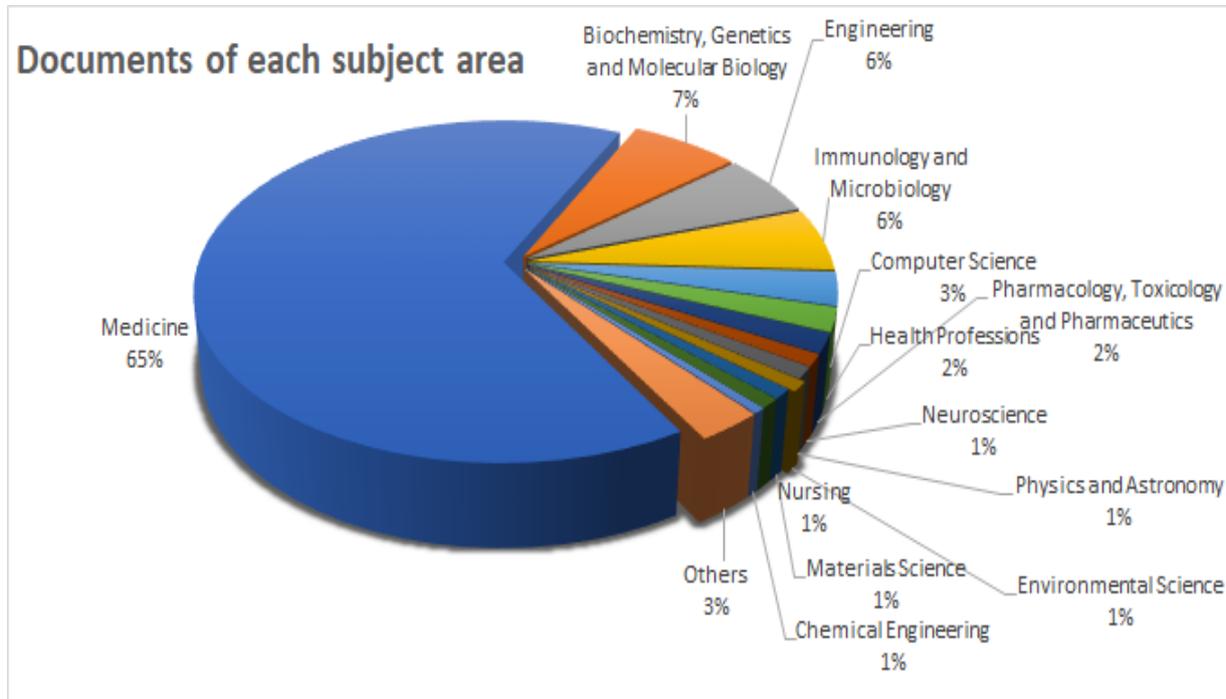


Figure 5. Distribution of documents by subject area

Source - The Scopus database accessed on 15th May 2021

2.7 Documents by Author

Figure 6 shows the most influential authors in the field of Digital PFTs. Gigante, A. (A., et al. 1984) is the most influential author with 7 papers published. The figure depicts the first 15 authors having the highest number of publications in the area of Digital PFT.

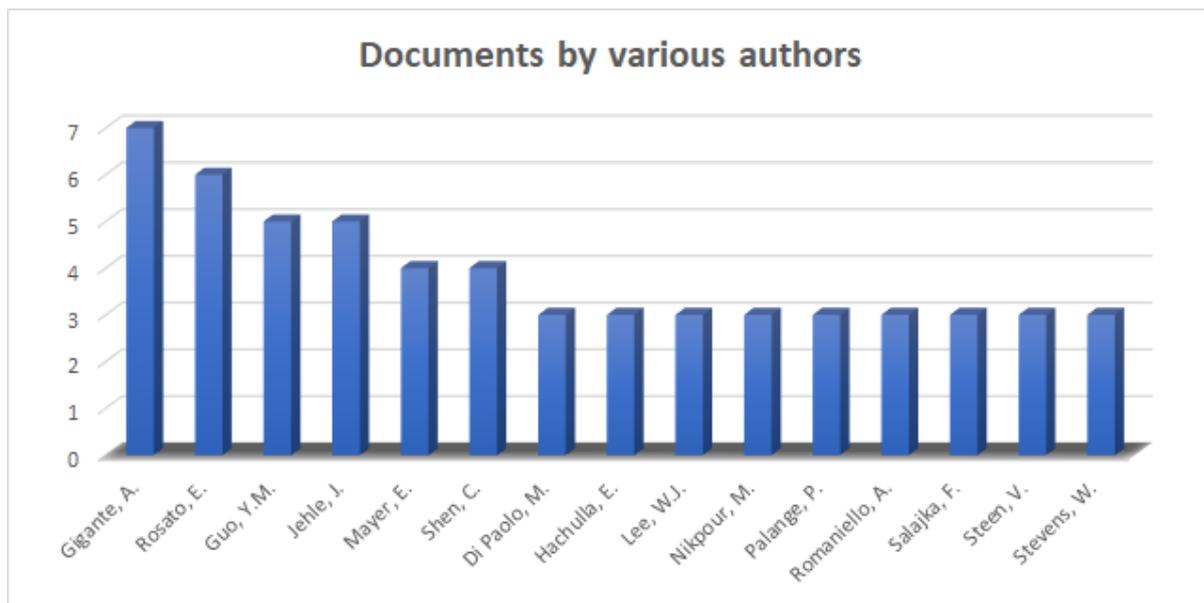


Figure 6. Count of documents by various authors.

Source - The Scopus database accessed on 15th May 2021

2.8 Documents Funded by various Agencies

The research project is regularly conveyed with the assistance of the assets given by the foundation or the organization. The point is to convey an item or a report of business importance to the business. Scientists from different agencies cooperate and create a definite research report. Various agencies in medical field have funded the research on Digital PFT. Figure 7 shows, fifteen such agencies funded for the research projects on this topic.

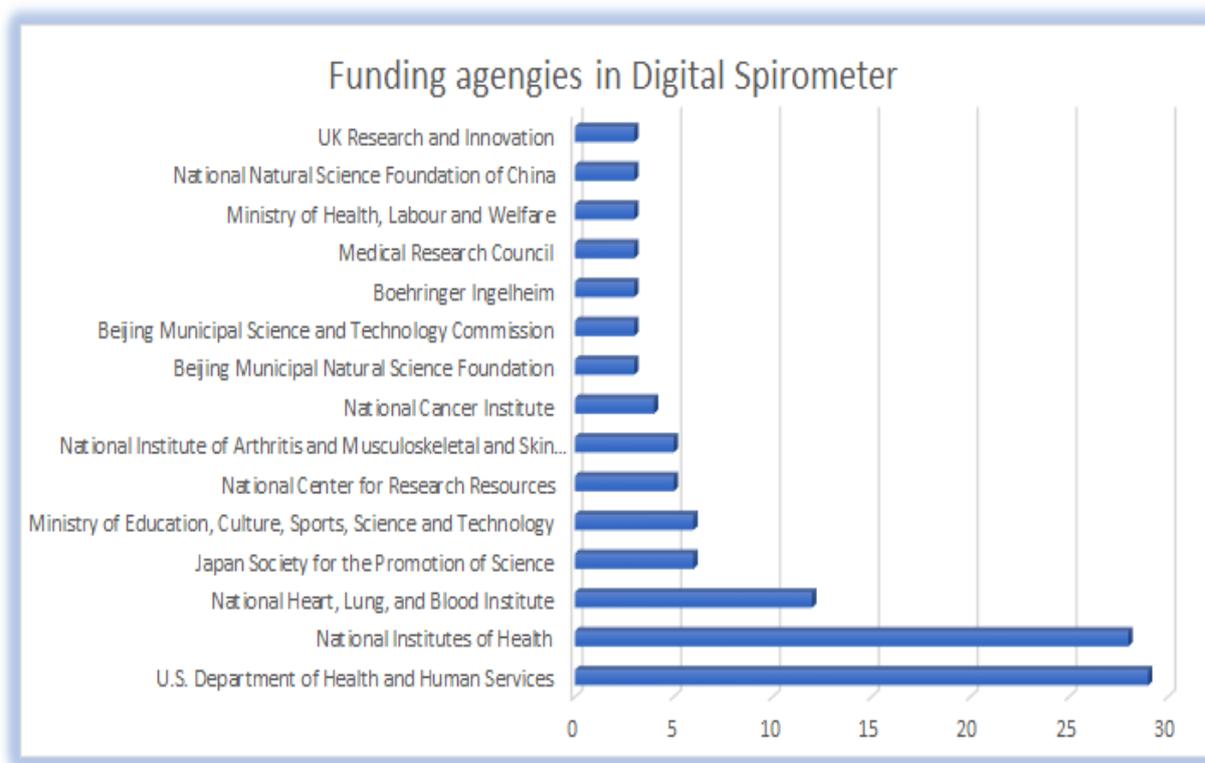


Figure 7. Distribution of documents with respect to sponsorship

Source - The Scopus database accessed on 15th May 2021

3. Network Analysis

Network analysis has been carried out using VOS Viewer, an open-source software. Scientific mapping of the research on Digital PFT is further carried out for parameters such as year of Publications, affiliations, Sources, Creators, Record types, source types, space and country.

Figure 8 shows the co-occurrence of the top keywords with reference to others. Human, Respiratory function tests, pulmonary function tests, forced vital capacity are the most co-occurring keywords in Digital Pulmonary Function.

Figure 11 shows the countries that have published documents in this particular research area. In this research area many European countries have published notable number of documents. With 116 publications the United States have published the highest number of papers followed by Germany and Japan.



Figure 11 Geographical locations of the publications on Digital PFT

Source - The Scopus database accessed on 15th May 2021

Conclusion

With each advancing day, different adjustments are being made in the field of Spirometry to make Pulmonary Function Tests more available and quicker. These discoveries have been converged with broad exploration from designers and specialists which have empowered the medical practitioners with latest, and accurate devices (Brawner and Hegarty 2003). The bibliometric investigation can be utilized by the sprouting specialist in the Digital Pulmonary Function Test research territory about the compelling creators, huge catchphrases, top affiliations, top diaries, top subsidizing organizations. Versatile, Digital, Spirometry are the critical watchwords utilized by the persuasive creators in their exploration work. The highest number of distributions have been from the United States followed by Canada and the United Kingdom. Ten exploration papers have been distributed under the financing of the National Institute of Health and the US Department of Health and Human Services. The number of

publications per year are found to be increasing highlighting the expanding use of technology in healthcare system.

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