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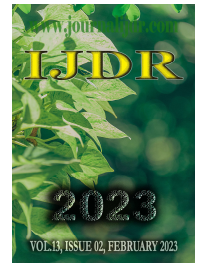
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RESEARCH ARTICLE

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POPULARIZATION OF SCIENCE IN HEALTH ENGENDERED BY DIGITAL INFORMATION AND COMMUNICATION TECHNOLOGIES

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ABSTRACT

This is a study on scientific production and its insertion in society, making known the access channels and the role of the agents involved, with the objective of investigating the approximation between science and society, verifying the virtual devices available for this interaction, observing the strategies and mechanisms correspondent academics based on these results to complete the analysis. The database of the Virtual Health Library, Periodicals Capes and PubMed were the chosen research sites with the time frame from 2015 to 2021. The results showed that the supply of digital technological resources for information and communication has been underused, but being limited to the process of making information available, lacking other factors such as transdisciplinarity in a collective and strategic task force seeking a common language that characterizes scientific popularization.

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INTRODUCTION

The precariousness and limitation of the means of publication in Brazil before the 19th century promoted an almost null scenario in the practice of disseminating and popularizing science. The first quality steps were taken with the implementation of the Royal Press in 1810, providing the production of approximately seven thousand periodicals, three hundred of which related to health, with institutions and scientific associations as authors. The media: *Revista Rio de Janeiro* and *Ciência para o Povo* (Rio de Janeiro and Science for the People Journal), both focused on scientific dissemination (SC), were examples of channels from this time, inserting a bridge between science and society, bringing health issues such as: yellow fever, brain and human behavior¹. In the "web generation", the scientific community acquired new impulses in its production and propagation in the context of digital information and communication technologies (DICT) that have been shaping the format of the relationship between society and science. Gama and Tavares² inform that this technology placed science in the "[...] era of interconnectivity where interaction/interactivity, the opportunity to coexist with the diversity

of ideas, dialogue, citizenship and collaborative production work stand out". They add that "the possibilities of information and communication, considerably mobile, based on anytime, anywhere, anyhow, beckon to multi-referential and creative perspectives in learning, with its dynamic, plural and interactive resources of digital technology". In this environment, students and educators are in a constant process of theoretical-practical training, learning and researching both the basic knowledge of professional training and technological innovations, identifying their concepts, resources and the policies that permeate them. The scientific community has been continuously providing instantaneous availability of its information with multiple forms of access to productions, advancing in exponential proportions, facilitated by the characteristics of DICT, such as: speed, storage, research, duplication and access, designing an inviting scenario for the popularization of science³. The source of energy that drives this popularization has at its core the figure of public policy programs. With this in mind, the Ministry of Health (MS) consistently invests in the production of digital propagation platforms and other DICT⁴ providing a gradual increase in access to productions, inserting a bridge between the non-scientist society and health professionals, improving the means for the development of

science, bringing quality and improvements, promoting a suitable environment for society to approach and appropriate the productions. The intrinsic characteristics of DICT provided a “golden age” never before experienced in the production and propagation of science. Image, sound, text, audio, virtual reality, augmented reality, in short, a great and fantastic variety of resources leveraging the democratization of knowledge, making it possible to be seen by society and understood by it. Obstacles in scientific dissemination in the pre-digital era were overcome with a set of hardware and software accessible to researchers and society that in their daily lives already use in their social, financial and educational activities. Geographic access difficulties were solved by providing the subject with an instant search without leaving work, school or home using a computer, cell phone or tablet. The physical space for storing information, which used to be a costly solution and complex variables (accessibility, security, maintenance, organization, etc.) is now solved in resources such as cloud storage capable of storing dozens of libraries, providing facilities never before available⁵. The redundancy of information for optimizing access, reliability and maintenance of data has become possible through digital devices at an impressive speed. A database such as the VHL can be duplicated in a matter of hours using sophisticated technological devices and advanced applications. However, the construction of bridges between the scientific community and society has not accompanied this same exponential growth in production. The non-scientist subject wants more than just data available on a web portal or video channel on Youtube⁶. He wants to know the paths through which science passes. A smokescreen was built due to the lack of clarity in intermediate procedures in scientific production, making society observe science with distrust, regarding its understanding and its destiny⁶.

Also, the scientific dialogue between researcher and society has not found impetus for the production of connections, designing a scenario of “isolated islands”. Some countries are aware of this issue, as is the case in England. A report produced by The Royal Society of London⁷ called on scientists to urgently promote dialogues with society through the prism of a public understanding of science. The report reported on the effort to no longer generate public mistrust and to encourage the union of scientific institutions and organizations in order to promote relations bringing society closer together, consolidating the understanding that “it is clearly a part of the professional responsibility of each scientist to promote public understanding of science”. After a careful reading of the report on the popularization of science produced by the London Parliament, the crisis established between science and society is observed due to this distancing, making scientific production unpopular⁸. There are no adequate dialogues with society, creating a scenario of isolation and distrust, advocates the report. Trust in science tends to continue to decline as the sources of scientific production remain distant from society, not only in their accessibility, but also in their reading and interpretation. To restore this relationship of trust, public deliberation and participation in science is necessary. It is important to emphasize that science needs to be “socially constructed” and adds that the stage of scientific production benefits from its propagation when permeated by non-scientific individuals promoting genuine science that is less objectionable to society⁶. Going ahead, the television media, digital media and private newspapers practice their science popularization strategies, with their due interests, by the way, winning the trust of society through their news, implementing connections at a higher level of relationship that public scientists⁸.

It is interesting to notice during the research that non-scientific subjects actually seek to understand the purpose of scientific productions for the improvement of society as a whole⁹. The legitimacy of science permeates and infiltrates society's daily life and must be perceived, understood and judged by it. It emphasizes that this initiative needs to start from the research centers, the school, the researchers and the students driven by public policy relations¹⁰. This approximation of society and science will not occur naturally if not for a collective effort going beyond disseminating or transmitting information by making data available on an article platform or in a scientific journal. Popularizing science is not just transmitting

knowledge as a one-way road in a vertical view of hierarchy. There is a need for strategies with dialogical characteristics of propagation, opening space for the participation and critical reflection of the different subjects of society, bringing into play the exercise of citizenship and the advancement of science. The reflection that does not shut up is that no man obtains knowledge alone, in fact men united and mediated by the world produce science and take it over¹¹. In the DICT scenario, we can find alternatives for the popularization of science in health within a more coherent model using new forms of coexistence and interaction, moving away from the scientific profile the monolithic discourse in its structure of production and propagation.

METHODOLOGY

According to methodological classifications recommended by scientific rigor¹² An integrative review was carried out, taking the period from January 2015 to June 2021 as a time frame, using the scientific databases of the Virtual Health Library (VHL), Periodicals Capes and PubMed. This is a qualitative research using information with an inseparable link between the scientific community and the paths presented for the production of knowledge and its popularization by digital technological means of information and communication (DICT). Qualitative research exposes specific information between the objective world and subjectivity of the subject that cannot be translated into numbers. The abundance of scientific information available, thanks to the advent of DICT, requires methodological rigor from researchers so that their searches do not lose their thematic focus. In this sense, there is the research strategy called PICO, which, similarly to a compass, provides a north for the researcher, guiding the construction of problematizing questions and helping in the processes with the databases, in addition to repositioning the direction of the research if by chance the researcher is attracted by information that does not adhere to the theme. It is a method that allows synthesis of the research through an investigative and rigorous process¹³. The word PICO is an acronym with the following structure: P (patients, population) indicating the population that will be included in the studies as well as its specificity; I (intervention, indication or interest) defining which intervention will be investigated; C (control) defining the control or comparison processes; The (outcome) indicating the outcome or expected result, which may be several. Conducting the review was based on the principles proposed by Mendes et al.¹³, maintaining methodological rigor in research production, which advocates a six-step system: 1) elaboration of the review question; 2) search and selection of primary studies; 3) data extraction from studies; 4) critical evaluation of the primary studies included in the review; 5) summary of the review results and 6) presentation of the method together with the results. In figure 1 we have the graphical representation of these procedures.



Source: Mendes et al.¹³

Figure 1. Steps in conducting an integrative review

The first phase took place in the researcher's work in defining keywords that were directly related to the research theme and the problem question described below: What means does lay Brazilian society have at its disposal to relate to the scientific community and its productions in a popular and harmonious language with your level of interpretation within the scenario of digital information and communication technologies?

In the second phase, searches for thesauri were carried out within the PICO strategy and it was observed that for better efficiency the PICO strategy should be used, as its intrinsic characteristics would guarantee better performance and consistency in non-clinical research¹³. Applying the PICO strategy, the structure was obtained as shown in Chart 1.

Chart 1. PICO acronym structure

Acronym	Meaning	Application in research
P	Patients, population → specify the population that will be included in the studies as well as their specificity.	Scientific community and its productions.
I	Intervention → it is defined which intervention will be investigated.	Means of popularization of science.
Co	Context → control or comparison processes are defined.	Scenario of digital information and communication technologies.

The databases chosen were: BVS, Periódicos Capes and PubMed using the following keywords: Popularization of science, health and technology. These databases were chosen due to the recognition and prestige they have in the scientific health scenario and the researcher's practice in using them. The inclusion criteria used in the search filtering were: works published between 2015 and 2021 containing the keywords ("popularization of science, health, technology) in their title or abstract resulting in the following filter: (Popularization of science) AND (health) AND (technology) AND (year_cluster:[2015 TO 2021]). The search resulted in a total of 41 works. In the exclusion criteria, it was defined: studies of the integrative review type, duplicate studies and those that were not related to the study question. In the third phase, the articles were selected by reading the titles and abstracts, taking into account the inclusion and exclusion criteria. Subsequently, a procedure called filing was carried out, which deals with the reading of the works obtained, cataloging and analyzing the level of adherence with the research theme. This phase was concluded with a total of 33 works selected. The fourth phase consisted of reading the articles in full, performing critical analyzes and observing the categories that would emerge from there. After this phase, the sample totaled thirteen articles. The fifth phase was the moment of interpretation and discussion of the results, shedding light on the works that most contributed to the answer to the research problem. At the end of this phase, three categories were defined: 1) science without popularization is not science; 2) spreading science is not the same as popularizing; 3) scientific popularization and DICT. In the sixth phase, the presentation of the results and synthesis on the problematizing issue of this article was concluded. From phase three onwards, the researcher used the QSR Nvivo program to assist in data analysis.

RESULTS AND DISCUSSION

Chart 2 shows the synoptic list of the articles read and analyzed in their entirety.

Science without popularization has no scientific legitimacy: The legitimacy of science has in its concept self-exposure to lay society in an accessible format and popular language, narrowing the path with people's daily lives. This two-way communication is what defines the "backbone" of science²⁴. Without this connection there is no scientific legitimacy.

In addition, the fact that society is aware of and monitors the productions is a question of the survival of science itself, as it is from society that funding comes, making its promotion, development and advances possible¹⁴. Public policy programs need to observe and implement means that shape the way in which the scientific community relates to lay society. National Law No. 12,527, of November 18, 2011, for example, grants and ensures citizens the right of access to information made available by digital means of information and communication, providing a society with a critical sense regarding the production of well-known knowledge. how to promote better well-being for society. Popularizing science calls for a teaching-learning relationship, demanding the promotion of an emotional atmosphere of joy and enthusiasm, with curiosity driving the whole process. It becomes relevant that popularization goes beyond the limits of scientific dissemination, going beyond publicizing knowledge. To popularize is to produce value in knowledge in the eyes of society by promoting importance and esteem in the subject of science, while scientific dissemination is concluded in mass public availability in an accessible language¹⁵. The popularization of science expects the scientist to awaken in society the desire for the tasting of knowledge, stimulating the desire for the taste of knowledge and provoking the knowledge of the informational flavor. In the scenario of scientific dissemination in health, society has at its disposal digital, private and public resources, where the production of knowledge by scientific institutions and associations is notorious. However, for a popularization within the criteria of a liberating pedagogy¹¹ and, in line with the London Parliament report⁷, the DICT found in this research lack a more adequate format for the popularization of science in health. Therefore, a more dynamic procedure is expected from the scientific community beyond simply transmitting or disseminating knowledge. When going through the portals of the Ministry of Health and its main partners, it is possible to observe several news and reports carrying out scientific dissemination and that could easily be confused with popularization of science. Popularizing involves enchanting, involving and relating in a language that is easy to understand for the non-scientist citizen.

Disseminating science is not the same as popularizing: The popular interpretation of scientific information is a challenge that needs to be analyzed by scientists, observing several issues such as choosing an easy-to-understand language using digital resources such as: video, images and applications. The scientific community needs to pay attention to its difficult language even for the journalistic community¹⁴. In the popularization of knowledge, if on the one hand there is the scientist as a researcher, on the other there is society that also holds diverse knowledge called "popular knowledge". Far beyond disseminating science, popularizing science involves empowering lay society by valuing its voice, perception and questions. In this teaching-learning relationship, the student and educator have knowledge that should not be discarded in the practice of knowledge production, promoting dialogicity, transforming the plastered "banking conception" into a libertarian pedagogy, making a legitimate and more assertive popularization of science¹¹. Analyzing a little more closely, it is possible to see that the non-scientific subjects have gone beyond the stage of being just readers of science, demonstrating a search and understanding of the influence of science in their daily lives, bringing reflections on overcoming their own specificities and demands⁹. That is why the importance of common and popular language to establish connections between society and science, bringing a greater sense of understanding regarding the productions and discourses of the scientific community. Scientific culture is characterized by permeating the daily lives of ordinary people and their relationships, allowing itself to be shown as a device for the benefit and improvement of individual and collective life¹⁰. However, scientific dissemination remains one of the stages of popularization that brings with it emotional as well as rational aspects. Bringing non-scientific society to knowledge of science is part of institutionalized public policy in Brazil in terms of social inclusion¹⁸. Science in its full conception must involve all subjects from the first steps in the search for information to its wide dissemination in non-scientific society, finally aiming at social use in favor of human development²⁵.

Chart 2. Synoptic relationship of the integrative review

Authors name/ Year of publication	Journal / Database	Title	Approach/ Type of research	Main results
BARCELOS, Janinne; GOMES, Suely Henrique de Aquino; OLIVEIRA, Frederico Ramos. 2018 ¹⁴	Em Questão/ Periódicos Capes	Análise e tracking do uso da fotografia na divulgação científica	Exploratory research with a mixed approach (quantitative and qualitative).	Experiment carried out with 24 volunteers who participated in experiments through specific software and hardware, analyzing the level of abstraction and interest in scientific content with the image as a supporting element. Experiment brought positive results regarding scientific dissemination in the use of photography and drawings.
SOUSA, Regina Célia; ARANHA, Carolina Pereira; SILVA, André Flávio Gonçalves; ROCHA, Juliana Rodrigues. 2019 ¹⁵	Ciência & Saúde Coletiva/ Periódicos Capes	Ciência Útil: Semana Nacional de Ciência e Tecnologia em escolas do campo	Non-experimental observational research with a quantitative approach.	An experiment involving eleven workshops and a display of photographs used to awaken in students from five schools the effects of nature and the presence of mathematics in everyday life was analyzed. The researchers observed growth in the level of awareness among science, technology and society in line with scientific popularization.
TAVEIRA, Gustavo Diniz de Mesquita; CARNEIRO, Gabriela da Silva; STRIBEL, Guilherme Pereira. 2021 ¹⁶	Periferia/ Periódicos Capes	Políticas públicas de popularização da ciência e movimentos anti-cientistas no Brasil: uma análise discursiva	Descriptive research with a qualitative approach.	The research brought to reflection hypotheses that the expansion of scientific dissemination causes the emergence of anti-scientist movements as protection of their ideological dogmas.
SANTOS-D'AMORIM, Karen Isabelle; CRUZ, Rúbia Wanessa dos Reis; CORREIA, Anna Elizabeth Galvão Coutinho. 2020 ¹⁷	Brazilian Journal of Information Science/ Periódicos Capes	O uso dos blogs de ciência no campo da Ciência da Informação no Brasil e seus papéis na cultura científica	Exploratory research of a quantitative nature.	Science blogs are presented as instruments that make it possible to expand the ways of communicating scientific knowledge, offering faster and more accessible means for exchanging information between scientists and society. In the end, the research demonstrates a very short lifespan and an increasingly smaller use of this technology, although it has great power for the popularization of science.
CANAN, Ivan; BIRK, Grazielle. 2017 ¹⁸	Revista Gestão, finanças e contabilidade/ Periódicos Capes	Divulgação científica da contabilidade: análise do conteúdo dos websites das instituições de ensino superior brasileiras	Exploratory research of a quantitative nature.	It brought the importance of the popularization of science and raised questions that Brazilian HEIs do not take advantage of the full potential made available by DICT.
PADILHA, Suiany Carvalho; PRESSER, Nadi Helena; ZARIAS, Alexandre. 2016 ¹⁹	Em questão / Periódico Capes	Divulgação científica: uso social do produto dos estudos científicos na Fundação Joaquim Nabuco	Descriptive research with a qualitative and quantitative approach.	The research found that the process of popularizing science in research institutions can be carried out through the productivity of researchers and the dissemination of production in scientific events, involvement in professional training activities and, also, through the involvement of researchers in actions involving or not the DICT.
ASSEF NETO, Rosangela Cordeiro de Souza; GUIMARÃES, Maria Cristina Soares; SILVA, Cicera Henrique da; LINS, Rosane Abdala. 2019 ²⁰	Informação & Sociedade/ Periódicos Capes	Fiocruz e a sociedade: uma visão da divulgação em jornais e revistas a partir da base de Currículos Lattes	Descriptive research with a quantitative approach.	When the researcher, in fulfilling the mission of giving satisfaction to society, addresses it directly, the process is called scientific dissemination. The research brought to the fore the importance of several DICT that boost scientific popularization and concludes by giving importance to this procedure so that science continues to advance.
CARVALHO, Vanessa Brasil de; MASSARANI, Luisa. 2020 ²¹	Revista FAMECOS/ Periódicos Capes	Adolescentes, televisão e ciência: um estudo exploratório a partir da publicidade brasileira	Descriptive research of a qualitative nature.	The research brought the information that society uses science to make decisions in its daily life, such as the purchase of products, among other resolutions.
MASSARANI, Luisa; ABREU, Willian Vieira de; ROCHA, Jessica Norberto. 2019 ⁶	Revista RECIIS/ BVS	Apoio a projetos de divulgação científica: análise de edital realizado pela Fundação Oswaldo Cruz	Descriptive research of quantitative and qualitative method.	The research ended by showing the need for programs and training of the scientific community to establish a dialogue with society, in a diversified, comprehensive, accessible and inclusive way.
BENTO, Sílvio Fernando Bento; MODENA, Celina Maria; CABRAL, Stephanie dos Santos. 2018 ⁹	Revista RECIIS/ BVS	Produção de vídeos educativos sobre saúde a partir da interlocução entre estudantes e pesquisadores	Experience report.	Research revealed successful results in the popularization of science with the TDCI as a supporting element permeated by strategies to provoke curiosity, enthusiasm and interest in the other.
HADDAD, Ana Estela; et al. 2017 ²²	Revista da ABENO/ BVS	A diretriz do Plano Nacional de Pós-Graduação de articulação com a Educação Básica: relato do projeto Experimentando Ciência	Experience report.	Experience of approaching scientific processes with 200 high school students. The result was demonstrated as positive through the curiosity and enthusiasm of the students, promoting the will to achieve protagonism in producing science.
SANTOS, Patrícia Aline dos; COSTA, Maria Conceição da. 2016 ¹⁰	Revista BIS/ BVS	Relações entre medicina baseada em evidências e jornalismo	Descriptive research / qualitative approach.	The research revealed that the partnership EBM (evidence-based medicine) and journalism can be proactive for the recognition of practices, for the understanding of scientific rationality and also for a critical view on how knowledge has been constructed.
BEVILAQUA, Diego Vaz et al. 2021 ²³	História, Ciências, Saúde – Manguinhos/ PubMed	Uma análise das ações de divulgação e popularização da ciência na Fundação Oswaldo Cruz	Descriptive research with a qualitative approach.	Research clarifies Fiocruz as an institution that promotes scientific dissemination, but highlights that most devices are unidirectional, lacking dialogue with society.

The absence of non-scientific citizen participation in the stages of scientific production opens a gap in society, giving rise to disbelief and doubts as to its legitimacy. The COVID-19 pandemic has clearly shown signs of this nature. Society's trust in science tends to decrease as the sources of scientific production become more distant, I mean not only in their accessibility, but in their interpretation and understanding of what is transmitted. In order to restore this relationship of trust, deliberation and public participation is necessary, from the beginning to the use and dissemination of the scientific product accompanied by a critical discourse on its effectiveness. Science needs to be "socially constructed" into "reliable knowledge" ⁶. One of the starting points would be the establishment of dialogical relationships between scientists and society, promoting a popular understanding of the productive stages of science and its use in society, allowing all the actors involved to judge its validation.

Scientific popularization and DICT: The public interest in science and technology in Brazil points to a percentage close to 62%. Among young people aged 15 to 24, this number increases to 67%, with television being the most accessed media for the perception of science, unlike Europe and the United States, where the Internet has consolidated itself as the most used channel for popularizing science²¹. In Brazil, the largest health research institution in Latin America is the Oswaldo Cruz Foundation (Fiocruz), whose main focus is the production of knowledge for the control of diseases such as AIDS, malaria, chagas, tuberculosis and others²⁰. AFIocruz produced several digital interfaces between science and society, which stand out:

- Fiocruz Portal – one of the largest scientific dissemination portals in the health area. It receives around 200,000 accesses per month via the email address: <https://portal.fiocruz.br/>.
- Health Channel – public open television channel that spreads knowledge about health in a journalistic format.
- Video Health – center for the production, dissemination and storage of audiovisual materials in health.
- RADIS health communication journal – printed and digital magazine with more than one hundred thousand subscribers across the country.

Another instrument for scientific propagation is the Ministry of Health portal, the official site of the Brazilian government for communicating health information to society through a journalistic and innovative format via the electronic address: <https://www.gov.br/saude/pt-br>. One of the largest digital media is Revista Ciência Hoje created by the "Brazilian Society for the Progress of Science"²⁰ (SBPC) published by Instituto Ciência Hoje (ICC), a private non-profit institution. The web address of this journal is: <https://cienciahoje.org.br/>. There are scientific databases in Brazil that store a wide variety of articles, theses, dissertations and other models of knowledge propagation, but they lack attributes in their format that characterize them as an instrument for the popularization of science, such as the use of a popular language and media resources that make the information attractive and easy to assimilate by the non-scientist citizen.

CONCLUSION

A starting point would be reflections on the establishment of devices for accessible and permanent dialogues between the scientific community and society, building "a two-way street" promoting popular understanding of science. Raising questions about paths that unite these two poles, science and society, becomes relevant for the scientific community to take its place with confidence and security and to be perceived by the people as a partner in search of solutions to the challenges of improvement and continuity of society. The expressive portals developed by Fiocruz and the Ministry of Health have proposals that only bypass the periphery of the powerful resource provider nucleus that DICT can provide. The most popular social media tools, such as Facebook[®], Tik Tok[®] and Instagram[®],

were rarely mentioned in the review articles. There is a need to invest in science in a transdisciplinary model involving health scientists, journalists and information professionals to build this broad two-way road called popularization of science. This research lacks a more in-depth study to analyze technical characteristics and emotional reasons that slow down dialogue between the scientific community and lay society. The proposal of this work has innovative potential due to its transdisciplinarity, as it aims to contextualize methodologies related to the field of science in health that can be incorporated into the teaching-learning process provided by the power of DICT with a focus on the principles of scientific popularization. It is in transdisciplinarity that the master column is found to promote dialogue between science peers and lay society and thus make the scientific popularization in health engendered by digital information and communication technologies happen.

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