RESEARCH PAPER

Knowledge dialogues for better health: complementarities between health innovation studies and health disciplines

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ABSTRACT
Health innovation studies and the health disciplines highlight the importance of using knowledge to improve human welfare. However, these disciplines rarely yield discussion about this issue. The objective of this paper is to establish a dialogue between health innovation studies and the health disciplines, and to reveal the complementarities between these approaches. We present a revision of selected models of health knowledge use. From health innovation studies, we consider two models focused on the nature of health innovation, and two others that orient health innovation studies towards addressing inclusive development issues. From the health disciplines, we analyse translational research and knowledge translation models. Using a systemic perspective, we structure our analysis of complementarities on four analytical dimensions:

(i) The actors, proposing the recognition of the public sector, the productive sector, the scientific community, and health services providers. We also define two dynamic actors: knowledge users and knowledge beneficiaries.
(ii) The interactions, considering them as asymmetrical to facilitate knowledge flows.
(iii) The process, based on specific models of healthcare activities and a broad set of validation mechanisms (not only market-related).
(iv) The institutional framework, proposing consideration of formal institutions (e.g. regulations) and informal institutions (e.g. socio-cultural background).

Introduction

Health knowledge production, transfer and application are of the upmost importance for ensuring human welfare. In this paper, we focus on the use of these concepts in two branches of the health literature: (i) the systemic perspective of innovation studies as applied to the health sector, which we call 'health innovation studies' and (ii) translational perspectives originating in the health sector which integrate disciplinary experience, referred to here as 'health disciplines'. These two branches explicitly recognize the importance of knowledge for better health; however, they barely interact with each other. In line with this, we wonder what the similarities and complementarities between these two approaches to health knowledge application might be. We outline some answers

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to this question. We do not aim to present a systematic literature review and we are allergic to monolithic analytical frameworks. We suggest that the complexity of the health sector does not warrant one-size-fits-all visions and, in contrast, we argue that the construction of analytical frameworks in the health sector should be problem- and context-specific. Therefore, our goal is to offer conceptual input by pointing out relevant connections between these two approaches. Our intention is to encourage an open evolving discussion in the scientific community. In order to do this, the paper presents a critical assessment of points of contact between these fields using selected models as a foundation. Thus, the objective of this paper is to establish a dialogue between health innovation studies and the health disciplines, and to reveal complementarities between them.

Our objective is justified for two reasons. First, from a theoretical perspective, it is necessary to have a better characterization of healthcare activities. Health innovation studies would benefit from integrating a deeper understanding of the dynamics and determinants of health activities to foster the use of knowledge. The health disciplines would also profit from considering the productive systems around their activities when providing new solutions. Second, even though knowledge derived from research has always been fundamental for the implementation of new health solutions and practices (Neelam *et al.*, 2013), interest in proposing formal models that focus on developing the processes to allow the transfer, adoption and implementation of health knowledge is relatively recent. Consequently, in practice, these processes normally do not benefit from sound guidance and do not have a defined critical path, which leads to longer lead times for results to materialize (González-Block *et al.*, 2008).

This paper presents the analytical framework that structures our analysis and briefly explains how we identified the models that are included. It then presents a review of influential models of health innovation using two models focused on products and services, and two others that orient health innovation towards addressing inclusive development issues. The paper then characterizes health discipline models for knowledge use, namely translational research (TR) and knowledge translation (KT) models. We present the four dimensions of this dialogue between health innovation studies and health disciplines. Finally, we draw out the conclusions resulting from this exercise.

Proposing analytical dimensions and identifying models for knowledge use in health

In this section, we discuss the structure of our study and the way we identified the models to be analysed. Because of its complexity, there is no consensus about the analytical dimensions to frame health knowledge use. Instead of pursuing an impossible task, we propose using the innovation systems (IS) framework as a point of departure. IS offers constructs developed as action tools and analytical frameworks to understand how science, technology and innovation (STI) take place in different contexts (Lundvall, 1992). Because of its flexibility and systemic perspective, we propose that innovation systems are suitable to structure how health knowledge can be used (Cassiolato and Lastres, 2007; Consoli and Mina, 2009; Hanlin and Andersen, 2016). Although there is a vast literature characterizing IS-using nations, regions and sectors as units of analysis, there are four analytical dimensions that are constitutive of this tradition (Natera, Suárez and Rojas-Rajs, 2017):

- **The actors**. Freeman (1987) identifies institutions in the public and private sectors as the main actors in STI processes. However, in a broader conception, there is room for the inclusion of other actors (Lundvall, 2016). Specifically, there is a recent tendency to incorporate the civil community as an IS key player (Cozzens and Sutz, 2014; Etzkowitz and Rickne, 2014; Dutrénit *et al.*, 2018).
- **The interactions.** Interactions between actors 'initiate, modify, and disseminate new technologies' (Freeman, 1987, p.1). The relationships and linkages established through actors' continuous exchanges allow knowledge flows and synergy creation (Niosi *et al.*, 1993). These interactions are hierarchical and they depend on power relationships based on capabilities and institutional asymmetries (Dutrénit *et al.*, 2018).

- **The process**. This dimension includes: (i) the learning process in which actors modify or create new useful products, methods or services (Lundvall and Johnson, 1994), considering that different modes of learning (by doing, by using and by interacting) take place on different levels (Lundvall, 1996); and (ii) the innovation validation process, which is normally represented by market mechanisms, but not limited to them. We will argue that there are other validation mechanisms in the health sector that represent knowledge application in terms of non-private utility (OECD/EUROSTAT, 2018).
- **The institutional framework.** The 'rules of the game' are a main part of IS (Nelson and Nelson, 2002). The way in which actors are organized will boost or delay the possibility of using knowledge (Nelson, 2008). These rules determine how social technologies emerge and possible new avenues to incorporate STI solutions in different contexts. We consider formal institutions (explicit and codified) and informal institutions (implicit and tacit).

Identifying relevant models to include in the analysis comes with some compromises. There are many available options and various literature reviews recommend a set of interesting models (Greenhalgh *et al.*, 2004; Tugwell *et al.*, 2006; Yazdizadeh, Majdzadeh and Salmasian, 2010; Vinot *et al.*, 2012). Since we do not aim to produce a systematic literature review, we follow two *ad hoc* strategies for model identification. For health innovation studies, we proceeded as follows. We listed all documents presented during the last ten years of the Globelics[1] conferences; keywords were searched in titles and abstracts with the aim of identifying authors and proposals focused on studying the relationship between health and STI using a systemic framework. We reviewed the most cited papers and their centrality in order to discover the most relevant documents using as criteria the number of citations in Google Scholar and, when applicable, the quality of the journals in which they were published. Then we selected models based on their different approaches to the subject. We are aware that, because of the Globelics community's interests, our analysis is biased toward development issues, but we decided to take this path since health inequalities are present in developing and advanced countries alike (Marmot, 2005).

For the health disciplines, we took a different route. The proposals of KT and TR have been exported throughout the world by international organizations and they suggest incentives, mechanisms and specific institutional tools to develop projects from these perspectives. Based on these strategies, we selected four relevant models in health innovation studies and three models in the health disciplines. In the next two sections, we describe how each of these models works, and we frame them using the four analytical dimensions described above (actors, interactions, process and institutional framework).

Health innovation studies

Not surprisingly, healthcare has been identified as an area in which STI might have a strong impact on development issues (Johnson and Andersen, 2012). In the following, we describe four models from health innovation studies. First, we present two general models that allow us to understand how healthcare products and services are conceived. Then, we introduce two models oriented to knowledge application in developing countries, offering a contextualized space to understand the possibilities of using STI for the inclusion of marginalized communities.

Understanding the nature of healthcare innovation

In the innovation literature, healthcare is defined as a sector. Therefore, we would expect it to be configured according to the premises of sectoral innovation systems (SIS) (Malerba, 2002).

[1] Globelics is a worldwide community of scholars working on innovation and competence building in the context of economic development (www.globelics.org).

However, the complexity of healthcare activities is such that its analysis normally drives the conceptual framework away from the regular SIS analysis. We can give at least three reasons why healthcare does not fit a regular SIS analysis (Ramlogan *et al.*, 2007). The healthcare sector is very diverse and since innovations are not necessarily executed by firms, it is not easily typified by international classifications of economic activities. The number and nature of the actors involved are greater than in other sectors; for instance, hospitals, health institutions, regulation institutions, patients and other healthcare service providers are quite heterogeneous. And the burden of the institutional framework is considerable with substantial impact on the introduction of new knowledge-based applications.

Health innovation system oriented towards delivering new products

Consoli and Mina (2009) propose a model of the health innovation system where the generation of new products is at the core (Figure 1). It comprises two building blocks – considered the model's gateways – which represent the transition in the development of new technologies to their incorporation into medical practice. At the top of the model, they place the interaction between science and technology, represented by the scientific community, and focused on the generation of publications that reflect new knowledge (new treatments, diagnostics methods, product effectiveness), and the technology market, which provides new pharmaceutical developments and new medical devices. At the bottom of their model are two spheres – service provision and the individual sphere. The first takes place mostly at a hospital or at other clinical centres where diagnosis and therapeutic treatments are delivered to patients. The second is where the patient and the practitioner interact.

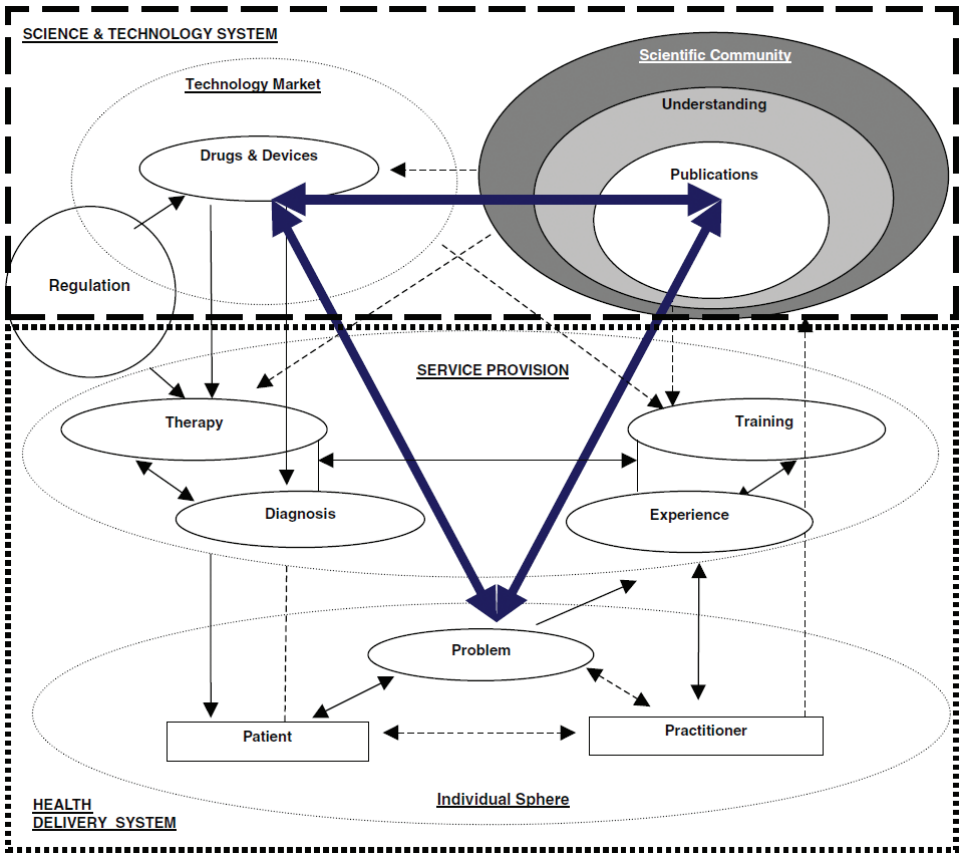

Figure 1. The health innovation system
Source: Consoli and Mina, 2009

The model's pathways are represented by the virtuous triangle that links the top and the bottom of the scheme. It is fuelled mainly by the interaction (in research projects and other regulatory affairs) between the clinicians and the scientific community, and by the dynamics of knowledge production in the health sector. Based on an evolutionary perspective (Metcalfe, James and Mina, 2005), Consoli and Mina (2009, p.309) propose that 'the incremental search for improvements, combined with the feedbacks generated by their application, give way to trajectories of problems and solutions', generating a problem sequence that dynamically contributes to the generation of a re-appreciation of knowledge and that ultimately defines technological trajectories (see Dosi, 1988). Regulation is represented as a sphere placed between the two building blocks; it has an influence on the rate and direction of health innovation (by setting priorities or defining allocation of funds).

Innovation in health services

Windrum and García-Goñi (2008) designed a model to study innovation in health services which appraises the complexity of healthcare by incorporating social and political considerations in a neo-Schumpeterian framework. Their model is based on previous work by Saviotti and Metcalfe (1984) and Gallouj and Weinstein (1997). At the centre of Figure 2, we find service characteristics which are determined by the interaction of three types of actors: service providers, policy

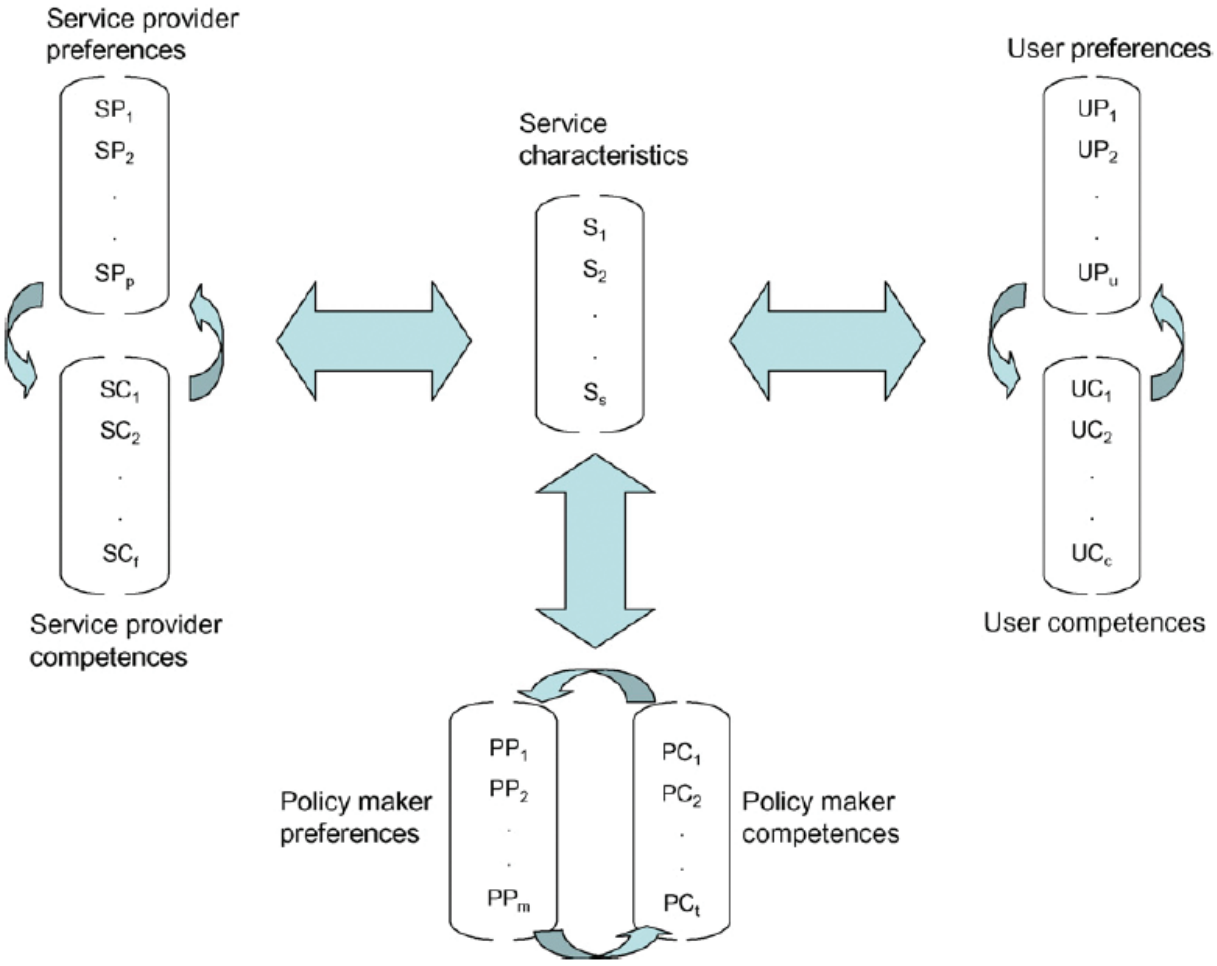

Figure 2. The health service innovation model
Source: Windrum and García-Goñi, 2008

makers and users. Each actor is involved systemically in an interactive process between their preferences and competences. Competences are defined as a combination of: (i) intangible and tangible assets, and (ii) human and organizational resources. Service providers are public or private sector institutions that perform healthcare activities. Policy makers contribute a set of resources that is provided by their roles and experience. Patients, on the other hand, have a network of social relations that, combined with their own capabilities, might guide their ability to perform specific tasks in the definition of health services. Preferences embody social and political aspects of the actors in the model. There is no clear definition of preferences in Windrum and García-Goñi's paper, but it can be inferred that they reflect the actors' willingness, interest and desire to adopt a particular health service, given their experience, knowledge and social background. Preferences are the source of possible conflicts and negotiations that may modify services characteristics and, over time, technological trajectories.

The interaction between actors' preferences and competences is what defines health service characteristics. Health services are a synthetic construct that represents a balance between the capabilities and interests of actors. Consequently, they are necessarily dynamic and are expected to evolve and adapt to actor changes. At the same time, actors change according to the new services they find, how they interact with them and the benefits they perceive from them. This co-evolutionary process qualitatively alters the system and defines the trajectories it will follow.

Health innovation for inclusive development

Inclusive health innovation models are rooted in the idea that, in modern societies, people's health conditions are factors that reflect economic and social development levels (Neelam *et al.*, 2013; Sáenz, 2015). Therefore, STI on healthcare has an enormous potential to produce a positive impact on development issues. We present two main streams for inclusive health innovation: one that starts from the advance of technology on a global level and another that considers the development of local capabilities.

Global health social technologies

The global health social technologies model proposes adapting STI generated in more technologically advanced regions into solutions (products and services) for less advanced countries (Chataway, Hanlin and Kaplinsky, 2014). Context consideration is necessary to observe local specificities (social, cultural, geographical conditions) and thus to achieve a successful insertion of products and services in ways of living. Innovation is described as a process in which physical technologies and social technologies co-evolve (Nelson and Sampat, 2001; Nelson, 2008).[2] According to Chataway *et al.* (2010), knowledge embedded in physical technologies is normally produced following Gibbons's Mode 2 (Gibbons *et al.*, 1994). In other words, social technologies are based on knowledge production that is oriented towards practical application and that comprises multidisciplinary approximation with a great diversity of multifaceted actors. Social technologies imply agencies involving actors that should be able to restructure the way they organize themselves to generate their own solutions.

Through social technologies, physical health technologies (generated on a global scale) can be used to solve problems in other countries. By focusing on their adaptation, many physical

[2] Physical technologies are the set of material resources necessary for the generation of a product or service. In drug development, physical technologies would be the active components present in medicine. Social technologies consist of forms of human organization necessary for the production process, labour division, assignment of responsibilities and even the way in which the products or services will be used.

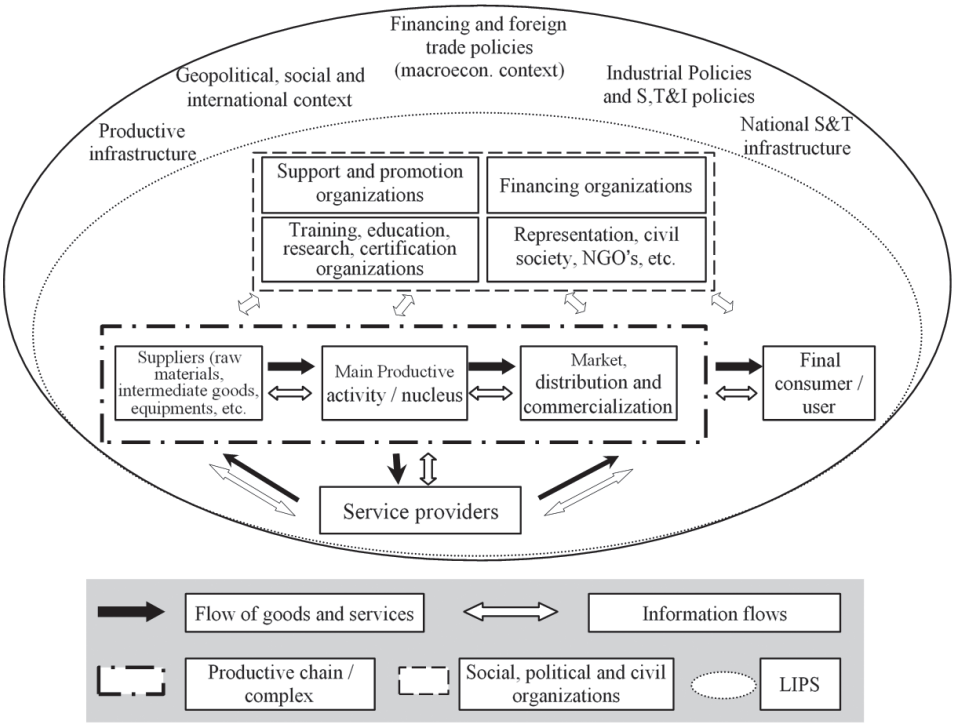

Figure 3. Analytical framework of local innovation and production systems
Source: Matos and Stallivieri, 2009

technologies (and the embedded knowledge they hold) can be transferred to less favoured contexts if the institutional framework allows. The strategy involves the formation of product development partnerships (PDPs) where the actors owning the technologies (national or foreign companies, public sector, academic sector) can interact with sectors affected by exclusion conditions and jointly develop solutions tailored to their needs (Chataway *et al.*, 2010). PDPs are the social technologies required for adoption, adaptation and intermediation among actors involved in the innovation processes. PDP capability to achieve knowledge circulation and information sharing is a key element in aligning STI objectives and achieving inclusive health solutions. In addition, PDPs can be configured as public-private alliances in which the productive sector and governments are able to generate new capabilities while solving health problems.

Local technologies in the health sector

In the local innovation and production systems (LIPS) in the health sector model (Soares Couto and Cassiolato, 2013), developing local capabilities is crucial when generating solutions to health problems in an inclusive manner. As shown in Figure 3, one fundamental characteristic of LIPS is the consideration of actors and their interactions around productive activities, since they are strongly interconnected and articulated with the institutional framework (Cassiolato and Lastres, 2000). LIPS frames their analysis within a geographical dimension, including diversity in terms of political, economic and social actors and activities. It considers tacit knowledge, interactions between innovation and learning processes, organizational forms within the system (governance), and it assesses production capabilities. At the core of the model lies interactions among the productive sector (suppliers, companies and distributors), consumers and end users, showing the importance of user-producer relationships (Lundvall, 1992). Other actors support the services and capabilities necessary for productive activities.

The LIPS model of inclusive health innovation links specific cultural and local contexts, considering their specificities and their effects on the involvement of actors in the process as well as the effectiveness and sustainability of the solutions provided. In addition, capability-building processes empower actors to produce new solutions for their own problems, which generates an inclusive health innovation process from a bottom-up process.

Comparison across health innovation studies models

Table 1 lists some characteristics of knowledge use in health innovation studies. It highlights four features of health innovation models. First, the models emphasize access to goods and services. For example, drugs and devices are at the core of the model of Consoli and Mina (2009); while services are selected by Windrum and García-Goñi (2008). This division is typical in the innovation literature, especially in sectoral innovation systems (Malerba, 2002). Consoli and Mina (2009, p.299) claim that their model is comprehensive for 'new drugs, devices and clinical practices introduced over time into the provision of healthcare'. However, in the text and in the scheme that represents their Health Innovation System, we observe that clinical services and practices are contingent on the introduction of new drugs and devices, placing new products in a hierarchical position over other innovation outcomes. Although access to products and services is not the only constraint in the processes of inclusive development (Arocena and Sutz, 2012; Cozzens and Sutz, 2012), it is perceived as a key element for the solution of urgent problems in the case of global health social technologies (Chataway *et al.*, 2010) and LIPS (Soares Couto and Cassiolato, 2013). We argue that stressing products and services as the main outcomes neglects a great many healthcare activities that do not find echoes in market structures, but that might be, nevertheless, knowledge intensive and invaluable in ensuring better living conditions. One of the most important examples is the contribution of knowledge to public policies and decision-making in health systems (Gordon-Strachan, Bailey and Ward, 2006; Ogilvie, Craig, Griffin, Macintyre, and Wareham, 2009; Grimshaw, Eccles, Lavis, Hill and Squires, 2012).

Second, health innovation studies take into consideration the actors' capability building process. In the four models analysed here, we observe that a problem-oriented perspective is the main driver of the capability increase and the direction of change in the system. Even in the case of global health social technologies, the adaptation process of foreign technologies that it proposes requires the generation of local capabilities (Mugwagwa *et al.*, 2013). Thus, a capability building approach is a relevant contribution to healthcare knowledge production, given that it opens the door to fostering a learning process in health innovation systems.

Third, the consideration of the health innovation process is limited in these models. In the selected models, understanding of innovation processes derived from other sectors have been used to develop an *ad hoc* model for the health sector. For this reason, it was not possible to include all the complexity that characterizes healthcare activities. Among these models, that of Consoli and Mina (2009) has perhaps the greatest specificity, but it still proposes an artificial separation between STI and the provision of healthcare activities. In terms of the institutional framework, health innovation models fall short when they do not include specific health institutions and regulatory affairs (such as clinical trials and safety tests) and allow for the informal rules of the game established between different actors, particularly between patients and medical practitioners, where hierarchical relationships exist. Windrum and García-Goñi (2008) state that medical practitioners could act as patient advocates, compensating for imbalances of information and capabilities between patients and health practitioners when patients select their health treatments. We suggest that this consideration is not valid for all cases since practitioners and patients may have different agendas.

Fourth, all the models consider at least four types of actors: public and private service and product providers, policy makers, the academic community and patients. The inclusion of patients

Table 1. Actors, interactions, process and institutional framework in selected health innovation models

	Nature of health innovation		**Health innovation for inclusive development**	
Model	Health innovation system oriented towards delivering new products	Innovation in health services	Global health social technologies	Local innovation and production systems in the health sector
Authors	Consoli and Mina (2009)	Windrum and García-Goñi (2008)	Chataway, Hanlin, Mugwagwa and Muraguri (2010)	Soares Couto and Cassiolato (2013)
Analytical dimension				
Actors	• Scientific community • Firms (pharmaceutical and device) • Policy makers • Health service providers (clinicians and practitioners) • Patients	• Service providers • Policy makers • Users	• Public sector. • Private sector (national and multinational). • Poor people (producers, innovators and consumers of innovation). • Non-governmental organizations (NGOs)	• Productive sector • Service providers • Consumers • Socio-political and civil organizations (financial, training, support, NGOs)
Interactions	• Based on knowledge • Fuelled by research and regulatory affairs	• Between actors: define service characteristics • Within actors: define their preferences and competences	• Actors interact to produce innovation • Interactions drive the innovation cycle • Based on knowledge	• User-Producer interactions are central
Process	• Co-evolution between existing knowledge and solutions to new problems • Dependent on technological trajectories • Market validation is needed	• Interactive model in which actor learning process co-evolves with delivering health services • Market validation is needed	• Physical technologies are developed anywhere • Social technologies are locally based and allow the introduction of physical technologies • Market and social validation are needed	• Interactive process where the productive system is linked to heterogeneous actors • Market and social validation are needed
Institutional framework	• Mediate the science and technology system and the health delivery system • Influence rate and direction of innovation	• Policy makers are accountable for regulation and approval	• More focus on formal institutions, but also recognize informal institutions • Influence development of social technologies	• Includes formal and informal institutions • Determine products and service acceptance

as recognized actors is particular to the health innovation process; they are configured as the demand side of the model. Because of this, patients are treated as equivalent to consumers, implying the existence of market-like mechanisms that drive knowledge supply. Treating patients as consumers does not take into account that (i) patients are limited in their choice possibilities, and that (ii) knowledge of healthcare activities is not selected according to a patient's preference, but through a negotiation process (given a set of resources) with the medical practitioner.

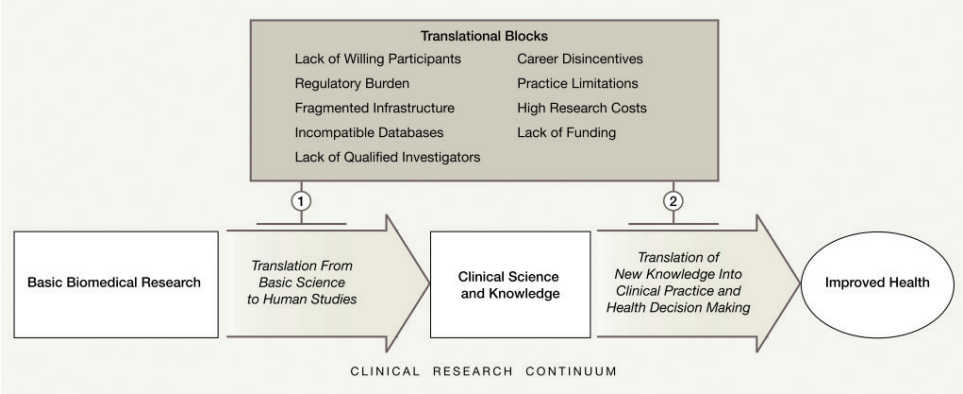

Figure 4. Translational blocks in the clinical research continuum
Source: Sung *et al.*, 2003

Translation models in health disciplines

In the innovation literature the term 'transfer' has been associated with interactions that allow knowledge flows among different actors in the system.[3] In the health field, 'translation' has been the term selected to express a similar concept: how the knowledge produced in different stages of the research process can be transformed into practical solutions in healthcare activities. The TR and KT models have a strong influence on health knowledge management. Both focus on knowledge flows and use. However, they differ in that TR is a linear model that seeks to achieve the bench-to-bedside goal as it translates basic knowledge into clinical application which is normally associated with pharmaceutical or medical devices. In contrast, KT has a wider definition of knowledge and considers multiple possibilities for its transfer and use, including public dissemination.

A translational block represents a set of obstacles that has to be overcome (Sung et al., 2003). The TR model emerged with the purpose of identifying these blocks in clinical sciences, proposing a simplified version composed of T1 and T2. T1 refers to the shift from basic and clinical research to ideas and products, known as bench-to-bedside. T2 is defined as the introduction of these products or ideas into clinical practice. Figure 4 shows the original TR model organized in terms of T1 and T2.

In practical terms, T1 is to be solved in preclinical stages through clinical trials when a new discovery occurs (for example, a new drug, a new diagnostic test or a new technique). T2, the second block, requires: (i) the evaluation of health technologies in major trials; (ii) research in health services; and (iii) a process of knowledge management to ensure its feasibility. Because of its simplicity, there are doubts about the TR scheme's ability to address the complexity of the health field (Greenhalgh and Wieringa, 2011). At the core of this criticism lies the proposed linearity of the process: the TR model implies that knowledge production is a unidirectional and linear process, placing health research in permanent dependency on basic science, and so favouring the development of pharmaceutical products. It seeks to benefit patients at an individual level and does not emphasize public health needs (Ogilvie *et al.*, 2009).

The knowledge translation model

KT is explicitly defined as a model which differs from TR. KT does not place the basic and biomedical sciences at the core of the translation process and proposes an alternative to linearity and

[3] The knowledge transfer tradition has offered a linear vision in which the Academy was responsible of producing knowledge that firms should incorporate into their productive processes. Nevertheless, the concept has evolved, opening the door for transfer activities among different actors and in multiple directions (Casas, 2005).

unidirectionality, characteristics that are found in the knowledge transfer models described above (Johnson, 2005; Landry *et al.*, 2006). KT models reflect the back and forth flow of knowledge at different research stages. These models focus on ensuring clinical application of scientific evidence and shortening the time spent developing and adopting scientific knowledge in health (Graham *et al.*, 2006; Morris, Wooding and Grant, 2011). Straus, Tetroe and Graham (2009, p.165) define knowledge translation as 'a dynamic and iterative process that includes the synthesis, dissemination, exchange and ethically sound application of knowledge to improve health, provide more effective health services and products, and strengthen the healthcare system'. KT models include as actors researchers and users of knowledge. Two representative models are described below, the global KT model, and knowledge to action process

The global KT model

Proposed by the Canadian Institutes of Health Research (CIHR), the global KT model establishes six actions for the research cycle (Sudsawad, 2007).

KT1: defining research questions and methods.
KT2: carrying out research (participatory).
KT3: publishing in plain language and accessible formats.
KT4: placing research findings in the context of other knowledge and sociocultural norms.
KT5: making decisions and acting informed by research findings.
KT6: influencing subsequent rounds of research based on the impacts of knowledge use.

These actions can facilitate translational processes by fostering interactions between users and/or research partners. The six steps are synthesized in Figure 5. KT models make social context explicit. This includes the interactions of researchers and knowledge users, which are mediated by cultural factors and institutional conditions. Knowledge users are recognized as actors with some degree of influence on translational processes; they are not just passive receivers of products and services. This model also takes into account that multiple actors participate in the production and use of health knowledge (Grimshaw *et al.*, 2012).

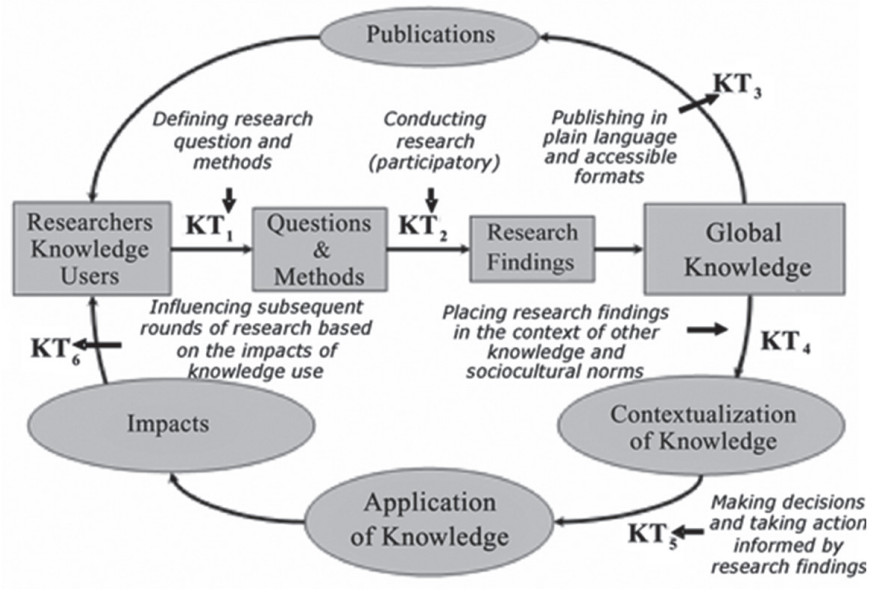

Figure 5. Global KT model
Source: Sudsawad, 2007

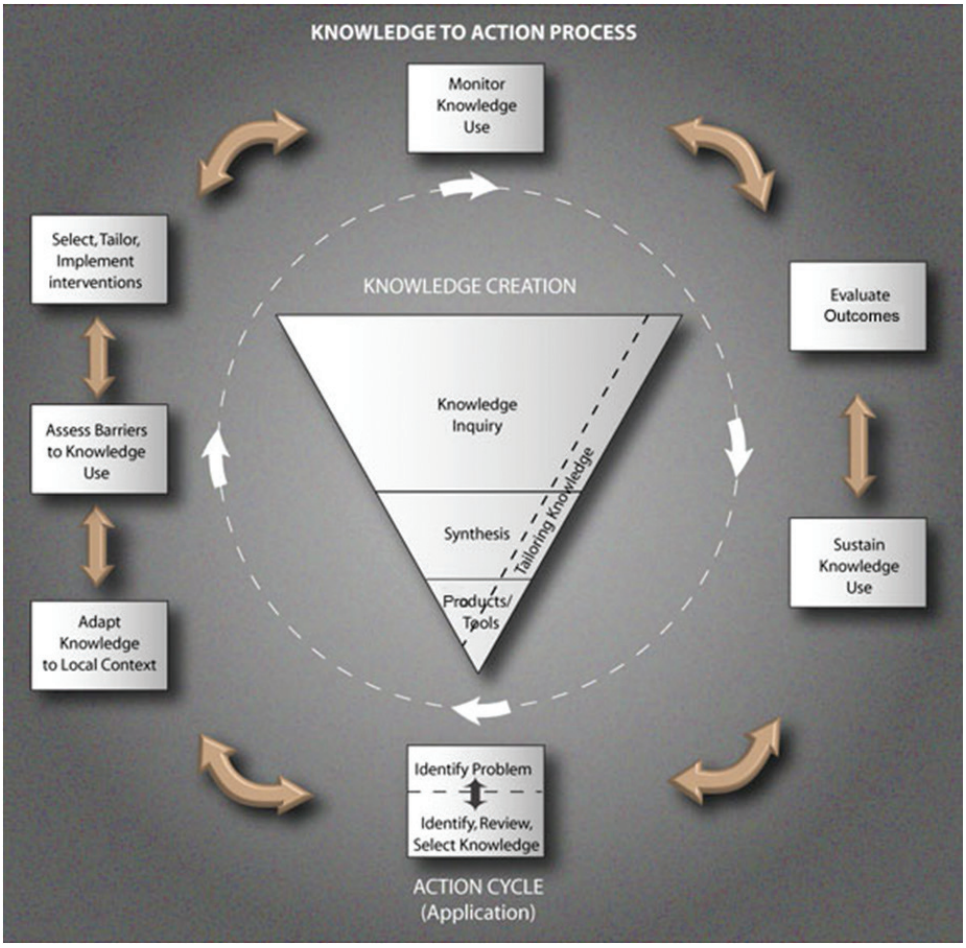

Figure 6. The knowledge to action process
Source: Canadian Institutes of Health Research (CIHR)

Knowledge to action process

The knowledge to action process (KTA) was proposed by Graham *et al.* (2006). KTA has had considerable institutional and academic impact. It is intended to encompass all possible outcomes of using clinical practice, technological knowledge and the dissemination of results in a single action model. KTA is fundamentally concerned with the process of knowledge implementation; it defines continuous cycles of action which can be implemented from knowledge syntheses derived from different knowledge generation processes (Figure 6). KTA's steps include: identifying problems, adapting knowledge to local contexts, assessing barriers and facilitators for the use of knowledge, selecting specific measures for implementation, monitoring and evaluating the use of knowledge and its results, and promoting continuous use of knowledge over time. The KTA model is the result of a synthesis based on the review of more than 30 theories of research use, action research and knowledge transfer. It emphasizes contextual understanding, identifying barriers and facilitators (Sudsawad, 2007).

In KTA, the knowledge-creation phase consists of three approximations to knowledge (questions, syntheses and tools). It is represented as an inverted funnel that reflects how knowledge is decanted into specific tools and/or products that allow their application (Sudsawad, 2007). Knowledge users' needs can be incorporated into any of the knowledge-creation phases, either by adapting research questions or by contributing to the identification of problems or issues relevant in the local context. Although the KTA model is conceptually rich and interesting, its implementation is not simple (Coutinho and Young, 2016), since KTA not feasible without strong institutional support.

Table 2. Actors, interactions, process and institutional framework in selected translation models in health disciplines

	Translational research	**Knowledge translation**	
Model	Translational blocks in the clinical research continuum	Global KT model	Knowledge to action process
Authors	Sung *et al.* (2003)	Sudsawad (2007)	Graham *et al.* (2006)
Analytical dimension			
Actors	• Not directly identified, but they imply: o Scientific community o Policy makers o Health service providers (clinicians and practitioners) o Patients	• Researchers • Knowledge users • Policy makers	• Knowledge users • Knowledge producers
Interactions	• Unidirectional. • Defined by linear scientific research sequence	• Feedback loops between different activities • Defined by the steps of the process	• Bidirectional between phases of the action cycle • Feedback loops in the knowledge creation process
Process	• Linear model from basic research to improved health • Research activities are linked to provide final solutions • Validated by patient use	• Knowledge flows are organized around scientific research (linking researchers and knowledge users to global knowledge) • Impact evaluation validates knowledge use	• Composed of two sub-processes – action cycle and knowledge creation. • Knowledge use evaluation is the validation mechanism
Institutional framework	• Regulate the introduction of research outcomes in medical practice • Static and defined, clearly applied in the process	• Regulate the introduction of research outcomes • Consider cultural and organizational factors	• Regulate the introduction of research outcomes • Consider cultural and organizational factors

Source: own elaboration

TR and KT have been developed outside the discussion of innovation in the economic sciences. For example, health field models do not regularly use the concept of innovation or consider it their main outcome. Health outcomes are conceived in multiple ways depending on the characteristics of the implementation (whether it is clinical, biomedical or a public health strategy), but how the productive sector is included in this process is not considered.

Comparison across translation models in health disciplines

Based on a revision of TR and KT models, we assess how knowledge use is interpreted in the health disciplines. We summarize this exercise in Table 2. This shows the substantial complexity that characterizes healthcare knowledge. There is a clear specification of health knowledge activities since health disciplines detail the scientific and technological steps (or phases) required to introduce new solutions. Highlighting the specificities of these activities and the actors that undertake them provides a comprehensive framework in which tailor-made policy strategies could be

implemented. Models from the health disciplines have been expressly designed for health issues and do not carry the normative commitment of generalist models like those proposed by IS. TR models have a list of activities that characterize T1 and T2. KT models include specific phases of the research process applied to health topics and their methods to validate knowledge creation, diffusion and usage.

However, it is also clear that health knowledge is fragmented across different disciplines that rarely interact (Gaudet, 2013). This is an issue when we look at the translational models and their scope. Three arguments are relevant here. First, the productive sector is not included in any of these models, which means that they oversimplify the transition from discovery in the lab (or any other phase) and the technological and production capabilities needed to convert them into useful and accessible outcomes. Second, TR models exhibit a high degree of linearity. In the innovation literature, we find sound evidence against linear innovation models as they do not recognize the feedback loops between different stages, and portray basic science as the only starting point (Godin, 2006). KT models partially overcome this linearity since they consider different starting points in the process, but they do not include all the activities and actors required to incorporate this new knowledge into the medical practice. Third, KT models include the public sector only in a limited way because they do not expressly consider its influence in the definition of the research agenda.

Approaches to knowledge use in health innovation studies and health disciplines

It is evident that health innovation studies and the health disciplines have a different focus. We argue that the construction of a dialogue between health innovation studies and the health disciplines is an important step in fostering knowledge application. Both approaches have strengths and shortcomings that condition the perception of the health benefits from STI activities. Based on the analysis of the two perspectives, we focus on their complementarities. Our analysis considers the dimensions specified earlier: actors, interactions, process and institutional frameworks. Table 3 summarizes our proposed framework.

Actors

Actors in healthcare activities are highly heterogeneous. Translational models focus on the description of the process, but they do not refer to interactions among actors. Hence, the actor description is not fully specified. In contrast, health innovation models are centred on the actor description, but they provide an economic interpretation of them and define them in terms of their participation in productive activities. They recognize two important actors: the public sector, in which policy makers play a central role, and the productive sector, which has the capabilities needed to transform health knowledge outcomes into products and services. Both approaches converge in considering two important actors: (i) the scientific community as a key player (including universities, research centres and institutions, health research institutes, and research hospitals); and (ii) health service providers (namely, care hospitals, medical care centres and laboratories).

The remaining relevant actors are patients, defined as final beneficiaries of knowledge applications. This focus on patients as final receptors keeps the system depicted in these models oriented towards improving people's health. In health innovation studies, patients are perceived solely as representing the demand side and are sometimes compared with consumers. The health disciplines, in turn, consider the patients' health conditions at an individual level, neglecting the possibilities of applying collective solutions. These solutions may target the whole population and may end up being at least as efficient as solutions for each person.

We argue that the patient focuses in both approaches makes invisible other possibilities of knowledge applications (such as policy design or reformulation, changes in medical curricula, or restructuring of health services) (Etzkowitz and Rickne, 2014). To address this issue, we propose

the definition of two dynamic actors: knowledge users and knowledge beneficiaries. These actors are not *a priori* defined sets; their specification depends on type of problem. Knowledge users are those actors who apply and play with health knowledge. They might be policy makers interacting with the scientific community to adjust a specific regulation, researcher making use of new techniques to determine glucose levels, or patients learning how to self-administer new treatments. Knowledge beneficiaries are actors who increase their welfare status thanks to health knowledge applications. They might be the population that benefits from a policy measure, the scientific community that will have faster access to publications on glucose thanks to a new test, or the patient who is self-administering the new treatment. Knowledge users and knowledge beneficiaries are not mutually exclusive.

Interactions

Actors' interactions are also heterogeneous. They cannot be observed in translational models since these interactions are not part of the model. Health innovation models point out how actors might be connected and the nature of their linkages. The problem with health innovation studies is that this approach does not recognize the hierarchical structure of the relationships created in healthcare activities. These hierarchies come from actors' capabilities and institutional asymmetries.

Unlike other many other activities, healthcare regulations are in place to prevent the application of new knowledge until it is proven safe for humans. Regulations imply that knowledge validation processes play a decisive role in the determination of knowledge applications. This process is managed in the first instance by the health scientific community, which considers whether a new application should be in place. In a second (and related) step, policy makers approve the implementation of the knowledge application. Regulations create hierarchies in which the scientific community and the policy makers are the gatekeepers of the process.

Different levels of capabilities among actors are another source of hierarchies. The scientific community and health services providers are normally identified as the most knowledgeable actors in healthcare activities; they are the ones entitled to evaluate new drugs, prescribe them, conduct surgeries and determine new treatments. As they are the ones validating knowledge use and its expected benefits, they have a power position over knowledge users and knowledge beneficiaries.

Hierarchies may foster or hamper knowledge flows. To deal with these hierarchical situations, we propose that asymmetrical interactions be used to evaluate actors' positions in the process. This recommendation indicates the necessity of understanding actors' agendas and establishing negotiation processes to decide how to manage the knowledge application process in healthcare activities.

The process

Health innovation studies fail to consider fully healthcare activity characteristics. They normally create adaptations from activities in other economic sectors and then try to accommodate healthcare actors and their interactions within these analytical frameworks. They outline a process that does not contemplate all the learning processes needed to achieve knowledge validation and to move to closer stages of knowledge application in healthcare. What they do recognize is the requirement for production capabilities to transform new knowledge into products and services, providing new tangible solutions or facilitating access to existing ones. This suggests that they have a focus on the utilization of market mechanisms in the validation process of knowledge applications.

Health discipline models do not consider how the productive sector takes part in the knowledge translation process. This is very much linked to the perception of the innovation process as a linear process which assumes that production activities are just an automatic step in the transformation of knowledge into solutions. This is one of the reasons why we argue that TR models are not of much benefit for health knowledge use. The other reason for not favouring TR models is their focus on basic science activities, which are more uncertain, have longer time frames and are less

oriented to any specific application problem. In contrast, KT models are designed to describe healthcare activities in a less linear fashion, offering a much more specific and adequate alternative. They also include a different set of alternatives to validate knowledge application since they consider patient wellbeing their main outcome.

Our approach is oriented to identifying complementarities between these approaches. We suggest that a more suitable path for knowledge application might comprise the following characteristics: (i) a specific and properly-designed description of healthcare activities and knowledge flows in which the actors' learning processes are considered; (ii) inclusion of production capabilities, making clear the problems related to scale factors (from laboratory, to prototypes, to making products and services available) and other constrains associated with the productive sector; (iii) feedback loops that tackle the problems of linearity and deterministic models, highlighting that basic science should not be the only or main source for knowledge applications and that knowledge sources are distributed throughout the components of the model; and (iv) the consideration of non-market mechanisms in the health knowledge validation process.

The institutional framework

Both approaches consider the institutional framework in a rather static way. Within formal institutions, regulation is considered as part of the context or as only affecting a part of the system; however, generally, formal institutions do play a fundamental role in the determination of knowledge application. We have discussed how health regulations can affect the way the interaction between actors takes place – and we could add the effect that other formal institutions (intellectual property rights, economic regulation, liabilities etc.) have on the development of production activities.

Informal institutions are also of the utmost importance. On the one hand, health decisions are rooted in people's cultural and social backgrounds (Soares Couto and Cassiolato, 2013; Natera *et al.*, 2017). The perception and opportunity for obtaining benefits are mediated by beliefs and lifestyles (Sáenz, 2015). Even if knowledge application occurs with respect to something other than a medical treatment, as in policy making, prospects of success will also be dependent on the adoption and adequate execution by the other system actors. On the other hand, the development of local capabilities calls for the consideration of socio-institutional conditions in which learning processes occur. Table 3 synthetizes this discussion of the complementarities between knowledge use in health innovation studies and the health disciplines.

Conclusions

We have discussed how health innovation studies and the health disciplines understand knowledge application. The objective has been to establish a dialogue between these two approaches and to highlight their complementarities using a systemic framework. We presented four models that explain how health activities are studied from health innovation systems: one oriented to product innovation (Consoli and Mina, 2009), one oriented to service innovation (Windrum and García-Goñi, 2008), and two focused on inclusive development (Chataway *et al.*, 2010; Soares Couto and Cassiolato, 2013). These models tend to fall short of including health specificities and are biased towards ensuring access to health products and services, making invisible the possibility of using health in non-market related mechanisms. A focus on describing actors and their interactions and the inclusion of the productive sector are the main contributions that health innovation studies can offer.

The health disciplines understand knowledge application through translational models. TR is a linear model that goes from basic science to knowledge application in patients (Sung *et al.*, 2003). KT models are non-linear and foster knowledge circulation through various health activities (Graham *et al.*, 2006). Translational models do not specify actors' interactions. Nor do they consider the productive sector and its role in the generation of products and services. They are centred on patient

Table 3. Complementarities between knowledge use in health innovation studies and health disciplines

	Health innovation studies approach	**Health discipline approach**	**Complementarities between the two approaches**
Analytical dimension			
Actors	• Focuses on actors • Recognizes the public sector, the productive sector, the scientific community, and health services providers • Equal patients to consumers	• Less focus on actors • Recognizes scientific community and health services providers • Characterization of health service providers is very detailed • Actions oriented to individual patients	• Recognition of public sector, productive sector, scientific community, health services providers • Definition of two dynamic actors: knowledge users and knowledge beneficiaries
Interactions	• Focus on describing interaction among all different actors • Do not consider the hierarchical dimensions of the interactions	• Place hierarchical interactions from the scientific community and policy makers to the rest of the system • Do not explicitly consider hierarchies between patients and medical practitioners	• Consideration of asymmetrical interactions
Process	• Generic innovation process adapted to healthcare activities; • lack of specificity • Consideration of the productive sector as the provider of health products and services • Market mechanisms validate knowledge use	• Greater level of specificity: *ad hoc* models to describe healthcare activities • Linear model of innovation: focus on basic sciences • Knowledge validated according to its use in patients' benefits	• Generation of specific models for healthcare activities • Consideration of the productive sector • Inclusion of feedback loops to avoid linearity: knowledge sources distributed in the model • Generation of different validation mechanisms for knowledge use (including, but not limited to market dynamics)
Institutional framework	Regulation part of the context or affects part of the system Socio-cultural background considered in the capability building process	Regulation part of the context Informal institutions are neglected	Consideration of formal institutions (regulations also affect productive activities). Consideration of informal institutions (socio-cultural background)

treatment at the individual level, neglecting the possibilities of collective solutions. Nevertheless, we argue that they add a good deal to the discussion about healthcare activities and non-market knowledge applications (phases, steps, regulatory affairs, and characterization of health service providers).

The paper proposes four analytical dimensions which can contribute to a dialogue for understanding health knowledge applications: actors, interactions, processes and institutional framework. In relation to actors, we propose the recognition of the public sector, the productive sector, the scientific community, and health services providers. We also propose the definition of two dynamic actors: knowledge users and knowledge beneficiaries. These two dynamic actors account for the different applications that knowledge might have. In terms of interactions, we recommend considering them as asymmetrical based on institutional and capability asymmetries.

We argue that an understanding of the process should be based on specific models of healthcare activities and learning processes, using market and non-market validation mechanisms. Finally, we propose the consideration of formal institutions (regulations also affect productive activities) and informal institutions (socio-cultural background) in the institutional framework.

These four analytical dimensions are not intended to provide *the* unified framework for health knowledge use. We offer them as a phase that precedes the definition of the analytical framework; they are intended as conceptual input. Healthcare issues are highly complex; they need problem and context specific analytical frameworks in which actors, interactions, processes and institutional frameworks can be configured in a tailor-made manner. We acknowledge the huge differences in health issues between developing and more advanced countries. However – and unfortunately – health inequalities are not limited to less developed regions and the problems we identify in existing models are present in countries at all income levels (Marmot, 2005). The consideration of the four analytical dimensions at different development levels could shed light on the characteristics of health knowledge application and serve as a starting point for policy learning among countries and regions.

From our conceptual exercise in this paper, new questions arise: (i) What are the mechanisms to identify the dynamic actors and do they exchange roles during the learning processes? (ii) Are there other relevant sources of hierarchies involved in actors' interactions? If so, how do they relate to institutional and capabilities asymmetries? (iii) How do market and non-market validation mechanisms relate to each other and what do they imply in terms of learning processes? And finally (iv), how do we balance formal and informal institutions in a comprehensive institutional framework?

As we surely fall short in outlining all the possible questions arising from this analysis, we send an open call to debate the issues raised in this paper. Our intention is to propose the four dimensions – actors, interactions, process and institutional framework – as a first step towards establishing a dialogue to foster health knowledge application. We recognize that our theoretical contribution is only one component of such a task. This dialogue requires multidisciplinary collaboration in which contributors from health innovation studies and the health disciplines can discuss their proposals and concerns. The possibilities for better use of health knowledge demand this discussion and future agreement.

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