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Impact of the Internet on communication flow of scientific health information

ABSTRACT

Communication flow of scientific information has been restructured with the development of new technologies and the Internet and their impact on social relations worldwide. The production of scientific knowledge has also been influenced by these cultural, social and economic changes and has contributed to new patterns of scientific communication. The objective of the study was to present the traditional scientific communication model and its evolution to electronic scientific communication stimulated by the use of electronic media and Internet and networking. While the traditional model is based on printed publications, the new one focuses on electronic publishing and open unlimited access to published literature. The challenges faced are in using all the potential of electronic media for improving traditional communication flow of scientific information and defining policies to support the new model of scientific communication to ensure quality, preservation and dissemination of information as a common good.

KEYWORDS: Internet. Publishing. Periodicals. Electronic publications. Scientific communication and diffusion.

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INTRODUCTION

Scientific communication flow comprises formal publication of research findings, information retrieval, access to published literature as well as informal communication and information exchange between researchers. It is a continuous flow as knowledge published and assimilated generates new knowledge, research and publications, ruled by a particular dynamics and influenced by social relations.

Pellegrini Filho¹⁰ (2000) divides scientific activity into three basic processes: knowledge production (research), circulation and incorporation. The author emphasizes these processes “are immersed in a social totality influenced by them; on the other hand, these processes are also mostly influenced through mediating instances such as financing, human resources training, legitimation, law and regulations, information dissemination and communication channels, health system structure, etc.”

With the advent of the Internet and the development of new technologies, social relations have changed and scientific communication flow has been restructured. Castells² says the Internet and the web have brought about social changes creating a society in which information can be produced and stored in different spaces and accessed by users from a distance, facilitating research development and work through collaboration networks. The globalization process in the twentieth-first century has gained momentum when people realized the capacity for collaboration through worldwide networks by making the most of the technology resources available.

Targino¹¹ (2003) stresses that “technological applications in the communication process have always led to new social relations and cultural practices, starting with the emergence of writing, then the establishment of literature and press, which enabled wide information dissemination”. Changes brought about by the Internet should be regarded as resulting from a joint transformation process of subjects and objects. Changes were introduced between knowledge producers and users. The development of communication networks through the Internet and electronic mail has allowed increased social involvement in political decision processes, participatory management in companies and institutions, collaboration groups, among others.³

Information has transformed the dynamics of collective knowledge construction by converging communication, decision, demand, response and action on a

common space. Equitable access to scientific knowledge has become a priority in the definition of social, economic, and cultural development policies.

Traditional scientific communication flow, relying on successive interdependent steps with extended time gaps between each instance, has moved to the virtual space where there are no time and physical restrictions. The dynamics of information diffusion and publication in Internet makes it possible for actions to follow concurrently and no longer at regular intervals.

Electronic publishing, one of the major expressions of the impact of the Internet and new technologies on scientific communication, is often associated to scientific journals but extends to other forms of formal communication such as books, official publications, theses, as well as informal scientific communication such as presentations delivered at meetings.

Many initiatives of using new technologies for scientific knowledge dissemination has been developed in the health field. In Latin America, the Virtual Health Library (VHL)* initiative has contributed to restructuring the scientific information and communication flow. VHL's purpose is to promote convergence of different actors on a common virtual space of public domain. The use of new methodologies and information technologies in VHL has allowed to expand and strengthen a collective space where decentralized and interactive forms of information organization and treatment are applied. VHL “also widens the characteristics of the networks of flows and sources of information, now including domains of implicit, factual, technical and scientific information and knowledge.” (Packer,⁹ 2005).

The present study describes and discusses the evolution of the traditional communication flow of scientific information and its transformation by the use of electronic media and the Internet.

TRADITIONAL COMMUNICATION FLOW OF SCIENTIFIC INFORMATION

The traditional communication flow of scientific information mirrors the printed publishing model and can be schematically divided into five stages: writing, review, publication, indexing and dissemination. These stages can be subdivided into intermediate instances that may follow different classifications.^{1,9} In the traditional flow, stages are sequential, time- and space-dependent and involve different actors who are not inter-

*The Virtual Health Library (<http://www.bvsalud.org>) was launched in 1998 by BIREME - Latin American and Caribbean Center on Health Sciences Information

connected. The results of each stage are communicated through printed documents that are physically transported from one instance to the next one.

In the first stage of the scientific communication flow, authors write their articles based on their research work or theoretical thinking. After being written, articles are submitted to a publisher or scientific journal for publication. In the next stage, known as peer review, other members of the scientific community, experts on the subject studied by the author, make comments and validate the articles submitted for publication. Peer review is a slow process of reviewing printed manuscripts sent through conventional means like postal services. Articles submitted for the approval of the editorial board of a journal or publisher can be sent back to the author as many times as needed before its approval. Manuscripts are then reviewed for the consistency of scientific language and publishing standards. The whole process can be expected to take months or years before the article is published and involves many members of the scientific community.

Approved articles then advance to the next publishing stage of word and image processing by publishing specialists. After being published, documents are distributed or purchased by users and organizations and/or processed and registered into databases of intermediate institutions in the scientific communication flow, such as libraries and information centers. Access to these databases is limited and often requires formal requests made to libraries or those database producers. Similarly, the process of obtaining any retrieved publications requires them to be physically available in library collections, not always close or accessible to users.

Information is disseminated through printed copies or database search services. Remote database access has started in 1970s through remote terminals connected by teleprocessing systems. Selective information dissemination services, based on bibliographies and databases, were also created at that time. Information in printed or electronic format was provided for increasing the visibility of scientific publications.

The organization of the traditional scientific communication flow has numerous limitations, which restrict access to published documents. The main limitations are: time elapsed from manuscripts preparation, approval, editing, printing and distribution, ranging from months to years depending on the flow management in scientific journals; difficult access and distribution costs of printed journals that are basically limited to

library collections not always accessible and to all public; high subscription fees charged by private publishers or distributors, and even by scientific societies; and continuous need for increasing spaces for filing printed collections. Such limitations affect all countries but especially developing countries.

To overcome these limitations, from the first decades of the twentieth century, propositions have been put forward to end up publishing journals in issues and privilege publishing them as reprints. In health, the U.S. National Institutes of Health (NIH) created the Information Exchange Group to promote direct contact between researchers and exchange of reprints of articles not published by the formal scientific communication system. Despite positive results, this initiative was terminated a couple of years later due to pressure from the publishing industry.* This initiative is regarded as the precursor of open repositories implemented only after the advent of the Internet.

ELECTRONIC SCIENTIFIC COMMUNICATION FLOW

Available in the last decades of the twentieth century, the Internet has changed not only the dynamics of scientific communication flow but also how science is conducted, by integrating the scientific community with other social segments and working through heterogeneous transdisciplinary collaboration networks linking a variety of organizations. These collaboration networks have evolved facilitated by advances in communication media and the Internet. The process of scientific knowledge production became non-linear involving all actors, from research conception to result application, and carrying implications to both writing and validation stages. The validation stage, formerly limited to the scientific community, has opened up to the community at large that can assess result reliability and social implications of research advancements.^{4,7}

Therefore, the evolution of scientific communication flow in the electronic era goes beyond electronic publishing of documents, also encompassing behavior changes of the scientific community and its relations with society. "Besides the innovative approach of the Internet as a publishing technology, a political perspective was brought about advocating scientific knowledge as a common good, critical to social and economic development." (Packer,⁹ 2005).

Linearity and sequentiality, intrinsic to the traditional model, have been replaced by an agile, fast, dynamic,

*Lemos AAB. Presente e futuro do periódico científico. Correio Brasiliense, 1968. Available from http://www.briquetdelemos.com.br/briquet/briquet_lemos6.htm [access in 2006 Mar 30]

and sometimes interactive communication flow in the virtual space created by the Internet. The new flow makes it possible the convergence of authors, reviewers and editors (information producers), libraries and information centers (intermediate instances) and users (readers and researchers) and promotes idea and experience sharing. Communication is established through messages and digital files automatically transferred from one stage to the next one that can be visible and accessible to many actors at the same time regardless of their physical distances.

In addition to opening up new possibilities of interaction, electronic publishing has added a new stage in the communication flow of scientific information: the generation of measures and evaluation indicators. Evaluation is pervasive in all stages: authors can track the indicators of the approval flow of their articles; editors and reviewers can track the flow of peer review and manage deadlines efficiently; and researchers, editors and managers can track the number of accesses, comments and received citations ..

Networking and electronic publishing allow actors to exchange roles in the many stages of the scientific communication flow: authors can play the role of publishers when they publish their articles in their own websites or in open or institutional repositories with no need of intermediaries; editors become database producers by providing access, in their journal's websites, to specific fields of data (author, subject, date and others) from the whole collection; database producers become information providers by ensuring access to full texts and, at the same time, promoting links among databases to increase visibility of scientific production. "The digital revolution is offering alternatives both to how the various stages of these processes are conducted and who does them." as stated in a report of The US National Academies symposium.⁶

Electronic publishing of scientific journals makes articles available ahead of print, right after being approved by editors. This publishing approach promotes increasing visibility of research results and reduced time between article approval and its publication in printed format. The scientific article becomes an independent information unit, though these units will be subsequently arranged in issues, when ruled by traditional principles. Additional information and versions in different languages can be included in

journal's websites, adding value to the printed format. Printed copies and issue arrangement in the new communication flow of scientific information are thus byproducts of the material electronically published.

Scientific communication flow has also been favored by the possibility of creating interactive spaces for scientists like discussion forums and virtual communities to be used from the early stages of a research project up to research writing. Many editors have offered opportunity for article discussion by the scientific community in their journals' websites. Comments added at the end of every article contribute to science development and represent a new approach to result validation. Mueller⁵ (1994) underlines recognition and opinions of other scientists are major promoters for authors to publish their scientific work.

The Open Access movement, starting in 2001, has ensured open publishing of electronic documents with copyrights reserved as long as sources are cited. In this regard, open access journal repositories and institutional and thematic collections have been strengthened. According to The National Academies report,⁶ editors have allowed articles published in their journals to be automatically filed in their repositories in the format of the final approved manuscript, right after or after a couple of months they are published, according to journals' access policies. Following this trend, in May 2005, the U.S. Department of Health and Human Services NIH* adopted a policy establishing all authors who were granted full or partial NIH financing and have published their research findings in scientific journals should file a copy of the approved manuscript in their digital library, the PubMed Central.**

The Internet has turned access to information democratic making it possible for countries to adopt similar methodologies and technologies regardless of their level of development. Developing countries have been and will be mostly favored by electronic publishing, which has enabled them to overcome obstacles of visibility and access to their publications, virtually inaccessible to the international community in the past. BIREME (Latin American and Caribbean Center on Health Sciences Information) has introduced open access initiatives in the VHL such as SciELO (Scientific Electronic Library Online).*** A seminar held in September 2005 culminated in approving the *Salvador's Declaration*

*National Institutes of Health. Department of Health and Human Services. Policy on enhancing public access to archived publications resulting from NIH-funded research. Estados Unidos, 2005. Available from <http://grants.nih.gov/grants/guide/notice-files/NOT-OD-05-022.html> [access in 2006 Mar 15]

**PubMed Central. Available from <http://www.pubmedcentral.org>

***SciELO (<http://www.scielo.org>) is an initiative of BIREME and the Fundação de Apoio à Pesquisa do Estado de São Paulo (Fapesp), in Brazil, with collections of about 300 Iberoamerican journals.

on Open Access: the developing world perspective,* which urges governments to make Open Access a high priority in science policies, including strengthening open access publications, repositories and other related initiatives and promoting integration of developing countries scientific information in the worldwide body of knowledge.

ELECTRONIC HEALTH JOURNALS

Scientific journals are the most visible form of electronic publication although this same model can be applied to all sorts of documents. In LILACS (Latin American and Caribbean Health Sciences Literature) database, 30% of all documents published in the last 10 years are available in the Internet, of which 98% are journal articles.

The first electronic scientific journal was the Online Journal of Current Clinical Trials, published in 1992 by OCLC (Online Computer Library Center) in Ohio, US, with full texts and charts. In March 2006, DOAJ (Directory of Open Access Journals),** coordinated by Lund University Libraries in Sweden, covered 2,160 open access electronic journals, of which 595 are searchable at article level. DOAJ covers 312 health journals, of which 77 are public health journals. Ibero and Latin American journals of SciELO collections are included in DOAJ.

SciELO was the first initiative of open access in developing countries. It was introduced in 1997, in Brazil, with the publication of ten different titles; four of them being health journals. In May 2006, SciELO Brazil included 160 titles, 83 (52%) were health sciences and indexed in LILACS database.*** The whole SciELO collections comprising Latin American and Caribbean countries, Spain and Portugal cover 167 health journals.

VHL Portal of Scientific Journals includes around 8,600 current health journals, 50% available electronically. Of 5,236 journals indexed in MEDLINE database and included in VHL Portal, 3,457 (66%) are electronic journals in open or restricted access mode. The proportion of electronically journals published in Latin American and Caribbean countries indexed in LILACS database grew from 18% in 2001 to 78% in 2006.

Increased visibility of public health journals elec-

tronically available can be evidenced by SciELO access and citation indicators. The most accessed journals in SciELO Brazil are *Revista de Saúde Pública* (Journal of Public Health) and *Cadernos de Saúde Pública* (Reports in Public Health), accounting for 9% of total accesses to SciELO. In SciELO's Public Health collection, Brazilian journals are not only the most accessed but also the most cited. This specialized collection,**** launched in 1999, contains the eight most representative titles in public health, published in six countries and indexed in international databases. Accesses to journals in this collection exceeded two million per month in 2006.

CHALLENGES AND PERSPECTIVES

Changes in the scientific communication flow after the advent of the Internet reflect an ongoing profound re-thinking of cultural, social and economic values. Besides requiring actors to constantly adjust to new technologies, these changes call for breaking resistance to the transience and reliability of electronic versions and to current academic communication standards. Oliveira & Noronha⁸ (2005) assert that "for digital communication to be fully accepted by the scientific community unsettled issues should be discussed and defined such as authorship and copyrights guarantees, information permanence and validity, and publishers' access policies".

Electronic publishing has been acknowledged as a solution for outdated methodology and technology in scientific communication flow with the potential of breaking with the standards of printed scientific journals, available for almost 400 years, or even eliminating them. However, while there are currently numerous electronic journals, electronic publishing is still replicating or enhancing the established standards. In 1968, Lemos***** anticipated that in the future journals would be replaced with other media, like image and audio recordings of researchers' reports, but such boldness and creativity is still experimental in scientific journals. Few journals are fully electronic or explore the potential of electronic publishing by promoting the use of dynamic imaging, sound and other multimedia resources in addition to links between text and cited sources. The electronic text could be dynamic allowing users to follow the same paths followed by authors while preparing their manuscripts or developing their research projects with unlimited connections between electronic docu-

*Salvador Declaration. Available from <http://www.icml9.org/channel.php?lang=en&channel=91&content=439>

**Directory of Open Access Journals. Available from <http://www.doaj.org>

***LILACS - Latin American and Caribbean Health Sciences, coordinated by BIREME. Available from <http://www.bvsalud.org>

****SciELO Public Health. Available from <http://www.scielosp.org>

*****Lemos AAB. Presente e futuro do periódico científico. Correio Brasiliense, 1968. Available from http://www.briquetdelemos.com.br/briquet/briquet_lemos6.htm [access in 2006 Mar 30]

ments and web sites. Text citation could be replaced by access to full texts of the original document; procedure descriptions could be replaced by dynamic imaging or videos; interviews and discussions could be replaced by their audio and video recording. Though electronic publishing should not replicate printed publishing, it is still so.

Challenges are posed for the use of the whole potential of electronic media by enhancing the positive aspects and quality of traditional standards of scientific communication flow and defining policies that would be supportive of the new system and would ensure information preservation and distribution as a common good.

During this transient period standards have been preserved, sometimes apparently contradictory, and some issues remain unanswered. Various journals publish articles online immediately after their approval but others publish them online long after printed publications are available. Printed publishing has effectively become a byproduct of electronic publishing and it seems to be maintained only to respond to traditional flow standards or preserve contents in a different format. It can be argued that printed publishing needs to be maintained as access to the Internet is the privilege of some and printed publica-

tions can reach out communities that still are not integrated to the worldwide network. On the other hand, distribution of printed scientific journals does not either assure its access in all communities.

The journal Science* has innovated by publishing printed, electronic and digital formats. The difference between the electronic and digital format is that the latter is a carbon copy of the printed format including sections not available electronically. Subscribers have access to the digital journal at a lower cost and can print it or store it in their computers. The purpose is to allow subscribers to save full collections in their computers and access to advertising material that financially support the journal, at the same time preserving the traditional values of scientific communication.

Electronic publishing has brought about endless perspectives for promoting changes in scientific communication culture. Open access through the Internet helps advance democratization and equitable access to scientific information. Opening up spaces for interaction and convergence of authors, editors and users can contribute to the inclusion of new actors in the scientific communication and information flow and encourage scientific research findings to be widely available.

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