Russian Contribution to Research on Virology: Bibliometrics Analysis, 2000-2019 on Web of Science

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ABSTRACT: *The speedy development of the Russian vaccine, "Sputnik-V," created by the Gamaleya National Research Center (the Gamaleya NRC), attracted great attention worldwide. However, it resulted from many Russian scholar's" contributions to virology research (Kramer A., 2020). This project aims to provide insights into important research development on virology through empirical analysis of Russian publications from 2000-to 2019. The metadata was retrieved from the Web of Science (WoS) Core Collection and InCites (Clarivate Anal.). The search strategy was discussed with an expert on virology. The Russian research performance (RP) growth rate was significantly higher - 290%, then the growth rate (190%) of the world dataset on virology from 2000 to 2019. The Dataset of Russian RP consisted of 6,636 records. A more detailed analysis was focused on the period 2015-2019.*

We selected for analysis three organizations that produced vaccines available for inoculation against COVID-19. These organizations are the Gamaleya National Research Center (the Gamaleya NRC) of the Russian Academy of Medical Sciences (RAMS), the State Research Center of Virology & Biotechnology (Vector), and the K.M.Chumakov Federal Research Center (Chumakov FRC).

Among three organizations, publications of the Chumakov FRC had shown the highest value of all bibliometric indicators (nCites). The quality of publications is high: more than 69.3% of articles published in journals belonged to Q1 and Q2 quartiles. The Gamaleya NRC has the highest number of publications (394 records). Its researchers prefer to publish their results in Russian journals: the share of Q3 and Q4 journals was more than 57%. The "Vector" is a prominent organization on new vaccine development and production (Wilson C., 2002). It is strongly focused on domestic collaboration (67.0%) compared with two other organizations and total Russian RP (29.0%). Its share (56%) of domestic collaboration is approximately twice higher than its share (29.4%) of international collaboration (IC). The leader of this collaboration was the Institute of Chemical Biology and Fundamental Medicine of the Siberian Branch (SB) of the Russian Academy of Sciences. Despite the low level of IC (19%), the USA is still the leading partner (10.8%).

Funding agencies (FAs) have played an essential role in the research community in Russia since 1994. The leading FA was the Russian Science Foundation (RSF), followed by the Russian Foundation for Basic Research (RFBR) in 2015-2019. The National Institute of Health (NIH) played a significant role in Russian research on virology. The USA lost its dominance. Our results could benefit research, funding agencies, and health policy decision-makers.

Keywords: Virology, Russia, Category Normalized Citation Indicator, Highly Cited Articles, Research Productivity, Web Of Science, InCites

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1. Introduction and Background

It has been about two years since the pandemic spread around the world. The scale of the pandemic was impossible to imagine. The WHO had to proclaim the State of Emergency caused by this deadly virus. www.who.org

The speedy development of the Russian vaccine "Sputnik-V" by the Gamaleya National Research Center of the RAMS (the Gamaleya NRC) attracted great attention worldwide. It provoked hot discussions in the science community, blaming Russian scholars for insufficient data on clinical trials (Logunov D., et al., 2021). https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(21)00234-8/fulltext

However, this vaccine creation is a tribute to many Russian scholars" contributions to virology (Kramer A., 2020). The first scientometrics paper îí virology was published by E.Garfield (1980). He called "the "premature discovery or delayed recognition" of sarcoma virus discovery by Peyton Rous in 1910 who was awarded the Nobel Prize in 1966. King J. published the first article on avian viruses in "Scientometrics" journal in 1988. We found only six bibliometric articles related to virology published by "Scientometrics" in the last 40 years. About 20 years ago, a scientometrics analysis on research trends on biological defense in Russia and USA was published by C.Wilson et al. (Scientometrics, 2002). The authors described the history and impact of a special Program, "Enzyme," to develop genetic engineering, vaccines, and antibiotics, leading organizations in the USA and Russia were evaluated.

It is worthwhile to indicate that since 1920 soviet virologists have been involved in the fight against infectious diseases (typhus, malaria, måàsles) spread in the Central-Asia republics of the USSR. A comprehensive bibliometric analysis by Zhang L et al. (2021) was recently devoted to the global response to the previous pandemic and COVID-19. The authors identified two characteristic patterns in international science distinguishing research in Europe and America that focuses more on public health. At the same time, China and Japan put more attention on biomedical research and clinical pharmacy, respectively. Universities contribute slightly less than half to global research. This paper also noted very few publications on viruses (Zhang L et al., 2021).

Our goal is to provide insights into significant research development on virology through empirical analysis of Russian publications from 2000-to 2019.

2. Methodology and Data Collections

The primary sources of bibliometric statistics were information resources designed by Clarivate Analytics. The metadata was retrieved from the Web of Science (WoS) Core Collection: Science Citation Index – Expanded, Social Science Citation Index, Arts & Humanities Citation Index (AHCI), Conference Proceeding Citation Index-Science, Conference Proceeding Citation Index-Social Sciences & Humanities. Throughout this paper, the total collection of these databases will be indicated as WoS. The additional sources were used Journal Citation Reports (JCR), the analytical tool InCites, and the national database Russian Science Citation Index (RSCI), which began operating in 2005. RSCI is located on the WoS platform.

We consulted search strategy with Associate Professor Dr.E.Toulchinskii (the Leicester University, England) who is an expert

on virology. It was used the following search strategy as in WoS as in RSCI: "ADVANCED SEARCH":

TS=(("virus*") or ("viral*") not ("viral vector")) and PY = (2000-2020);

TS=(("virus*") or ("viral*") not ("viral vector")) and CU=(Russia) and PY=(2000-2020)

We used the same strategy to collect data on the USSR's contribution to virology research. Metadata was retrieved from WoS (on 25 November 2020), with at least one author affiliated with Russia indexed in WoS during the period 2000-2019. USSR publications were downloaded from 1973-1992 (on 25 November 2020). Option "Research Analysis" was used to rank world and Russian datasets by subject category (SC), years, organizations, collaborative countries, and funding agencies. Dataset of Russian research performance (RP) on virology consisted of 6,636 records.

Soviet scholars published 4,889 articles from 1973-to 1992. There were 7,287 records indexed from 2005-to 2019 in RSCI. These data were selected for five-years periods 2000-2004, 2005-2009, 2010-2014, and 2015-2019 to avoid annual fluctuation. A more detailed analysis was focused on the period 2015-2019.

To compare the performance of Russian leading research organizations and their impact on knowledge dissemination in the world research community, statistics on various bibliometric indicators were derived from the InCites on Feb.19, 2021. The following indicators will investigate quantity and quality: the number of publications or research performance (RP); the number of highly cited articles (HCA); number and share of domestic or internationally collaborative articles (IC); journal's quartile, category normalized citation impact (CNCI); impact relative to the world.

3. Results and Discussion

The world dataset on virology demonstrated the growth rate of RP at 190% (from 23,549 records up to 44,415) compared between 2000 and 2019. The Russian RP growth rate was significantly higher - 290% from 2000 to 2019. It observed the yearly growth of USSR publications from 1974 until the disintegration of the USSR in December 1991 (Figure 1).

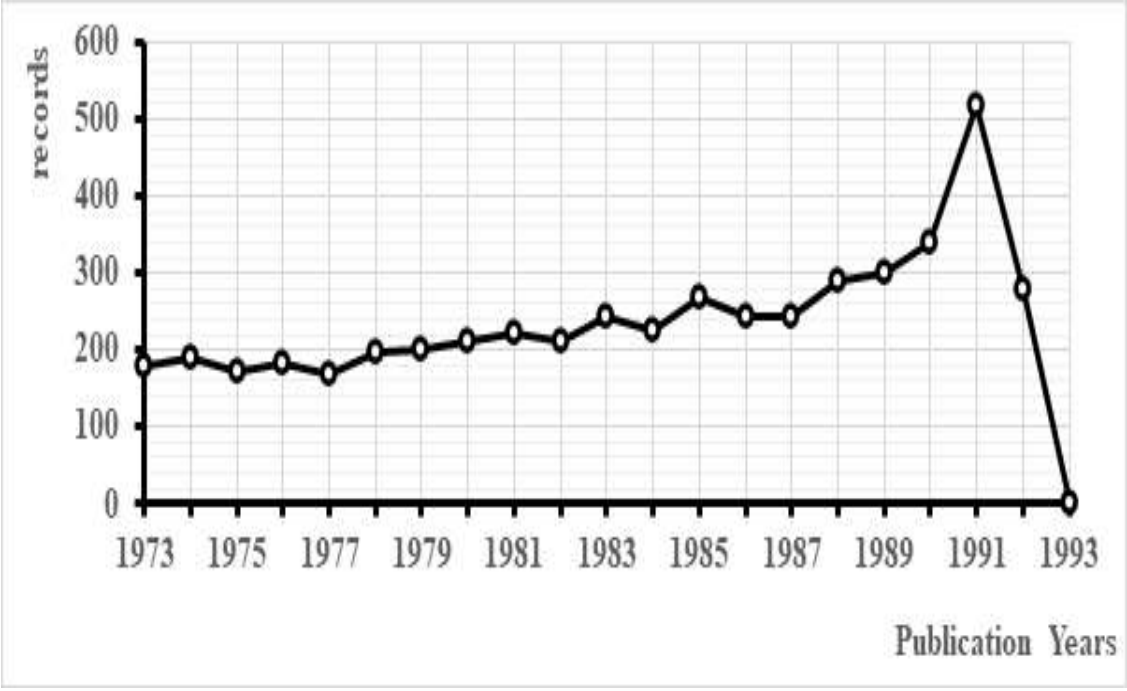

Figure 1. Trends of research performance on virology in USSR, WoS

The growth rate of RP was 220% in the RSCI comparing 2019 with 2005 (see Figure 2).

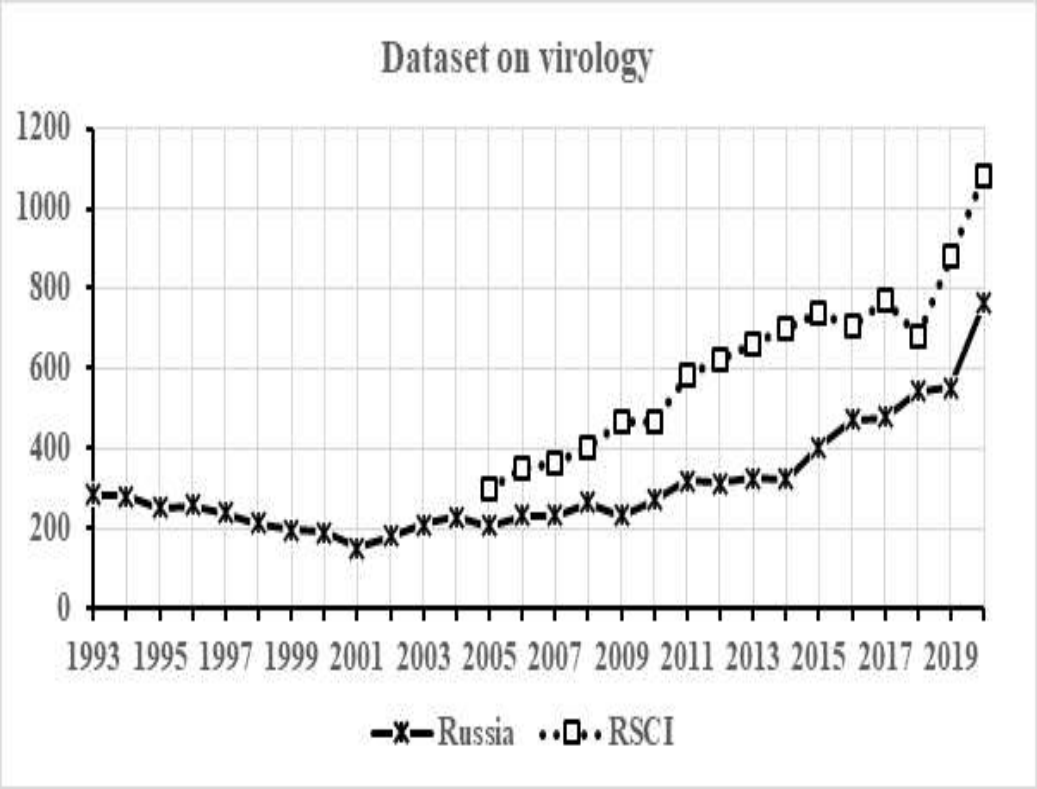

Figure 2. Trends of RP on virology by WoS and national database RSCI

The review articles play a significant role in virology research in both datasets. Their share increased from 8.5% to 11.2 % in the world dataset compared 2000-2004 with 2015-2019. The same trend in the review articles was observed in the Russian dataset on virology: from 6.8% to 11.4 % (Appendix, Table 1.)

The leading SC were "Virology," "Immunology," "Infectious Diseases," "Microbiology," and "Biochemistry & Molecular Biology" in both datasets. However, SC Biochemistry & Molecular Biology" was the first leading discipline for 20 years in the Russian dataset. Significant growth (up to 7%) in multidisciplinary research was observed in 2015-2019 compared with 1.6% in 2000-2004. SC "Public Environmental & Occupational Health" (share 1.2%) appeared in the Russian dataset only in 2015-2019, while this SC was among 25 leading disciplines in the world dataset from 2000-to 2004. Mainly the disciplines belong to health-related science fields in both studied datasets. But there are some outsiders such as: "Applied Physics" or "Science and Nanotechnology" in 2015-2019. The same phenomena were observed by Zhang L. et al. (2021).

The average citation per article on virology was 16.4, with its value 2.5 times higher than in total Russian RP during 2015-2019 (InCites).

A different picture was observed in publications indexed by RCSI from 2015-to 2019. The 3,472 articles on virology were cited 1,688 times (0.5 citations per article). We did not expect a massive citation value gap between Russian articles indexed by WoS and RSCI.

Share of HCA is the indicator of research quality. Among Russian publications on virology were 31 highly cited articles (1.1%) compared with HCA share (0.6%) in total Russian RP during 2015-2019 (InCites). These HCA accounted for 16,125 (42.3%) citations in our dataset. The average citation per article was 520. Citations range from 3,303 values (HCA published in 2016) to 62 discounts (HCA published in 2019). The most highly cited article has a multi-authorship (551 co-authors) published in "Lancet" in 2016. Its title is "Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015". However, the HCA

Affiliation	RecordCounts	% of 2,447
RUSSIAN ACADEMY OF SCIENCES	1045	42.705
LOMONOSOV MOSCOW STATE UNIVERSITY	377	15.407
RUSSIAN ACADEMY OF MEDICAL SCIENCES	295	12.056
MINISTRY OF HEALTH OF THE RUSSIAN FEDERATION	216	8.827
SECHENOV FIRST MOSCOW STATE MEDICAL UNIVERSITY	188	7.683
GAMALEYA NATIONAL RESEARCH CENTER FOR EPIDEMIOLOGY MICROBIOLOGY RAMS	144	5.885
ENGELHARDT INSTITUTE OF MOLECULAR BIOLOGY RAS	136	5.558
INSTITUTE OF BIOORGANIC CHEMISTRY OF THE RUSSIAN ACADEMY OF SCIENCES	134	5.476
STATE RESEARCH CENTER OF VIROLOGY BIOTECHNOLOGY (VECTOR)	130	5.313
NOVOSIBIRSK STATE UNIVERSITY	128	5.231
INSTITUTE OF CHEMICAL BIOLOGY FUNDAMENTAL MEDICINE SIBERIAN BRANCH OF THE RAS	107	4.373
CHUMAKOV FEDERAL SCIENTIFIC CENTER FOR RESEARCH DEVELOPMENT OF IMMUNE BIOLOGICAL PRODUCTS OF RUSSIAN ACADEMY OF SCIENCES	102	4.00

Table 1. Ten leading organizations by RP on virology during 2015-2019

with the lowest citation value (62 citations) was the recent review article "Current Development of siRNA Bioconjugates: From Research to the Clinic published by three Russian authors (Chernikov I.V, Vlassov V, V, Chernolovskaya E.L.) in " Frontiers in Pharmacology" in 2019. All co-authors are affiliated with the Institute of Chemical Biology & Fundamental Medicine, Siberian Branch of the RAS.

The most frequent SC was "Virology" (25%). Major topics of HCA were devoted to the study of "Global prevalence treatment, and prevention of hepatitis B (or hepatitis C virus)" in different years (8 records); "Taxonomy and the International Code of Virus Classification and Nomenclature ratified by the International Committee on Taxonomy of Viruses" (six articles). Two pieces discussed mosquito-borne flavivirus Zika, spread in Africa in 2013. This virus has deadly affected female health, especially pregnancy outcomes. https://www.who.int/news-room/fact-sheets/detail/zika

HCA was published in Russian collaborations with hundreds of eleven countries. The most represented country was the USA.

The shares of joint publications were high: USA (63%) compared with 10% US share in total Russian RP during 2015-2019.We selected for our analysis three organizations that produced vaccines available for inoculation against COVID-19.

The Gamaleya NRC is one of the oldest Russian research centers on virology and infectious diseases, founded in 1891. The D.I.Ivanovskii Institute (founded in 1944) became a part of the Gamaleya NRC. The Gamaleya NRC is an employer of 1,200 persons.

The second vaccine, "EpiVaCorona," was created and produced by the State Research Center of Virology & Biotechnology (Vector) in December 2020. Vector was organized in 1974 to execute the government Program "Enzyme." Vector is located near the Novosibirsk, which has vital research human resources, and the Novosibirsk State University. This is why Vector has post-graduate training and scientific training of higher qualifications in Virology, molecular biology, and biotechnology through graduate school and higher education. The staff of the Vector consists of 1,614 persons, including 392 Ph.D. https://ru.wikipedia.org

The third vaccine CoviVac was developed by the K.M.Chumakov Federal Research Center FSC (Chumakov FRC). It was registered for use in Russia on February 20, 2021. https://radiosputnik.ria.ru/20201230/vaktsiny-1591503078.html

The Chumakov FRC was organized in 1961 due to the efforts of outstanding virologist Prof. M.P.Chumakov. He and his wife developed the first oral vaccine against malaria (Kramer A., 2020). Previously, this Institute was named the Institute for Polio Study. The staff consists of 1,300 personnel.

Previously two vaccines against Ebola were developed by each of the Gamaleya NRC and the Vector in 2016-2018. These vaccines were used in a few African countries but they still are not approved by the WHO.

There is a significant difference in the number of publications among these organizations and their bibliometric performance in the InCites for 2015-2019 (see Table 2).

Category normalized citation impact (CNCI) allows us to compare organizations with various disciplines. As we can see, all Russian publications on SC "Virology" have a high level of bibliometric performance compared with selected organizations and the total Russian RP. All selected organizations have a value of CNCI approximately the same (0.7) as in total Russian RP. The SC "Virology" value of CNCI has acceded to 1.8 value in the entire world dataset, equal to 1. This artifact could be partly attributed to the high level of IC (63.4%).

Among three organizations, publications of the Chumakov FRC had shown the highest value of all bibliometric indicators. The leading SC were Virology (25%), "Biochemistry and Molecular Biology" (12%) and "Infection Diseases" (10%), and a few SC on chemistry.

Nowadays, an international collaboration (IC) is an integral part of the research, and modern technology significantly facilitated its growth. According to Adams J. (2021), the share of IC among advanced economies is about 70%. The Chumakov FRC level of IC (40.3%) is higher among the three organizations than in total Russian RP. The quality of publications is high: more than 69.3% of articles published in journals belonged to Q1 and Q2 quartiles. These journals are: "Archives of Virology," "Viruses Basel," PLOS, "Scientific Reports," and "FEBS Journal." Germany was the leading partner (its share of 20%), followed by the USA (10%). Ghana, Gabon, and India were among the 25 collaborative countries.

The Gamaleya NRC has the highest number of publications (see Table 1). Its leading SC is "Biochemistry and Molecular Biology" (more than 32% of publications.). The Gamaleya NRC share of domestic collaboration is approximately twice higher (56.4%) than its share of IC (29.4%). This is why the percentage of publications in Q4 journals was twice higher (40%) than its share (20%) in the Chumakov FRC. These journals are Russian: "Biochemistry and Molecular Biology," "ActaNaturae," and "Bulletin of Experimental Biology and Medicine." As its leading researcher, Ph.D.Logunov (who was in charge of "Sputnik-V" development) noted in the interview (Yaffa J., 2021) that he and his colleagues were focused more on the results of clinical trials than on publications. We assume that it is why their researchers are selected for publications in domestic and less prestigious journals indexed in WoS. It is essential to underscore that researchers receive additional income if their publications are indexed in any database of WoS, including the Emerging Science Citation Index since 2015 (Moed et al., 2018).

	Chumakov Federal Scientific Center for Research & Development of Immune & Biological Products of RAS	Gamaleya National Research Center for Epidemiology & Microbiology of the (MoH)	State Research Center of Virology & Biotechnology (VECTOR)	Russ. Public SC Virology	RUSSIA
Web of Science Documents	142	394	209	394	321,895
% Docs Cited	80.3	74.1	69.4	95.8	61.3
Category Normalized Citation Impact	0.7	0.7	0.5	1.8	0.8
Citation Impact	8.9	7.1	4.4	14.9	5.8
% Documents in Top 10%	6.3	5.8	2.9	11.5	6.3
% Highly Cited Papers	0.7	0.8	0.0	2.5	0.4
% Domestic Collaborations	57.0	56.4	67.0	29.4	26.7
% International Collaborations	40.1	29.4	19.1	63.4	29.4
Impact Relative to World	1.1	0.8	0.6	1.8	0.7
% Documents in Q1 Journals	35.4	19.8	17.6	21.8	28.2
% Documents in Q2 Journals	33.9	24.7	20.2	32.2	19.1
H-Index	17.0	24.0		26.7	

Table 2. Bibliometric indicators of Gamaleya SRC, the Vector and the Chumakov FRC, total Russian RP and publications on SC "Virology", InCites, 2015-2019

Bibliometric indicators of the "Vector "were surprisingly low compared to other selected organizations. The "Vector" is a prominent organization on new vaccine development and production. Compared with two other organizations, it has strong (67%) domestic collaboration. This artifact indicates why "Vector" researchers prefer to publish their results in Russian journals: the share of Q3 and Q4 journals was more than 63.2%%. The leaders of this collaboration were the Institute of Chemical Biology and Fundamental Medicine of the Siberian Branch (SB) of RAS (52 papers), the Gamaleya NRC (48 papers), and the Chumakov FSC (47 papers). Among 50 leading collaborative organizations, there is not any foreign agency. The USA was the first country with which "Vector" collaborated internationally in 1993. (Wilson C. et al., 2002). Despite the low level of IC (19%), the USA is still the leading partner (10.8%). It's leading research areas in SC are: "Biochemistry and Molecular Biology," "Virology," and "Infectious Diseases."

Since 1994, funding agencies (FA) have played an important role in Russian science. 71.2 % of virology publications expressed gratitude for financial support in our dataset. The leading FA was the Russian Science Foundation (RSF), followed by the Russian Foundation for Basic Research (RFBR) in 2015-2019. The National Institute of Health (NIH) played a significant role in funding Russian research on virology from 2000-to 2014. However, the USA lost its dominance from 2015-to 2019.

3. Conclusion

Our preliminary results have shown publication growth on virology as in the world dataset and in the Russian dataset. Our results could benefit research, funding agencies, and health policy decision-makers. The best bibliometric performance among the three Russian organizations that produced vaccines against COVID-19 had research from the Chumakov FSC, partly due to a strong international collaboration. Quite the opposite, the well-known organization, the "Vector," was focused on domestic collaborations (67.0%).

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