A "First Look" on Frailty: A Scientometric Analysis

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Abstract. Frailty is a new and interesting concept that describes a preclinical condition in which elderly are more vulnerable and the possibility to develop pathologies increases. Often, the physical decline is related to cognitive impairments: Subjects in this situation are defined as cognitive frail patients. The literature connected to this syndrome is growing steadily and a bibliometric analysis is needed to better understand the evolution and the current state of the art. In this article, several domains are analyzed: Authors, categories, countries, institutions and journals. An interesting scenario emerged from the data: On the one hand, outcomes show a strong interest in understanding the real diffusion of this phenomenon using demographics and statistical methods. On the other hand, it emerged the increasing application of mathematical models to the study of medical phenomena.

Keywords: Frailty · Scientometric · Bibliometric · Cognitive frailty

1 Introduction

Ageing is a physiological process involving both cognitive and motor domains, and affecting therefore many aspects of everyday life. According to the World Health Organization, the proportion of people older than 60 years-old is increasing rapidly and faster than all the other age groups [1]. Within this part of the population, in the last decade there has been a lot of interest in "frail" patients, constituting the 6.9% of adults

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older than 65-year-old [2]. Specifically, frailty is a clinical condition and a state of vulnerability associated with increasing age and affecting multiple domains like gait, mobility, balance and cognition [3]. According to the standardized definition of Fried and colleagues, three or more of the following criteria should be met: Unintentional weight loss (10 lbs in past year), self-reported exhaustion, weakness (grip strength), slow walking speed, and low physical activity [2]. This condition has been directly associated with higher risks for adverse health outcomes, such as mortality, disability and, especially, high risk of falls [2, 4–6]. A few years after the systematization of this concept, the International Consensus Group organized by the International Academy on Nutrition and Ageing (IANA) and the International Association of Gerontology and Geriatrics (IAGG) proposed the identification of a new important condition: "Cognitive frailty" [7]. This new definition is strongly connected with physical frailty, but it also requires the presence of cognitive impairments in addition to the criteria mentioned above, whereby, the main factors of cognitive frailty are: (1) Presence of physical frailty and cognitive impairments, and (2) exclusion of concurrent dementia or underlying neurological conditions [7, 8]. In order to diagnose cognitive frailty, a complete neuropsychological assessment is needed [8]. However, a specific profile has not yet been clearly defined: As a consequence, some authors describe cognitive frailty as a hypothetical condition without clear available data to support it. However, this construct is potentially interesting as it would allow to identify a promising target condition for the development of preventive interventions against age-related problems, with a main focus on the rehabilitation of both cognitive and physical aspects.

It is well known that chronic diseases may accelerate ageing through a reduction of the body's adaptation abilities. Decreased physiological reserve leads to a homeostatic imbalance or frailty, a pre-clinical condition that increases the possibility to developed pathologies [9]. Therefore, a timely intervention could lead to a great advantage and to a better healthy outcome. A rehabilitation programs will must be focused on both physical and cognitive aspects.

Even though cognitive and motor impairments have been always considered and treated independently, literature is showing evidence for a strong relation between them, both in healthy and pathological conditions. An example of this relationship is the risk of falls. Among frail patients, indeed, falls are one of the most critical public health problems, as well as the major cause of injuries: One in three old people, indeed, falls at least once in a year [10], with subsequent consequences in terms of loss of independence and adverse psychosocial problems [11, 12].

In this article, we present a systematic and computational analysis of the state of the art of the frailty field in terms of various co-citation networks, aiming at exploring the evolution of the intellectual structure of this knowledge domain over time.

2 Methods

Data Collection. The input data for the analyses were retrieved from the scientific database Web of Science Core Collection, based on a topic search for Frailty papers published during the whole timespan covered. The data were lastly updated on October 11, 2017. Web of Science Core Collection is composed of: Citation Indexes, Science Citation Index Expanded (SCI-EXPANDED) –1970-present, Social Sciences Citation Index (SSCI) –1970-present, Arts & Humanities Citation Index (A&HCI) –1975-present, Conference Proceedings Citation Index- Science (CPCI-S) –1990-present, Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH) –1990-present, Book Citation Index– Science (BKCI-S) –2009-present, Book Citation Index– Social Sciences & Humanities (BKCI-SSH) –2009-present, Emerging Sources Citation Index (ESCI) –2015-present, Chemical Indexes, Current Chemical Reactions (CCR-EXPANDED) –2009-present (Includes Institut National de la Propriete Industrielle structure data back to 1840), Index Chemicus (IC) –2009-present. The resultant dataset contained a total of 11,071 records. The bibliographic records contained various fields, such as author, title, abstract, and all the references (needed for the citation analysis). The research tool to visualize the networks was Cite space v.4.0.R5 SE (32 bit) 32 under Java Runtime v.8 update 91 (build 1.8.0_91-b15). Statistical analyses were conducted using Stata MP-Parallel Edition, Release 14.0, StataCorp LP.

3 Results

The analysis of the literature on frailty shows a complex panorama. Here we will try to systematize this field in order to understand how literature has developed both temporally and geographically, which are the major areas of interest and who are the most productive authors.

3.1 Authors

Articles Counts. The top ranked author by article count is Rockwood K, with a total of 235 articles. The second one is Walston JD, with an article count of 139. The third is Morley JE, with an article count of 121. The 4th is Fried LP, with an article count of 121. The 5th is Vellas B with an article count of 107. The 6th is Mitnitski A with an article count of 107. The 7th is Cesari M with an article count of 101. The 8th is Ferrucci L with an article count of 85. The 9th is Hubbard RE with an article count of 66. The data are reported in Fig. 1.

The picture clearly shows that Rockwood, Mitnitski, and Hubbard are strongly interconnected among them, as well as Fried, Ferrucci, Walston, Vellas, and Cesari.

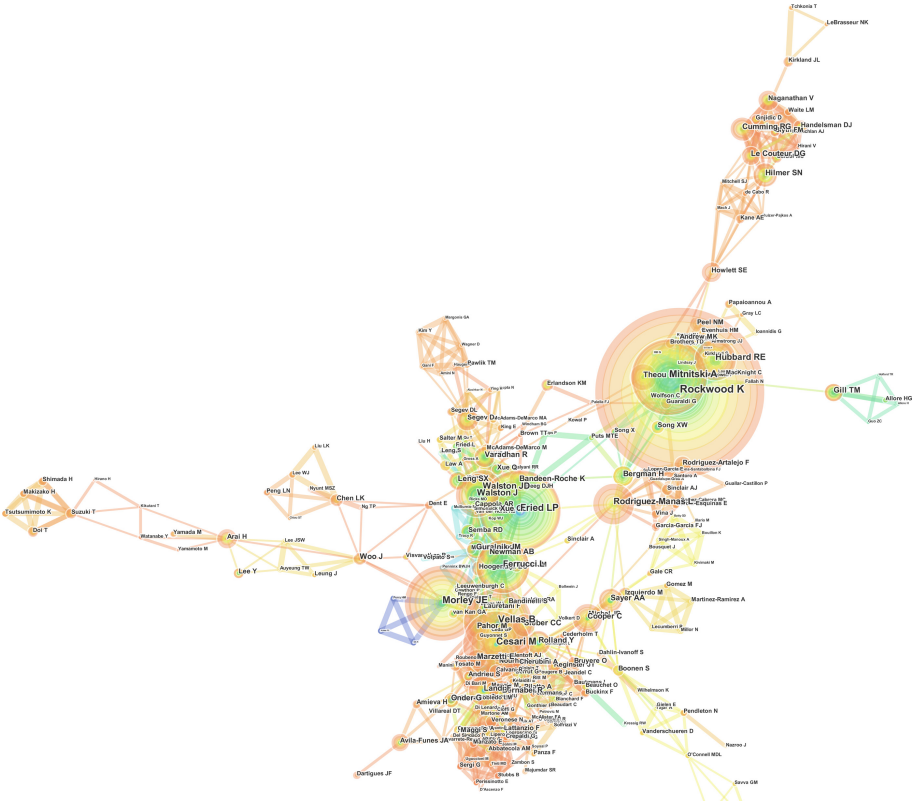

Fig. 1. Network of authors: the dimension of the nodes represents centrality.

3.2 Categories

Articles Counts. The top ranked journal by article count is GERIATRICS & GERONTOLOGY with a total of 3599 articles. The second one is GERONTOLOGY with an article count of 1895. The third is MATHEMATICS with an article count of 1033. The 4th is MEDICINE with an article count of 1025. The 5th is STATISTICS & PROBABILITY with an article count of 998. The 6th is GENERAL & INTERNAL MEDICINE with an article count of 881. The 7th is CARDIOVASCULAR SYSTEM & CARDIOLOGY with an article count of 789. The 8th is CARDIAC & CARDIOVASCULAR SYSTEMS with an article count of 685. The 9th is PUBLIC with an article count of 650. The 10th is SURGERY with an article count of 604. A graphical representation of this analysis is reported in Fig. 2.

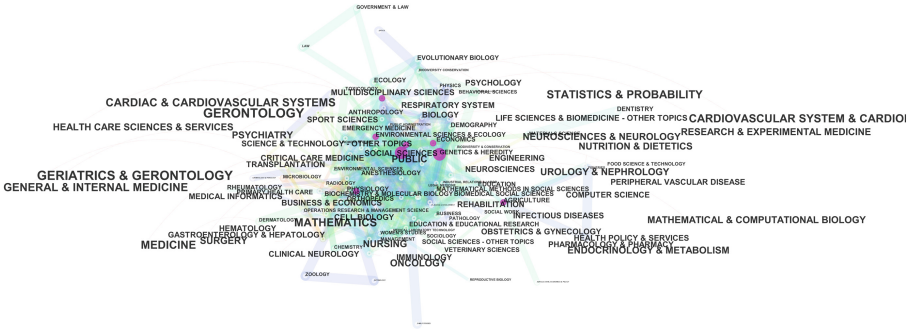

Fig. 2. Network of categories. The dimension of the nodes represents centrality

3.3 Countries

Articles Counts. The top ranked country by article count is USA with a total of 3732 articles. The second one is ENGLAND with an article count of 874. The third is CANADA with an article count of 824. The 4th is ITALY with an article count of 636. The 5th is FRANCE with an article count of 603. The 6th is NETHERLANDS with an

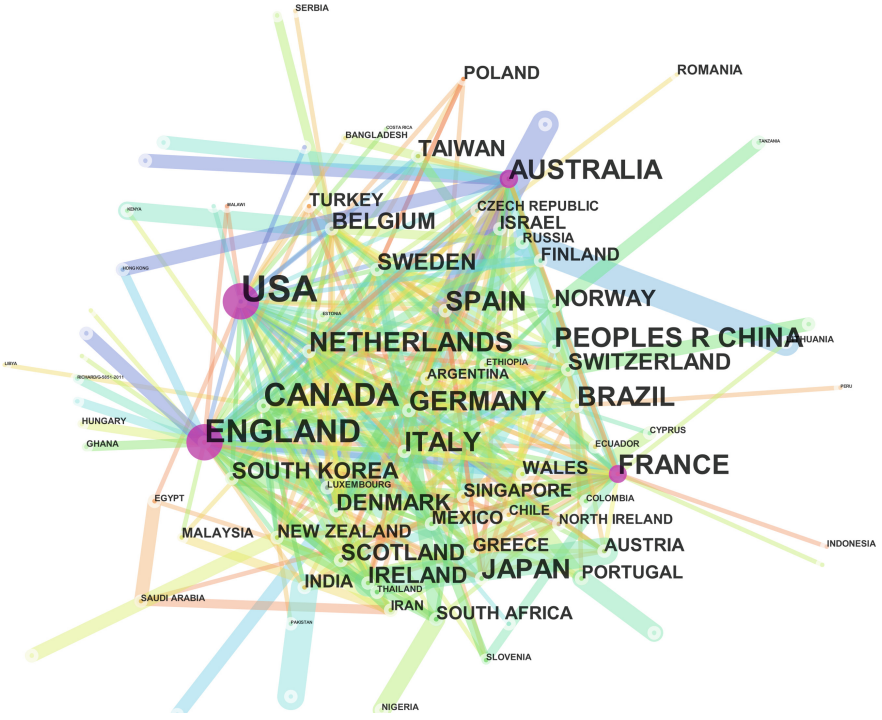

Fig. 3. Network of the countries. The dimension of the nodes represents centrality.

article count of 569. The 7th is AUSTRALIA with an article count of 489. The 8th is GERMANY with an article count of 429. The 9th is SPAIN with an article count of 398. The 10th is BRAZIL with an article count of 292. A graphical representation of this analysis is reported in Fig. 3.

The situation changes when the analysis is focused on the countries with strongest article bursts. Burst is an indicator of a most active area of research. Burst represent a detection of a burst event, which can last for multiple years as well as a single year. A burst provides, for example, evidence that a particular publication is associated with a surge of citations. The burst detection was based on Kleinberg's algorithm [13]. The Top 11 includes almost all European nations, as showed in Table 1.

Table 1. Top 11 countries with strongest citation bursts.

Countries	Year	Strength	Begin	End	1996 - 2018
USA	1996	7.8515	**1996**	1997	
DENMARK	1996	15.9834	**1997**	2006	
ENGLAND	1996	3.7486	**1998**	1999	
FINLAND	1996	3.2681	**1998**	2004	
SWEDEN	1996	5.0102	**2002**	2004	
NORWAY	1996	4.9469	**2004**	2007	
ISRAEL	1996	3.4958	**2005**	2007	
SOUTH AFRICA	1996	4.3657	**2007**	2013	
IRELAND	1996	10.8544	**2013**	2014	
POLAND	1996	8.6131	**2015**	2018	
TURKEY	1996	3.4813	**2015**	2018	

3.4 Institutions

Articles Counts. The top ranked institution by article count is Dalhousie University with a total of 234 articles. The second one is Johns Hopkins University, with an article count of 213. The third is University of Michigan with an article count of 117. The 4th is St Louis University with an article count of 114. The 5th is University of California, San Francisco with an article count of 113. The 6th is University of Sydney with an article count of 112. The 7th is Duke University with an article count of 105. The 8th is Mayo Clinic with an article count of 92. The 9th is Yale University with an article count of 84. The 10th is McGill University with an article count of 84. A graphical representation of this analysis is reported in Fig. 4.

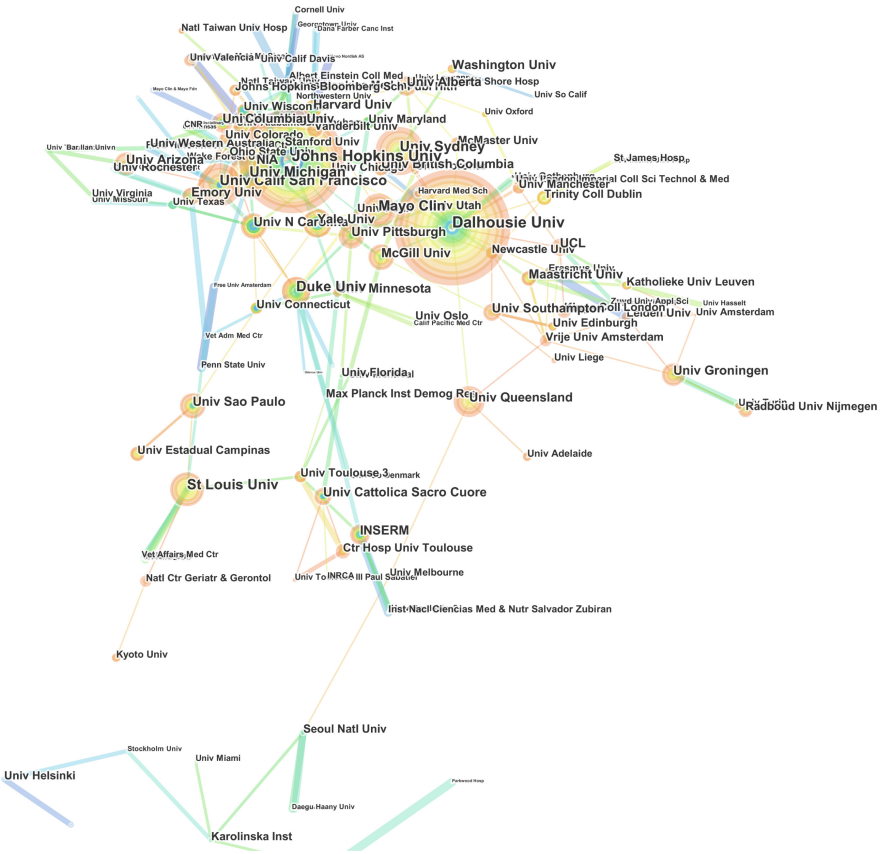

Fig. 4. Network of institutions. The dimension of the nodes represents centrality.

3.5 Journals

Citations Counts. The top ranked journal by citation count is JOURNAL OF THE AMERICAN GERIATRICS SOCIETY with a total of 5058 citations. The second one is THE JOURNAL OF GERONTOLOGY, SERIES A: BIOLOGICAL SCIENCES AND MEDICAL SCIENCES with a citation count of 5040. The third is JAMA-JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION with a citation count of 3042. The 4th is NEW ENGLAND JOURNAL OF MEDICINE with a citation count of 2965. The 5th is AGE AND AGEING with a citation count of 2847. The 6th is LANCET with a citation count of 2795. The 7th is ARCHIVES OF INTERNAL MEDICINE with a citation count of 2189. The 8th JOURNAL OF NUTRITION HEALTH & AGEING with a citation count of 1682. The 9th is JOURNAL OF THE AMERICAN MEDICAL DIRECTORS ASSOCIATION with a citation count of 1554. The 10th is BRITISH MEDICAL JOURNAL with a citation count of 1509. A graphical representation of this analysis is reported in Fig. 5.

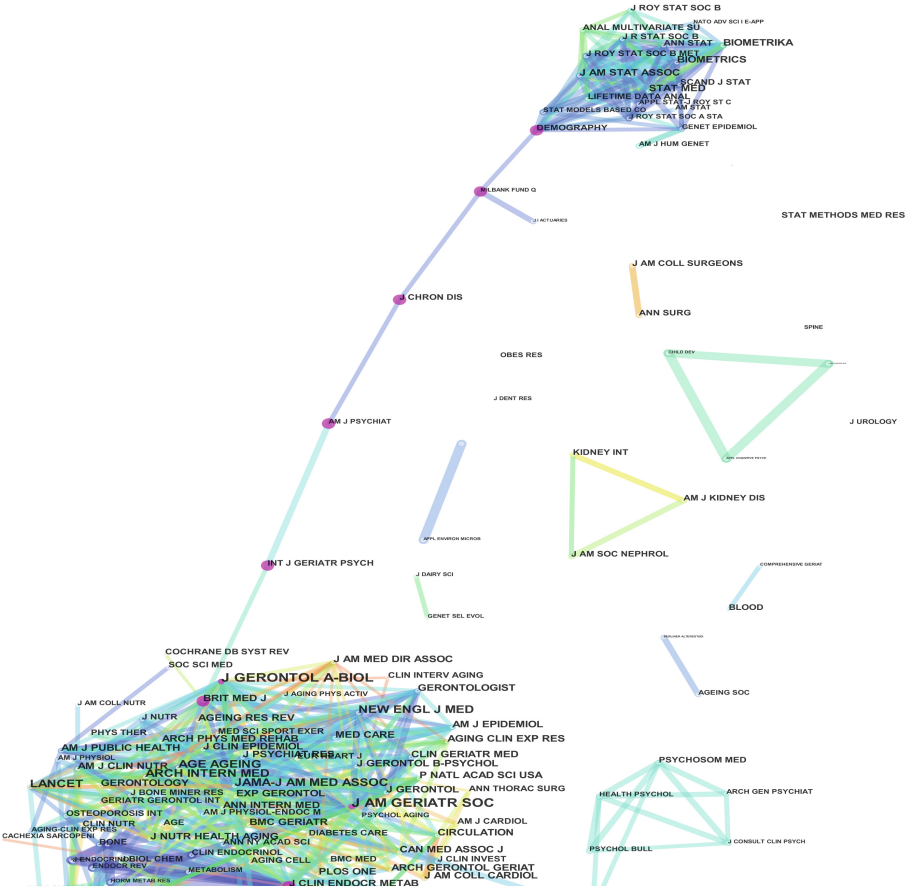

Fig. 5. Network of Journals: The dimension of the nodes represents centrality.

4 Discussion

In order to understand the complex panorama of frailty literature, we analyzed the data from Web of Science using scientometrics techniques. The factors included in this analysis are: authors, categories, countries, institutions and journals. An interesting scenario emerged from the data.

Concerning the "Categories" section, it is not surprising to find "GERIATRICS & GERONTOLOGY", and "GERONTOLOGY" at the top of the list. Interestingly, the third and fifth positions are occupied by "MATHEMATICS", and "STATISTICS & PROBABILITY". This trend highlights two important factors. On the one hand, it shows a strong interest in understanding the real diffusion of this phenomenon using demographics and statistical methods. On the other hand, these outcomes highlight the increasing application of mathematical models to the study of medical phenomena.

The analysis involving the count of articles per country show that the observed network is well connected, and it includes 6 European and 4 non-European countries. This data chances analyzing the countries with strongest citation bursts. Table 1 highlights that, to the current literature, the interest in frailty is moving from the USA to European nations; specifically, Denmark and Ireland are leading the top positions for article burst.

Another particular result emerged from the analysis of journals. As showed in Fig. 5, two different clusters of journals that deal with frailty emerged: The bigger one is related to medical and health topics. The second and smaller one is about biostatistics and epidemiologic. These outcomes relate to what emerged from the Categories' analysis and stress the strong interest that is emerging in the use of statistical and mathematical models for the understanding and prediction of frailty.

These analyses are a "first look" at this phenomenon, but a future deeper study is needed to better clarify the situation and the new trend in the study of frailty.

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