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Towards Healthcare Innovation in Online Patient- and Researcher Communities: Social Organization and Knowledge Organization

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Abstract

This paper adds to the research on open healthcare innovation by examining two online healthcare communities: One for professional researchers and one for cancer patients. 500 threads were analyzed and serve as data basis for the study. Building on findings about the successful contribution of online communities to healthcare innovations and on theories from network- and community-literature, the article investigates which factors determine open community conversations to deliver solutions and new ideas. The study also elaborates on the differences between professional- and non-professional communities. Congruent to findings from the literature, the applied regression model confirms that cross-community knowledge pipelines and the sharing of objectificated information in reciprocal approaches positively influence discussion-outcomes in a professional research community. Other results of this study suggest challenging some prior assumptions: Embeddedness in physical space, measured by locational references, has no significant influence and a high density of users within a discussion even reveals a negative effect on the development of solutions in both the researcher- and the patient-community. Particularly latter finding indicates that a central organizer is more important than the quantity of different contributions. Eventually, patterns of social coherence are partly positively associated with the successful development of solutions in the patient-community. The paper concludes that social organization seems to be important among patients whereas researchers distinctly rely on knowledge organization.

Jelcodes:O31,I18

1 INTRODUCTION

Today, innovation processes are rarely within the complete power of one single firm but often based on corporate, academic, start-up, and venture partnerships or the integration of and co-creation with users and consumers in innovation systems (Hagedoorn, 2001; Potts et al., 2008; von Hippel, 1976). Lead users are intentionally identified and their knowledge exploited for R&D processes, for instance in medical devices or sports equipment (Lettl, 2005; Hienerth, 2006). The wisdom of large consumer groups (Chariot, Chessel & Hilton, 2006) and specialized expert groups through crowdsourcing platforms (Norman et al., 2011; Lakhani, 2008) are valuable idea sources and provide evaluation opportunities (Hienerth & Riar, 2013). Firms generate innovations in ecosystems, sophisticated hybrids of multiple open- and user-innovation models, for example LEGO´s interplay between the firm´s R&D, lead users, LEGO communities, and leading technology experts (Hienerth, Lettl & Keinz, 2013). To sum up, innovation often occurs at boundaries between disciplines (Leonard-Barton, 1995), at the boundaries between firms (e.g. Lakhani & Tushmann, 2012), and innovation shifts from firm-based to community-based models (Lee & Cole, 2003). Such community-based open and user innovation approaches frequently refer to co-development in virtual environments, as new communication technologies enable firms, consumers, and users to share information at low costs in online communities (e.g. Antorini, Muniz & Askildsen, 2012; Dahlander & Frederiksen, 2007; Füller, Jawecki, Mühlbacher, 2006; Sharat & Usoro, 2003). Almost any company is in one or another way engaged in online conversations and making significant investments to such interaction with the purpose to profit from it (West & O´Mahony, 2008). This is prevalent in the computer industries, such as *Dell´s Idea Storm* community (Bayus, 2012), sports equipment, e.g. the *Niketalk* forum (Füller, Jawecki & Mühlbacher, 2006), and even traditional sectors such as fashion (Di Maria & Finotto, 2008). Unsurprisingly communities which are not sponsored or hosted by firms but which have a univocal interest in a producer or product can likewise be valued knowledge sources for innovation, such as the *Nikonians* photo-community or the *Ikea Hackers*, passionate about self-modifying Ikea products (see Grabher & Ibert, 2013). The most frequently involved members of such communities are considered to be experts of the brand and products (Amine & Sitz, 2004: 13) and often demonstrate to be "*in advance of the market*"-lead users (von Hippel, 1987: 108). Füller, Jawecki & Mühlbacher (2006) identify innovative activities in basketball communities where creative members develop entirely new technologies and basketball shoes (Füller, Jawecki & Mühlbacher, 2006: 64). Also, completely firm- and product-independent users modify and innovate based around topics of interest (e.g. a sport) or epistemic objects (e.g. a piece of furniture). For example, self-organized users developed the rodeo kayak already in the 1970s (Hienerth, 2006). Today, commercially attractive developments driven by such independent communities and commenced through or supported by online interaction are still prevalent in the sports industry (windsurfing, skateboarding, snowboarding, canyoning, handicapped cycling) where many innovations are ideated and evaluated through the community-crowd (Hienerth & Riar, 2013; Shah & Mody, 2009; Franke & Shah, 2003) and in software´s independent open source communities. Linux (Raymond, 1999) still serves as the most pertinent example and framework for the *how to* of collaborative innovation, reflecting a shift from firm-based to community-based models of knowledge construction (Lee & Cole, 2003), which are today powerfully supported by increasingly larger networks such as *Facebook*, *MySpace* or *Twitter* (Brandtzæg et al., 2010: 50).

The focus of this study: User- and community-innovation in healthcare

The general importance of active public involvement through on- and offline healthcare communities has been underpinned in earlier studies (Boote, Baird and Beecroft, 2010; Paterson, 2004; Stevens, Wilde, Hunt, & Ahmedzai, 2003). However, the value of patient movements, for instance, was mainly considered to influence the political and regulatory landscape (Epstein, 1997; 1995), to enable funding opportunities (Godmann, 2013), or to

improve the understanding of patient-views (Bullinger et al., 2012: 166). Actual innovations driven by patients or users were mostly found in the medical equipment industry (Shaw, 1995; Biemans, 1991; Luethje, 2003; Lettl, 2007) where "*the identification of such creative users can increase the creative capacity of an organization as radically new ideas and solutions can be gained.*" (Lettl, 2007: 69) In this field, lead users or early adopters and doctors often provide a relevant basis of knowledge (Lettl, 2005; von Hippel, 1976), for example implemented at *Coloplast* (Hienerth, Lettl & Keinz, 2013).

Recent studies have deliberately focused on the potential value creation of healthcare online communities (Bullinger et al., 2012; Kuenne et al., 2011) not restricted to the medical equipment sector. Bullinger and colleagues (2012) demonstrate how patients have collaboratively invented and commercialized a rare disease passport with emergency service on the website *gemeinsamselten*. Knowledge-contributing online healthcare communities do provide input to incremental (product modifications) and to radical innovations (product inventions) (see Kuenne et al., 2011). Such patient-focused healthcare communities are characteristically *hybrid virtual communities* (Grabher & Ibert, 2013) compiled of a mix of patients, experts, and other stakeholders (Kuenne et al., 2011: 6). They can also add to more patient-focused drug development, improving the identification of areas of unmet needs in collaborative review processes with patients (Mullin, 2012: 4). Gathering in online communities is not only popular among patients but has also become vital is the early phase of drug discovery (Munos, 2006). Researchers meet and collaborate in open biomedical forums, often compared to the open source software world (Hope, 2007) as analogies of bioinformatics and software development are assumed to provide respective capabilities for collaborative R&D (e.g. Rai, 2005). The number of such active groups (online and offline) of open source collaboration, mainly in the field of neglected diseases (see Munos, 2006), and now also in pre-competetive space (Perakslis, Van Dam & Szalma, 2010) is considerable and their potential impact and ambition for value creation have been underlined (Maurer, 2008; Munos, 2006). However, specific studies on the success factors of community-collaboration in online communities of professional researchers have so far rather been neglected.

Both described types of healthcare online collaboration have the potential to fill gaps along the pharmaceutical value chain, such as the research gap in neglected diseases (Pécoul, 2004), and the gap between patient-needs, the society and big healthcare innovators (Kuenne et al., 2011; Smits & Boon, 2008). Even the FDA (U.S. Food and Drug Administration) states that Patients "*are in a unique position to contribute to drug development*" (Mullin, 2012: 3). Based on recent findings about interaction patterns of knowledge sharing and knowledge creation in geographically disembedded communities (e.g. Amin & Roberts, 2008) and about the characteristics of open online communities (e.g. Hathornthwaite, 2002; Hemetsberger, 2002; Preece, 2000) this paper proposes the following research question for healthcare online communities in collaborative early stage research and active patient engagement: **Which parameters determine the successful collaborative work among researchers and among patients, resulting in the development of solutions?**

2 THE SELECTED CASES

The two communities in focus of the present study are set up by independent individuals. Patient-self-help groups (Ferguson, 2007), such as emerging cancer communities (Klemm et al., 2003) can be considered as prominent examples for this community-type. As already stated in the introduction of this article, independent communities usually neither focus on a particular company or products but are built around a unique field of interest or enthusiasm (e.g. palliating a disease) or around an epistemic object (Knorr Cetina, 2001) (e.g. a molecule). Grabher & Ibert (2013) find that such independent communities contribute more sophisticated and hence potentially more relevant knowledge to innovation (Grabher & Ibert, 2013: 10) as compared to firm-related types of communities. While the latter ones do

contribute mainly knowledge about experience with products or optimizing the design and applicability, independent communities prove to share more procedural knowledge such as about the process and mechanism of modifying and further developing an idea, thereby demonstrating "*the ability […] to self-organize the division of labour in a complex constellation of collaboration among physically dispersed settings (including the protocols of knowledge circulation)*." (Grabher & Ibert, 2013: 10)

This article distinguishes the settings of a professional and a lay-person community in order to scrutinize differences among both.

Professional community: The Synaptic Leap (www.thesynapticleap.org)

The Synaptic Leap is a professional community within which only a minority of members would be characterized as *hobbyists*. The rate of lay-persons or non-professionals is considerably low in this community; the majority of members are specialized experts and some professionals from not directly research-related fields. Their focus is on neglected diseases and the community is based on the open research group *Tropical Disease Initiative*, driven by scientists (chemists, biochemists) from the University of Sydney and the University of California San Francisco / Berkeley. Its main website has about over 400 members and was accessed at peak times by some 2,000 unique monthly visitors (Information from the founder of the community). The site has four dedicated sub-communities for the diseases of Malaria, Schistosomiasis, for Taxoplasma research, and Tuberculosis. The members upload freely available batches and formulas through a kernel on an additional website and the findings are further discussed and developed in collaborative effort on the major community-website. The community thus works almost completely virtual.

Patient (lay-person) community: DCA (www.thedcasite.com)

The DCA site is a cancer information website built around the chemical compound dichloroacetic acid, which has shown slow down effects of tumor growth in animal and some in vitro studies but "*available evidence does not support the use of DCA for cancer treatment at this time.*" (American Cancer Society, 2012) Therefore the drug is currently used off-label for cancer treatment in a few selected clinics and countries (e.g. Canada, Mexico). Undeniably patients have an intrinsic motivation to further test and research on a therapy applying DCA. The site has approximately 2,500 active members (http://www.thedcasite.-com/cgi/-dcboard.cgi) and offers a variety of information and services. All features are designed to enhance the therapy development or to influence stakeholders and decision making. Latest papers, information on recent studies, patient-cases, efficacy and side effects information can be found and members meet in a chat room (community board). In this chat room, the group of patients openly shares disease- and medical information in order to enhance cancer therapy development. The community mainly consists of non-professionals (that is with regard to the topic of *cancer research and cancer therapy development*): Cancer patients, their relatives or close friends, plus some chemists interested in the chemical substance DCA, a few cancer researchers, presumably some contributors not directly affected (that is personally or professionally), and readers (lurkers). There are some medical doctors involved who do, however, not frequently contribute according to their rules of action and standards of care.

Solutions developed in the selected communities

The TSL community defines "completed projects" as their most sophisticated solutions. While the outcomes are neither Malaria vaccines nor any other commercialized *end-products*, their outcomes are significant steps on the development path. The community has concluded the comparative modeling of proteins in the Malaria genome, the functional characterization of protein sequences that "*is central to problems in biology*" (http://www.thesynapticleap.-org/malaria/projects/SP). The results have been published and are freely available for non-commercial purposes (Eswar et al., 2008; Eswar et al., 2006). The DCA site has provided the DCA-caffein survey in order to answer the question whether caffeine helps DCA to work

better, based on an initial patient-finding experiencing better efficacy as a heavy tea-drinker. The survey data is subsequently being published on the website, showing the latest findings on interaction of caffeine and DCA. In the discussion forums, collaborative solutions are telemedicine-like assisting a particular suffering patient with very comprehensive information and knowledge, often built on experiential basis and in-depth familiarization with cancer treatment science.

3 THEORY AND HYPOTHESES

An online community is defined as a "*[…] group of people who interact in a virtual environment. They have purpose, are supported by technology, and are guided by norms and policies.*" (Preece, Maloney-Krichmar & Abras, 2003: 1) Communities´ characteristics vary depending on whether they operate also in physical environment, on their particular purpose, the software environment (e.g. listserver, bulletin boards, chats, instant messaging), size, duration of existence or stage in life cycle, culture of members, and the governance structure (norms and rules). In general, users participating in online communities are likely to be people with shared passions, beliefs, hobbies, or lifestyles (Horrigan & Rainie, 2001) of which 90% are usually lurkers, 9% do contribute from time to time, while about 1% of users account for virtually all generated conversations (Nielsen, 2006). The distinctive characteristic of an online community is determined by social interactions and dynamics of its members and by the software and technological design. Both communities researched in this paper apply asynchronous bulletin boards, leaving time for replies. In such forums, a newly opened discussion is entitled a thread: A "*chain of questions and answers (or comments) on a particular topic posted by members of a special interest group or visitors to a website.*" (Business Dictionary, 2013) In the present analysis, the interactions and dynamics within a thread are analyzed over a large sample of threads to conclude on interrelation between interactions, dynamics, and thread results.

Networks and boundary spanning

Based on the described community-patterns, the factors that influence community development and their success (physical embeddedness, social structure, culture, governance principles and so forth) have often been studied by network approaches referring to the wide body of literature existing about communities of practice and their personal, formal, and informal ties (Brown & Duguid, 1991; 2002). Respective studies about any decentralized organization likewise referred to network approaches (Gallie, 2009; Grabher, 2002; 2004; Sydow & Staber, 2002). Therefore it is not unexpected that online community research applied principally network concepts to investigate structures, relationships, culture, institutionalization, and governance in communities.

The following findings seem particularly relevant to studying knowledge creation in the form of developing solutions in online environments.

Physical space

The real-world relation, the embeddedness in physical space, of online community members is emphasized in various studies and the interplay between the two different spaces, *on*-line and *off*-line, is often perceived as a crucial parameter for successful collaboration (e.g. Matzat, 2006; Schloen, 2004). Only a few studies have elaborated that physical embeddedness is rather negligible (Haythornthwaite, 2002; Levin & Cervantes, 2002). In fact, also business organizations increasingly operate in two environments, a physical and virtual one (Kimble, Li & Barlow, 2000; Crowston et al. 2005). It is widely assumed that barriers of trust and identity are sometimes difficult to overcome in virtual communication, so that the introduction of virtual communities of practice seems to be a practical solution (Kimble, Li & Barlow, 2000) to combine effective online and offline meetings. This notion accentuates the role of social bonding as a necessary pre-condition for effective co-work. The concept of *death of distance* (Ohmae, 1991) which emerged with the increasing shift to

virtual communication methods is therefore rather challenged in present studies (see Kimble, Li & Barlow, 2000; Matzat, 2004; Schloen, 2004). Crowston et al. (2005) find that face-to-face interactions are a fundamental aspect of successful virtual work, but however can be limited to the time when a community has already started their work. The meetings are presumed to create acceptance among members and build and maintain social ties (Crowston et al., 2005). Events such as conferences are hence introduced to enable core users developing a liking for each other as well as further proceed with the project, while rather passive users join these events in order to learn more about the content of the project (Crowston et al., 2005; Bowes, 2002). In open source biotechnology, face-to-face meetings are seemingly beneficial, often rather at the beginning of virtual co-work in order to get to know each other (Tamoschus, 2014). The findings are generally underpinned by other works supporting the perception that corporeal meetings enhance the social coherence and afford an effective exchange of knowledge among community members (Matzat, 2006; Schloen, 2004). Matzat (2006) points out that better results of collaborative work in online communities would be achieved under conditions of embeddedness, confirmed by the studies of Schloen (2004) stating that a higher degree of embeddedness decreases the likelihood of free-riding, trust issues, and fluctuation problems, and eventually leads to a higher group stability. In another stream of research the interplay between physical and virtual space is examined by the idea that while online communication enables expanding ties to faraway people, a stronger bonding of virtual users takes simultaneously place within their real-world home place (Horrigan & Rainie, 2001), referring to the notion of *glocalization* (Wellmann, 2001). Besides the widely studied form of *physical* embeddedness, relational embeddedness also plays a role in successful online interaction. Cultural differences in globally dispersed communities, emerging from the cultural variances of different home locations, would equally incorporate difficulties for collaboration (Vishwanath, 2004), so that similar cultural or social contexts could be beneficial.

The following hypothesis on virtual collaboration and physical space is proposed:

> ***Hypotheses 1: References to physical space have a positive influence on successful collaboration and increase the likelihood of developing solutions***

Cross-community interaction

Online communities usually represent a social network, though one which is not necessarily related to one focal community but which can over span various *on*-line and *off*-line networks (Baym, 2007). Swedish independent music fans for example interact on a number of online platforms while also meeting at music festivals (Baym, 2007). They gather in imagined communities as their barriers are not defined by a distinguishable border but rather exist in imagination and their mutual interest or passion (Baym, 2007). This finding introduces a boundary spanning mechanism across communities which is also crucial for the willingness to contribute to online communities (Dahlander & Frederiksen, 2007). When a community is solid in boundary spanning and offers valuable options to further connect oneself beyond one focal network, allowing to create numerous ties across the communities´ (virtual) borders, the likelihood that members seek and provide information increases (Dahlander & Frederiksen, 2007). However, cross-community boundary spanning does not necessarily relate to further virtual communities but can also refer to prior technologies such as telephone conferences or mailing lists, for instance when effective knowledge generation and collaboration fail in web-based interaction (Hoadley & Pea, 2002: 331).

> ***Hypotheses 2: Cross-community interaction increases the likelihood of developing solutions***

Density and centrality

An extensive stream of research focuses on network structures. The density and centrality among users, such as whether contributions are primarily provided by various users or

whether few central leaders dominate communication activities, might impact the innovativeness of communities in general. This article therefore suggests transferring the concept of network density and centrality to the networks within community-threads. For example, in offline networks of new media and biotechnology a high density of ties is associated with a higher degree of innovativeness (Gilsing & Noteboom, 2005). As exploration needs redundancy, the costs of maintaining redundancy of ties matters less in comparison to other costs, hence explorative networks rely on a lower level of centrality (Gilsing & Noteboom, 2005). The assumption that exploration is associated with density is further enhanced by Kenis and Knoke (2002: 279) who conclude that "*low density implies that messages are likely to propagate slowly […], a high-density communication net rapidly floods the system with information.*" In contrast, exploitative networks show a higher degree of centrality, respectively a lower degree of density. Another relevant conclusion for the present study is that professional communities are more likely to form centralized structures, e.g. by assigning procedural authorities (Gilsing & Noteboom, 2005). Moreover, instable communities might reveal unexpected ideas or surprising associations more often and are thus more likely to elaborate cumulative innovation. Instability and hence a higher degree of unexpected ideas, would yet again rather be associated with a higher degree of density (many contributors with weak ties rather than few contributors with strong ties).

> ***Hypotheses 3: A high density of users in community discussions, that is many posts contributed by different users, increases the likelihood of developing solutions***

Information sharing

When it comes to information sharing, two aspects seem to be important: First, why do members share information and what leads to higher response rates? Second, in which format is information shared?

The "why" of information sharing has partly been explained by the boundary spanning mechanisms which apparently attract community members to provide information (Dahlander & Frederiksen, 2007). However, there is one further aspect by which willingness to share information is described: Theory of reciprocity (see Mauss, 1990; Korf, 2007; Kobayashi, Ikeda & Miyata, 2006) as a culture of responding to something positive with further positive action (Falk & Fischbacher, 2006). According to Kollock (1999) reciprocity emerges in online communities in a system of exchange in which information benefits are not necessarily balanced by the recipient but by other members. Reputation benefits and a sense of efficacy motivate members to contribute to online communities. In the sense of equity theory people will balance a knowledge gain by appropriate rewards in return (Walster et al., 1978). In this article it is argued that the mechanism of reciprocity is reflected in online communities through culture of *open questions* and *open requests for support*. This interpretation is corroborated by the finding that personal messages shared in online healthcare communities to vast extend refer to the posing of *questions* (Bullinger et al., 2012: 171). The successful innovation outcomes found in particular online healthcare communities could thus be associated with the process of openly posing questions, especially as other frequent messages, such as about support or about experiences, are likely the corresponding replies to openly posted questions (Bullinger et al., 2012). This indicates a functioning reciprocity mechanism which allows concluding that with an increasing number of open questions or support-requests, the viability of community-conversations would increase.

Besides the mechanism behind information sharing, it seems crucial to elaborate on the format of shared information in online communities. In fact, different types of information are shared in online communities. For example, communities aiming at more professionally debating or expanding their knowledge-base would rely more on practical knowledge and the sharing of institutional practices rather than just sharing personal opinions, personal suggestions, or "book knowledge" (Hew & Hara, 2007). Deeper knowledge than merely that of personal opinions or news is supposed to be of higher relevance for the creation of innovations. In-depth practical or institutional information normally reflects highly situated

knowledge (Haraway, 1991), containing specific experiential procedures which often only the community-specialists possess. This knowledge usually makes the community a commercially viable one. In this article it is argued that the type of information shared, reflecting the depth of knowledge, influences the format of information shared. There is evidence on the importance of objectification of information for new knowledge creation (Bechky, 2003). The asynchronous bulletin boards applied in both communities enable more sophisticated information sharing formats and serve as "*hall of mirrors*" (Schön, 1999) while synchronous communication such as phone calls or instant messaging would only be used to coordinate tasks (Hemetsberger & Reinhardt, 2004). Through asynchronous communication, members are provided with sufficient response time, which allows creating more sophisticated information-formats than only swift textual replies. Instead of using written formats, ideas are often objectificated (Bechky, 2003) to "*provide the required tangibility a team needs in order to co-create a common understanding and imagination of their future action*" (Hemetsberger & Reinhardt, 2004: 6). This appears important particularly in biotechnology, where physical objects in order to proceed tasks matter to large extend (Tamoschus, 2014). Moreover, it is assumed that collaboration works better as when knowing the material context and surrounding in which development takes place. At least, material pre-conditions sometimes need to be displayed in graphical or verbalized format and in a common language around these preconditions. Grabher & Ibert (2013: 17) find *sandboarders* in an online forum to situate their knowledge generating practices around "*hill gradients, sand granularity, weather conditions, ramps, board characteristics*". And Nikon users find collaborators by the same camera equipment: gear twins, a similar physical pre-condition. As this pre-condition is not always available in the form of having the same equipment at home (like the Nikon camera), at least specifying the parameters of material preconditions or having seen the material context seems to be meaningful. For this reason it is concluded that the need and benefits of exchanging material or at least *objectificated material* (a photo of a machine or a graphic of a prototype etc.) would be reflected in exchanging graphics, photos, and videos, or prototype-like objects.

Based on the concept of mutually beneficial information sharing and the positive impact of "*objectifying*" information, the following hypothesis is proposed:

> ***Hypotheses 4: Openly posing questions and the use of non-textual information sharing positively influence the development of solutions***

Social structure

A broad base of literature exists on the social structure of networks and its influence on the success of online communities. Some studies refer in first instance to the norms, habits and institutionalized mechanisms evolving in online communities (Preece, 2000; Amine & Sitz, 2004; Schoberth, Preece & Heinzl, 2003), others discuss the shared identities among members, such as the "*mothers of young children*", producing a feeling of closeness among members of spatially distributed teams (Wilson et al., 2008). It is widely assumed that the community-specific norms developing over time, as well as the norms enclosed in rules of interaction, are a "*stepping stone to social capital*" (Preece, 2004), which is in turn presumed to be positively associated with the capabilities of knowledge sharing and knowledge generation (e.g. Sechi, Celmins & Spurins, 2008). Another stream of research investigates the social structure through the perspective of institutionalization patterns. The construction of *rituals and symbols* for instance can be an integral component of a shared social basis, implying interactions to become strongly ritualized and interaction patterns to become taken for granted (Amine & Sitz, 2004): As members adopt informal rules and rituals, the capabilities of self-management of the community increases. These mechanisms can become counterproductive in more sophisticated communities in which members have a stronger tendency to turn against rules and norms (Amine & Sitz, 2004). However, a well-developed community is then also able to solve potential conflicts. A community "*can be considered as an institutionalized one when it has a structure of conflict resolution […].*" (Amine & Sitz, 2004: 12) Additionally, mechanisms of loyalty, sometimes disclosed in

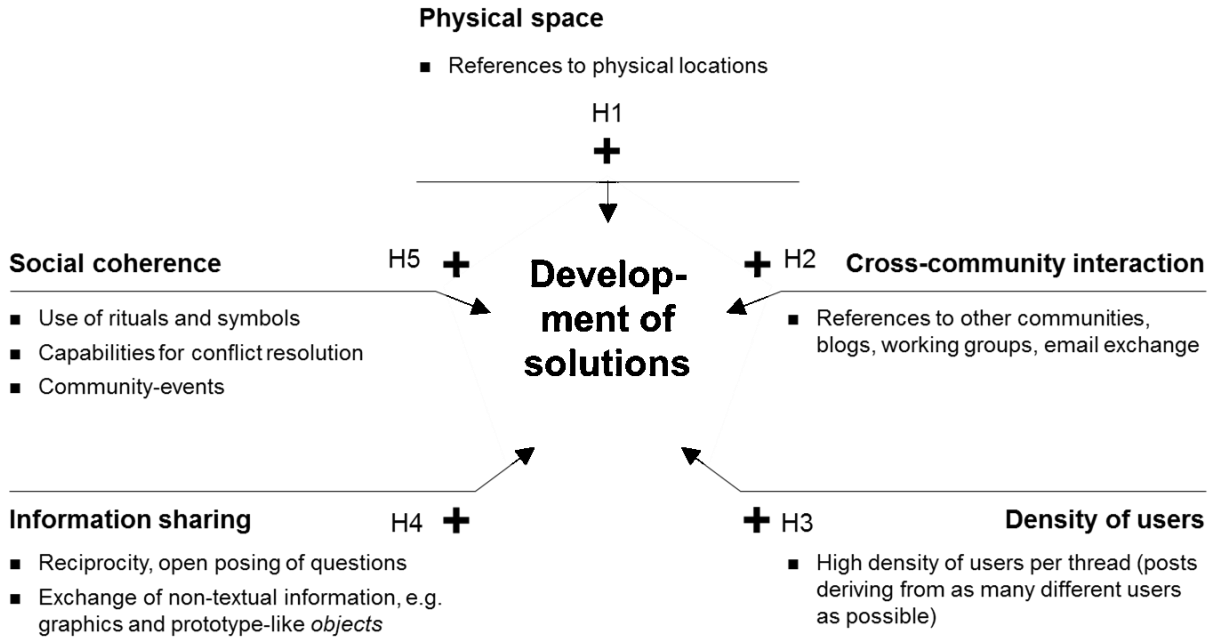
complaints about "*enemies*" (products, producers, governments etc.), are regarded as common cultural reference to enable social coherence (Amine & Sitz, 2004; Barlow & Møller, 1996) and the introduction of *social events* is assumed as a success factor, particularly for professional communities (Bowes, 2002). Events can take place in the format of facilitated discussions (Bowes, 2002: 72) or for instance as online guest events (Williams, 2000), and are perceived as value and quality adding to the online network. They can be furthered by face-to-face events (Bowes, 2002).

In conclusion, the community is a social model in which the "*general social indebtedness*" (Hemetsberger, 2002: 8) provides the basis (Haas & Deseran, 1981) on which knowledge sharing takes place.

> ***Hypotheses 5: Sophisticated social structures reflected by the use of rituals and symbols, capabilities in conflict resolution, and by social events increase the likelihood of developing solutions***

Figure 1 provides an overview on the derived hypotheses for this article.

Figure 1: Overview on hypotheses



4 DATA AND METHOD

The following section provides details on the method of community selection, the thread analysis, and gives an overview on the collected data and the coded variables.

Community selection

Both communities analyzed in this article were consciously chosen based on the following criteria: *Stability* of contribution for various years, indicating coherence of the community; *Relevance in search engines* considering multiple results, e.g. for the terms "open/online drug discovery", "online health community", "e-health", "patient communities"; *Relevance and status of individuals* driving the network, investigated through pre-interviews and literature screening (for the professional community); *Media relevance* in terms of press releases and any journalistic material (regardless whether positive or negative); *Relevance of the topic for society*, e.g. a cancer community would have been chosen over a lifestyle community. In total, over 30 medical and health communities have been reviewed in detail.

Data collection, sample, and coding method

Data collection was accomplished through freely available threads on www.thedcasite.com and www.thesynpaticleap.org, both offering extensive online forums, on DCA labeled *chat room*, on TSL entitled *community posts*. Thread analysis was conducted in the four major research communities of the TSL website: *Malaria*, *Schistosomiasis*, *Tuberculosis*, *Taxoplasma*, thereby covering all threads and posts focused on research outcomes. Only the general open research forum was not considered. The 250 threads contain a total number of 597 posts written between 2005 and 2013. 111 of over 400 active users (according to http://www.thesynapticleap.org/) contributed to the analyzed threads. On the DCA website, the analysis covered 250 threads focusing on the drug and the further development or improvement: *Clinical trials*, *creating health*, *DCA*, *Caffeine & V-B1*, and *General DCA discussion*. The total 1,425 posts by 368 different users on DCA derive from the older community board closed in May 2011, which contains posts until 2012 (written as replies to threads opened before May 2011). In total, 2,022 posts were analyzed across both communities.

According to the theoretical framework of the paper, a coding system for the threads was applied (see next section: Variables). The coding of threads was conducted applying selected categories based on deductive category application (Mayring, 2000). This structured theory-driven content analysis (Krippendorf, 1980; Weber, 1990) is considered more reliable (Namey etal., 2007) for the purpose of this study than thematic analysis or data-driven approaches, as the likelihood of similar results regardless of the coder is higher. However, the dependent variable *development of solutions* is partly investigated through a thematic approach (Namey et al., 2007) and coding required some interpretation as when a solution or new idea was generated (see paragraph about variables). If a thread as a discrete segment included one or more of the categories it was respectively assigned to it, following co-occurrence technique (Namey et al., 2007: 145; Guest et al, 2005). In contrast to a structural coding of frequencies (Guest & MacQueen, 2007), co-occurrence and hierarchical clustering techniques (Aldenderfer & Blashfield, 1984) do not focus on the number of times a code was applied in a discrete text segment but identify only the presence of the code. This can antagonize numerical biases which occur when a code is repeatedly applied to a single discrete text segment. This technique is particularly supportive to measure correlations between codes among larger datasets (Namey et al., 2007; LeCompte & Schensul, 1999).

Additional data about the networks and users was produced and is displayed in the following tables 1 and 2.

Table 1: Overview of the user sample

	Total # of active users	# of users contributed to analyzed posts	% of posts provided by 10 major users	% of top ten users of all users
DCA	2,481	368	32.93%	2.72%
TSL	422	111	55.72%	9.01%

Table 2: Overview of the thread sample

	Total # of analyzed threads	Average duration of threads (d)	# of posts in analyzed threads	Average # of different users per thread	Density of network per thread
Total all	500	56.34	2,022	2.57	0.84
DCA total	250	60.56	1,425	3.38	0.79
TSL total	250	52.11	597	1.76	0.89

Variables

To test the hypotheses with a quantitative data sample, the following variables are introduced.

Dependent variable

The solutions discussed in this article are steps towards solutions of more ultimate character. The dependent variable includes the parameters of *development* and *solutions*. a) Development refers to threads characterized as changing and improving the operation procedure based on the approach that "*community members arrange where to store data for joint use, how to solve software incompatibilities or how to distribute sub-tasks among fellow peers*" (Grabher & Ibert, 2013: 12) usually in iterative knowledge-integrating processes (Tamoschus, 2014: 12). b) Solutions refer to actual new ideas from which the community or the "end-product" clearly benefit and which are obviously relevant contributions to the further development towards the ultimate solution, e.g. improved therapy (DCA). Solutions were split into "ideas" as rather individual suggestions and into "solutions" as based more on an approach of discourse through feedback and discussions. A thread positively coded as development of solutions can therefore include one or all of the above described characteristics. In the following a few examples for the coding will be provided. **Development**: A typical process solution would be the following proposal to improve community-outcomes in general by standardization: "*I think it would severe a greater purpose if we had all new users of DCA register and answer a medical intake form consistent with what is done in standardized studies. The data would be compiled in flow sheet available for all members to read. With conclusion to treatment being formed after periodic evolution of patient reports."* (DCA forum) **New idea**: A user comes up with a totally new or innovative idea on a procedure or a future solution, often based on experiments: "*I even made this other experiment and plan to put it into video and make it available on Utube. I mixed olive oil, EPA/DHA supplement from fish oil and flaxoil, all with cottage cheese. Then, I tried to mix the result into water. In all cases, I got a water soluble solution. No oil at the surface and a cloudy milky solution in the recipient.*" (TSL forum) Patients develop ideas for other members in need of help, such as suggestions to removing the capsule from the drug to palliate gut pain after taking the medicine: "*The residue on the capsules makes sense.... maybe wipe them off with a tissue before taking and see if it helps. […]*". (DCA forum) **Solution**: Based on community interaction and collaborative co-work on a process, solutions are developed and/or the nature of the procedure changed: A: "*How else would you add the TLC? Do you have anything in mind?"* B: *"We've been adding your reactions to the […] and these are represented in a way that machines can understand. For example you can do substructure searches for reactants or products, reaction success, yield, etc. The entries will always point back to your lab notebook.*" (TSL forum)

Independent variables and controls

Table 3 provides an overview on and explains the independent and control variables which are developed based on hypotheses and community-patterns described in section three of the article.

Table 3: Overview of independent variables used in modeling

Variable		Value		Explanation / "*Example*"
Explanatory variables				
H1 [1]	Physical space	1 0	Identified Not identified	References to physical space such as mentioning differences across countries or towns/places of importance for the community, reflecting that physical co-work or meetings have taken place and that locations are of particular importance. "*We met in*

				Sydney on February 24th 2012 and had a fascinating day, then sunset beers in Glebe and dinner."
H2	Cross-community interaction	1 0	Identified Not identified	Other forms of conversation means are applied / applied with non-community-members. References to communication with other groups. "*Thanks to [JG] (Almac Sciences Physical Sciences Dept) for recording these patterns."; "We've posted a list of compounds on OpenWetWare that contains a range of the things were after […].*"
H3	Density users / thread	0 - 1	1 = all posts written by different users	Calculated based on the total number of posts per thread divided by the number of users participating in the thread.
H4	News (Scientific)	1 0	Identified Not identified	Sharing of purely textual news, e.g. media releases or scientific articles.
	Graphic video	1 0	Identified Not identified	Sharing of graphical images directly on the community board, as attachment, or sending of e.g. video files either as attachment or link.
	Prototype-like object sharing	1 0	Identified Not identified	Reference to prototypes or sending of prototype-like photos, graphics etc.
	Question request	1 0	Identified Not identified	Any open questions posed to the community or in course of an interaction as well as requests for co-work etc. "*Any and all help is gratefully received*"; "*Which other chiral acids are good candidates for this resolution?*"
H5	Rituals / symbols	1 0	Identified Not identified	Rituals which are repeatedly seen in the threads or specific symbols / abbreviations used. "*Keep up the Fight!*"
	Social event	1 0	Identified Not identified	Reference to events taking place or meeting minutes etc. which the community refers to in their conversations, not necessarily physical meetings. "*This meeting was the first of what will become regular monthly meetings for the OSDD malaria project. Open to all, so please feel free to come along to them.*"
	Community conflict resolution	1 0	Identified Not identified	Threads where members show a sense for solving a conflict between other members complaining or arguing. "*Best wishes on your continued progress.*" - "*Wait one moment. I am not recovering, I am not cured, I am not in remission as far as I know. I am doing OK.*" - "*Sorry […], I meant that you are recovering in terms of what you reported regarding reduction in your tumors and increase in your quality of life – nowhere did I imply that you are cured.*"
Control variables				
	Duration of thread	# days	# of days between first and last post of a thread	Calculated by the duration between first post and last post of a thread in days (last community-entry for analysis is June 15, 2013).
	Year of discussion	1-7	Year 1 to year 7	Tracked whether the conversation took place in the earlier or in more recent years of the existence of the community (as per thread-starting date).
	No interaction	1 0	Identified Not identified	Threads in which no interaction took place either because only one initial post was written or because only one individual user wrote more than one post without a dialogue with other users.

[1] H = Hypotheses

5 RESULTS

Because the dependent variable is dichotomous, a binary logistic regression model (Agresti, 2002) for each of the two communities was applied. Control variables were only introduced in the first step of modelling. The results of the analysis are presented in Table 4. The classification table shows that the inclusion of the explanatory variables increases the proportion of the models correctly predicted results by 8.8% for the TSL Community and by 1.6% for the DCA community. Concluding, the model works better for the professional research-community than for the patient community. A Hosmer Lemeshow test provides a chi-square of 16.382 with a significance of .022 for the TSL community and a chi-square of 16.428 with a significance of .021 for the DCA community (Hosmer & Lemeshow 2000). The pseudo-r2 (Nagelkerke, 1991) is .483 for the professional researcher-community TSL and .314 for the patient community DCA. Five out of the nine introduced explanatory variables turn out significant for the professional researcher community and four variables show significance for the patient community.

Table 4: Logistic regressions on community-level[1]

		Patient-community DCA			**Researcher-community TSL**		
		mean	standard deviation	odds ratio[1]	mean	standard deviation	odds ratio[1]
Dependent variable							
	Development of solutions	.14	.35		.26	.44	
Explanatory variables							
H1[3]	Physical space	.05	.22	(-) .46	.06	.25	(-) .56
H2	Cross-community interaction	.11	.32	(+) 1.64	.24	.43	**(+) 2.12***
H3	Density users / thread	.79	.25	**(-) .03*****	.89	.19	**(-) .03*****
H4	News (Scientific)	.54	.50	(+) 1.14	.58	.50	**(-) .28*****
	Graphic video	.02	.15	(+) 1.34	.48	.50	**(+) 2.44*****
	Prototype-like object sharing	.01	.11	- [2]	.22	.42	(+) 1.41
	Question request	.67	.47	**(+) 4.20*****	.46	.50	**(+) 4.70*****
H5	Rituals / symbols	.16	.37	**(-) .30****	.02	.15	(+) 1.35
	Social event	.01	.09	.00	.09	.29	(-) .46
	Community conflict resolution	.05	.21	**(+) 3.61***	.04	.20	(+) 3.41
	Constant			(-) .75			(+) .2.46
	N			**250**			**250**
	pseudo r_2			**.314**			**.483**
	Chi2			**48.517**			**100.318**
	Hosmer-Lemeshow			**.021**			**.022**

Significances are flagged on a * .1 level, ** .05 level and on a *** .01 level
[1] (+) and (-) specify the direction of influence as indicated by the regression coefficient
[2] Variable insignificant at .1.0-level and with too strong effects
[3] H = Hypotheses

[1] Modeling was performed with SPSS 21.0. Correlation tables for explanatory variables can be found in the Appendix.

Hypotheses 1 is not supported by the model. *Physical space* was found as having even a negative impact on innovative outcome in the form of development of solutions in both selected communities, but was not significant in the models. However, this challenges some findings from recent literature about the importance of physical embeddedness and the physical environment in general (Matzat, 2004; Horrigan & Rainie, 2001).

Hypotheses 2 is strongly supported for the professional TSL community. *Cross-community interaction* demonstrates a significant positive influence on the development of solutions or appropriation of new ideas in a community thread, with a likelihood of increasing them by over 200% when such outside interaction and knowledge-inflow takes place. This confirms findings from other studies on the positive influence on contribution behaviour when boundary spanning activities are prevalent (Dahlander & Frederiksen, 2007) and on the fact that an online community is not only defined by its distinct virtual borders but instead over spans multiple other communities (Baym, 2007). However, in the DCA community, *cross-community interaction* had no significant influence on the development of solutions.

Hypotheses 3 is not confirmed: The variable *density* within individual threads (= subsets) of the community works opposed to the findings of Gilsing & Noteboom (2005). In both analyzed communities, the density would decrease the likelihood of developing solutions by about 170%. Two limitations apply: *Density* was tested per thread and thus in a very small subset of community members; and *density* is not assumed as relationship between members but between the posts and the contributing members. However, rather than dense networks, community leadership and gatekeeping seems to play a more crucial role for the capability to manage the knowledge towards a solution (see Schloen, 2004).

Hypotheses 4 is strongly confirmed for the professional researcher community TSL by the variables of *sharing graphics or videos* instead of purely textual *news* (scientific), as well as by the prevalent feedback loops through *questions and requests*. Hypothesis 4 is partly confirmed for the patient-community DCA, where only *open questions and requests* positively influence solution development. In the TSL community *sharing graphics or videos* increases the likelihood of generating innovative solutions or new ideas by over 240% whereas the pure textual exchange of *scientific news or news* has a negative impact on developing solutions by decreasing the likelihood of valuable outcomes by over 70%. Concluding, objectification is a significantly influential factor for successful collaborative work in professional communities, confirming Bechky´s assumptions (2003). The results for the communication mechanism of *posing questions or requests* underpin theory of reciprocity (Korf, 2007). The *posting of questions and requests* apparently leads to a significant increase in the likelihood of coming up with solutions by about 420% in the non-professional DCA patient community and by about 470% in the professional TSL community. *Prototype-like object sharing* demonstrates a positive influence on development of solutions in the professional community TSL which is not significant, and has no effect in the DCA community.

Hypotheses 5 about the influence of social structure on successful healthcare community innovation is not fully confirmed. Significant effects are only found for the patient-community DCA. In contrast to the findings presented in the theory section, *rituals and symbols* would have a negative influence on successful discussion outcomes, decreasing the likelihood of developing solutions in a thread by about 70%. However, *conflict resolutions* as indicator for a well-developed social community structure (Amine & Sitz, 2004) and respectively presumed to be a positive factor for social capital to enhance knowledge creation, increase the likelihood of developing solutions by over 360%. *Social Events* were presumed to create acceptance among members, build and maintain social ties (Crowston et al., 2005) and to have positive impacts particularly in professional communities (Bowes, 2002). However opposed to this assumption *social events* would have turned out as a negative influence (but non-significant) in the professional community, decreasing the likelihood of solutions or ideas by over 50%, and to have no influence in the patient-community.

The following controls were performed but are not displayed in the final calculation. The *duration of threads* had no significant impact for both communities (odds ratios of 1.0 for both communities). The *endurance of the community* has no influence for the professional network, with a non-significant odds ratio of 1.07. However, in the patient-community, less solutions and new ideas are generated with longer existence of the community, the variable *year*, measuring the longevity of the community, showing a significantly (.07) negative impact on the innovativeness of discussions. Longer existence of the community (meaning more recent threads) slightly decreases the likelihood of solutions and new ideas by about over 30%. Probably the community has solved some of the major problems at the beginning of existence. Eventually, *no interaction* turns out non-significant (.88) with almost no effect (odds ratio of 1.11) for the patient-community, and shows an expected negative effect of .11 (decreasing the likelihood for developing solutions by about 90%) for the professional researcher community (significant: .00).

Finally, *complaints*, assumed to reflect a well-developed social structure (Amine & Sitz, 2004; Barlow & Møller, 1996) were not calculated due to robust (and expected) correlation with the variable *conflict resolution* (.72 for the researcher community and .37 for the patient community).

Differences between communities

For the lay-person community DCA, the strongest determinants for innovative outcomes are the positive influence of conflict resolution potential, and the negative influences of both, a high density of users and the use of rituals and symbols. Graphics and videos are found to have strong impact on solutions in the professional TSL community, while at the same time purely textual sharing of news shows negative effects. Further to this cross-community knowledge pipelines are apparently an inevitable mechanism for developing solutions in a professional researcher community. This is congruent with the finding of Dahlander & Frederiksen (2007) about the effects of boundary spanning and with the finding of Gilsing and Noteboom (2005) that professional communities more often form centralized networks in which gatekeepers can bring in the relevant knowledge through cross-community pipelines. Reciprocity mechanisms of openly requesting support appear to be predominant in both communities.

6 SUMMARY AND CONCLUSION

This paper has investigated the factors determining the development of solutions and new ideas within community discussions in healthcare online communities. The study confirms a number of assumptions from the literature but also contrasts some of the findings on online communities. The hypotheses about community networks are partly confirmed. The results support the literature on community boundary spanning and allow concluding that cross-community interaction has a positive influence on the communities' outcomes (particularly Dahlander & Frederiksen, 2007) in a professional research community. The density of networks as a supportive factor for exploratory community discussions and hence a more innovative outcome (Gilsing & Noteboom, 2005; Kenis & Knoke, 2002) were, in contrast, not confirmed: Discussions in threads of the two healthcare communities rather seem to rely on community leaders who organize and structure the interaction (Schloen, 2004). The assumption that objectification positively influences knowledge sharing and creation (Bechky, 2003) is confirmed by the analysis but relation to and referencing physical space as critical success factor (Kimble, Li & Barlow, 2000; Matzat, 2004; Schloen, 2004) is challenged in this article. The results rather confirm findings assuming communities to be fairly liberated from geography (e.g. Haythornthwaite, 2002). The study finds theory of reciprocity (Korf, 2007) to be a good explanatory factor for innovativeness in communities as the parameter of openly posing questions and requests has a positive effect on solutions and new ideas. This indicates that communities follow a culture of reciprocal and mutually beneficial feedback loops. The results on the influence of social structure are ambivalent. On the one hand, the

positive influence of conflict resolution potential on the degree of innovativeness in the patient community confirms the findings by Amine & Sitz (2004). In contrast, the use of rituals and symbols, which would likewise disclose a high social coherence (Amine & Sitz, 2004), has a negative influence on the degree of innovativeness in the patient community. None of the assumptions could be confirmed or refuted for the professional community.

Social organization

Within a non-professional interest community the determinants of social coherence and network density are more crucial than determinants emerging from type of information shared or cross-community knowledge pipelines. A patient community appears to be based on social organization. Conflict resolution potential has a strongly positive effect on innovative outcomes. The finding about rituals and symbols to be negatively associated with development of solutions seems to be confusing. However, building communication on rituals and symbols is presumably not less important as it still enhances stability of the community (see Amine & sitz, 2004) but it is simply not found in the most innovative, creative, and solution-oriented conversations but rather in compassionate conversations. The findings within the patient community suggest that the development of solutions is mostly based on a stable social network which enables trust among members to share their experiences which are critical for the community-solutions. A characteristic solution is the better body tolerance of the drug with other food supplements, for which the test-results of patients are required. To share these experiences, the community relies on the trust and empathy of its members (see Nambisan, 2011) rather than on sophisticated information-formats (such as graphics and objects). However, a central leader in value adding conversations organizes the social construct and the knowledge retrieval and exploitation. This is not only confirmed by the negative effects of user-density, but also by the finding that over 30% of all posts are written by the top ten users. Often they do organize in first instance the social basis, and in second instance the knowledge, such as John in DCA General Discussion Topic #76. In the first place he offers his sympathies to members: "*We all feel for you and your mother and others in a similar position*", he tries to resolve conflicts diplomatically: "*We need to compare Apples with Apples and not Apples with Oranges*", and organizes knowledge deposition: "*Your technical reference was excellent. Please register so that your expertise can be shared by all.*" Hence, among patients a central leader for the trustworthy collection of patient information and capability of making distributed experiences useful is inevitable.

Knowledge organization

Somewhat in contrast to the social construct among patients, a professional research community appears to be distinctly based on the organization of knowledge. The finding that knowledge objectification and knowledge pipelines across communities are so positively influential are assumed to mostly relate to the type of professional knowledge created across TSL, for which sophisticated information formats in order to make the knowledge explicit are required. At the same time, the generated knowledge requires such a level of expertise as that it cannot be found or built up within the focal network but instead it needs to reach out across various other on- and offline communities. A typical solution is a new chemical reaction which usually requires both, sharing of graphics as well as professional input through cross-community knowledge pipelines. Similar to the DCA community, the importance of central leadership is confirmed by the negative effects of user density on developing solutions and by the fact that over 55% of total posts derive from the top ten members. Here, community leaders organize in first instance the knowledge and in second instance they do organize the social construct. Mat on TSL manages cross-community knowledge inflow: "*In response to the above question, some replies came in via email overnight*", he structures and makes timelines: *"[…] this starts a 2-week or so period of consultation […] Final list to be ready by about June 22*", he reorganizes knowledge input and results: "*So we need to order these molecules. It seems to me that we could remove one of 3 or 9, given the level of similarity*", and eventually pays attention to social aspects by complimenting others: "*You know how much of a fan I am of your original paper*." This

certainly stimulates the idea that the leader is mainly the knowledge-organizer and gatekeeper across communities (see Tamoschus, 2014).

7 IMPLICATIONS, LIMITATIONS, AND FUTURE RESEARCH

The study proposes the following considerations for stakeholders in the healthcare landscape. Community managers should focus on social coherence in patient communities, e.g. by enabling effective seeking and finding of knowledge through central community leaders. This is in line with the finding about the positive impact of effective information seeking on perceived empathy (Nambisan, 2011). For professional research communities it is all about designing an environment for graphical sharing of research results, using standardized software (Gregory & Bunnin, 2005); to enable reciprocal mechanisms through particular seek and find boards; and to ensure connectivity to respective cross-community networks by formally connecting to and collaborating with peer-networks. Healthcare authorities and regulators might consider that communities on the one hand can contribute to innovation while at the same time communities require prerequisites which can be sustained by authorities with monetary support but also by providing the institutional framework and by making use of forums and networks for a dialogue with patients or other healthcare organizations.

This paper argues that firms in the healthcare and pharmaceutical sector could have sustainable interest in assimilating and exploiting knowledge generated in virtual environments. This study contributes to the conceptual understanding of different online communities, applicable regardless of whether the firm acts as a professional lurker or actively engages in the community. Healthcare companies should be aware that knowledge in such communities can best be found through community leaders; which means establishing ties to them can be constructive. For this purpose, the organizational design must provide that interface (see Keinz, Hienerth & Lettl, 2013). If a company intends to build an own community, the same recommendations as for community managers and designers apply. In conclusion, organizational capabilities (Teece, 2007) such as professional managers to participate in and access online communities will be required and respective processes to enable integration and assimilation of the knowledge (Kogut & Zander, 1992) will be a key to successfully leverage the effects.

Future research on the topic of open healthcare should further scrutinize the landscape of healthcare communities, categorizing their archetypes and evaluating their contributions, both qualitatively and quantitatively. Quantitative community-studies would support investigating the presented conflictive findings to assumptions emerging mainly from qualitative studies, such as to what extent physical space matters and when dense or when central networks are more beneficial. Finally, it remains to be explored how a linkage to the money-filled parts of healthcare, corporates or venture capitalists, can be established in order to make online healthcare environments more viable.

The study contains limitations due to focus on only two different community settings and due to possible coding-biases in thread-analysis. Moreover, particularly for the DCA case it should be critically considered that hopes and expectations of patients are strongly capitalized, while at the same time other drug candidate´s approved clinical trials are probably hindered through off-label therapies.

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Appendix 1: Correlation table (Pearson) for explanatory variables for the professional community TSL

	Physical space	Prototype-like object sharing	Cross-community interaction	Density users / thread	News (Scientific)	Graphic video	Question request	Ritual symbol	Event	Community conflict resolution
Physical space	1									
Prototype-like object sharing	,016	1								
Cross-community interaction	,156*	,075	1							
Density users / thread	-,094	-,242**	-,208**	1						
News (Scientific)	-,040	-,257**	,092	,070	1					
Graphic video	-,221**	,267**	-,066	-,073	-,108	1				
Question request	,056	,336**	,153*	-,455**	-,238**	-,067	1			
Ritual symbol	-,041	,041	,033	-,057	,082	,110	,066	1		
Social event	,313**	-,038	,238**	,005	,217**	,052	-,152*	,312**	1	
Community conflict resolution	,197**	-,012	,122	-,172**	-,155*	-,034	,141*	-,032	,006	1

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Appendix 2: Correlation table (Pearson) for explanatory variables for the patient community DCA

	Physical space	Prototype-like object sharing	Cross-community interaction	Density users / thread	News (Scientific)	Graphic video	Question request	Ritual symbol	Event	Community conflict resolution
Physical space	1									
Prototype-like object sharing	-.026	1								
Cross-community interaction	.202**	-.039	1							
Density users / thread	-.034	-.090	-.090	1						
News (Scientific)	.001	-.118	-.077	.013	1					
Graphic video	-.037	-.017	.027	.015	,093	1				
Question request	.050	.000	.116	-.211**	-.469**	-.167**	1			
Ritual symbol	.045	-.048	.087	-.163*	-.207**	-.068	.169**	1		
Social event	.181**	-.010	.110	-.195**	-.006	-.014	-.032	-.039	1	
Community conflict resolution	-.053	-.025	.098	-.089	-.016	.087	-.001	-.047	-.020	1

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).