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Science Communication and Citizen Science: Strategies for the Ordinary Citizen

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Abstract

Citizen science (CS) is a paradigm shift in communicating scientific findings to society. CS aims to produce knowledge with society and democratize it through participatory approaches between researchers and citizens. International research entities have been developing strategies for communicating about scientific knowledge and getting closer to the citizen. This study aims to identify the strategies for communicating science to ordinary citizens used by international research entities practicing CS. This exploratory and descriptive study used documentary analysis on the websites of 23 internationally recognized scientific entities with relevant work mostly focused on the health area. The text corpus was organized and submitted to the thematic content analysis technique. The results reveal several strategies for communicating science to citizens, such as the review of information materials by citizens prior to their dissemination; courses and training of citizens on issues related to science and science communication; lectures and presentations in schools or informal settings (e.g., cafés, stores, theater plays, stand-up events); and digital information materials with simplified and user-friendly scientific content. Scientific entities tend to promote CS through innovative strategies to get closer to and engage with ordinary citizens.

Keywords

scientific diffusion, citizen science, scientific literacy

Comunicação de Ciência e Ciência Cidadã: Estratégias Para o Cidadão Comum

Resumo

A ciência cidadã (CC) assume-se como uma mudança de paradigma na comunicação de resultados científicos à sociedade. A CC tem como propósito produzir conhecimento com a sociedade e promover a sua democratização por meio de abordagens participativas entre investigadores e cidadãos comuns. Visando aproximar-se do cidadão comum, entidades de investigação internacionais têm vindo a desenvolver estratégias de comunicação do conhecimento científico. O presente estudo tem por objetivo identificar as estratégias para promover a comunicação de ciência aos cidadãos comuns, implementadas por entidades de investigação internacionais que praticam a CC. Trata-se de um estudo exploratório de natureza descritiva, com recurso à análise documental. Foram analisadas as páginas de internet de 23 entidades científicas internacionais, com idoneidade e trabalho relevante, em sua maioria, voltadas para a área da saúde. O corpus textual foi organizado e submetido à técnica de análise de conteúdo temática. Os resultados revelam diversas estratégias de comunicação de ciência para o cidadão comum, entre as quais se destacam: a revisão de materiais informativos por parte dos cidadãos prévia à sua disseminação; cursos e capacitação dos cidadãos sobre temáticas relacionadas com a ciência e comunicação de ciência; palestras e diálogos em ambientes escolares ou informais (e.g., cafés, lojas, espetáculos de teatro, stand-up); materiais informativos digitais de conteúdo científico simplificado e amigável. Verifica-se uma tendência das entidades científicas para promover a CC, através de estratégias inovadoras que visam a aproximação ao cidadão comum e o seu envolvimento.

Palavras-chave

divulgação científica, ciência cidadã, literacia científica

1. Introduction

Science communication in health has evolved significantly worldwide, despite being a recent discipline (Magalhães et al., 2021). It has emerged due to the growing need to ensure that academic knowledge is a driver for societal behavioral changes. Despite the commitment to science communication, science is usually communicated through traditional approaches based on the transfer of scientific knowledge, neglecting the democratization of knowledge (Jünger & Fähnrich, 2020).

Emerging situations, such as the public health crisis caused by the COVID-19 pandemic, further encourage reflection on the characteristics of this communication process. Therefore, it is paramount to identify the strategies used and the level of citizen involvement in science communication. Researchers and academics should address and discuss the following questions: what scientific information do citizens want to receive; how do they want to receive it; what is the most appropriate format; and what type of language should be used?

Citizen science (CS) is a growing field of research and practice that can be used to overcome the traditional and unidirectional paradigm that has long guided the production and dissemination of knowledge. CS involves engaging citizens throughout the

research cycle and thereby learning about what is truly important to society (Roche et al., 2020; Wu et al., 2019).

By involving citizens in the research process, CS brings researchers and society closer together, benefiting both parties due to this close relationship and collaborative work (Bento et al., 2016; Roche et al., 2020). For researchers, the goal is to develop more relevant research that focuses on the real needs of individuals and more easily responds to the sustainable development goals of the United Nations (United Nations, n.d.). For citizens, it facilitates their collaboration in knowledge coproduction and promotes the exchange of experiences and engagement. These processes increase awareness, literacy, and empowerment to guide decision-making processes in health and the sociopolitical context (Goi & Tan, 2021; Roche et al., 2020).

In health care, although CS is still an underexplored area, renowned institutions such as the National Institute for Health Research, the Research Governance Framework for Health and Social Care, the Research and Development Directorate of the National Health Service, and the National Institutes for Health advocate this good practice. They believe that citizen, patient, family, and caregiver engagement should be a priority area of research requiring further analysis (Ahmed & Palermo, 2010; Hayes et al., 2012; Vale, 2012).

Communication and dissemination of scientific knowledge are crucial steps in the research cycle, and as such, they should follow specific formats and occur in spaces closer to the citizens. Therefore, this study aims to identify the strategies for communicating science to ordinary citizens used by international research entities that practice CS.

2. Method

This exploratory and descriptive study had the following research question: what strategies for communicating science to ordinary citizens are used by international scientific entities that practice CS?

A purposive sample of websites of renowned international scientific entities with relevant work in CS was analyzed. This study included entities that put forward specific actions or initiatives for communicating science to the citizens in their website menus and/or have ongoing or completed research projects based on the CS paradigm.

This study was conducted in December 2021. Data were obtained from the websites of these entities.

Knowing in advance that the ideal sampling technique in this type of study translates the dimensions of the phenomenon, both in quantity and intensity, a sufficiently comprehensive text corpus was identified, which resulted in data saturation (Green & Thorogood, 2018).

The text corpus consisted of the content extracted from these websites. It was then translated into Portuguese by Elaine Santana and validated by Rosa Silva (both authors), organized using Microsoft Excel, and analyzed using the content analysis technique proposed

by Bardin (1977/2016). According to the principles of this technique, content analysis allows exploring the information contained in the messages through systematic procedures, that is, their meanings and significance, revealing what lies behind the analyzed words. By achieving these indicators, content analysis allows the inference of knowledge related to the conditions of production and reception of these messages (Bardin, 1977/2016).

Bardin's (1977/2016) technique for thematic content analysis establishes three chronological phases: (a) pre-analysis, (b) exploration of the material and treatment of the results, and (c) inference and interpretation. In the pre-analysis, the material was organized after skimming the text, which later resulted in formulating objectives and hypotheses that grounded the interpretation. In the second phase, the material was explored and organized into data coded by the registration unit. Finally, in the third and last phase, data were treated based on their similarities and differences, then categorized and regrouped according to their similar characteristics (Bardin, 1977/2016).

Word clouds were built to represent each category using the Tagul Cloud online word cloud generator to facilitate the analysis and presentation of results. This resource helps to better visualize the categories and analyze the content because it identifies the most frequent words, culminating with their graphic representation in a word cloud.

There was no need for ethical review of this study because it did not involve human beings (no contact of any nature was made with those responsible for the websites or individuals who integrated the analyzed strategies), and data were collected exclusively from open-access websites.

3. Results

A total of 23 websites of international scientific entities were analyzed, 16 of which met the inclusion criteria. They present science communication actions or initiatives to the citizens on their websites. Consequently, the eligible text corpus consisted of 12 websites of scientific organizations/associations, two websites of research centers, and two websites of governmental agencies/institutions (Table 1).

ID	Entity	Country	Association/ organization	Research centers	Governmental agency
E1	Comprehensive Clinical Trials Unit — University College London	United Kingdom		X	X
E2	National Institutes for Health Research	United Kingdom			
E3	European Patients' Academy on Therapeutic Innovation	European Union	X		
E4	Imperial College London	England		X	
E5	Voice	United Kingdom	X		
E6	Crohn's and Colitis UK	United Kingdom	X		
E7	European Citizen Science Association	European Union	X		
E8	Vetenskap & Allmänhet	Sweden	X		
E9	Health and Care Research Wales	Wales, United Kingdom	X		
E10	Scientific American/ Springer Nature	United States of America	X		
E11	Scottish Intercollegiate Guidelines Network	Scotland	X		
E12	Value for Health CoLAB	Portugal	X		
E13	Agency for Clinical Research and Biomedical Innovation	Portugal			X
E14	Australian Citizen Science Association	Australia	X		
E15	International Consortium for Health Outcomes Measurement	United States of America	X		
E16	Cochrane Collaboration	United Kingdom	X		

Table 1 *Characterization of the scientific entities per type and country*

Four categories emerged from the analysis: "citizen engagement", "citizen empowerment", "usual and innovative interactions", and "communicating with accessible resources and formats".

The analytical categories are presented below. The category "citizen engagement" highlights science communication strategies that enable ordinary citizens to be engaged and actively participate in the research process.

As shown in the word cloud (Figure 1), the analyzed information indicates that some scientific entities involve the citizen in science communication through groups, such as patient groups. These citizens can be representatives who collaborate in evidence reviews and give their opinion about information materials that will be shared with society.

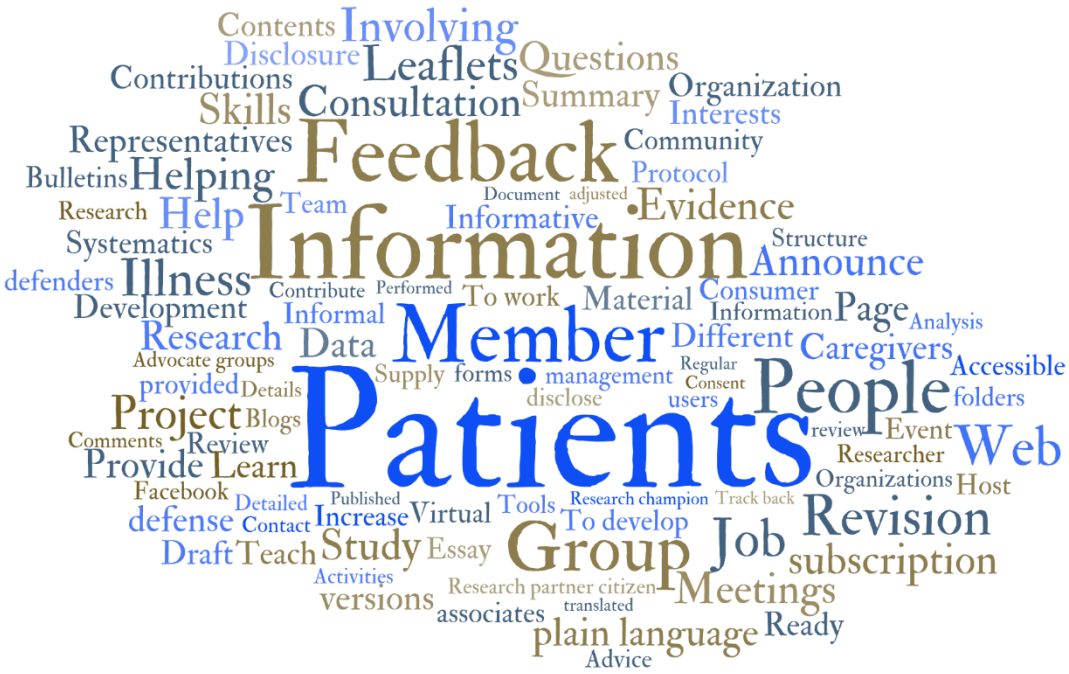

Figure 1 *Citizen engagement*

These strategies can be observed in the excerpts below:

- "patients provide feedback on the information leaflets we design and simplify the scientific language" (E1);
- "Reader Volunteers provide feedback on our information resources, (...) help us to improve our information, making sure it is relevant and easy to understand" (E6);
- "the role of a Research Champion is to be part of a research project, attending meetings, sharing their own views and experiences" (E6);
- "citizens [patients] provide feedback on the draft versions of our sets [sets of informational materials]" (E15);
- "citizen research partners, global teams, and advocacy groups are coproducers of information leaflets" (E15);
- "citizen [patients with Cushing's disease] and patient organizations announced and disseminated information about the studies on Cushing's disease" (E3).

The category "citizen empowerment" represents a strategy used by the entities to empower the ordinary citizen in science communication and increase their literacy

in their topics of interest, transforming them into disseminators and multipliers of this knowledge.

The following excerpts include the strategies identified in this category:

- "mini-course: health technology and medicines safety to foster patient involvement in co-construction and co-validation" (E3);
- "workshop: to encourage citizens to share their opinions to help improve the acceptance of lung function testing" (E4);
- "training platform: raises citizen awareness about the importance of protecting biodiversity by organizing citizen science activities" (E7);
- "a free online resource offering an introduction to health evidence, and how to use it to make informed health choices" (E16);
- "interactive courses in a storytelling format, with readings, videos, audio, questionnaires, including self-assessment processes of the knowledge acquired" (E16);
- "training: Collections of resources that offer the opportunity to develop self-directed online learning through online courses, individual learning modules, videos, slideshows, webinars, international workshops, conferences, scripts, and manuals" (E16).

Figure 2 shows several capacity-building strategies, such as workshops, forums, webinars, modules, courses, and mini-courses in digital format. These strategies work as a guided resource to raise awareness and empower ordinary citizens to communicate science and are illustrated by the highlights in the word cloud.

Figure 2 *Citizen empowerment*

The category "usual and innovative interactions" highlights the strategies that involve both conventional initiatives, such as lectures, meetings, and open classes, and innovative initiatives, such as discussions in non-academic environments (e.g., cafés and city squares) to make the dialogue simpler and closer to the citizen.

Conventional interaction strategies are illustrated in the following excerpts:

- "dialogue between researchers and the public (...) a project connecting Swedish schools with scientists" (E8);

- "lectures and debates: panel with researchers to promote a dynamic conversation" (E8);
- "we have already jointly given a talk (speakers are researchers, experts, but also citizens, in this case, people with cancer) at the Rare Cancer Forum" (E9).

The promotion of debates in non-academic spaces for casual and informal interaction is demonstrated in the following excerpts:

- "sipping science with a science café" (E8);
- "exhibitions: poster displays, outdoor exhibitions, museum exhibitions, traveling exhibitions, film screenings, art exhibitions, photography exhibitions" (E8);
- "shop with researchers: researchers are available to answer questions about the products on sale/display" (E8);
- "visits, tours, and open-house events: bus tours with researchers, city walking tours, excursions, study tour; open-house events or visits to various research facilities such as laboratories, research facilities, Science Centers, zoos, and museums" (E8);
- "Science square: researchers are available to answer questions and talk with visitors. It is an easy way to create opportunities for dialogue" (E8);
- "borrow a scientist: researchers visit schools or workplaces at the request of the participants" (E8).

In this category, the use of artistic language by the entities also stands out as an innovative resource to communicate science to ordinary citizens:

- "theatrical production on the challenges of aging" (E5);
- "demonstrations and theater: Forum theater, an interactive form of theater in which the audience gets the opportunity to change and influence the performance" (E8);
- "comical and poetic performances revolving around the beautiful and fantastic aspects of physics and the universe" (E8);
- "stand-up: an unconventional and attractive format for science communication" (E8).

Figure 3 shows the word cloud that characterizes these strategies. On their websites, the entities revealed how they communicate science and highlighted the need to bring researchers closer to citizens. This approach involves interaction activities, school visits, open classes, meetings, and discussion groups. More casual events included exhibitions, theater performances, museum visits, and science dissemination events in cafés or shops.

Figure 3 *Usual and innovative interactions*

The use of strategies that prioritize making scientific knowledge available in an accessible format is highlighted by the category "communicating with accessible resources and formats".

These strategies focus on providing citizens access to information materials with high-quality scientific content in a friendly language at a click.

This concern can be seen in the following excerpts:

- "openly accessible versions of articles" (E9);
- "lay abstracts to be published on the website (...) about diabetes" (E9);
- "booklets with patient-friendly versions of guidelines that 'translate' recommendations and their rationale from clinical guidelines for health professionals into a more easily understandable and usable format for patients and the public" (E11);
- "publication of plain language texts, opinion articles, and interviews" (E13);
- "plain language summaries: they are created using standard content, structure, and language to ease understanding and translation" (E16);
- "sets of patient-centered outcome measures, including all reference guides, leaflets, 'data dictionaries', and press releases, are available free of charge" (E15).

In order to intensify the communication of science, research centers and their affiliates/partners reaffirm the commitment to make scientific knowledge available and accessible through plain language. Digital platforms (in some cases, collaboration in the design of information materials is possible), social networks (e.g., Facebook, Twitter, and Instagram), and other innovative tools were used to integrate the new characteristics of the science communication process, as can be seen in the following excerpts:

- "digital platform designed to promote health literacy in society" (E12);
- "COVID-19 Collaborative glossary in partnership with several institutions (...). Terminological resource for non-specialists. 'This collaborative glossary comprises the terminology used by official health care agencies, healthcare professionals, (...) allow access to organized terminological information on the disease, in clear, easy-to-understand language'" (E12);
- "educational application to educate citizens about how to manage rainwater in the urban fabric" (E7);
- "interactive website on the developed projects and initiatives: Blog, News, Videos, document Library" (E9);
- "video of the findings: share, in a report and video format, the experiences of the people involved in the study through publication in journals, websites, and social media" (E9);
- "podcasts, videos, multimedia, photo features, and other forms of storytelling" (E10);
- "digital platform to increase environmental awareness" (E14);
- "blogs, targeted emails, audio/visual products, blog posts (video blogs), podcasts, infographics, videos, social media (Twitter, Facebook, Instagram) and Wikipedia" (E16).

Figure 4 shows a representation of the main strategies, demonstrating that the entities share information materials through digital resources, such as videos, websites, blogs, podcasts, and social networks. The entities also ensured that this information and evidence (in the form of summaries, reports, or other information products) meet the criterion of accessibility and use plain language that is close to ordinary citizens.

Figure 4 *Communicating with accessible resources and formats*

4. Discussion

According to the CS paradigm for doing and communicating science, the practices of scientific and non-scientific actors should be readjusted to co-construct innovative research ecosystems (Bento et al., 2016). In the current international scenario, several initiatives have considered the innovative potential of transforming the citizen into a scientific communicator by focusing CS on the real needs of citizens and their social context (Silva et al., 2021).

Citizen engagement allows recognizing citizens' knowledge, interests, and motivations as members and representatives of society, so it is important to build sensitive science communication close to the citizens that leads to better decision-making processes (Besley et al., 2015).

In line with the findings of this study, the involvement of ordinary citizens in science communication has been encouraged through the creation of representative groups (e.g., citizen research partners, advocate groups, research champions) aimed to coproduce the materials in plain language through reviews (i.e., feedback; Campos et al., 2021; South et al., 2016; Ward et al., 2020).

The strategies identified in the "citizen engagement" category demonstrate that the involvement of ordinary citizens in science communication facilitates the process of transferring scientific knowledge to society. This involvement can be developed at different levels of proactivity, designated in the literature as different types of public involvement (Hayes et al., 2012). Concerning the different levels of citizen engagement identified

in the literature on CS, many researchers, mainly in the health area, recognize that citizen engagement can occur based on three types of approaches: (a) consultation, (b) collaboration, and (c) coproduction (Biddle et al., 2021; Hayes et al., 2012; Hickey, 2018).

The consultation approach consists of organizing meetings or consultative groups to gather opinions from citizens (patients [experts], caregivers, or stakeholders) interactively and systematically.

On the other hand, the collaboration approach involves partnerships with citizens, and research champions, advocate groups, or citizen research partners are elected. These citizens will participate in shared decision-making with researchers and be involved in meetings, workshops, working groups, panels, or committees. Finally, the coproduction approach consists of the active participation of citizens as members of the research team in the research's control, direction, and management. In the context of communication, the citizen coproducer can participate as a translator, reviewer, and coauthor of the content that will be shared (Biddle et al., 2021; Hayes et al., 2012; Hickey, 2018).

It is important to clarify that the engagement strategies identified in the analysis of the text corpus fall within these three types of approaches. In this case, the contribution of these citizens, through the adaptation of information materials to a more straightforward and accessible language, takes the form of a consultation approach. Strategies such as coauthoring shared content and identifying citizens' representatives to share their experiences in workshops and meetings are part of coproduction and collaboration approaches.

The premise of science communication within CS is to bring citizens closer to research contexts and academic processes, demonstrating that ordinary people's opinions, experiences, and knowledge have great relevance (Oliveira & Carvalho, 2015). This premise seems to be a priority of the analyzed entities.

According to Campos et al. (2011), besides empowering citizens for concerted participation in science communication, the strategies in the "citizen empowerment" category provide the opportunity for social interaction with other citizens and with the researchers themselves.

Reaffirming the primary goal of science communication, especially in raising health awareness, it is paramount that science communication contributes to and allows engaging and empowering both citizens and the society in which they are inserted (Richter et al., 2019; Schiavo, 2014). Moreover, giving ordinary citizens opportunities for exchanging experiences and acquiring knowledge helps build trusting relationships and value science (Amaral et al., 2017).

The transition movement in scientific production, which tends to be increasingly focused on problem-solving, impels citizens to assume an active collaboration so that the knowledge produced and shared is relevant and applicable in practice (Bento et al., 2016). The answer to the challenge of countering misinformation may lie in restoring society's respect and trust in science. Given the arguments already presented, getting closer to the citizens through the CS paradigm will certainly bring science and society

closer together. Thus, the interaction and dialogue between researchers and citizens is a strategy with great potential used by international entities.

However, as presented by the "usual and innovative interactions" category, despite the growing movement towards openness in the processes of creation and dissemination of scientific knowledge, many researchers and research centers continue to implement interventions focused on informing rather than on communication, interaction, and the development of a trust-based relationship with citizens. This aspect is confirmed by Dudo and Besley (2016) in a study aimed to explore how scientist communicators evaluate five specific communication objectives. The authors concluded that the main priority in science communication is educating the population and fighting misinformation, while the least prioritized aspect is building a trust-based relationship with society (Dudo & Besley, 2016). Therefore, reaffirming the challenge of science to develop innovative forms of communication and promote the trust and interest of society in scientific topics, future initiatives should include several stakeholders, whether they are researchers in natural, social, and health sciences, citizens, or political agents, and diversify the resources and spaces where this sharing of knowledge can occur (Bento et al., 2016).

In this regard, the innovative strategies used in some interventions by the entities analyzed in this study promote the approximation process and add value because they prioritize communication in informal and relaxed environments or environments familiar to citizens. These situations are more likely to arouse interest in exchanging experiences and learning (Amaral et al., 2017; Ward et al., 2020). Moreover, the use of artistic languages, such as theater or comedy, is described in the literature as an innovative resource to communicate and engage citizens in science-related topics (Amaral et al., 2017; Pinto et al., 2015; Riesch, 2015).

Through these creative ways, researchers become more involved in society and better scientific communicators, helping the general public to better understand science-related topics by the general public, especially through the emotions and awareness that theater and laughter provide (Amaral et al., 2017; Bultitude & Sardo, 2012; Richter et al., 2019; Riesch, 2015).

As to provide simple and clear scientific knowledge, the strategies in the "communicating with accessible resources and formats" category are in line with the initiatives in the "citizen engagement" category, demonstrating that the use of a language accessible in several formats brings citizens closer to science-related topics to increase their awareness and literacy is a common concern.

Therefore, given the wide reach of the internet and its contribution to health awareness and promotion, the analyzed entities recognize the importance of introducing digital tools in their communication processes to provide reliable and easily accessible scientific content (Magalhães et al., 2021; Mheidly & Fares, 2020). However, the development of digital resources increases the concern with the quality of what is made available and consumed on social networks. For this reason, it is even more important that science

communication reaches the most diversified settings, namely digital environments, as seen in the strategies identified in this study.

In the era of hyperconnectivity, digital tools are crucial to combat misinformation and the negative influence of distorting mechanisms on shaping public opinion and reducing trust in science (Haklay, 2018).

Pulido et al. (2020) analyzed the tweets published on February 6 and 7, 2020, on the social network Twitter and found that false information was "tweeted" more than science-based evidence, which leads to an important reflection on the responsibility of communicating science in the field of public health.

Science communication within this new paradigm of CS has major potential for improving the quality of access to knowledge and increasing the involvement of ordinary citizens, who will now be included in the development and dissemination of scientific knowledge (Edwards et al., 2018).

Therefore, the results of this study are of practical utility for scientists and science communicators. They promote the recognition of the work of those who already develop this practice and encourage the adoption of similar strategies by those researchers and research units that still have not included these initiatives in their work plans.

Concerning limitations, some entities with recognized work in this area may have been excluded due to the small sample size and the selection strategy. Therefore, interesting data may have been lost.

5. Conclusion

Regarding implications for practice, we conclude that the strategies for citizen engagement in science communication processes were more frequent among the analyzed entities, with the main objective of bringing scientific knowledge closer to the citizen through accessible and attractive formats. We recommend the implementation of initiatives to transform ordinary citizens into team members, promoting their involvement through consultation, collaboration, and coproduction approaches.

However, it should be noted that the information on the websites included in this sample does not allow checking if these strategies are sufficient, relevant, or still incipient or analyzing the meaning attributed to them by citizens or researchers. Therefore, this topic requires further exploration, namely by listing the gaps to be addressed in future studies and assessing the impact of these strategies.

The entities recognize the importance of science reaching the population through different formats, usual strategies, and innovative tools that promote greater interest, understanding, and appreciation of these topics.

Another implemented strategy was citizen empowerment through workshops, courses, and practical meetings to communicate science by translating scientific terms into a more accessible language, sharing experiences, and promoting health literacy.

Innovative ways to communicate science were highlighted, namely strategies of interaction between researchers and citizens in unconventional spaces, such as cafés/pubs, theaters, stores, and city squares, promoting a conversational approach. However, most of these initiatives were implemented by a single entity, which shows that, despite the progress in deconstructing the standardized and citizen-distant model of science communication, it still needs further analysis.

As for the implications for research, we believe there is an urgent need to explore the issues surrounding CS and its impact on the processes of doing and communicating science. The effects of these initiatives must be evaluated and measured to help build knowledge in this area and improve the quality and effectiveness of these initiatives.

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