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INTRODUCTION

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1. Science, technology, innovation and health in a world of inequalities

In the present century, important advances in healthcare have been experienced all around the globe. However, these improvements have been unevenly distributed, widening the gaps between countries, groups and individuals. Over the past 15 years, for example, there has been a substantial decline in under-five mortality rates, in both low and high incomes countries, but the gap between these groups of countries has increased. Children continue to have a higher risk of dying before the age of five if they are born into poor households in rural areas or if their mothers have not received basic education (WHO 2016). Many maternal and childhood programs have failed to generate impacts on children and families in the lowest income quintiles (UNICEF 2016).

While it is recognized that ensuring health of the population is related to poverty reduction and strengthening economic welfare, there is no consensus on the causality of this relation (Husain 2010). For some authors the direction goes from income to health. Researchers who adhere to this perspective support an optimistic vision: increasing national and per capita income will improve the health of the population. Others argue that increases in income are not enough to ensure improvements in the health of the population, and they give priority to public health interventions, including the dissemination of knowledge and innovations in the area of health. There are also arguments about the importance of investing in health, which are justified by its relevance as a primary good. Nussbaum (2011) places health in his list of ten basic capacities. According to the author, for a person to live with human dignity, he must be able to have a complete and satisfactory life until old age, that is, to live in good health.

By and large, the discussion suggests that it is necessary to better understand what the causal processes and paths are that drive the intricate relationship between health, wealth and well-being. This is not a trivial matter because the emphasis on some of these dimensions and the causality between them are the bases for informing of the design and implementation of public policies in this area.

Recently, good health and well-being have been defined as a goal of the 2030 Agenda for Sustainable Development. Achieving good health, as Sustainable Development Goals

(SDGs), requires comprehensive and multisectoral actions such as: moving towards universal healthcare coverage, improving sanitation and hygiene, reducing environmental pollution, ending poverty and reducing inequalities (Ramani 2019). The 2030 Agenda recognizes the complementarity between good health and quality of life and other key goals. For instance, access to quality education generates tools to develop innovative solutions and technological progress at the service of good health and well-being and other SDGs.

If health is no longer defined from a restricted view – as the absence of disease - to become understood broadly - related to well-being and opportunities, then the role of Science, Technology and Innovation (STI) to promote health must also be rethought. This implies going beyond frameworks of health innovation solely as an economic sector by incorporating the articulation with new social and environmental dimensions. The Innovation Systems approach is useful for analysing how health knowledge could be inserted into these complex relationships (Hanlin and Holm Andersen 2019); since they consider actors, different types of interactions, a variety of learning processes and the characteristics of the institutional framework (Natera et al. 2019a).

Systemic approaches should problematize some key challenges in terms of how research agendas are oriented, how the benefits of knowledge and innovations are disseminated and what the best institutional arrangements are for promoting STI in healthcare aligned with sustainable development. However, defining what the criteria of problem prioritization are and who the actors with a voice in the STI agendas are is the main challenge. There are health problems that we still cannot solve because we do not know the answers; we still do not know how to cure certain diseases (Mahoney and Morel 2006). There are orphan funding agendas, such as those for neglected diseases, which are mostly linked to poverty (Røttingen et al. 2013). Likewise, persistent problems in terms of reducing maternal and child mortality, improving nutrition and emerging problems, such as antimicrobial resistance, also need attention (WHO 2016).

On the other hand, the possibilities of contributing to the improvement of the quality of life are closely related to the dissemination processes of the STI. There are a variety of obstacles in this regard, many of them reinforced by the belief that investment in basic research will automatically lead to the development of new tools and their adoption by health systems. This linear vision has hidden the difficulties of translating research on health into policies and practices and has underestimated the complexity of the relationship between basic science and technological innovation in the field of health (Morel 2003).

One of the main obstacles in the processes of prioritization and distribution of STI in health is the disconnection and weak dialogue between actors and agencies in the orbit of innovation policies and healthcare policies (Lehoux et al. 2008). This disconnection is unfortunate and common, and we think that it is closely related to the absence of strong bridges between the two main fields that analyse the role of STI in health: innovation studies and health disciplines (Natera et al. 2019a). So far, innovation studies have shown a tendency to focus on products and services aimed at solving health problems. By doing this, they might neglect healthcare activities that do not follow market mechanisms and yet, are knowledge intensive and of priceless relevance for improving living conditions. Two examples are: (i) community health work, where knowledge is also a basis for users' participation (Estey, Smylie, and Macaulay 2009) and; (ii) public

policies and decision making for the health system, having knowledge as a backbone of evidence-based strategies (Gordon-Strachan, Bailey, and Ward 2006; Grimshaw et al. 2012; Ogilvie et al. 2009). Healthcare activities are highly diverse and not necessarily executed by firms; they involve a great number and nature of heterogeneous actors (such as hospitals, healthcare institutions, regulation institutions, patients and other healthcare service providers). Besides, the institutional framework is a heavy burden on the introduction of new knowledge-based applications. Therefore, healthcare does not fit into a regular sectoral innovation systems analysis (Ramlogan et al. 2007).

Healthcare disciplines are concerned with promoting the use of scientific knowledge to generate new solutions; they recognize the necessity of knowledge management to support their implementation. They are focused on the patient and the possibilities to improve his/her health. They have adopted the term "translation" to express how knowledge produced throughout different stages of the research process can be applied to practical solutions. Different approaches have emerged. *Translational Research (TR)* is a linear model that seeks to achieve the bench to bedside goal by translating basic knowledge into clinical application (normally associated with pharmaceuticals or medical devices) (Goldblatt and Lee 2010). *Knowledge Translation (KT)* models emerge as an alternative to TR high linearity; they do not place basic and biomedical sciences at the centre of the translation process. Instead, KT models propose a new concept that reflects permanent back and forth of knowledge flows and includes the synthesis, dissemination, exchange and application of knowledge to improve health (Grimshaw et al. 2012). Nevertheless, these approaches also come with shortcomings: (i) they focus on the individual and rarely on the collective groups as a unit of analysis, even when many health issues are socially determined; (ii) they do not explicitly recognize the productive sector, oversimplifying the transition from lab discoveries to generating useful applications (and the technological and production capabilities required); (iii) they include the public sector only at a limited level, and do not openly consider its influence on the definition of the research agenda; and (iv) they do not include intermediary activities and context variables actually needed to incorporate new knowledge into medical practice. The discussion is still open, and clearly there is space to contribute with new research oriented at achieving the SDG on good health and well-being.

2. The contribution of the articles of this Special Issue

As we can observe, we are missing a truly systemic perspective for understanding STI in health. The two main traditions that we have briefly described do not fully incorporate the complexity that characterizes healthcare activities and, even less so, the participation of STI in these. This is an important symptom of the lack of coordination that we observe when assessing actors' interactions, the regulation systems and, finally, knowledge applications in health. Unfortunately, this assessment is valid in many places around the world, but reaches dramatic levels in less developed societies. Keeping these concerns in mind, we have organized this special issue called "*Policy analysis and knowledge application for building a healthy health innovation system in developing countries.*" From a systemic approach to innovation, we propose that the translation and application of knowledge is an interactive and collaborative process between various actors -such as: basic and clinical researchers, healthcare professionals, agents of the

industrial sector and services, actors of civil society, users of healthcare services, etc., which takes place under specific local conditions and that is embedded in social institutions (Kale, Hanlin, and Chataway 2010). All the papers included in this special issue share this vision and collaborate to close the gap of a systemic perspective evidence of STI in health.

2.1. Policy analysis for STI in health

Six scientific articles of this special issue review the experience of four countries (Argentina, Brazil, Kenya and Mexico), synthesizing diverse experiences and lessons from the application of STI policies and instruments in healthcare. The joint studies start by recognizing the complexity that developing countries face in order to strengthen their healthcare systems and improve the quality of life of their populations. The papers cover three fundamental aspects: (i) conceptual frameworks for policy design, implementation and evaluation; (ii) definition of research agendas and their relationship to policy objectives; and (iii) interactions between STI and health policies.

The paper of Hanlin and Holm Andersen (2019) synthesizes the main contributions of the 2016 Globelics Thematic Report (GTR) on "Innovation and strengthening of health systems" focusing on the construction of a conceptual framework called 4F (Form, Field, Flows and Functions). With this base, they analyse Kenyàs health system showing the importance of capacity building, learning processes and power relations. The main recommendation is to move from isolated policy-building healthcare and wellbeing to a long-term holistic approach, focusing on 'competence building systems in the area of health and wellbeing'. One of the key aspects for achieving such a goal, is understanding how STI policy has a relevant impact on the generation of knowledge aimed at collaborating on the solution of health problems. Two papers tackle this issue, using the Brazilian and Mexican cases to illustrate the effect of policy on capacity building and the setting of research agendas.

Tomassini, Bianchi and Couto Soares (2019) focus on the regional distribution of the function of knowledge production in Brazil, using network techniques to analyse data of research projects carried out during the period of 2000-2015. Given the great diversity of socio-economic and healthcare demands that characterize the Brazilian territory, the authors study the evolution of regional research networks. They show that, despite the concentration of research capabilities in the richest regions, there was a strengthening of knowledge production in historically more neglected regions. They linked it to the health research priority agenda as defined by the Ministry of Health and found a diversity of regional profiles. The authors highlight the importance of the interaction between health policies and STI policies in these trends. However, they observe the need to improve the coordination between health demands and research agenda setting.

The Mexican experience shows that STI polices have not succeeded in orienting knowledge production to collaborate with the solution of a national health problem. By applying Pasteur's quadrant (Stokes 1997) to the knowledge production for diabetes research, Natera et al. (2019b) analysed publicly-funded projects from 2002 to 2014. They found that most of the funds for research were not devoted to projects with high levels of "consideration of knowledge use." In this case, they argue that the set of Mexican STI policies placed incentives for basic research and did not have enough mechanisms for

orienting the use of new scientific knowledge. Their policy recommendations include research system reorientation towards a greater consideration of use of knowledge and the democratization of the process of project approval to incorporate different social actors.

Policy interaction is the final aspect analysed. From the experience of a Sectoral Technology Innovation Fund for Health in Argentina, Bortz, and Thomas (2019) address one of the central questions of this special issue: what are the main barriers for translating and using knowledge production towards attending the needs of health policies and of health systems? Specifically, the authors analyse the congenital Chagas disease diagnosis project to understand knowledge production, translation, application and use in healthcare. The article reconstructs the development of diagnostic kits using a qualitative "backwards mapping" strategy. The results acknowledge some success in the translation of biomedical knowledge into technological applications. However, over the years of negotiation and implementation, the projects lost the initial intentions of the policy instrument. In that sense, the systemic actions were quite restricted, especially in terms of learning processes and capacity building.

By studying the Brazilian ability to make patented antiretroviral (ARV) drugs universally accessible to people living with HIV/AIDS, Urias (2019) shows a different perspective. He found that industrial policy can support health policy through the construction of technological and innovation capabilities. This virtuous relationship between policy instruments is a source of policy learning that could help other countries to develop similar strategies. Unfortunately, finding good examples of synergic implementation of two policies, supported by capacity building, public procurement, and institutional changes is not so common. This paper highlights new pathways for policy interactions in health.

We think that the collection of varied perspectives is the main contribution of these five scientific articles. They encompass different theoretical approaches (national innovation systems and the socio-technical approach), different methodological approaches (case studies, network analysis, structural equation models), and different analytical levels (conceptual and applied research). We strongly believe that this broad vision is necessary for understanding the complexity of policies related to knowledge use in the health sector. Analysis of power relations, disarticulation of innovation and health systems, policy incentives and their effects on the process of knowledge generation and the interaction between the multifaceted actors of the health system require the conjunction of diverse points of view.

2.2 Knowledge application of STI in health

The final three papers include evidence from Argentina, Mexico, Uruguay and Zimbabwe. By selecting different case studies, the papers explore ways to generate new insights about health knowledge application: (i) methodological approaches to operationalize knowledge use and; (ii) socio-institutional conditions needed for knowledge application.

Gras, Dutrénit, and Vera-Cruz (2019) present a causal model for inclusive innovation in the health sector. Departing from the literature of inclusive innovation, they approach the agents, interactions and policies related to the creation, adoption and diffusion of knowledge of health. In their model, social needs and government income trigger

governments' STI, Productive, and Social public policies. The model stylises three case studies: the development of breast milk pasteurizers in Uruguay, the implementation of telemedicine in Mexico and the creation of a functional probiotic yogurt in Argentina. Based on the model, the authors suggest that having inclusive and innovative healthcare solutions might be a potential driver of growth.

Socio-institutional conditions for knowledge of healthcare applications are at the core of two other papers. Using the case of testing in the early infant diagnosis of HIV in Zimbabwe, Ncube and Chataway (2019) argue against vertical interventions that are limited by a lack of integration. Organisational and institutional learning across different components of healthcare and of governance are identified as key processes, where the inclusion of different social actors has a fundamental role in the possible success of knowledge application.

Torres Vargas and Castellanos Gómez (2019) also emphasize the role of institutions and organizations in closing the gap between the knowledge generated in academia and its application. They study, the Newborn Screen project, a university initiative that became a National Healthcare Program in Mexico. By reconstructing a 15 years story, they identify two aspects that are crucial for overcoming the obstacles in the process: an institutional entrepreneur and the creation of an interface unit that enables knowledge transfer.

The three papers offer relevant evidence for better understanding the process of application of the health knowledge in developing countries. We would like to highlight the explicit effort made by all the authors to generate policy recommendations, transcending the particular cases to complement the existing literature in the field. Nevertheless, we believe that there is a clear necessity for collecting additional evidence to understand the vast complexity of knowledge translation and application in healthcare.

3. Looking ahead: towards an agenda for future research of STI in health

The promotion of STI in health does not always mean improvements in the quality of life; it may even imply greater inequalities. In developing countries, the persistence of these inequalities has to do with poverty, the lack of infrastructure and health services, but also with the enormous limitations in the prioritization of research agendas and the application of STI to meet local needs. Health represents an area of knowledge and technology generation where the definition of agendas mainly focuses on the needs of developed countries and serves populations with greater purchasing power (PATH 2014).

The gap between what we know from research and what is done to apply this knowledge continues to have a negative impact on developing countries (Santesso and Tugwell 2006). This gap between "knowing and doing" includes two especially problematic moments in the area of health: (i) the translation of the results of biomedical research into applications, and (ii) the translation of applied knowledge and its adoption into clinical practice, public policies, health services and society in general.

Improvements in the quality of life and human health present great challenges for the research agenda of STI. Universalizing healthcare services and achieving their quality and sustainability in the long term is hard work. Despite the importance of these issues, the collection of empirical evidence, as well as evaluations of existing mechanisms and their effective impact on improving the health of the population or health services, is still

limited. In Mexico, November 2018, we coordinated a special session of STI on health at the LALICS 2018 Seminar "STI challenges of CTI for solving national problems: sharing experiences in Latin America and the Caribbean"; scholars from 12 Latin American countries participated in a collaborative exercise that summarizes three topics for encouraging the debate on strengthening health innovations and their impact on the quality of life in developing countries. These points are inevitably interrelated and not exhaustive, but they recapitulate much of the specialized discussion on the subject.

3.1. Specifying research agendas

There exists a mismatch between the research agendas that are being developed and those that are needed to meet demands of health systems in developing countries. Two aspects are at the core of this issue: (i) the link between public and private actors for the promotion of STI in health, and (ii) the prioritization of health systems' demands in STI policy and instruments. Both aspects call for research related to topics on public policy of interest in health, on one hand, and the supply of knowledge and national capabilities and their potential application, on the other. Likewise, the capability to express social demands in health policies and the actors linked to the health system is complex. Only the fact of defining what a demand for knowledge or for innovation in health is, requires further investigation as health demands are fuzzy; for instance, demands expressed in health policies are based on epidemiological profiles that often leave out health research agendas from a social perspective. We need research on the set of criteria by which these demands could be defined in health systems and translated into research agendas.

3.2. Defining new ways of knowledge application: products, services, interventions and techniques

Knowledge application should be defined in a broader sense, including products and services but also new interventions and techniques (normally not related to market mechanisms). Additional research is needed to understand analytical frameworks for studying the application and translation of knowledge into healthcare innovations (Natera et al. 2019a). The establishment of bridges between the different approaches (innovation studies and health disciplines) is welcome; particularly those studies that begin with the micro analysis of specific technologies to understand how processes work at the macro level. Some critical points should be taken into account: (i) the translation of applied knowledge into useful evidence for health policies and health services; (ii) the strategies to strengthen the link between biomedical research, applied research, public health and technological developments to the needs of the population and health systems; (iii) the integration of agendas on research and innovation that consider a wide variety of possible applications; and (iv) the importance of analysing the interaction between Intellectual Property regimes and access to information sources (data banks, codes, protocols, etc.), and between Intellectual Property regimes and access to treatments and/or biomedical products (vaccines, drugs, biopharmaceuticals, methods, diagnostic reagents, etc.) (Basant 2011).

Power relations that condition the dialogue between actors, the relevance of local contexts and institutional frameworks are relevant dimensions for studying the processes of

knowledge generation oriented at different applications. On the institutional side, it is important to analyse the negative influence of healthcare systems' fragmentation, and the lack of coherence in regulation as a condition that inhibits the translation of knowledge and its application. This, of course, calls for an interdisciplinary effort.

3.3. Access to products, services and techniques: dissemination of innovations

The dissemination and application of STI for the solution of health problems is of upmost importance. Specially, the identification of actors, mechanisms and programs, the barriers and influence of regulatory frameworks must be studied in depth to specify the determinants of the diffusion of STI solutions in healthcare problems. Likewise, the possibilities of expanding access to healthcare services and products (based on cost reductions) and incentives for generating health innovation adjusted to local resources and contexts of scarcity could have a great impact in developing countries (Chaudhuri and West 2015). In order to do so, we need research on the combined strategy of developing local capabilities while strategically adopting foreign technologies that could help to scale up available solutions (Bortz and Thomas 2017).

Finally, we would like to acknowledge the fundamental role of two research networks in making this Special Issue possible: the GLOBELICS network (http://www.globelics.org/) provided the first input of documents that were analysed, which came from the 15th International Globelics Conference, held in Athens, Greece in 2017; and the LALICS network (http://www.lalics.org/), which was crucial to designing the characteristics of the Call for papers and to diffuse this call.

Disclosure statement

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