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The COVID-19 Pandemic and Scientific Community Response in France, Greece, Norway, and Spain

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Abstract:

Purpose – *COVID-19 pandemic claimed millions of lives and changed everyday life for billions of people worldwide. Europe was severely impacted in health, social and economic aspects. Research efforts reallocation was a necessity to battle against this threat.*

Design/methodology/approach – *The scientific community responses against COVID-19 were assessed in terms of country paper productivity indexed in PubMed, Scopus, Web of Science, Dimensions and iCite databases. This research project was designed and performed in the framework of Health Information and Libraries Erasmus+ course with the participation of information science students from France, Norway, and Spain.*

Findings – *Prior to COVID-19 emergence, coronaviruses related publications accounted for approximately 0.15% of the total research output of more than 800,000 reports affiliated to France, Greece, Norway, or Spain. After COVID-19 pandemic the related scientific output was increased by 60-times to a 7% of the total scientific output of more than 900,000 affiliated reports. Between 2020 and 2022, 21,299 COVID-19 publications were affiliated to France, 6897 to Greece, 5353 to Norway, and 29,195 to Spain accounted collectively for approximately 9% of the global scientific output. The coronavirus related publications involved Medicine, Immunology and Microbiology, Biochemistry, Genetics and Molecular Biology but also humanities and social sciences, and economics and business.*

Originality/value - *COVID-19 spread fast across the globe from Asia to Europe despite quarantines and social distancing measures. International collaborations, space and funding reallocation led to an enormous original research output within months. Lessons from these responses are invaluable in future pandemic preparedness.*

Index Terms — SARS-CoV-2, SARS-CoV-1, influenza, cancer, cardiovascular, bibliometrics.

I. Introduction

Coronaviruses were responsible for the first two major epidemics of the new millennium, the Severe Acute Respiratory Syndrome (SARS-CoV-1) and Middle East Respiratory Syndrome coronavirus (MERS-CoV) **[1-3]**. These outbreaks mostly affected Asia to a total of 11,000 cases with nearly 2,000 fatalities altogether worldwide but with no more than 40 sporadic cases in total in Europe **[4]**. The imprint of SARS and MERS in Southern Asia and Arabian Peninsula respectively, and their high mortality rate were of such a magnitude that coronaviruses were considered as a top potential health risk for a communicable disease pandemic with a greater impact in morbidity and mortality than of the pandemic influenza A strain of the World War I era **[5]**. However, despite the warnings, no effective anti-SARS or anti-MERS vaccines and therapeutics have been well developed two decades after SARS and one decade after MERS outbreaks **[6]**. When COVID-19 (SARS-CoV-2) emerged causing severe pneumonia with a lower than SARS and MERS but significant mortality rate **[7]**, the European population was immunologically naïve and the clinical and biological information available was extremely limited.

Global leaders, civil servants, corporates, private industries, healthcare personnel, and the scientific community worldwide were confronting a viral pandemic communicable disease that could evolve to a catastrophe. Multistakeholder participation in disaster management was necessary in COVID-19 pandemic case. International health organizations proposed public health strategies, the European Union set plans of action, but it was the government officials' responsibility in each country to decide on their own set of policies. Government officials should decide among social distancing restrictions till the availability of proper vaccination, herd immunity, flattening the curve of active cases per time and raising the line of healthcare capacity **[8, 9]**. Reallocation of funding, staff,

equipment, and resources took place among state and non-state actors **[10]**. The aim of this report is to assess the scientific community response in four European countries France, Greece, Norway, and Spain in alphabetical order, corresponded to the nationalities of the student participants and the tutor by applying bibliometrics.

II. Related Work

Most of the existing works based on COVID-19 in relation to specific countries, seldom or investigated in combinations, were focused on cases **[11]** and deaths tracking **[12, 13]**, genetic versus clinical correlations to assess severity **[14]**, international innovation cooperation **[15]**, vaccination programs **[16]**, and policies adoption **[17]**. There are also reports investigated the COVID-19 bibliography burst through bibliometrics including evidence for France, Greece, Norway, or Spain.

In a book chapter in "Data Science for COVID-19" on prioritization of health emergency research, the authors applied a "Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)" methodology in assessing the scientific literature published within the first 3 months of the pandemic indexed in Web of Science or Scopus **[18]**. From the 817 reports found after screening and applying of eligibility criteria, the authors found 12 papers with a corresponding author from France accounting for 1.5% of the total reports, 3 written in French and 2 in English-French, 7 papers from Spain accounting for 0.6% of the total, one written in Spanish. Less than four papers were originated from Greece or Norway, one report written in Norwegian language. However, these reports, 696 out of the 817 from Scopus database, represent less than 30% of the COVID-19 papers indexed and published between January and March 2020 possibly because of publication or indexing delays, which is a drawback for the conclusions extracted.

In a preprint announced early in June 2020 **[19]**, a different approach followed through assessing PubMed indexed reports of the first 5 months of the pandemic. However, the aim of the study was to collectively estimate the scientific community response against COVID-19 when compared to the rest 21st century epidemics, in particular SARS-CoV, MERS-CoV, Ebola, Zika, avian (H5N1), and swine influenza (H1N1) controlled by HIV or AIDS reports during the same period of the epidemic or pandemic outbreak. This work accurately delivered the actual number of COVID-19 related publications of the first three months of the pandemic to a total of 2984 reports which rapidly increased to a total of 16213 by May 2020. This analysis found 43 papers affiliated to France (3.3% of the total), 28 to Spain (2.1%), 9 to Norway (0.7%), and 7 to Greece (0.5%).

Another report by Gong et al **[20]** investigated the early responses of the scientific community in the first two months of the pandemic January and February 2020, the research topics investigated and the scientific collaboration networks. The clinical manifestations of the virus represent the dominant research trend, whilst Chinese articles lead the scientific investigations among 44 countries first responders with 26% international collaboration reports mostly between China and USA and to a lesser extend Europe. France, Greece, Norway, and Spain are presented as collaborative countries in the COVID-19 research scientific networks. The high risk of SARS-CoV-2 transmission to other countries as a 24% for France and 15% for Germany before the implementation of the travel ban in Wuhan, China has been described.

Wang and Hong **[21]** deliver the bibliometrics of more than 27,000 papers five months in the pandemic. USA originated COVID-19 reports surpassed China by May 2020 whilst France and Spain were found in the top ten of productive countries in the 5th and 7th place respectively. The dominant research topics identified were: (a) epidemiology and public health interventions, (b) virus infection and immunity, including vaccine development as a subtopic, (c) clinical symptoms and diagnosis, and (d) drug treatments and clinical studies. The report concludes that vaccine research was lagging during the initial COVID-19 research.

Giannos et al **[22]** presented a bibliometric analysis of the first year in the pandemic of more than 53,000 publications affiliated to the 20 highest-ranked countries according to their gross domestic product (GDP). The authors reported 1,617 publications from France and 1,673 from Spain, but because of study design Greece and Norway were not included. The GDP criterion restrict the research output investigated to the rich countries alone.

Ohniwa et al **[23]** performed a broader coronavirus-related reports analysis by including all data since SARS outbreak in November 2002 till August 2020, 8 months after COVID-19 outbreak. France and Spain were in the top ten of coronaviruses paper contributing countries with reduced reporting during 2007-2012 for France and 2003-2006 and 2013-2019 for Spain. The differences of research prioritization per country were discussed. The major effectors of prioritization were the emergence of disease cases in a certain country, and the existing international collaboration networks between investigators from different countries of the same specialty.

Here we are focused in four countries France, Greece, Norway, and Spain as case studies of scientific community response by combining the bibliometric information and empirical experience to consider priorities, collaborations and research impact.

III. Methodology

In the framework of Health Information and Libraries course for Erasmus+ students (course code: ALIS-ER-11) of the Department of Archival, Library & Information Studies, University of West Attica, Athens, Greece, librarians and information science trainees become familiar with clinical and biomedical information, the research publishing environment, the health information databases and resources, as well as bibliometric analysis. After the introductory description on the methodologies of bibliographic databases interrogation for specific topic of interest during a chronological setting, data extraction,

collection, analysis, and interpretation, the students were assigned to perform case studies on the biomedical research response of their country of origin to the COVID-19 pandemic challenge during 2020-2022. Each case study report for France, Greece, Norway, or Spain should be designed according to the following lines.

A. Research Questions

The aim of this study is to address specific questions concerning the COVID-19 pandemic biomedical research response in different countries:

- RQ1: What were the scientific fields of research involved?
- RQ2: What were the most popular subjects of research?
- RQ3: What was the impact of these contributions?
- RQ4: What was the degree of participation in international collaborations of your country's investigators in COVID-19 reports?
- RQ5: Were there any contributions regarding public information by experts versus misinformation?
- RQ6: Can you access and deliver the altmetric impact of major scientific contributions by your country in terms of news outlets, blogs, tweets, Facebook and reddit mentions?
- RQ7: What are your conclusions on the biomedical research interests shift of your country's investigators towards COVID-19 related topics?

B. Search Strategy Design

The keywords of interest were: "COVID-19" or "SARS-CoV-2" in Title, Abstract or Keywords, with or without country affiliation, and when used "France", "Greece", "Norway", "Spain", or combinations, chronological span 2020-2022, 3-year period. Additional keywords for further investigations of other topics were used, in specific: "misinformation" or "fake news" or "conspiracy", "international", "SARS" or "SARS-CoV-1", "vaccine" or "vaccination", "influenza", "cancer", and "cardiovascular". For comparative reasons with the research trends before the COVID-19 pandemic, these bibliographic searches were also performed within the chronological span of 2017-2019, 3-year period. The bibliographic searches were performed on the following databases according to each platform Boolean operators, field codes, and use of auxiliary filters such as publication date range, subject area, document type, keyword, affiliation, or language:

- PubMed (https://pubmed.ncbi.nlm.nih.gov/),
- Scopus (https://www.scopus.com/),
- Web of Science (https://www.webofscience.com/),
- Dimensions (https://app.dimensions.ai/) and
- iCite (https://icite.od.nih.gov/).

All search results were extracted and downloaded as comma-separated values format files. The last time the databases were accessed was November 21, 2023. All searches described were repeated by the tutor.

C. Data Analysis

The data collected were combined and delivered in worksheets for further analysis. All reports were accompanied by a brief text addressing the proposed research questions and discussing the findings by combining bibliometrics with the empirical observations by the authors. All data were recollected and crosschecked versus the students' reports by the tutor.

IV. Results

A total of 11,829,890 scholarly reports were published between 2020 and 2022 worldwide suggesting an increase in global research productivity of 17% when compared with 2017-2019. The publications affiliated to France, Greece, Norway, or Spain were altogether 928,691, approximately 8% of the total reports, 392,259 (3% of global) out of them affiliated to France, followed by 368,369 (3% of global) to Spain, 89334 (0.8% of global) to Norway and 78,729 (0.7% of global) to Greece **[Fig. 1]**. When compared to the 3-year period before the COVID-19 pandemic Greece exhibited a 22% increase in scientific productivity followed by Spain with 20%, Norway with 15% and France with 2%.

Cancer research dominates the research efforts with 12,725 reports or 16% of the total productivity for Greece, 56,978 reports or 14.5% of the total for France, 51,101 reports or 14% of the total for Spain, and 10,912 reports or 12.2% of the total for Norway in 2020-2022 according to Scopus **[Fig. 2]**. Cardiovascular research, another leading cause of morbidity and mortality because of a non-communicative disease in Europe, is accounted for 11.5% of reports for Greece, 8% for Spain, 7.5% for Norway, and 6.6% for France in 2020-2022 Scopus data **[Fig. 3]**.

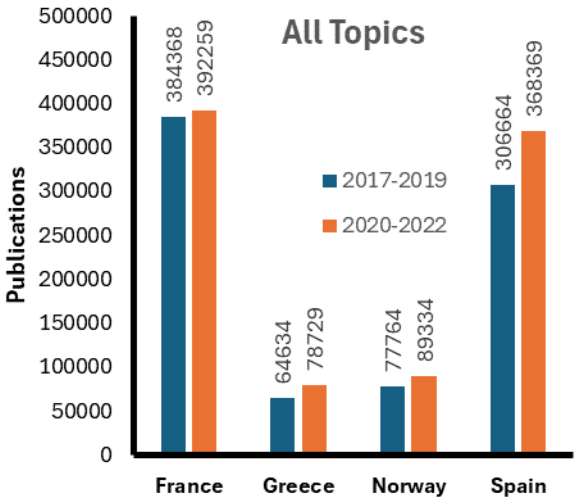

Fig. 1. All topics publications released between 2017-2019 and 2020-2022 affiliated to the countries examined according to Scopus.

COVID-19 pandemic changed the perspective of scientific efforts by bringing communicable diseases into the spotlight of research. This is evident in coronavirus research field when the data of SARS related publications of 2017-2019 compared to the COVID-19 papers, almost all of which include SARS as a keyword, of 2020-2022 **[Fig. 4]**. It is also

evident in influenza research field with an almost doubling of the related reports that exceeds 10-fold the trend of increase of global paper productivity **[Fig. 5]**.

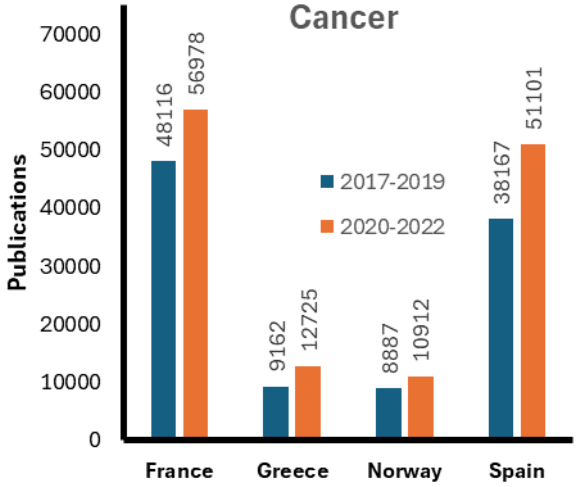

Fig. 2. Cancer research in the four European countries examined released between 2017-2019 and 2020-2022.

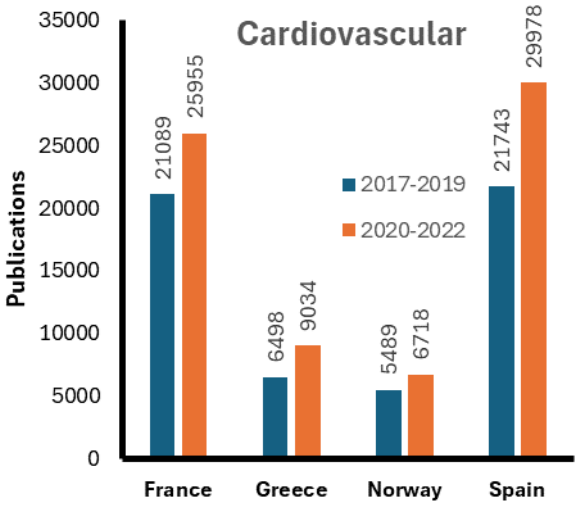

Fig. 3. Cardiovascular research in the four European countries examined released between 2017-2019 and 2020-2022.

The case reports of France, Greece, Norway, and Spain scientific community response against COVID-19 are presented in the following sections.

A. France

France responded to the significant challenges of COVID-19 pandemic by coordinating decisive actions such as increasing the capacity of its healthcare system together with intensify scientific research. The French government responded to the crisis with various policies aimed at controlling the spread of the virus and improving the nation's ability to cope with the pandemic. These included implementing strict lockdown measures, increasing testing capabilities, and launching extensive scientific research initiatives **[24]**. To coordinate the scientific research response, France assigned this task to the REACTing consortium, headed by the French National Institute for Health and Medical Research (INSERM), a preexisting body set up after the 2009 influenza A H1N1 pandemic which had already deal with Zika virus and Ebola virus diseases **[25, 26]**. The consortium has set up French researchers' task forces to collect information on the progress of various fields related to the COVID-19 pandemic such as vaccines, new therapeutic approaches, animal models, epidemiologic modelling, and digital monitoring of active cases through hundred million of diagnostic screenings **[26]**. Another notable project was the French-Covid national cohort, which collected comprehensive data on COVID-19 patients across France **[26]**.

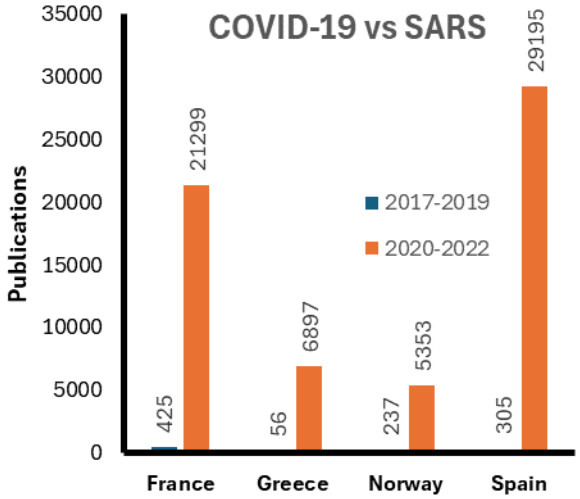

Fig. 4. COVID-19 research output in 2020-2022 versus SARS published between 2017-2019 in the four European countries.

According to Scopus the total COVID-19 research output of scientific reports affiliated to France and published between 2020 and 2022, was 21,299. The scientific fields involved in French researchers' publications were mostly Medicine (58%), Biochemistry, Genetics, and Molecular Biology (13.3%), Immunology and Microbiology (9.6%), Social Sciences (9%), Computer Science (7.1%), Environmental Science (5.7%), Engineering (5.5%), and Business, Management and Accounting (5.5%), according to Scopus. If we take a closer look and add vaccines to research the field of Immunology and Microbiology reports appeared increased when compared to other fields to 25.5%.

The most popular subjects of research for France involved Major Clinical (34%), cases and management reports, Epidemiology (31,7%), Aging (31,1%), as middle-aged and older adults exhibited an increased risk of life-threatening dangerous symptoms, and Severe Acute Respiratory Coronavirus 2 (29,7%). In the results of the research subjects, keywords such as Human (92.9% of research) or COVID-19 (87.8%) prevailed. When "vaccine" was added to the searching query the results were mostly emphasizing on Immunology, Epidemiology, and Prevention and Control research areas. The differences point to the precision of the subjects linked to the vaccine. The need for precision in research on the various subjects related to the vaccine was strong during this pandemic period.

The impact of the French contributions exceeding half a million citations during 2020-2022. The most cited papers,

all at the top 99th percentile of citations in Scopus database with more than 2,000 citations in total, were from basic research on the structure, function, and antigenicity of the SARS-CoV-2 spike glycoprotein with 5,797 citations and an erratum update evidence of the competition stressor of the period **[27]**, from clinical research on the use of hydrochloroquine and azithromycin for the treatment of COVID-19 with 3712 citations **[28]**, from structural biology and pharmacology on an interaction map revealing potential repurposing drugs for COVID-19 with 2,845 citations **[29]**, from clinical research on COVID-19 and thrombotic or thromboembolic disease and the use of antithrombotic drugs for its prevention with 2,164 citations **[30]**, and from clinical research on compassionate use of remdesivir for patients with severe Covid-19 with 2,005 citations **[31]**.

On iCite, the total number of reports of this period and affiliation country is 12,511 receiving 358,378 citations. iCite offers a triangulation of translational research with vertices molecular and cell biology, animal, and human related research. The translational research index indicates a transition of research interest from basic research, molecular and cell biology reports in 2020 to human, mostly clinical reports in 2022 **[Fig. 6]**.

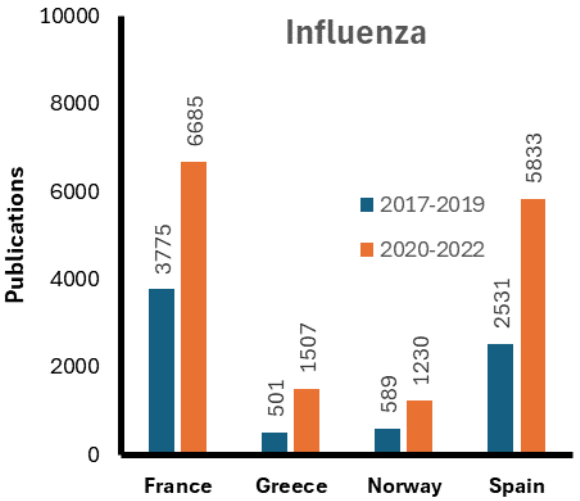

Fig. 5. Influenza scientific productivity in the four European countries before and after COVID-19 pandemic.

Regarding the participation in international collaboration projects of COVID-19 research it appears that France affiliation is associated with European as well as with non-European countries as depicted with VOSviewer **[Fig. 7]**. If "international" is considered as a prerequisite for the global perspective of a report, then it appears that one out of five COVID-19 papers with affiliation to France were performed from international collaborative networks according to Scopus.

A total of 229 reports (1% of the total reports) affiliated to France were about misinformation including subjects such as information overload, confusion, discontinuance intention during the pandemic lockdown, or vaccine hesitation. These reports collectively received 4450 citations. Public trust in scientific announcements and authorities' decisions in many countries. Despite the discussions in social media and news agencies in scientific literature the vast majority of publishing articles was about new biological or clinical information on COVID-19 rather than battling against scientific refuting and misunderstanding theories.

The Dimensions platform was used to assess the altmetric impact of the scientific contributions affiliated to France. The tweets now called the X platform, Facebook, blog or vlog mentions reflect the public response to research and therefore may significantly differ from citations which show the response of the scientific community. Top altmetrics have been recorded by retracted works that gain a big share of the public interest, household transmission of SARS-CoV-2, increase risk of mortality for the elders or reports that criticized the mandatory nonpharmaceutical interventions by the authorities such as the stay-at-home and business closure measures expressing concerns by experts. The public interest for COVID-19 papers was very high but not always in agreement with the citations received by them. It is also evident that certain scientific publications became the center of discussion in social media where they were used as proof of one or the other theory.

Certain subjects of biomedical research gain significant increase of interest during 2020 to 2022. These subjects include viral pneumonia, coronavirus infection, betacoronavirus, middle aged, aged, mortality, intensive care unit, hospitalization, hydroxychloroquine, very elderly, comorbidity, psychology, artificial ventilation, quarantine, or depression as depicted in co-occurrence network **[Fig. 8]** and in overlayed by the publication year representation **[Fig. 9]**.

France encountered difficulties in finding the optimal balance between protecting public health and minimizing economic and social harm. The country experienced criticism regarding its handling of the pandemic, especially during the first wave, where a full lockdown was imposed **[32, 33]**. Nonetheless, France's scientific contributions to the global effort against COVID-19 have been substantial, ranking second among countries in terms of the number of highly cited papers related to SARS-CoV-2 and COVID-19 **[26]**. Overall, France's response to the COVID-19 pandemic highlighted both successes and failures, providing valuable lessons for future pandemics. Strengthening health system capacities and improving collaboration between central and local governments remain critical steps towards achieving a balanced approach to addressing future crises **[34]**.

B. Greece

Greece responded quickly and flexibly to the COVID-19 pandemic, declaring a state of emergency on March 3rd, 2020, shortly after the first confirmed case on February 26th, 2020 **[35]**. The government imposed strict measures aimed at containing the epidemic and avoiding the collapse of the healthcare system. The administration of the public health crisis was assigned to Civil Protection Ministry and the coordination between the healthcare system, the Greek Universities and Research Institutions was assigned to the Greek National Organization of Public Health a nearly one-

year old establishment that replaced the Greek Control and Prevention Center of Diseases. Jointly daily briefings by these two organizations and academic experts served the needs of public updating on the pandemic local cases, measures, and overall situation. These actions resulted in a relatively low mortality rate compared to other countries during the first COVID-19 wave, with a mean age of deceased individuals being 75 years old and a death toll representing approximately 0.8% of annual deaths in 2019 **[36]**. However, these successes did not resolve existing challenges such as the country's weakened healthcare infrastructure and ongoing socioeconomic difficulties stemming from previous financial crises **[37]**. Despite the effective implementation of control measures, the Greek public health system experienced significant strains, revealing pre-existing weaknesses and limitations. Stakeholders perceived that the system lacked sufficient resources and failed to address long-term challenges adequately. Economic support measures received mixed reviews, balancing the need to encourage compliance with the lockdown rules without jeopardizing future sustainability. Researchers and scientists played a vital role in supporting the public health effort, providing valuable insights into demographic, social, and geographical factors influencing the pandemic's impact on society **[38]**.

The Greek scientific community was responded by producing a total of 6,897 papers which represent 9% of the total scientific publications' productivity of Greece during 2020-2022. This is a remarkable increase when we consider that only 56 papers of SARS-CoV-1 were published with Greek affiliation during the three-years before the pandemic, 2017-2019 **[Fig. 4]** and strongly suggests that many Greek researchers changed their scientific interests by focusing to coronaviruses whilst there was an excess reallocation of the few funding resources because of the Greek financial crisis and austerity of 2008-2017 **[39]**.

The scientific fields involved in Greek affiliated research were Medicine (51.5%), Social Sciences (14%), Computer Science (14%), Biochemistry, genetics and Molecular Biology (13.4%), Engineering (9%), Environmental Science (9%), Immunology and Microbiology (7.4%), Business, Management and Accounting (5%), and Pharmacology, Toxicology and Pharmaceutics (5%), according to Scopus.

The most popular subjects of research in Greece beside the common keywords Human (54%), COVID-19 (41%), Pandemic (22.5%) or SARS-CoV-2 (22%), were controlled study (11%) and Major Clinical Study (10%), mostly refer to clinical reports, Aged (9.4%), Middle Aged (8.4%), Disease Severity (7.4%), Risk Factor (6.9%), Mortality (6.4%), Vaccination (6.3%), Hospitalization (5.9%), and Viral Pneumonia (5%). The keyword co-occurrences in the top cited scientific contributions of the period are depicted with VOSviewer **[Fig. 8]** as well as overlayed by the year of publication **[Fig. 9]**.

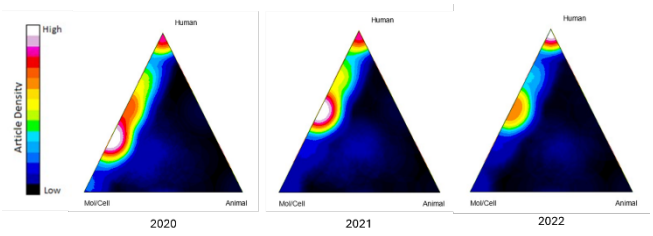

Fig. 6. Translation research on COVID-19 between 2020 and 2022. A transition from molecular and cell biology reports to human, mostly clinical reports, is evident.

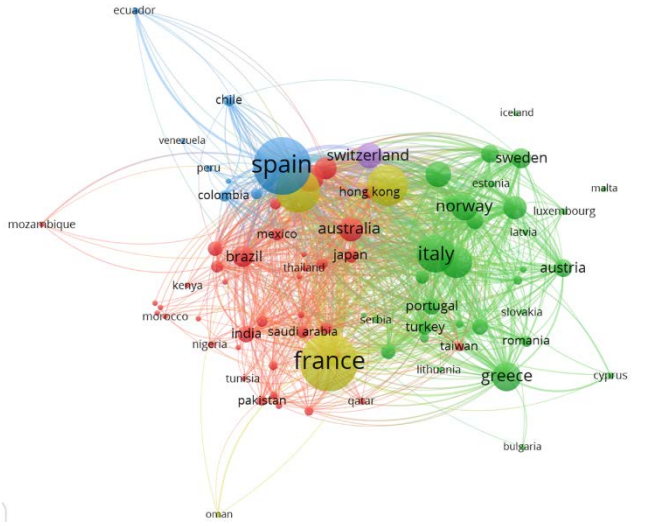

Fig. 7. VOSviewer network of collaborating countries in COVID-19 research based on the top 2,500 mostly cited international reports.

All papers related to COVID-19 affiliated to Greece and published between 2020 and 2022 received a total of 156,044 citations, 22,6 citations/paper on average. Almost one thousand contributions out of them (14.5%) didn't receive any citations by the time of contacting this report. The most cited contribution was the ACTT-1 Study on Remdesivir for the treatment of COVID-19, the prevalence of depression, anxiety, and insomnia among healthcare workers during the COVID-19 pandemic, COVID-19 and Thrombotic or Thromboembolic Disease, hypertension and diabetes mellitus as risk factors for COVID-19 infection, and autoantibodies against interferon as a risk factor of life-threatening COVID-19.

There is a significant degree of international collaborations in Greek affiliated reports with co-affiliations to United Kingdom (19%), United States (16.8%), Italy (16.2%), Germany (12.9%), Spain (10.7%), France (9.3%), Netherlands (9%), Switzerland (7.6%), Belgium (6.5%), Canada (5.7%), Cyprus (5.7%), Poland (5.6%), Portugal (5.5%), Turkey (5.5%), Sweden (5.4%), Austria (5.3%), and Australia (5.2%). The country collaborations network of the top cited reports is depicted with VOSviewer **[Fig. 7]**.

There were 88 contributions (1.3%) out of the total affiliated to Greece on fake news, conspiracy, or misinformation, according to Scopus, receiving a total of 1,426 citations, 16.2 citations/publication on average. These papers were about disinformation, substance use disorders, information seeking behavior of the general public, politics and COVID-19 health-protective behaviors, tweets,

nowadays platform X, and medical and health-related misinformation on social media.

Altmetrics found to be increased in retracted reports with few citations retrieved with subjects like immune suppression because of COVID-19 mRNA vaccinations, criticism on the necessity of lockdowns, pharmaceutical administration against COVID-19, estimating mortality due to COVID-19, correlation between mask compliance and COVID-19 infections, and retracted reports of the stay-at-home policy fallacy or whether children vaccination against COVID-19 is necessary. The altmentric behavior clearly demonstrates the differences of the public perception of research papers versus the scientific community. Also, it is evident that the public is attracted by strong titles and controversial data interpretations.

Overall, Greece's response demonstrated flexibility and adaptation to the changing nature of the pandemic, although it exposed deeper flaws in the nation's public health system **[37]**.

C. Norway

Norway's scientific response to the COVID-19 pandemic involved a combination of effective public health strategies, high levels of trust in authorities, and a focus on balancing various aspects of the crisis. Key features of the Norwegian response included: (a) High Trust, according to a survey, 53% of respondents considered COVID-19 a large to very large threat to the population, and trust in the health care system and self-reported compliance with preventive measures was high **[40]**; (b) Strict Measures, on March 12, 2020, Norway imposed stricter measures, closing schools, kindergartens, and nonessential businesses, and instituting quarantine for travelers entering the country **[40]**; (c) Collaborative Decision Making, the Norwegian government employed a consensus-based approach, involving collaboration between political parties, which contributed to the success of the response **[41]**; (d) Communication, effective communication with the public played a role in building trust and ensuring compliance with guidelines **[42, 43]**; (e) Preparedness, factors contributing to Norway's ability to handle the crisis effectively included a highly educated populace, a robust welfare system, and a low population density **[41, 43]**.

Additionally, studies have shown that migrants in Norway faced systemic barriers to healthcare due to language, low socio-economic status, and sociocultural factors, but overall, the Norwegian response was appreciated by migrants for its effectiveness and transparency **[41]**.

The Norwegian scientific community responded to the challenge by contributing 5,353 reports according to Scopus which represent a 6% of the total scientific productivity of this country. It should be noticed that SARS-CoV-1 contributions from Norway between 2017-2019 were four-times more than Greece, suggesting that Norwegian virologists were interesting in coronaviruses research even prior to COVID-19 pandemic.

The scientific field involved in COVID-19 research in Norway were Medicine (45.3%), Social Sciences (21.7%), Computer Science (12.2%), Environmental Science (10.7%), Business Management and Accounting (9%), Engineering (9%), Biochemistry, Genetics and Molecular Biology (7.8%), Psychology (6.4%), and Immunology and Microbiology (5.5%).

The most popular subjects of scientific research on COVID-19 affiliated to Norway were Human (48.7%), SARS-CoV-2 (15%), Controlled Study (12%), Major Clinical Study (9.7%), Epidemiology (8.3%), Aged (8%), Middle Aged (6.4%), Questionnaire (5%), Risk Factor (5%), and Public Health (5%).

Collectively Norway publications received a total of 143,553 citations, 26.8 citations/paper on average. The most cited contributions were guidelines, global burden of disease and risk factors outline, pandemics, tourism and global change, autoantibodies against interferon in patients with life-threatening COVID-19, repurposed antiviral drugs for COVID-19, mental health consequences because of the physical distancing, genome wide association of sever COVID-19 with respiratory failure and the effects of COVID-19 pandemic on business and research.

International collaborations in Norway affiliated reports have co-affiliations to United Kingdom (24%), United States (21.4%), Sweden (14.5%), Germany (14%), Italy (13%), Netherlands (11%), Spain (10.1%), France (10%), Australia (9.8%), Denmark (9%), Switzerland (8.5%), Canada (8.3%), China (7.4%), Belgium (7.2%), India (6.8%), Finland (6.4%), Austria (6.2%), Poland (5.8%), and South Africa (5.3%). The country collaborations network of the top cited reports is depicted with VOSviewer **[Fig. 7]**.

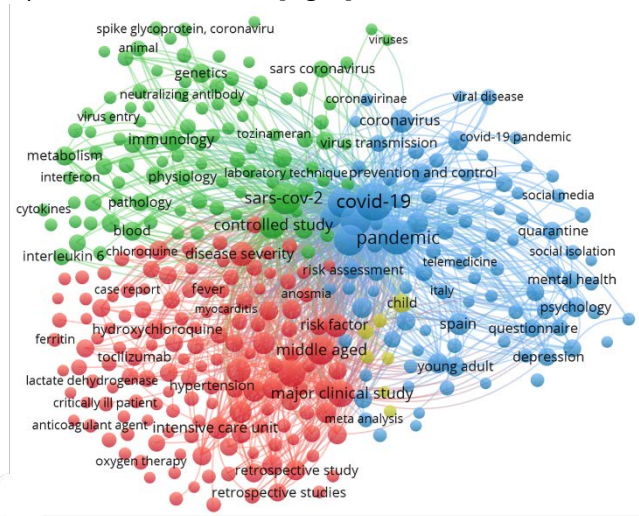

Fig. 8. Top keyword co-occurrences in scientific papers network by VOSviewer

A total of 106 reports (2% of the total) affiliated to Norway concern public information and misinformation issues, collectively receiving 3092 citations, 29 citations/paper on average. The issues described were the unusual consumers' purchasing behavior during the early stages of the pandemic, misinformation on Twitter, now X platform, and food delivery and consumption.

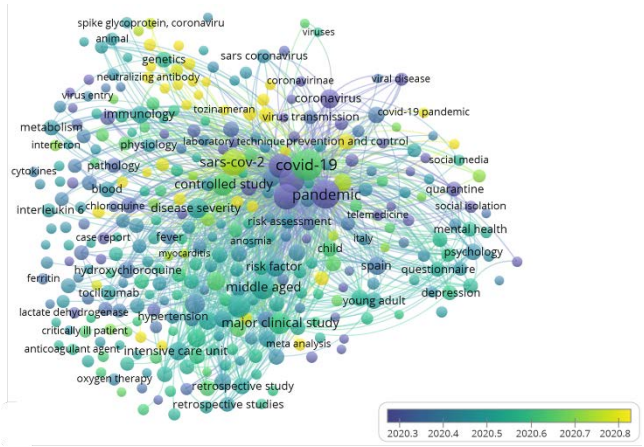

Fig. 9. Top keyword co-occurrences overlayed by publication year of the scientific paper. Newer contributions with yellow, older with blue. The scientific network was generated by VOSviewer.

The publications with the most altmetric receiving interests were on SARS-CoV-2 delta infection risk of vaccinated and unvaccinated people, the fatality rate by COVID-19 in the non-elderly population, vaccine boosters for young adults and benefit assessment for universities, systematic analysis of COVID-19-related mortality, and vaccination-associated myocarditis in children. For the Norwegian affiliated reports, it is evident that highly cited and high altmetrics reports matched well.

During the COVID-19 pandemic, Norway has been involved in various scientific research projects to understand the impact of the pandemic on the population and to develop strategies for managing the crisis.

D. Spain

Spain's scientific response to the COVID-19 pandemic encompassed various facets, including research, governance, and public health initiatives. Initially, the Spanish government's approach was characterized by complacency, focusing on controlling the importation of the virus from foreign travelers instead of addressing domestic transmission. However, when the first locally acquired infection occurred, the government began implementing measures like contact tracing, quarantine, and limiting social interactions. Despite these actions, Spain experienced a significant increase in cases and fatalities, leading to criticism of the government's handling of the crisis **[44, 45]**. In terms of research, Spanish scientists contributed significantly to the understanding of the virus and the development of countermeasures. However, doubts about the reliability of COVID-19 research emerged, with concerns about questionable research practices and the overall quality of work **[46]**. To address this, the Ministry of Science and Innovation established a multidisciplinary working group on COVID-19 **[47]**. Public health experts noted challenges in managing resources, particularly in primary care centers, where many infected individuals sought treatment. Professionals and citizens alike expressed concerns about the inconsistent application of control measures and the lack of transparent communication from authorities **[45]**. Overall, the Spanish experience highlights the importance of effective governance, robust scientific research, and open communication between authorities and the public in responding to pandemics **[48]**.

A total of 29,195 COVID-19 papers published between 2020-2022 were found to be affiliated to Spain. The scientific fields involved in these contributions were Medicine (49%), Social Sciences (21%), Computer Science (11.5%), Environmental Science (11%), Biochemistry, Genetics and Molecular Biology (9.6%), Engineering (7.7%), Immunology and Microbiology (5.7%), and Psychology (5%).

The most popular research subjects among COVID-19 contributions from Spain were Human (40.6%), SARS-CoV-2 (21.5%), Pandemic (21.5%), Controlled Study (13.5%), Major Clinical Study (12.3%), Aged (11.5%), Middle Aged (9.5%), Epidemiology (7.5%), Viral Pneumonia (6.1%), Risk Factor (5.8%), Mortality (5.6%), Complication (5.5%), Disease Severity (5.5%), Cohort Analysis (5.3%), and Hospitalization (5.3%).

Collectively the impact of all COVID-19 contributions from Spain exceeds the 525,000 citations, more than 18 citations per paper on average. Among the most cited works are clinical guidelines, reviews on COVID-19, reports on possible drugs against this disease, symptoms and complications of COVID-19, the administration of systemic corticosteroids and mortality of critical ill patients, inhibition of infections by using soluble ACE2 in vitro, surviving septic shock, and the impact of COVID-19 in cancer patients and in perioperative cases.

The international collaboration networks of Spanish scientists involved colleagues from Unites States (12.4%), United Kingdom (11.8%), Italy (11%), Germany (7.3%), France (6.9%), and the Netherlands (5.1%). These data suggest that most of the Spanish contributions were performed at the national level.

A total of 642 (2.2% of the total) Spanish contributions on COVID-19 receiving 9792 citations, 15 citations per paper on average, were concerned on public information and misinformation issues. Norway and Spain appeared to have the highest percentage of such contributions when compared to France and Greece, indicating a significant importance of this issue for these countries. Some of the subjects of these contributions, the most cited ones, include the 5G conspiracy theory with COVID-19 in the social media, the impact of the pandemic on the media system and its political consequences, the infodemic as the mass social media distribution of scientific reports, and the disinformation and hoaxes on COVID-19.

The altmetric data suggest a similar to France and Greece effect with an important imbalance between citations and altmetric score. Representative examples are revelations of poor practices of Pfizer's pivotal COVID-19 vaccine trial, drug treatments for COVID-19, questioning the reality of COVID-19 pandemic, adverse effects of COVID-19 vaccination during the randomized trials, questioning the lockdown policy, as well as theories on COVID-19 origins. Some, now retracted, publications that received very few citations, received significant altmetric scores, thus adding to the

confusion of the people regarding the disease, the prophylactic measures, the clinical interventions, the vaccinations, or medications.

Spanish scientific research during the COVID-19 pandemic has been focused on various aspects, including the sharing of research data, assessing the impact of the pandemic on the population, and exploring the credibility of science among Spanish scientists.

V. Discussion

The Lancet Commission on lessons for the future from the COVID-19 pandemic reported that the profound death toll was the outcome of a massive global failure at multiple levels: (a) fail of many governments to adhere to basic norms of institutional rationality and transparency, (b) misinformation influenced too many people against public health precautions, and (c) fail of the world's major powers to collaborate to control the pandemic, including inadequate sharing of funds and medical supplies to low- and middle-income countries **[49]**. However, research was a major contributor in shedding light on this disease nature by identifying the pathogen, describing the infection route, monitoring cases, predicting the epidemiological curves, introducing prophylactic measures, investigating the clinical manifestations of patients, and identifying populations at risk, developing vaccines, testing drugs, and introducing adequate therapeutic approaches **[50]**. Global research networks as well as national and institutional contributors add significantly to the overall effort.

Europe after Wuhan China became the epicenter of the pandemic by March 2020 **[51]**. European countries such as France, Greece, Norway, and Spain declared an emergency and rapidly responding by taking measures to reduce the territorial impact of the pandemic in various dimensions mostly like health, economics, social aspects, and fiscal implications **[52]**. Healthcare systems were reinforced to enhance containment and mitigation, national lockdowns were implemented in response to major outbreaks, and digital infrastructure was utilized to effectively manage the crisis. Research communities were recruited in this effort and produced a multifaceted product encompassing all aspects of the pandemic. Leveraging these experiences and insights will be crucial in future preparedness for such health challenges.

In this bibliometric study we assessed the scientific community response and the contributions output in these four European countries. France, Greece, Norway, and Spain collectively contribute 62,744 papers (8.6% of global) on COVID-19 within three years, 2020-2022, out of the total 725,866 papers produced worldwide. The findings of these contributions were significant in understanding and fighting COVID-19 pandemic. The most prevalent scientific fields involved were medicine, social sciences, computer science, biochemistry, genetics and molecular biology, environmental science, engineering, immunology and microbiology, psychology, and business, management and accounting in all four countries. Most efforts were aimed in fast translational research from bench to bedside. It is evident, according to iCite, that during the three years period after the declaration of the pandemic the research subjects rapidly move from basic research to the clinical arena.

Public trust in science and governments was an important issue in handling the pandemic. Countries that cultivated a high degree of trust in their societies achieved better results in fighting the pandemic versus countries where mistrust and misinformation were dominant effectors. Proper education and information of the public was critical in understanding scientific data as it can be postulated by the altmetric versus bibliometric data. Huge imbalances may appear if the public perceives scientific or pseudoscientific data equally, and these may generate falsified information, hypothesis or theories that could be easily distributed through social media.

VI. Conclusions

The response to the COVID-19 pandemic clearly demonstrated the importance of international cooperation, data sharing, investment in public health infrastructure, the strong association between health and the economy, the need of co-ordination, infrastructure and personnel reallocation, efficient dissemination of scientific information to the public, building of public trust, and partnerships. It is also essential to prioritize early-stage research with emphasis on basic science and facilitate the transition to applied translational technologies to the clinical arena. Digital platform technologies are necessary for monitoring and public support. State preparedness should be built upon specialized organizations responsible for health crisis control. The availability of emergency research funds is of vital importance to rapidly establish new methodologies, diagnostic tests, disease, and epidemiological models. An important lesson of the SARC-CoV-2 viral pandemic is that a reduced threat alert by no means is not equal to zero risk. Preparedness for future unexpected emergencies strongly suggests the continuous research, monitoring, and updating of a communicable or non-communicable health compromising agent.

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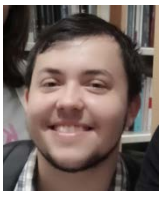
VIII. AUTHORS



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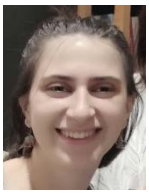

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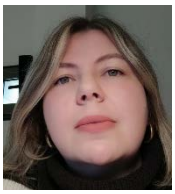

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