Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Telemedicine as technoinnovation to tackle COVID-19: A bibliometric analysis☆

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ABSTRACT

Telemedicine has become fundamental for the challenges posed to healthcare. This set of instruments turns pivotal for facing one of the most relevant emergencies in human history: the COVID-19 pandemic. The multisectoral crisis led to a vigorously sustained adoption of innovations, including telemedicine technology. Telehealth was proven, in this context, to be a relevant tool to reduce healthcare costs, reduce not-needed hospitalizations, and improve the results in health care. Some barriers such as the costs of technologies, patient privacy and technical literacy have slowed down telemedicine adoption. Amidst the COVID-19 era, telemedicine calls for a managerial duty to change healthcare's organizational models. The present work aims to explore the growing literature to illuminate the relationships between telemedicine, innovations and healthcare in the COVID-19 framework. A bibliometric analysis of the existing literature based on 285 published works in 2019–2020 is put forward with the aim to detect the relevant literature, themes and approaches on telemedicine and COVID-19. Making use of community detection on the co-occurrence keywords network, we identify the "semantic cores" in the literature representing the relevant results on critical themes. The sorting implications are important for researchers and policymakers by mapping the existing literature and results in evidence-based analysis. We provide the key communities as the "semantic core" of the publications and results for the considered period. This allows for future research to be oriented towards perduring health policies that could lead to the adoption of telemedicine technologies in a post-pandemic scenario.

1. Introduction

Our thinking on health, treatment, diagnosis and communication has reached unprecedented development. The Fourth Industrial Revolution has nudged research, policymaking and business osmosis between healthcare and management scholars and professionals. These events have dramatically changed the administration and structure of health systems (Ćwiklicki et al., 2020; Gomes de Melo e Castro e Melo and Araújo 2020; Massaro 2021). Therefore, telemedicine has acquired an essential role in the transition towards more advanced medical technologies and the interplay between the Fourth Industrial Revolution and health management.

Telemedicine is the provision of medical treatment and the supply of health services across a distance via technology (Hyder and Razzak 2020). As a result of the ongoing multi-layered crisis, technologies such as telemedicine have been increasingly used. Particularly relevant have been the consumer's perception and the essential investments that have been driving the sector (Bestsennyy et al., 2020). As new technologies have emerged over several decades, telemedicine has gradually but consistently grown in popularity (Rahaman 2021).

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Telemedicine has, indeed, been used for many years. However, growing data demonstrates its ability to improve the desired medical performance and health outcomes provided to patients (Hyder and Razzak 2020). In this respect, telemedicine can reduce hospitalizations and costs for the actors involved in the healthcare processes as patients and organizations (see Kumar et al., 2013; Hyser and Razzak 2020; Kruse et al., 2021). As physicians realize the advantages of telemedicine, patients have more access to treatment and payers perceive a decrease in the cost of care, the use of telemedicine is becoming increasingly widespread (Kruse et al., 2021). This also applies to severe pathologies such as cancer, where the benefits of telemedicine co-production of oncological care and the co-learning approach have been demonstrated (Miceli et al., 2021).

Nevertheless, hurdles and facilitators to telemedicine adoption exist (see Almathami et al., 2020). At the same time, noteworthy barriers exist in the use of telemedicine: in fact, implementing a virtual care program requires considerable operational assistance (Doshi et al., 2020). Following Kruse et al. (2021) and Smith et al. (2020), obstacles have delayed the adoption of telemedicine (costs of technologies, patient privacy and technical literacy, among others). Significant problems for health care can be the possibility of accessing these technologies for the majority of the population and concrete implementations in diverse situations (see Khodadad-Saryazdi 2021).

Following Smith et al. (2020), the use of telehealth also necessitates a significant shift in the managerial effort and the rethinking of current organizational models of medical care. Thus, a relevant problem in the organizational management of technology shall be remarked. In this respect, the mentioned authors suggest a different implementation of telemedicine, based on a proactive approach: telemedicine should be used routinely in the health system, overcoming existing barriers and limitations, considering relevant healthcare management changes.

However, during the COVID-19 epidemics, social distancing policy measures have imposed lockdowns all around the world (Calandra and Favareto 2020, Garcia García Vazquez et al., 2020, Le et al., 2020). At the same time, an overloaded healthcare system prompted a significant increase in the usage of telemedicine and the development of telehealth policy (Rahaman 2021; Hyder and Razzak 2020). Furthermore, the use of artificial intelligence and robotics, amongst other technical advances, may allow for telemedicine and the development of a more remarkable ability to react to upcoming pandemics, surpassing the existing COVID-19 timeframe of reaction (Secinaro et al., 2020; Bhaskar et al., 2020).

The growth of the related literature calls for statistical methods aiming to portray, track and synthesize the actual existence of a large scientific corpus that has been recently produced. In this sense, bibliometrics can fill the gap of repeatable, quantitative and nonsubjective methodologies applicable to obtaining some results that can be useful to orientate both the scientists, managers and policymaker in this literature. Systematic reviews are a reputed and valuable tool. However, they need to be accompanied by quantitative methodologies applicable to detect works that can be more relevant and useful to summarize the ongoing publications (Zupic and Čater 2015, Secinaro et al., 2020., Massaro et al., 2016 Secinaro et al., 2021) In this respect, this work aims to analyze the relationships between telemedicine and COVID-19, studying selected ways telehealth can innovate interconnected medical, healthcare and management processes in healthcare. Bibliometric analyses serve this purpose: synthesizing the existing literature allows to represent the relevant results and map the essential themes useful in decision-making (Holden et al., 2005). At the same time, bibliometrics is helpful to identify the works which can be considered to retain a high impact on literature. In this way, bibliometric analyses may be thought of as maps of existing scholarship to be used in evidence-based assessments (Iftikhar et al., 2019).

As theoretical and practical implications, using the techniques handled in the paper allowed to retrieve and synthesize the evidence from the international research on the field. In this respect, considering its practical implications, telemedicine can transform and enhance healthcare delivery. However, there is a need for relevant organizational change in various healthcare contexts (for example, training). A bibliometric analysis of the literature on telemedicine and COVID-19 is conducted to synthesize and glean insights into the topic.

The article is divided into four remainder parts: in Section 2, a presentation of the data and the methodology used on the work is put forward. Section 3 shows the results of this work and is divided into different subsections related to the diverse methodologies used. In Section 4, a discussion of the outcomes is put forward. Finally, section 5 policy implications and conclusions are elicited to terminate the article.

2. Data and methodology

As a research procedure on data collection, we followed Pirri et al. (2020), considering the PRISMA Extension for Scoping Reviews. In this respect, we have exploited a two-phase approach to accomplish our research objectives. The first step is to conduct the Scoping Review based on Arksey and O'Malley (2005). Then, after having retrieved the relevant works from the SCOPUS database, grounded on the search string, a bibliometric analysis was performed. In terms of language, we considered articles published in English. This is a possible limitation. However, English will continue to be the *de facto* international language of science (Kamadjeu 2019) – at least for economics and social sciences. We do not consider any other restrictions on our analysis, so we used all the papers retrieved making use of this research string. In this respect, in terms of time, we worked on 2020 and 2021.

The original material reviewed and analyzed bibliometrically for this study was published in peer-reviewed journals and indexed in a bibliographic database as Scopus. This served as the foundation for the current study. Scopus is a database that embeds abstracts and citations for scientific publications. In this respect, Scopus includes information and content that has been peer-reviewed by members of the scientific community (Baas et al., 2020). Because of the high number of references available via Scopus, this database was selected as a source (see also Valenzuela-Fernandez et al., 2019). However, it is essential to note that Scopus is a structured repository ("a curated database"), which implies that material is chosen for inclusion in the database after a thorough review procedure (see Baas et al., 2020). Therefore, academic research in quantitative scientific studies may benefit from Scopus, defined as a bibliometric data source in which "[…] Serial content (i.e., journals, conference proceedings, and book series) submitted for possible inclusion in Scopus by editors and publishers is reviewed and selected, based on criteria of scientific quality and rigor […]" (Baas et al., 2020). Following Ellegaard and Wallin (2015), the researcher may build a representative and relevant corpus of scientific documents for scholarly purposes to perform a bibliometric analysis. For example, in order to collect the relevant articles and to construct the bibliometric database, we use the following search string profile in Scopus:

TITLE-ABS-KEY (telemedicine OR telehealth AND COVID-19 AND innovation) performed on 21/7/2021.

The query was performed on Scopus on the day 21/7/2021. In this respect, this search analyzed 285 articles published between 2020 and 2021 using bibliometric analysis to reach the sorting conclusions. Bibliometrics is now ubiquitous in many sectors of science for its capacity to serve as a way to perform "quantitative systematic reviews" useful in decision-making. This is specifically important for detecting analyses in multidimensional economic investigations (see Ho and Gatto 2021, Ho and Gatto, 2020, Au-Yong-Oliveira et al., 2021, Gatto and Drago 2020, Drago and Bertelli 2020, Drago and Hoxhalli, 2020 and Drago and Aliberti 2018, for bibliometric analyses in economics facing large datasets and big data).

The analytical approach was divided into three parts (see Aria and Cuccurullo 2017; Moral-Muñoz et al., 2020 about different quantitative and computational methods to conduct bibliometric analyses). First of all, we analyzed the data descriptively to evaluate the bibliometric

dataset's general trend and content. The analysis of the bibliometric dataset using descriptive techniques is aimed to detect the principal features of the data structures on the bibliometric dataset. These statistical techniques belong to exploratory data analysis (Tukey 1977) and help to explore the dataset's contents.

Secondarily, the analysis is run taking into account the co-occurrence network, which can be obtained from the publication. So we extract from the bibliometric dataset all the keywords for each work and then construct a relational dataset. More specifically, each node as keyword connects to other nodes by means of papers containing the same keyword. This kind of analysis is essential to determine the most relevant literature themes to be studied (Dal Mas et al. 2019, 2020; Uluyol 2021; Chao et al., 2007). Then, a structural network analysis of the literature is helpful to identify the relevant works in terms of network characteristics as centrality and authority (Wasserman and Faust 1994; Newman 2008). An analysis of networks is a collection of methods used to illustrate relationships between actors and study the systems that emerge from the repetition of these relationships (Chiesi 2001). In order to evaluate the centrality of the different keywords on the co-occurrence network, we use two distinct measures: the betweenness and the Freeman degree. Following Wasserman and Faust (1994), given a determined network or graph $G := (V, E)$, where we have nodes (also defined vertices) $|V|$ and links (also defined nodes) $|E|$

The betweenness measured for each node v can be expressed as:

$$BET(v) = \sum_{s \neq v \neq t} \frac{\sigma_{st}(v)}{\sigma_{st}} \tag{1}$$

Where considering two nodes s and t we can refer to $\sigma_{st}(v)$ as the number of shortest paths on a network passing through a considered node v , where at the same time σ_{st} is the total number of shortest paths between s and t

Then Freeman degree:

$$FD(v) = \deg(v) \tag{2}$$

The Freeman degree is the number of connections that are incident on a particular node v. Then we move to analyze and identify the detectable data communities (Fortunato 2010; for an application see Drago and Ricciuti 2017). Following Lu et al. (2018), community structure is an essential characteristic of networks, defined as a grouping of nodes with strong ties on a local scale. Thus, it is crucial to understand complex systems to identify the communities of nodes (the keywords) that form complex systems (the literature on the considered subject). In this respect, it is possible to adopt an approach based on community detection using the walktrap algorithm (Pons and Latapy 2005 Csardi Nepusz 2006). We discover the literature's relevant "semantic cores" from the community, as the most relevant identifiable themes and topics (acting as groups of keywords). Each community detects some keywords or topics in the literature that are maximally connected to each other (Fortunato 2010). Then considering also for each community the different structural indexes of centrality (betweenness and Freeman degree) for each node is possible to elicit the relevance for each topic. Lastly, we use multidimensional statistical techniques to analyze and map the literature (Greenacre and Blasius 2006; Aria and Cuccurullo 2017).

3. Results

3.1. Characteristics of the publications from the bibliometric dataset

This section presents the findings of the bibliometric analysis conducted. Table 1 shows the pertinent descriptive analysis of the bibliometric dataset studiedin this work. In particular, we observe the time frame of the article, which is the period 2020–2021. The number of documents in the final set of publications examined in the work at hand is 285. At the same time, some additional crucial pieces of information show the relevance and vitality of the problems and themes (average citations per document and average citations per year per document). Most of the inspected documents are articles (163), where some other relevant shreds of information are related to the document's contents, the number of authors. In this sense, the higher number of authors having more than one publication is a crucial feature because in this literature, the number of co-authored papers is significant, whereas the number of single-authors is the minority (26 authors on a total of 1714). Then it is possible to study the most productive authors with three articles in 2 years and the full manuscripts per citation. It is interesting to note the total number of citations and the total number of citations per year. The publication which leads the ranking is Singh et al. (2020), with 187 citations, and the second work is Torous et al. (2020) with 171 citations. Other relevant information come from the geographical appraisal – the USA show the highest number of publications on this topic (113 articles). In the same table, visualizing the corresponding authors by country, other countries appear – the United Kingdom, Australia, Canada and Italy. Similar results are obtained for the total citations by country, outlining notable differences from the first ranking. Italy ranks fourth, whereas Australia ranks at seventh place.

Interestingly, the highest number of publications for the topic is from the Journal of Medical Internet Research, which combines innovation, health and telemedicine research. Other journals tend to show the growth of telehealth, telemedicine and innovation in health in general and COVID-19 more specifically. Following the distinction between *keyword* and *keyword plus*, it is possible to find the most used keywords for the articles that belong to this topic. Some keywords are directly related to COVID-19: this is the case for "pandemic", "coronavirus" and "betacoronavirus", "coronavirus disease 2019" but also "digital health" and "innovation", where some other keywords call for exciting considerations. This is the case of the procedures, which means that telemedicine and telehealth can become parts of relevant procedures that offer an anti-COVID-19 strategy. Similarly, "organization and management" show the necessity to use these technologies and innovations in concrete situations. Finally, "mental health" shows the timeliness of mental health innovations in telemedicine and telehealth. At the same time, a rise in the theme of artificial intelligence emerges. These keywords are relevant because they first recognize the most relevant topics considered in this literature.

In Fig. 1, a visualization of the most productive countries is provided.

3.2. The co-occurrence keywords network analysis

In order to assess the relevance of the different topics in the selected body of literature, we can study the co-occurrence network (Table 2). The co-occurrence network is based on the fact that different keywords can appear in many papers (and the ubiquity of the different keywords is a relevant element in the analysis see Tijssen and Van Raan 1994). However, there is still the possibility that the same keyword tends to share the presence on a paper with other keywords. In this sense, we can identify a relation between two publications that are part of the keyword list for many papers. These relations allow us to study the network from the different keywords.

In this respect, a higher centrality is crucial in the analysis because it allows identifying more relevant keywords than others. The centrality at a specific time shows topics that are more popular than others. A first empirical evidence that shows the high level of interconnections between the most central keywords is plotted in Fig. 2, which shows the structure of the central part of the entire network. At the same time, keywords with less centrality allow identifying more enthralling themes for publications because they are perhaps rising in popularity. However, they are not the "center" of the literature on these topics. The size of the network (Table 2) is related to the number of the keywords entailed, where the density shows the number of links on the total possible linkages (so it represents an index to evaluate the network structure better).

Table 1
Main information about data.

Timespan	2020 : 2021
Sources (Journals, Books, etc)	221
Documents	285
Average years from publication	0.614
Average citations per documents	5.909
Average citations per year per doc	3.168
References	8986
DOCUMENT TYPES	
Article	163
book chapter	2
conference paper	5
Editorial	24
Letter	16
Note	14
Review	59
short survey	2
DOCUMENT CONTENTS	
Keywords Plus (ID)	1949
Author's Keywords (DE)	717
AUTHORS	
Authors	1714
Author Appearances	1748
Authors of single-authored documents	26
Authors of multi-authored documents	1688
AUTHORS COLLABORATION	
Single-authored documents	28
Documents per Author	0.166
Authors per Document	6.01
Co-Authors per Documents	6.13
Collaboration Index	6.57

Most Productive Authors	Authors	Articles	Authors	Articles Fractionalized
1	LUC JGY	3	LIAO JM	2.00
2	TOROUS J	3	VOSE JM	2.00
3	ALLISON S	2	NAJAFI B	1.50
4	ALVISI P	2	FISCHER SH	1.25
5	ANITESCU M	2	LUC JGY	1.17
6	ARMSTRONG WS	2	BERLIN J	1.00
7	BASTIAMPILLAI T	2	BHAVNANI SP	1.00
8	BECKER SJ	2	EGAN K	1.00
9	BLOEM BR	2	HREVTSOVA RY	1.00
10	BRANCOLINI S	2	IP-JEWELL S	1.00

Top manuscripts per citations	
1	SINGH AK, 2020, DIABETES METAB SYNDR CLIN RES REV
2	TOROUS J, 2020, JMIR MENT HEAL
3	DEDEILIA A, 2020, IN VIVO
4	FISK M, 2020, J MED INTERNET RES
5	BARNEY A, 2020, J ADOLESC HEALTH
6	CRAWFORD A, 2020, J MED INTERNET RES
7	O'CONNOR CM, 2020, J ARTHROPLASTY
8	BADAWY SM, 2020, JMIR PEDIATR PARENT
9	YELLOWLEES P, 2020, PSYCHIATR SERV
10	SAMUELS EA, 2020, J ADDICT MED

	DOI	TC	TCperYear	NTC
1	10.1016/j.dsx.2020.04.004	187	93.5	20.95
2	10.2196/18848	171	85.5	19.16
3	10.21873/invivo.11950	85	42.5	9.52
4	10.2196/19264	60	30.0	6.72
5	10.1016/j.jadohealth.2020.05.006	48	24.0	5.38
6	10.2196/19361	42	21.0	4.71
7	10.1016/j.arth.2020.04.038	39	19.5	4.37
8	10.2196/20049	38	19.0	4.26
9	10.1176/appi.ps.202000230	37	18.5	4.15
10	10.1097/ADM.0000000000000685	35	17.5	3.92

Corresponding Author's Countries	Country Articles	Freq	SCP	MCP	MCP_Ratio
1	USA	113 0.4913	99	14	0.124
2	UNITED KINGDOM	16 0.0696	10	6	0.375
3	AUSTRALIA	14 0.0609	11	3	0.214
4	CANADA	12 0.0522	6	6	0.500
5	ITALY	11 0.0478	8	3	0.273
6	INDIA	8 0.0348	7	1	0.125
7	IRELAND	6 0.0261	6	0	0.000
8	FRANCE	5 0.0217	2	3	0.600

(*continued on next page*)

Table 1 (*continued*)

Corresponding Author's Countries	Country Articles	Freq	SCP	MCP	MCP_Ratio
9	SINGAPORE	5 0.0217	4	1	0.200
10	GERMANY	4 0.0174	4	0	0.000

Total Citations per Country	Country	Total Citations	AverageArticle Citations
1	USA	686	6.07
2	UNITED KINGDOM	138	8.62
3	CANADA	82	6.83
4	ITALY	77	7.00
5	SINGAPORE	46	9.20
6	IRELAND	33	5.50
7	AUSTRALIA	32	2.29
8	INDIA	30	3.75
9	NEW ZEALAND	27	13.50
10	MALAYSIA	24	12.00

Most Relevant Sources	Sources	Articles
1	JOURNAL OF MEDICAL INTERNET RESEARCH	9
2	JOURNAL OF SUBSTANCE ABUSE TREATMENT	6
3	JOURNAL OF GENERAL INTERNAL MEDICINE	5
4	INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH	4
5	ASIAN JOURNAL OF PSYCHIATRY	3
6	FRONTIERS IN PUBLIC HEALTH	3
7	INFLAMMATORY BOWEL DISEASES	3
8	JMIR MENTAL HEALTH	3
9	JMIR RESEARCH PROTOCOLS	3
10	JOURNAL OF ADDICTION MEDICINE	3

Most Relevant Keywords	Author Keywords (DE)	Articles	Keywords-Plus (ID)	Articles
1	COVID-19	129	TELEMEDICINE	352
2	TELEMEDICINE	73	HUMAN	242
3	TELEHEALTH	47	PANDEMIC	239
4	PANDEMIC	28	HUMANS	208
5	DIGITAL HEALTH	17	BETACORONAVIRUS	170
6	INNOVATION	15	CORONAVIRUS DISEASE 2019	160
7	SARS-COV-2	13	PANDEMICS	144
8	CORONAVIRUS	12	PROCEDURES	115
9	MENTAL HEALTH	8	ORGANIZATION AND MANAGEMENT	114
10	ARTIFICIAL INTELLIGENCE	7	COVID-19	110

Centralization as a metric is helpful to measure the most central node regarding the centrality of all the other nodes. In this sense, the network seems to be highly centralized. In order to evaluate the nodes (in this respect, the different keywords centrality), we can analyze the level of betweenness (Table 3) and the Freeman degree (Table 4) for each keyword. In this way, we can measure the "global centrality", the nodes that are the most central considering the entire network and the nodes based on a higher "local centrality". In the latter case, these are most central in their location, but they cannot be considered central for the entire network.

The distinction in terms of keywords is determinant because the betweenness measures the capacity for a keyword to be relevant for the entire topic considered. At the same time, the Freeman degree shows the capacity for some keywords or nodes to be maximally central on their network position. The highest centrality in terms of betweenness is related to keywords such as telemedicine and human but also keywords related to COVID-19 as "pandemic", "betacoronavirus", "coronavirus disease 2019" and "pandemics". Interestingly, we found some relevant keywords that are maximally central in the network, which is "procedures". The relevant interpretation of the betweenness ranking can be obtained by exploring all the first keywords on the ranking. In fact, telemedicine allows to improve healthcare by the means of increased ease of access to the services. At the same time, it is needed a different organization to allow this type of health care delivery. In this sense, it is particularly important to lead processes of organizational innovation that can allow the routinely use of telemedicine.

The focus on "female" as a keyword is also important. The possible interpretation is that these organizational innovations are useful to implement in scale telemedicine. Furthermore, this can be helpful to women who highly benefited from telemedicine (Atanda 2020).

In the case of the Freeman degree, we took into account a different centrality approach based on the "local centrality" (the number of links by each node). So this measure can be explicitly interpreted as an active theme of research in the keyword occurrence network multiplying over time the exploration and the study of themes that are logically connected. Also in this case, we can observe some relevant keywords which are related to COVID-19, such as "pandemic", "betacoronavirus", "coronavirus disease" and also "coronavirus infection". We have got a keyword explicitly on "organization and management". This allows us to reflect on the fact that in the literature is essential to define and to find a new type of organization and management for the institutions involved in the processes. This is useful to speed-up the adoption of telemedicine. Also in this case, the focus is based on "female" because at the same time it is possible to observe a specific interest in the literature on the use of telemedicine for women's health studying ways to allow face-to-face consultations with specialists avoiding specific contacts (see also Bindra 2020; Atanda 2020).

In this respect, "health care delivery" can be found in "organizational innovation". From the analysis of the structural indexes of the network, we can identify the communities. This group of nodes are "the semantic cores" of the literature we are exploring quantitatively.

3.3. Community detection and the discovery of the "semantic cores" of the literature vs the MCA analysis

Following Fortunato (2010), the communities on a network are a group of nodes that are maximally connected but at the same time are weakly connected with the other communities. In this respect, it is essential to note that the groups of nodes that are maximally connected tend to indicate some relevant meanings and contents, which can be

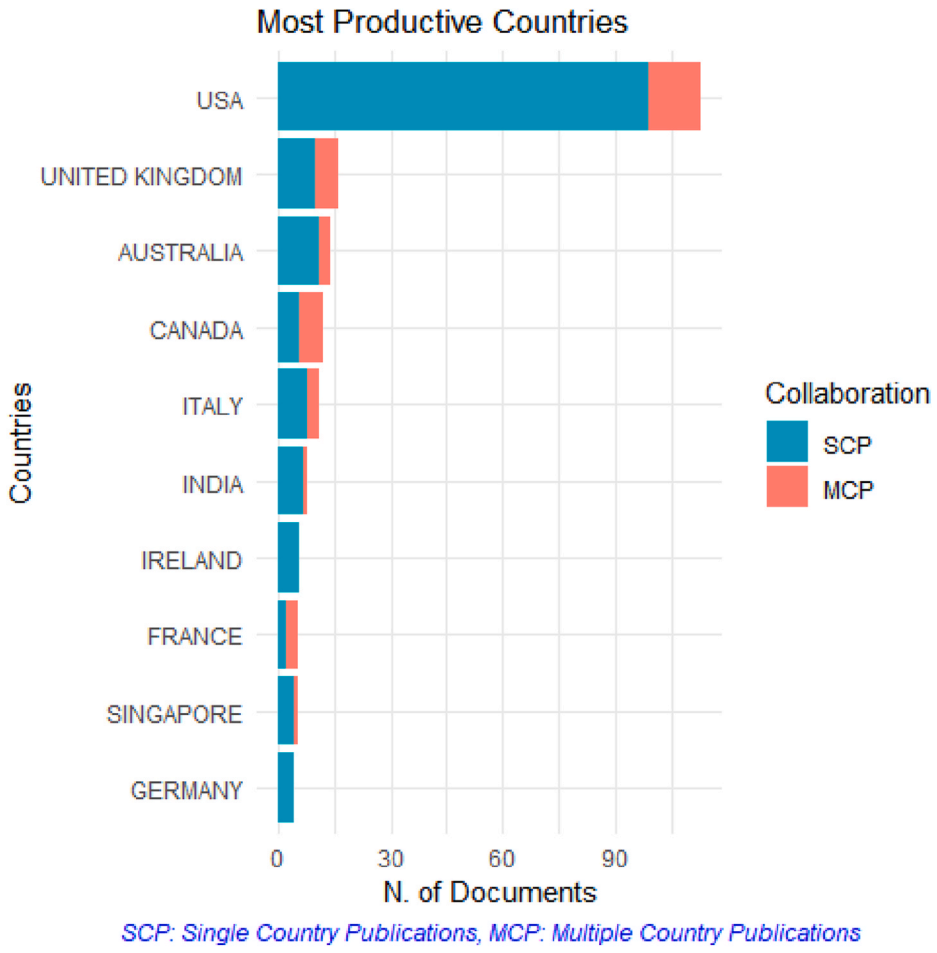

Fig. 1. Most productive countries.

Table 2
Main statistics about the network.

Size	1949
Density	0.047
Transitivity	0.217
Diameter	3
Degree Centralization	0.932
Average path length	1.972

defined as "semantic core". These groups of nodes or keywords identify some relevant, helpful content to resume the entire literature. So each community can be interpreted to identify some relevant meanings that are important to better understand the analyzed literature. In order to compute and identify the different communities, we used the walktrap algorithm (Pons and Latapy 2005), which allows better performances in the selected case in partitioning the relevant networks in multiple communities of nodes (or keywords). At the end of the procedure, it is possible to detect 55 different groups containing all the different keywords. Each community incorporates different nodes (keywords) and can be interpreted through the presence or absence of the keywords which are mutually logically connected. Not all communities show the same relevance as general betweenness or Freeman degree. In fact, communities that are central represents a corpus of research that is more pertinent for the study and the contemporary analysis. We focus on the hottest and most central communities (also in terms of number of nodes in the same community), interpreting the most relevant results from each group of nodes:

Community 1. Communication and disinfection as pillars of the anti-

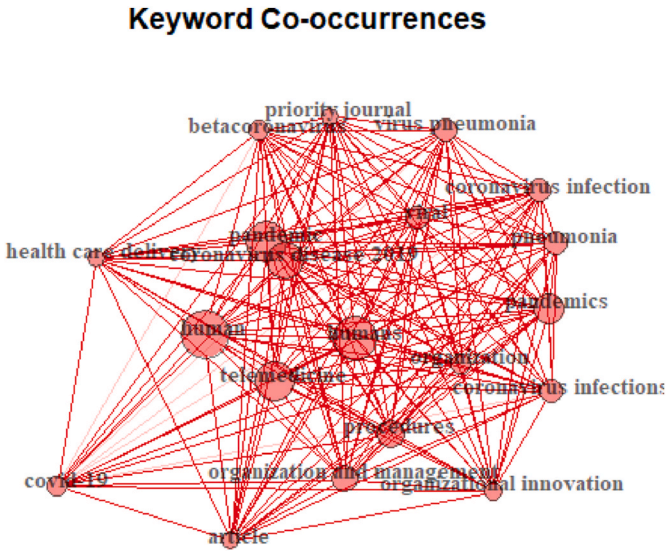

Fig. 2. Network of Keyword Co-occurrences (first 20 keywords by centrality).

COVID-19 strategy (and for this way communication by means of strong development of the telemedicine. Fernández and Couñago 2020).

Community 2. COVID-19, telemedicine and the necessary change in the managerial organization (Smith et al., 2020, Kruse et al. 2020).

Community 3. COVID-19, telemedicine as a very relevant innovation in the long-run in order to avoid costs related to COVID-19 allowing

Table 3
Node centrality: Betweenness.

	Betw
TELEMEDICINE	142072.04
HUMAN	210212.51
PANDEMIC	128819.78
HUMANS	141672.91
BETACORONAVIRUS	25614.16
CORONAVIRUS DISEASE 2019	128568.52
PANDEMICS	61677.07
PROCEDURES	60810.48
ORGANIZATION AND MANAGEMENT	46093.76
COVID-19	80123.95
CORONAVIRUS INFECTION	31898.69
CORONAVIRUS INFECTIONS	31898.69
PNEUMONIA	31471.48
VIRAL	31471.48
VIRUS PNEUMONIA	31471.48
FEMALE	12428.42
HEALTH CARE DELIVERY	27655.48
ORGANIZATION	27843.68
ARTICLE	42746.49
ORGANIZATIONAL INNOVATION	26687.11

Table 4
Node centrality: Freeman degree.

	Degr
TELEMEDICINE	1702
HUMAN	1908
PANDEMIC	1677
HUMANS	1756
BETACORONAVIRUS	1024
CORONAVIRUS DISEASE 2019	1646
PANDEMICS	1351
PROCEDURES	1306
ORGANIZATION AND MANAGEMENT	1202
COVID-19	1166
CORONAVIRUS INFECTION	1119
CORONAVIRUS INFECTIONS	1119
PNEUMONIA	1116
VIRAL	1116
VIRUS PNEUMONIA	1116
FEMALE	687
HEALTH CARE DELIVERY	927
ORGANIZATION	1027
ARTICLE	1043
ORGANIZATIONAL INNOVATION	1010

simple interactions between who is involved in all processes related to health (Zimmerling and Chen 2021).

Community 4. COVID-19, mental disease, mental health and telemedicine as an instrument to allow better-specialized services useful to a general increase of the quality of the health-care (Arafat et al., 2021; Tourous et al., 2020). The role of social media in this context can either be undervalued, for instance for education purposes or communications in an emergency (Li and Zhang 2020).

Community 5. Telemedicine and continue medical care (Iyengar et al., 2021).

Community 6. Gender-related issues for male and female, innovations in telemedicine and COVID-19 (Atanda 2020).

These communities (selected as the highest average betweenness of the members of the node of the communities) show the most relevant topics in literature and as well the most relevant groups of results obtained from the actual literature. Overall it is possible to observe the strong relevance of telemedicine in various medical contexts, allowing better delivery of health care. This result is crucial: telemedicine means a better capacity to communicate and in the COVID-19 time allow to minimize contacts allowing to reduce the spread of the pandemics. At the same time, the development of telemedicine and the adoption of this technology routinely, request specific organizational changes (for instance a specialized training in the use of technologies). All these organizational changes need a new paradigm, supporting higher investments in healthcare in which telemedicine is routinely used. Telemedicine can be an innovation that leads to increased communication and quality of care. So it can facilitate an anti-fragile healthcare system (Cobianchi et al., 2020 –a; Cobianchi et al., 2020 -b).

The analysis of the networks may be accompanied by a different approach to examine the robustness of our findings – previously described. In this sense, we can use multiple correspondence analyses on the matrix representing the specific keywords for each document (Fig. 3 "Conceptual Structure Map using Multiple Correspondence Analysis") Therefore, it is possible to use hierarchical clustering techniques in order to identify the relevant groups of keywords. These results confirm our preliminary interpretation. At the end of the analysis, we discover four relevant clusters which are aimed to synthesize the relevant themes of the literature as well. The three clusters identified can be interpreted as follows:

Cluster 1 (the red cluster) is a very general and comprehensive group and confirms all our findings in the second part of the analysis with the community detection. More in particular, this cluster is related to the corpus of literature that analyze the way in which innovations as telemedicine can positively impacts the quality of care. Videoconferencing, for instance, can allow the possibility to improve the quality of care in psychology and in mental health services applications of telemedicine in hospitals and telemedicine used for adolescent health care (see Wood et al., 2020 Carretier et al., 2021). In all these cases we can confirm the relevant necessity to contemplate a relevant change in organizations. So these elements represent a clear challenge for the management of healthcare delivery for the future.

Cluster 2 (the blue cluster) is related to all themes in literature that are based on prevention and control.

Cluster 3 (the green cluster) rely on the relevance of new technologies and innovations as artificial intelligence which, combined with telemedicine, allow it to better act as a support on the fight against COVID-19.

4. Discussion

In this respect, bibliometrics was an essential tool to explore and synthesize the entire corpus of literature (Pirri et al., 2020; Secinaro et al. 2020, 2021a, Secinaro et al., 2021; Tijssen and Van Raan 1994). These studies provide bibliometric analyses based on classic approaches.

We propose a novel outlook to analyze the different nodes based on Drago and Hoxhalli's (2020) and (2021) works. In this respect, these statistical units are part of the identified community, interpreted and analyzed as a whole and not as single nodes. It is essential to retain semantic cores as a group of nodes because it allows interpreting the meaning of the relevant results in the literature implied in the group. However, another critical reason arises: this way, we can measure the central data looking at them as intervals instead of single observations. Then, for a second time, their relevance to the network of concepts in the literature can be measured (in the same fashion as Drago Hoxhalli 2020 and 2021).

Measuring the centrality of each semantic core as an interval for the assessed group, it is easier to assess the relevance of the publications' findings. Taking into account this work's practical implications, we discuss their beneficial role, analyzing the advantages and critical points.

The first benefit is the enhanced ease of communication enabled by these technologies – which is critical in certain specialized medical services. The second advantage is the exponential decrease in the costs of prevention through COVID-19 avoidance of patient interaction. As a result, Smith et al. (2020) emphasize a crucial point: telemedicine alters the healthcare's organizational paradigm. For the authors, telemedicine may also widen the gap between those who access technologies and those who do not. This may imply an additional step toward health

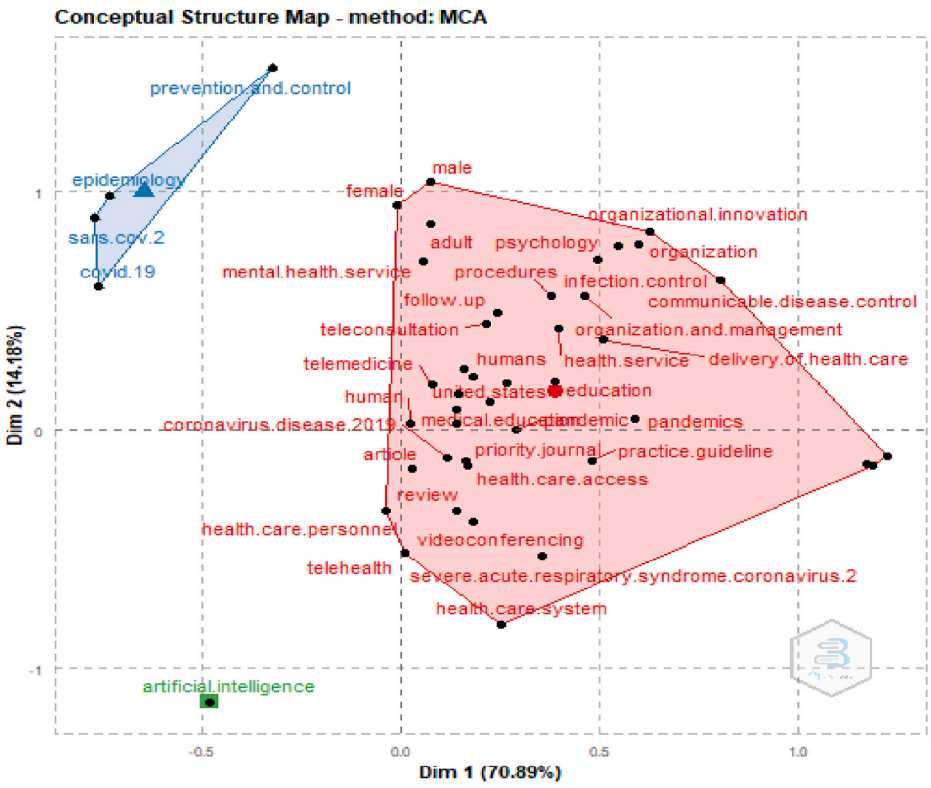

Fig. 3. Conceptual Structure Map using Multiple Correspondence Analysis.

justice, especially for those countries lacking a solid, universal national health coverage (Gatto et al., 2020). Again, this issue relates to the management of telemedicine adoption in healthcare organizations and its socio-economic and political impacts. Hence, the administration of healthcare is a second determinant aspect of telemedicine integration into the business and, hence, society. Nonetheless, the larger numbers of women making use of telemedicine with respect to men may help to mitigate gender inequalities, as shown.

The major limitation of the work is the use of a single community detection approach (i.e. the walktrap algorithm by Pons and Latapy 2005). However, researchers may also prefer to use different approaches in the future to combine different algorithms of community detection to measure the semantic cores (see Dahlin and Svenson 2013; Drago and Balzanella 2015; Duan and Binbasioglu 2017; Drago 2018). In addition, a prospective study may examine whether the adoption of these new technologies has been successful and underpins the conditions to allow their use (Kruse et al. 2020).

5. Policy implications and conclusion

Telemedicine is the delivery of medical treatment and the provision of health services across vast distances via the use of technology (White et al., 2001). Here, we have exploited bibliometric techniques to synthesize and find relevant insights into the literature on telemedicine and COVID-19. We found different "semantic cores" representing the hottest elements to be evaluated using network analysis and community detection. The first advantage that modern technologies provide is the increased ease of communication they carry (which is paramount in certain specialized medical services). The second benefit is the exponential reduction in the expenses of prevention that results from the absence of patient contact with COVID-19. Problems can be related to the need for a change in the organizational paradigm in the healthcare industry.

A key question is whether this would imply a potential increase in the gap between those patients who have access to technology and those who do not have such capability. Also, socio-economic, geographical and context features may turn determinant, where a multi-stakeholder outlook in medical care, whereby inclusion and diversity are promoted, seems to be necessary (Cobianchi et al., 2021-a and 2021-b, Biancuzzi et al., 2020). The diverse nature of the involved actors and entities implies proactive roles in the medical ecosystem – and novel knowledge (Secundo et al., 2019). In this sense, a problem in certain zones and situations may exist. Nevertheless, results from the inquiry at hand suggest encouraging participation of at least one socio-economic vulnerable group amidst COVID-19 – i.e. women.

The bibliometric analyses run enable the discovery of new crucial possibilities of research and development. At the same time, intriguing possibilities to identify hot research venues arise from an exploration of the existing scholarship. The sorting outputs and the "semantic cores" are helpful to understand the different results suggested by the literature. The clear advantage of using bibliometric techniques is their capacity to synthesize a large corpus of literature. This approach allows for the identification of the most relevant topics and works, which are, for example, members of a community (thus demonstrating relevant internal connections) and are decisive to elicit the interconnections that can appear on the network of co-occurrences (i.e., those which are central in the network).

These topics show the focus in contemporary research (years 2020–2021) and make the synthesis of the most insightful outcomes. These results can also be quantified by identifying from the communities the different works belong to each community.

These outputs can be helpful to decision-making because they pave the way to represent synthetically and understand the trends in this literature and the associated problems. Identifying the most crucial publication results, the trend also flag the perceived importance exhibited by the scholars and possible policy implementation.

The digital revolution has dramatically redrafted how we conceive the enterprise and its connection with the economy, society, the environment, the institutions and academia (Gatto and Sadik-Zada 2021; Aldieri et al. 2020 and 2021, Gatto 2020, Rippa and Secundo 2020 and

2019). Medicine and healthcare technological innovation are cornerstones of this process. In this scenario, telemedicine can be seen as a part of the general revaluation of the health policies of the modern health ecosystems forced by the COVID-19 outbreak and further crises. In this sense, it is possible to recognize a clear transition from "resilience" to situations of "anti-fragility", towards sustainable, mitigated healthcare systems (see Romani et al., 2021, Cobianchi et al. 2020-a, Cobianchi et al. 2020-b, Gatto et al., 2020 and Presch et al., 2020).

In this study, we have presented a bibliometric analysis of a new dataset comprehensive of 255 high quality works from Scopus. The search string used is exhaustive of the problem we are investigating and is a useful tool to identify and collect the crux literature on the topic. The purpose of this work was to examine the connections between telemedicine and COVID-19, as well as the important ways in which telehealth may innovate healthcare procedures. In this respect, by using different quantitative bibliometric statistical approaches we were able to identify a key path to the anti-fragility of the healthcare system by means of digital innovations and telemedicine in particular.

The first advantage is the increased ease of communication allowed by these technologies (prominent in some specialized medical services). Secondarily, this may assist the uptake of procedures favoring the exponential reduction of the costs of the prevention by COVID-19, avoiding the contact with the patients. At the same time, it exists a relevant point to be taken in mind: telemedicine necessitates an additional management responsibility – altering healthcare's organizational paradigms (Smith et al., 2020).

A relevant problem, linked to the last one, is that access to telemedicine innovations is problematic. In this respect, the possibility to increase the difference and the inequality between who can access these technologies and who does not exists (for instance the availability of relevant technologies or the sufficient literacy to use them). That problem refers to the "organizational management" of the adoption of telemedicine in health organizations. This issue feeds inequality divides and feeds socio-economic and political problems.

A second important aspect is inserting telemedicine in organizations and the management of healthcare in the peculiar context. For instance, higher investments in training the workforce and in technologies would be necessary (Smith et al., 2020).

This study has as a drawback: it only uses one community detection method (the walktrap algorithm). The technique could possibly be improved exploiting other approaches to examine community detection. This would be useful to identify relevant patterns on the analysis of the literature different "semantic cores". Future research might combine different community identification algorithms to identify the "semantic cores". Research in the future may also focus on conditions of success regarding the adoption of these new technologies. Upcoming investigations may also examine health policies that could lead to the use of telemedicine technology in the aftermath of COVID-19 and pandemics (Kruse et al. 2020).

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