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Sharing user innovations: Characteristics of patient-developed solutions and online communication

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Abstract

The challenges to healthcare systems are common worldwide. The need to identify new treatments and solutions that reduce the burden on society is top priority for all public policy makers. This study investigates the role of patients and caregivers as innovators. Drawing on Rogers' diffusion of innovations theory, we aim to understand how well lead users in the medical field are communicating their inventions. Based on a sample of 248 submissions in a patient innovation platform, this study assesses the likelihood of innovation diffusion. Overall, our results show that patient innovations are not communicated effectively online. Nevertheless, the levels of radicalness and complexity positively impact on the quality of communication. Our findings are important as communication strongly influences diffusion and, consequently, adoption. Hence, educating users on how to better communicate their solutions on dedicated online communities is appointed as the key to boosting adoption by others, which in turn leads to increased social welfare. Further implications for theory and practice are discussed.

Key words: lead users; user innovation; patient innovation; healthcare; radicalness; communication; diffusion; adoption.

Resumo

Os desafios aos sistemas de saúde são comuns em todo o mundo. A necessidade de identificar novos tratamentos e soluções que reduzam o fardo na sociedade é uma prioridade para todos os países. Este estudo investiga o papel de pacientes e prestadores de cuidados de saúde enquanto inovadores. Com base na teoria da difusão de inovações de Rogers, temos como objectivo perceber quão bem os *lead users* do campo médico estão a comunicar as suas invenções. Baseado numa amostra de 248 submissões numa plataforma de soluções desenvolvidas por pacientes, este estudo avalia a probabilidade de difusão das inovações. Em suma, os resultados da nossa análise demonstram que as inovações desenvolvidas por pacientes não são eficazmente comunicadas online. No entanto, os níveis de radicalidade e complexidade têm um impacto positivo na qualidade da comunicação. Os nossos resultados são importantes pois a comunicação influencia fortemente a difusão e, consequentemente, a adopção. Portanto, a educação de utilizadores na forma de comunicar as suas soluções em comunidades online dedicadas é apontada como a chave para aumentar a adopção por outros, que por sua vez faz subir o bem-estar social. São discutidas mais implicações teóricas e práticas.

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1. Introduction

In recent decades, life expectancy has been growing exponentially (World Health Organization, 2015). This is a major achievement, yet as the population ages, health spending rises alongside. The need to meet an increasing demand for health care services has lead to an overall struggle to reduce costs. In fact, medical expenses are expected to accelerate by an average of over 5% every year until 2018 (Deloitte, 2015). This increase is not only due to an aging and growing population, but also because of a rising prevalence of chronic diseases, the growth of emerging markets, and advances in treatments and technologies.

As the world recovers from an economic crisis, the pressure to reduce costs builds and the search for newer, more efficient business models and operating processes intensifies. Innovation has been identified as a solution to alleviate this economic burden in public health (Kuusisto et al., 2013). The concept of user innovation, which revolves around the idea that one is more likely to find a solution to a problem as it becomes more pressing and harder to deal with, has been extensively studied by many researchers. Namely, von Hippel (1986, 1994, 1998, 2005) has dedicated a significant amount of his work to the user innovation theory, which agrees with the English proverb 'necessity is the mother of invention' (anonymous) by arguing that people will engage in innovative behaviours when unsatisfied by existing solutions.

However, despite the research attention the concept of user innovation has been receiving (Schreier and Prügl, 2008; Shah and Tripsas, 2007; von Hippel, 2015), its study in the specific context of health care is far from being exhausted. The topic gains relevance as nowadays access to information and, consequently, knowledge, a vital component of innovation, is becoming easier and no longer limited to a few. Advances in technology have created the ideal conditions for user innovation and the potential of patients and caregivers as developers of solutions has yet to be studied.

The innovative capabilities of users in the healthcare sector have already been proven (Lettl et al., 2006; Shah and Robinson, 2006; Oliveira et al., 2014), though little has been done so as to instigate this behaviour. To best of our knowledge, only one platform has the goal of promoting and facilitating the sharing of solutions developed by patients and their non-professional caregivers[1]. Communication plays a huge role in the diffusion of new ideas (Rogers and Shoemaker, 1971) and we truly believe the study of the former can lead to enhancements of the latter, thus it is important, firstly, to have a platform to share the ideas and, secondly, to communicate them well. Given the early stage of the Patient Innovation

[1] www.patient-innovation.com

project, much can still be studied and subsequent conclusions used for development and improvement of not only the platform itself, but also of the entire health care system, which is in candid need of a reform.

Research on user innovativeness introduced us to the concept of lead users (von Hippel, 1986), a distinct group of users who experience a need well ahead of the rest of the market. Evidence shows that lead users are likely to significantly benefit from developing their own solutions and that these self-developed innovations are expected to be radical. We believe that the level of radicalness influences the ability to communicate an innovation, as new-to-the-world solutions fall outside consumers' mental schema and their benefits are sometimes not understood by potential users (Mugge et al., 2013).

Rogers (1995) developed the diffusion of innovations theory, which attempts to explain the process of communication entailed in the spreading of messages that are perceived as somewhat new ideas. The theory has been broadly studied in several fields, such as Education, Geography, and even Public Health and Medical Sociology. However, the application of the innovation diffusion theory to the user innovation concept has still not been studied, which is what we hereby propose to do.

User-developed solutions are non-commercial in nature; their initial goal is self-benefit, even if they end up being commercialized in a later stage. Hence, the question we wish to address with this work relates to the diffusion process of user innovations and to what extent it resembles the one of traditional innovations, developed by producers. Ultimately, we have two goals: to evaluate the role of user innovation platforms as spotlights to the community and catalysts of diffusion, and to help with the empowerment user innovators as marketeers of their own inventions.

The importance of studying this matter has been growing exponentially, as the phenomenon of user-driven innovation grows worldwide. According to Kuusisto et al. (2013), 3.7% of consumers in Japan created at least one user innovation in the previous three years, this means about 4.7 million consumers, unsatisfied with the offers in the market, who decided to actively engage in innovation to solve a personal need. This number is 5.2% in the USA, 5.4% in Finland, 6.1% in the United Kingdom and 6.2% in the Netherlands.

Nonetheless, these consumer innovations are not being diffused. In Finland, only 18.8% of all user innovations are adopted by other users or firms (Kuusisto et al., 2013). In the UK the frequency is 17.1% (von Hippel et al., 2012), 6.1% in the USA, and this number drops to

5.0% in Japan (Ogawa and Pongtanalert, 2011).[2] On the one hand, these results prove how meaningful to other users these innovations can be, and on the other, they show how about 80% of all consumer innovations do not even become available to the wider society. This insufficient diffusion indicates a potential social welfare loss (Henkel and von Hippel, 2005), which is why it is imperative to create incentives to share.

Kuusisto et al. (2013) show how consumer willingness to freely share their innovations is almost 85%, being the biggest motivation the potential to help others (54%). However, willingness to share and efforts to actually to it are not aligned, unfortunately. The fraction of innovators who have done any kind of effort to diffuse their own solutions averages a mere 21.2%. This low value reflects a clear lack of incentive to share, because, unlike producer innovations, consumer innovations are developed for self-benefit and not for selling or licensing.

User innovation is especially relevant in the health sector, as these patient-developed solutions may lead to breakthroughs in the medical field or even save lives. Typically, the starting point for these innovative users are the difficulties they face in their daily lives, for which a solution has yet to be found (Lettl et al., 2006). This lack of existing medical equipment, technology or therapy to meet their needs instigates patients to search for more suitable solutions, giving them a 'motivation induced by problem', as defined by Lettl et al. (2006). Studies on creativity also show that high problem pressure propel a creative behaviour (Boden, 1994; Collins and Amabile, 1999; Csikszentmihalyi, 1988).

A study conducted in Finland shows that 5.4% of patients and their family members have experienced at least one particular problem regarding the functioning of the medical sector in the past three years and have consequently identified at least one solution to solve it. This rate is 5.7% for doctors, and 15.3% for nurses (Kuusisto et al., 2013). These numbers suggest that user innovation can indeed start a revolution in the management of public sector activities. In particular, we believe it is the key to renewing the healthcare sector, which is struggling to juggle limited budgets and soaring demands.

[2] Percentages indicate what fraction of innovations has been diffused to peers or commercial producers. New venture creation as a diffusion mechanism is not included.

2. Literature Review

This chapter is dedicated to the review of the literature gathered and analysed in the development of the present thesis. It is the literary foundation of this paper and, thus, comprises the most important theoretical bases and concepts inherent to its elaboration and posterior understanding.

2.1. Sources of Innovation

2.1.1. Innovation: concept, importance and prevalence.

An innovation, as defined by Zaltman, Duncan and Holbek (1973, p.10), is 'any idea, practice, or material artefact perceived to be new by the relevant unit of adoption' and it may vary in the degree of newness to an adopting unit. This distribution is partly detained by the notion of radicalness. Radical innovations are fundamental changes that represent revolutionary deviations in technology, they signify clear departures from existing practice and lead to shifts in consumer usage patterns (Duchesneau, Cohn and Dutton 1979; Ettlie 1983; Mugge and Dahl, 2013). Incremental innovations are minor improvements or simple adjustments in current products or technology, which lead to improved performance (Mugge and Dahl, 2013; Munson and Pelz, 1979).

Globalization has contributed to an increased market competition, highlighting the importance of having a long-term competitive advantage. According to the authors, the answer lies in constantly being innovative, meaning firms have to constantly differentiate its products and services (Popadiuk and Choo, 2006).

Producers and designers within firms have been the only source of innovation for many years, however, the involvement and empowerment of consumers throughout the innovation process have become an increasing trend (von Hippel, 2005). Several studies have attempted to measure consumer perceptions with regards to user-designed products, such as the one conducted by Schreier and colleagues (2012), which shows a positive correlation between common design by users and the perceived innovation ability of a firm.

The level of involvement of consumers in the innovation process may also range from minimal, such as customization or even co-creation, to substantial, where the end-user idealizes and further develops a solution to satisfy their own needs, having in mind personal gratification as opposed to commercialization (von Hippel, 2005).

In addition, innovations differ in degree of openness. Open innovation is generally found to have a positive contribution towards innovation performance (Chesbrough, 2003; Dahlander and Gann, 2010; Enkel et al., 2010; Fu, 2012) and, given the informal nature of user innovations, the potential gains from collaboration are greater than the possible drawbacks of disclosing an idea (Chesbrough, 2003). Keupp and Gassmann (2009) found that firms adopt open innovation to gain otherwise difficult access to external talents and resources, diversify risks and share uncertainties whilst promoting learning. Grandstrand et al. (1992) believe that technological convergence and the shortening of product cycle times are also two key advantages of using external sources of knowledge.

2.1.2. User Innovation

Users, as defined by von Hippel (2005, p.3), 'are firms or individual consumers that expect to benefit from using a product or a service'. With a contrasting underlying motive, manufacturers seek to sell products or services, benefiting from the generated profits.

Bearing this difference in intent to commercialize in mind, firms using the manufacture-centric innovation process look for a differentiating factor that will maximize their sales. Thus, in order to maintain a competitive advantage, these organizations see the need to develop products and services in a closed way, resorting to the use of patents and copyrights in order to protect their investments. On the other hand, the user-centric model is characterized by its openness, as users' major incentives to share are helping others and the hope that others might further improve their solutions (Kuusisto et al., 2013; von Hippel, 2005).

Von Hippel (1986) has contributed extensively to the literature on user innovations, having categorized user innovators as lead users by examining their unique set of characteristics. According to the author's definition (1986, p.791), 'lead users are users whose present strong needs will become general in a marketplace months or years in the future'. In addition to experiencing needs before others, lead users are bound to greatly benefit from obtaining a solution to their needs, leading them to innovate.

Many researchers have since built upon the concept, suggesting that lead users' innovative behaviour can also be seen in their faster and heavier adoption of new commercial products, when compared to ordinary users (Morrison et al., 2000; Schreier and Prügl, 2008; Urban and von Hippel, 1988). Moreover, Schreier, Oberhauser and Prügl (2007) uncover that lead users are more likely to exhibit stronger opinion leadership rather than opinion seeking tendencies. For example, a field where lead userness is seen to cause great impact is extreme sports such as sailplaning and kite surfing, because the ones heavily practicing these activities, the experts, are the first to face a given problem and the ones who will benefit the most from solving it (Schreier et al., 2007; Schreier and Prügl, 2008).

The belief that lead users possess the ability to innovate and satisfy their own needs is strongly related to the unique type of knowledge they acquire through experience (Caraça et al., 2009; Johannessen et al., 1999; Schreier et al., 2007; Schreier and Prügl, 2008). Tacit knowledge is linked to experience (Nonaka, 1994), it is inherent to users and a challenge for organizations to obtain (Popadiuk and Choo, 2006). Jensen et al. (2007, p.680) have defined two modes of innovation: the Science, Technology and Innovation (STI) mode, based on 'the production and use of codified scientific and technical knowledge' and the Doing, Using and Interacting (DUI) mode, which relies on 'informal processes of learning and experience-based know-how'. Their study reveals that a combination of both modes should be used in order to achieve higher levels of innovativeness, hence emphasizing the significance of users in the innovation process.

2.1.3. Diffusion of user innovations

An important aspect of an innovation is not only its utility, but also its potential of adoption, which happens as a consequence of diffusion. As defined by Rogers (1995, p.5), 'diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system'. An innovation's adoption rate is determined by the users' perceptions of its characteristics. These attributes consist of five variables:

1) Relative Advantage: 'the degree to which an innovation is perceived as better than the idea it supersedes';
2) Compatibility: 'the degree to which an innovation is perceived as being consistent with existing values, past experiences, and needs of potential adopters';
3) Complexity: 'the degree to which an innovation is perceived as difficult to understand and use';
4) Trialability: 'the degree to which an innovation may be experimented with on a limited basis';
5) Observability: 'the degree to which the results of an innovation are visible to others'.

All of these variables have been proved to have a positive influence on adoption, to the exception of complexity which impacts adoption negatively. Hence, a successful communication of an innovation's characteristics is of utmost importance, as they are the basis of the decision to adopt.

Effective communication is defined as 'a two way information sharing process which involves one party sending a message that is easily understood by the receiving party' (TheBusinessDictionary.com). Communication theory (Shannon and Weaver, 1949) argues that a message must be clear in order to be de-codified and subsequently understood by its receiver. In the context of sharing new ideas, the same principle is maintained; for an innovation to be adopted by its target, the latter must first understand it. Hence, for the above-mentioned characteristics to play a role in the diffusion process, they must be communicated in a way that will be understood by others.

In the particular setting of user innovations, it is common for lead users to engage in informal collaborations with other users when developing solutions, in order to increase speed and effectiveness through knowledge sharing (von Hippel, 2005). Organized communities can also significantly accelerate the processes of diffusion and testing, in numerous areas from software to physical products (Franke and Shah, 2003; von Hippel, 2005).

By definition, user innovation is driven by the expected benefit of using the solution developed (von Hippel, 2005). The primary goal of these innovators is personal use, being the use by others sometimes not even considered. Thus, unlike producers, who have maximum profitability as a strategy, in the process of user innovation, diffusion is considered but an externality, meaning it will only be implemented for as long as its costs do not exceed the expected benefits (Fidélis, 2013; Raasch and von Hippel, 2012).

Raasch and von Hippel (2012) determine two innovation diffusion channels: peer-to-peer and market forces. The former consists of free revealing and is associated to user innovations, whereas the latter usually has a financial cost and is the more traditional diffusion strategy of producers. Figure 1 illustrates this point.

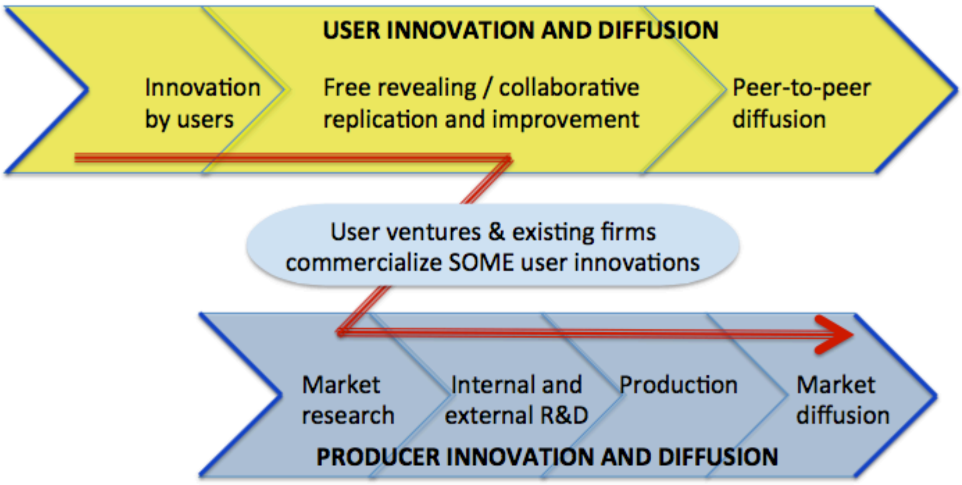

Figure 1 – The user and producer innovation and diffusion paradigms (Raasch and von Hippel, 2012)

2.1.4. User entrepreneurship

Researchers have not yet reached a consensus regarding the definition of innovation. Nevertheless, according to Popadiuk and Choo (2006), three concepts remain constant in the literature as inherent to the term: novelty, commercialization and/or implementation. The dissociation from monetization seldom occurs in an advanced stage of a user innovation, regardless of initial intentions of self-benefit (von Hippel, 2005).

The truth is that user innovations, as a means of solving pressing and urgent needs, might be transferable to other users with similar needs, and possibly even life-changing, especially in the medical context. Rare diseases are an example of a market that is under-catered to; orphan drugs are not attractive in commercial terms, for they require huge investments and offer limited returns, hence enhancing the conditions for user innovations to occur (Oliveira et al., 2014).

Market segmentation is a common technique used by producers to match the perceived needs of consumers. Yet, this process proves to be ineffective when the needs of users are highly heterogeneous; when highly specific needs arise, so does the propensity to innovate. In their study of software systems, Franke and von Hippel (2003) depicted that there is a positive correlation between the level of heterogeneity of users' needs and their willingness to pay for personalized solutions.

Shane and Venkataraman (2000) define entrepreneurship as the discovery, evaluation and exploitation of opportunities to create future goods and services. In broad terms, the main difference between user-entrepreneurs and a more traditional kind of entrepreneur is that the former intends to benefit from its products both by using and selling them. In some cases of user entrepreneurship, the formal and well-defined steps of product development might be blurred or skipped, as the entire process naturally evolves, giving birth to the term 'accidental entrepreneur' (Shah and Tripsas, 2007).

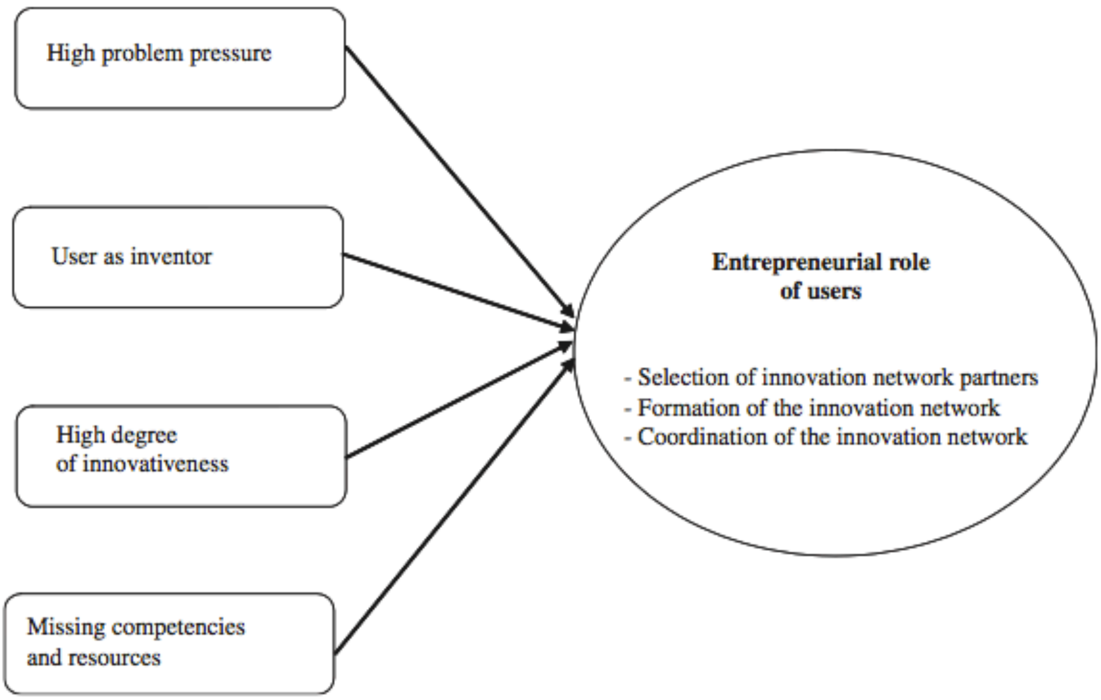

Figure 2- entrepreneurial role of users (Lettl. et al., 2006)

As illustrated by Lettl. et al. (2006) in figure 2, the process of user innovation arises from a motivation to solve a pressing issue, which in turn leads to the user engaging in a role of inventor, articulating needs and idealizing prototypes. Another layer in the entrepreneurial role of users is the high degree of innovativeness, which the authors have found to be negatively correlated to manufacture involvement in early stages due to increased uncertainty of the market and the lack of technological development. Also, as radical innovations in the medical field, their application is usually just emerging and their market potential highly speculative. Moreover, a key factor leading to user entrepreneurship is the lack of competencies and resources the users have to transform their prototypes into actual marketable products, hence having to rely on external support.

2.2. User Innovation in the Healthcare sector

2.2.1. Patient Innovation

Patient innovation (PI) is the notion of user innovation applied to the specific context of healthcare. According to Habicht et al. (2012), patient innovators are those who develop novel treatments, strategies, and medical or non-medical equipment to help them cope with a disease. For the purpose of this thesis, we will use a slightly broader definition of patient innovators, defining them as individuals, patients or caregivers, who develop a new offering with the intention of benefiting from its use, not commercialization (Shcherbatiuk, 2012; Czernin, 2013).

2.2.2. Ideation and development of PI

The development of highly specific medical solutions requires thorough understanding of user needs, which is obtained almost exclusively by experience and experimentation. Von Hippel (1994, 1998) defined this type of knowledge as 'sticky', for it is challenging and costly to transfer to third parties. In their study of users' contributions to radical innovation, Lettl et al. (2006) used innovative medical doctors as a sample. These possessed both the in-depth scientific knowledge within the domain of surgery and the knowledge from previous experience of using existing medical equipment. Therefore, they had enough knowledge to conceptualize a solution, but lacked the technical knowledge to manufacture it, which is why the collaboration of users and producers in early stages of the development process proved to be so successful.

In addition to problem-induced motivation and prior knowledge, Lettl et al. (2006) outlined 'openness to new technologies' as another fundamental condition for innovativeness. According to the authors, the fact that the users at study searched for solutions outside of the medical domain was crucial in achieving radical innovations. Also, whether they had access to many or few resources for research, such as time, funds or help, was irrelevant as users who lacked access to these supportive elements displayed strong 'intrinsic motivation', another key enhancer of creative activities (Csikszentmihalyi, 1988).

2.2.3. Diffusion of PI

Patient-developed innovations, as solutions to highly specific needs, may appear to have minimal marketable potential. The intent to commercialize goes beyond the initial intrinsic motivation to solve a personal problem, however it is not uncommon for user innovations in the healthcare sector to naturally wind down the road of commercialization (Lettl et al., 2006). The reasoning behind this phenomenon is two-folded; diffusion may happen less formally via peer-to-peer or more consciously via the forces of the marketplace (Raasch and von Hippel, 2012).

In the first scenario, the user innovator shares their solution with individuals or a community of peers who display the same needs. Incentives to share are mostly philanthropic rather than commercial; given the particularity of the context, patient innovators see a genuine benefit from freely revealing and sharing their solutions (Franke and Shah, 2002; von Hippel, 2005). Diffusion is seen as an externality to the innovation process and the new solution may, or may not, attract the scientific community in order to be further studied and developed (Fidélis, 2013).

Users who follow the second channel assume, to different degrees, a more entrepreneurial role as innovators. According to Lettl et al. (2006), users who are willing and able to idealize a concept but lack the skills or resources to create a prototype usually invest the time and efforts to look for external help with some degree of expertise. Hence, diffusion occurs as part of the problem-solving process, due to lack of competencies and/or resources.

2.3. Patient Innovation Adoption

2.3.1. Active users in healthcare

Active patients, as the term suggests, are those who actively seek for solutions to their medical problems and, in contrast with passive patients, are engaged in the management of their health and take control of the decision-making process (McAllister et al., 2012; Oliveira, 2014). For example, an active patient would take into consideration several doctors' opinions, search for other solutions outside the medical community and measure all their options before committing to a treatment. A passive patient accepts whichever treatment their doctor suggests without questioning it or looking for alternatives.

All patient innovators are active users, yet the inverse is not necessarily true. The majority of active patients will look for existing solutions, but only a few will actually engage in the innovation process. The former are the most likely adopters of the solutions developed by the latter (von Hippel, 2005).

2.3.2. The sharing process

The adoption process of user innovations in the healthcare context is quite particular, in the sense that it is not vital for the success of a user innovation, bearing in mind the goal of these solutions is to benefit from personal use. Thus, unlike the solutions developed by producers and organizations, the adoption by others is somewhat irrelevant (Raasch and von Hippel, 2012).

Furthermore, because the topic is people's health, it is of high overall relevance because user innovations in this field might yield positive externalities of great magnitude. It is of social interest to have organized communities dedicated to this purpose so as to boost sharing and collaboration among users. In fact, the sharing itself has been linked to advances in the innovation process, such as improvements of the solution developed after receiving feedback from other patients. In a more advanced stage of the development process, innovators are usually more concerned with the opinions of other patients, who are potential adopters, than with sharing their solutions with doctors or complying with validation requirements or regulations (Fidélis, 2013).

Measuring the success of a patient innovation is a challenging endeavour, as the usual measure of adoption is sales and this is in some cases non-existent. Going back to the definition of a user innovation, a solution is successful if it fulfils its main goal of self-benefit. Hence, any posterior diffusion and/or adoption by others is purely profit.

To the best of our knowledge, there is no model conceptualized for predicting the adoption of non-technological innovations, which is why we resorted to innovation characteristics research, which 'describes the relationship between the attributes or characteristics of an innovation and the adoption and implementation of that innovation' (Tornatzky and Klein, 1982). According to the authors, the ideal study should be predictive, rather than retrospective, which is in line with the present work, where most of the innovations (66%) have still not been implemented or commercialized.

Given this literature gap - the lack of a model to predict patient innovation adoption - we hereby propose to study the potential adoption of patient-developed solutions by measuring the factors we already know play a role in this process.

Diffusion and communication are tied together (Rogers, 1995) and in order to boost the former, the latter must be effective. A successful message reception is one of two key elements of communication effectiveness, and in order to augment the likelihood of this scenario happening, the same message must be clearly voiced, which is the second key element. Patient-developed solutions have the potential to create highly positive externalities, yet for this to occur they must be effectively communicated. However, diffusion of user innovations is considered a secondary activity to the process and not enough efforts are directed into the sharing of an innovation, which leads us to our first grounding hypothesis:

H1 = The average quality of communication of patient innovations shared online is low.

Furthermore, research established that user innovators are more likely to create radical innovations because of their lead-userness; since they feel a need way before others and intend to use their innovation for own benefit, they are likely to create something that falls outside the boundaries of convention and satisfies very specific needs (von Hippel, 1986).

Moreover, the definition of a radical innovation shows that highly innovative solutions generally do not fit into the mental schema of consumers (Dewar and Dutton, 1986; Mugge et al., 2013). They sometimes lead to entirely new product segments or categories and users do not understand what the product is for as they have yet to experience a need for it. Hence, the communication of radical innovations needs to be quite detailed in order for the message to be clearly received by potential adopters (Creusen and Schoormans, 2005). Thus leading to our second hypothesis:

H2 = Radical patient innovations have a higher quality of communication than incremental ones.

Moreover, Jensen et al. (2007) argues that experience-based knowledge (DUI), when combined with more technical knowledge (STI), is key to achieving higher degrees of innovativeness. Different types and degrees of knowledge also contribute to higher or lower levels of complexity of an innovation.

Zaltman et al. (1973) state that the complexity of an innovation undoubtedly impacts its acceptance. The authors believe that, in general terms, the more complex an innovation is in terms of operating, the slower its acceptance will be. They do not define the concept, but explain that complexity can be displayed on two levels: on the one hand, the innovation may contain complex ideas, and on the other, the actual implementation of the innovation may be complex. For purpose of this thesis, the first manifestation was considered. Given their inherent complexity and substantial amounts of technical knowledge, these solutions are harder to communicate, so:

H3 = The quality of communication of less complex innovations is higher than the quality of communication of more complex innovations.

All in all, an innovation might be great, in the sense that it solves pressing issues common to a large community. However, if no one besides from its developer knows about it, the solution is not living up to its full potential. In order to help several people and increase social welfare, the user innovation must be shared. Having an online platform created for this purpose, it is then the innovator's responsibility to communicate its solution in a way that is clear to everyone and will be understood by others with the same needs. Only through effective communication will a patient innovation be able to create positive externalities that will maximize its value. But user innovators are usually not marketing experts, which is why we believe enlightening them about the importance of this topic might yield extremely positive outcomes.

3. Methodology

3.1. Secondary Data

To generate valid and reliable results, we used data from a social network designed to share and promote solutions developed by patients and non-professional caregivers – www.patient-innovation.com – the first and only one of its kind, to our knowledge. Anyone can access the platform and browse through the innovative solutions already shared. People are encouraged to become registered users, as this free feature allows one to join patient groups related to their specific condition, where the sharing of knowledge among users is stimulated. Also, registering in the platform enables the publishing of new self-developed solutions.

Given that users actively search for this platform and make the conscious decision of freely revealing their ideas for the community's sake, we believe they capture the lead-userness we intend to study, and are therefore an appropriate sample. The database used in this work consists of 248 posts from users describing the issues they faced and the solutions they developed. These people are from over 16 countries and bring awareness to more than 85 diseases and conditions.

3.1.1. Filtration

We started by separating actual innovations from mere testimonials or ideas, so that the former could be object of study and the latter disregarded. This filtration process was made using the previously mentioned definition of innovation by Zaltman, Duncan and Holbek (1973, p.10): 'any idea, practice, or material artefact perceived to be new by the relevant unit of adoption'.

The categorization of posts as innovations or non-innovations was performed by an expert in the topic and consisted in verifying whether, or not, the solution described in the platform fitted this definition. If it did, then it could be used for the purpose of this study, if not, it would not be considered. In the end, 164 solutions (66%) were considered to fulfil the requirements of the above definition and were thus contemplated as innovations. The remaining 84 posts (34%) did not to fit the definition, hence were labelled as non-innovations. This first step was crucial in maintaining the validity of the data, so that only actual innovations were object of study. Thereafter, other categorizations had to be made in order to look for any patterns among user innovations in the healthcare sector.

3.2. Measurement of the Variables

3.2.1. Complexity

We also categorized the solutions by levels of complexity, as within the group of innovations there were visible disparities in this regard and the literature considers this one to be an important variable for diffusion and adoption by others (Damanpour, 1988; Pelz, 1985). For this categorization, complexity was defined as the degree of difficulty of ideating and developing a solution, thus a qualitative approach was used to evaluate the level of complexity of the ideas involved in the innovation process.

Due to the lack of an approved scale to measure this variable, experts' perceptions were used to rate each innovation on a three-point scale (low, medium or high) in terms of apparent difficulty of idea generation and effort involved in the development process. The degree and type of knowledge used were also considered in this rating process, as Damanpour (1988, p.551) defined complexity as 'the degree of special knowledge available to the organization'. In this case, the perceived amounts of both technical and experience-based knowledge used by the innovators were considered. The second manifestation of complexity, regarding ease-of-use and implementation, was not taken into consideration. To avoid bias, three raters graded all innovations individually, having as reference the same definition of complexity and set of guidelines.

3.2.2. Radicalness

Radicalness is another variable already proven to affect diffusion and implementation (Damanpour, 1988). For the measurement of this variable, a scale built and tested by Dewar and Dutton (1986) was used. Innovations were rated on a three-point scale indicating whether each innovation: (1) had no new knowledge contained in the machine or process; (2) represented an improvement over existing technology; or (3) represented a major technological advance. The ratings of three judges were compared and the average value used to establish whether an innovation belonged to the radical (score ≥ 2.5) or the incremental (score < 2.5) categories.

3.2.3. Communication

To best of our knowledge, an agreed-upon rating system to evaluate the quality of sharing of a message does not exist. Thus, an index was created to measure the communication quality of the innovations shared in the Patient Innovation platform.

This new variable was constructed as a combination of seven characteristics of an online-shared innovation, having as a basis Rogers' (1995) diffusion of innovations theory. One of the four main elements in the diffusion of new ideas is communication. It is the process by which participants create and share information with others so as to reach a mutual understanding. Bearing in mind that the majority of people evaluate an innovation through the subjective appraisals of others, rather than by relying on scientific research presented by experts, an online presence is a catalyst for diffusion.

However, whilst having the Internet as a mass communication channel is positive in creating awareness of the innovations, it can be quite ineffective in forming and changing attitudes towards an idea. This difficulty in influencing the decision to adopt or reject an idea happens because the interpersonal, more humanistic components of communication are easily lost when sharing a message online. Hence, even though the platform does not allow users to physically share their innovations with others, providing some sort of visual aid, like pictures, sketches, or videos, can help potential adopters to better understand the concept, i.e. decode the message (Zhao et al., 2009).

Moreover, Rogers (1995) points out five characteristics of an innovation which determine its rate of adoption: relative advantage, compatibility, complexity, trialability and observability. As the purpose of this variable is not to evaluate the innovation itself, but rather to measure the quality of its sharing, assessing the above mentioned attributes is irrelevant in the construction of this index. Yet, all these characteristics will indeed be studied and weighed in by users when deciding whether to adopt, or not, an innovation (Tornatzky and Klein, 1982).

Hence, in order to be considered by potential adopters, they must be clear to them, which is why the mentioning of these five characteristics in the description of an innovation is fundamental.

Furthermore, communication is all about the sharing of knowledge, and even though sometimes too much information might be counter-productive as it becomes confusing to the receiver, for the purpose of this study, an assumption was made that more information is positive, as it translates into a more informed decision-making process and also because having a greater online presence boosts diffusion.

To sum up, the index was built as a combination of seven binary variables, in the form of seven questions to yes or no answers. Basically, each solution was attributed a value between 0 and 7, according to how many items were checked from the following list of questions.

1) Visual: Is there a visual support (picture/video/sketch) of the innovation?
2) Compatibility: Are reasons to innovate shared?
3) Complexity of Use: Is there an explanation on how to use the innovation (or is it obvious)?
4) Relative Advantage: Is the innovation compared with alternatives?
5) Observability: Are the beneficial outcomes of using the innovation explicit?
6) Trialability: Is it clear how to acquire/replicate innovation?
7) Hyperlink: Is there a link for additional information?

Three raters were given the task of applying questions 2 through 6 to every innovation post. Given the objective nature of questions 1 and 7, only one rater was required to answer them. If the answer to one of these questions was positive, a 1 was attributed. A 0 was given otherwise. Subsequently, the variables were simply added up to obtain a final index value for quality of communication.

4. Results

4.1. Descriptive Statistical Analysis

In order to test our proposed hypotheses, primary data was collected in the form of variable measurements by three judges. The ability to use this gathered data is dependent on its statistical reliability; variables can only be used if proven to have measured what they were designed to. Therefore, seven reliability tests were preformed to check for inter-rater agreement in the Complexity and Radicalness variables, and for five (Compatibility, Observability, Complexity of Use, Trialability, and Relative Advantage) of the Communication Index items[3].

- *Testing for inter-rater agreement in Complexity*

Item Statistics

	Mean	Std. Deviation	N
Judge1	1.8720	.79226	164
Judge2	1.6402	.68182	164
Judge3	1.6463	.74095	164

Table 1 – Item Statistics for judges' measurements of Complexity variable

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.557[a]	.472	.638	4.779	163	326	.000
Average Measures	.791	.728	.841	4.779	163	326	.000

Two-way random effects model where both people effects and measures effects are random.
a. The estimator is the same, whether the interaction effect is present or not.
b. Type C intraclass correlation coefficients using a consistency definition. The between-measure variance is excluded from the denominator variance.

Table 2 – Inter-rater Reliability Results for Complexity variable

Table 1 depicts the mean values of the measurements of complexity by judges 1, 2 and 3 for all 164 observations. The three means are quite similar in value, being Judge1's slightly higher (M_1=1.87) than the other judges' (M_2=M_3=1.64). This tells us that the variable in question is likely to be measuring what it is supposed to. But our confirmation of validity is shown by a statistically significant ($p < 0.05$) interclass correlation of ICC=0.79 (ICC > 0.7),

[3] The items "Visual" and "Hyperlink" were measured by a single judge, as they are not of a subjective nature.

which tells us the Complexity variable has been accurately measured and can be used in our analysis.

- *Testing for inter-rater agreement in Radicalness*

Item Statistics

	Mean	Std. Deviation	N
Judge1	1.8293	.72306	164
Judge2	1.5549	.76946	164
Judge3	1.9024	.80808	164

Table 3 – Item Statistics for judges' measurements of Radicalness variable

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.495[a]	.404	.582	3.942	163	326	.000
Average Measures	.746	.671	.807	3.942	163	326	.000

Two-way random effects model where both people effects and measures effects are random.
a. The estimator is the same, whether the interaction effect is present or not.
b. Type C intraclass correlation coefficients using a consistency definition. The between-measure variance is excluded from the denominator variance.

Table 4 – Inter-rater Reliability Results for Radicalness variable

Table 3 illustrates the individual means for the measurements of radicalness by all three judges, being Judge2's somewhat lower (M_2=1.55) than the rest (M_1=1.82 and M_3=1.90). Yet, average measures of interclass correlation of ICC=0.74 (ICC > 0.7) significant to a 5% level validate our variable and allows for its use in the testing of hypotheses.

- *Testing for inter-rater agreement in Compatibility*

Item Statistics

	Mean	Std. Deviation	N
Judge1	.8720	.33517	164
Judge2	.9512	.21607	164
Judge3	.8171	.38779	164

Table 5 – Item Statistics for judges' measurements of Compatibility variable

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.469[a]	.377	.559	3.653	163	326	.000
Average Measures	.726	.645	.792	3.653	163	326	.000

Two-way random effects model where both people effects and measures effects are random.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type C intraclass correlation coefficients using a consistency definition. The between-measure variance is excluded from the denominator variance.

Table 6 – Inter-rater Reliability Results for Compatibility variable

Measurement means of all three judges for the 164 observations are shown in table 5. Their similarity (M_1=0.87, M_2=0.95, M_3=0.81) leads to the interclass correlation of ICC=0.73 seen in table 6. As this value shows statistical significance ($p < 0.05$) and is over 0.7, one can assume the measurements for the Compatibility variable are valid and may be used for analysis.

- *Testing for inter-rater agreement in Observability*

Item Statistics

	Mean	Std. Deviation	N
Judge1	.8110	.39273	164
Judge2	.9329	.25091	164
Judge3	.7378	.44118	164

Table 7 – Item Statistics for judges' measurements of Observability variable

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.446[a]	.352	.537	3.411	163	326	.000
Average Measures	.707	.619	.777	3.411	163	326	.000

Two-way random effects model where both people effects and measures effects are random.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type C intraclass correlation coefficients using a consistency definition. The between-measure variance is excluded from the denominator variance.

Table 8 – Inter-rater Reliability Results for Observability variable

As seen in table 7, means differ among judges (M_1=0.81, M_2=0.93 and M_3=0.73), which tells us that measurements for Observability were not unanimous for some observations. However, a reliability test, presented in table 8, demonstrates an acceptable degree of correlation within classes (ICC=0.71). It is just over 70% thus this variable is considered reliable and may be used for our hypotheses testing.

- *Testing for inter-rater agreement in Complexity of Use*

Item Statistics

	Mean	Std. Deviation	N
Judge1	.7195	.45061	164
Judge2	.7927	.40663	164
Judge3	.8537	.35453	164

Table 9 – Item Statistics for judges' measurements of Complexity of Use variable

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.456[a]	.363	.547	3.519	163	326	.000
Average Measures	.716	.631	.784	3.519	163	326	.000

Two-way random effects model where both people effects and measures effects are random.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type C intraclass correlation coefficients using a consistency definition. The between-measure variance is excluded from the denominator variance.

Table 10 – Inter-rater Reliability Results for Complexity of Use variable

Means for the measurements of judges 1, 2 and 3 for Complexity of Use are represented in table 9, where some disparities can be observed (M_1=0.72, M_2=0.79, M_3=0.85). Nonetheless, average measures of interclass correlation shown in table 10 (ICC=0.72) prove the validity of the measurements to a level of significance of 5%.

- *Testing for inter-rater agreement in Trialability*

Item Statistics

	Mean	Std. Deviation	N
Judge1	.4207	.49519	164
Judge2	.4451	.49850	164
Judge3	.5305	.50060	164

Table 11 – Item Statistics for judges' measurements of Trialability variable

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.535[a]	.448	.618	4.457	163	326	.000
Average Measures	.776	.709	.829	4.457	163	326	.000

Two-way random effects model where both people effects and measures effects are random.
a. The estimator is the same, whether the interaction effect is present or not.
b. Type C intraclass correlation coefficients using a consistency definition. The between-measure variance is excluded from the denominator variance.

Table 12 – Inter-rater Reliability Results for Trialability variable

Item statistics for measurements of Trialability are depicted in table 11, where a similarity in means can be observed, being Judge3's (M_3=0.53) somewhat greater than the others (M_1=0.42 and M_2=0.45). A reliability test shows that there is a meaningful (ICC > 0.7) and statistically significant ($p < 0.05$) interclass correlation of ICC=0.78. Hence, this variable has been successfully measured and can be included in our data analysis.

- *Testing for inter-rater agreement in Relative Advantage*

Item Statistics

	Mean	Std. Deviation	N
Judge1	.3415	.47565	164
Judge2	.4390	.49779	164
Judge3	.2744	.44757	164

Table 13 – Item Statistics for judges' measurements of Relative Advantage variable

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.585[a]	.502	.662	5.227	163	326	.000
Average Measures	.809	.752	.854	5.227	163	326	.000

Two-way random effects model where both people effects and measures effects are random.
a. The estimator is the same, whether the interaction effect is present or not.
b. Type C intraclass correlation coefficients using a consistency definition. The between-measure variance is excluded from the denominator variance.

Table 14 – Inter-rater Reliability Results for Relative Advantage variable

The last variable to be tested for inter-rater agreement was Relative Advantage and, even though means vary quite substantially within judges (M_1=0.34, M_2=0.44, M_3=0.28), an interclass correlation of ICC=0.81 shown in table 14 tells us that this is the variable with highest consensus among raters and can thus be considered valid and used in future analysis.

Furthermore, the constructed communication index had to be tested for internal consistency:

- *Reliability Analysis of Communication Index*

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.897	.897	3

Table 15 – Cronbach's Alpha Reliability Statistics for Communication Index

Item Statistics

	Mean	Std. Deviation	N
Judge1	4.7744	1.33993	164
Judge2	5.1707	1.31350	164
Judge3	4.8232	1.36537	164

Table 16 – Item Statistics for Communication Index

Inter-Item Correlation Matrix

	Judge1	Judge2	Judge3
Judge1	1.000	.695	.786
Judge2	.695	1.000	.749
Judge3	.786	.749	1.000

Table 17 – Inter-Item Correlation Matrix for Communication Index

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Judge1	9.9939	6.276	.793	.644	.856
Judge2	9.5976	6.536	.764	.590	.880
Judge3	9.9451	5.966	.834	.698	.820

Table 18 – Item-Total Statistics for Communication Index

As can be seen in table 15, our constructed communication index has Cronbach's alpha coefficient of α=0.897, which proves its internal consistency, meaning this variable can be considered reliable. This interpretation is further justified by looking at table 16, where similar means among judges can be seen (M_1=4.77, M_2=5.17, M_3=4.82). In addition, table 17 illustrates strong positive inter-item correlations ($IIC_{1,2}$=0.70, $IIC_{2,3}$=0.75, $IIC_{1,3}$=0.79) and corrected high item-total correlations presented in table 18 (ITC_1=0.79, ITC_2=0.76, ITC_3=0.83) point towards the same conclusion of reliability. Thus, the scale is valid and the data is reliable, therefore it is justifiable to interpret scores that have been aggregated together.

	Low	Medium	High
Complexity	74	70	20
Radicalness	66	73	25

Table 19 – Independent Variables Frequencies

	1. Visual	2. Compatibility	3. Complexity of Use	4. Relative Advantage	5. Observability	6. Trialability	7. Hyperlink
Total	137	144	129	58	136	76	127
%	0.835	0.878	0.787	0.354	0.829	0.463	0.774

Table 20 – Communication Frequencies by Item

Tables 19 and 20 give us an overview of the Independent (Complexity and Radicalness) and Dependent (Communication Index) variables. We can see that most solutions fall under the Low and Medium categories both in degree of complexity and radicalness, whereas only 20 and 25 solutions, respectively, were considered to belong to the highest level.

Regarding the Communication Index, table 20 illustrates each one of the seven items that construct it and their individual total scores. Highest scores belong to the Visual (n_{visual}=137) and Compatibility ($n_{compatibility}$=144) elements and with only less than half of the observations answering positively to these questions, Observability and Trialability received the lowest scores, $n_{observability}$=58 (35.4%) and $n_{trialability}$=76 (46.3%), respectively.

4.2. Hypotheses Testing

H1 = The average quality of communication of patient innovations shared online is low.

Statistics

COMMUNICATION

N	Valid	164
	Missing	0
Mean		4.9230
Median		5.0000
Mode		5.67

Table 21 – Communication Statistics

COMMUNICATION

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.33	2	1.2	1.2	1.2
	2.00	1	.6	.6	1.8
	2.33	1	.6	.6	2.4
	2.67	6	3.7	3.7	6.1
	3.00	5	3.0	3.0	9.1
	3.33	5	3.0	3.0	12.2
	3.67	7	4.3	4.3	16.5
	4.00	17	10.4	10.4	26.8
	4.33	18	11.0	11.0	37.8
	4.67	12	7.3	7.3	45.1
	5.00	16	9.8	9.8	54.9
	5.33	11	6.7	6.7	61.6
	5.67	22	13.4	13.4	75.0
	6.00	17	10.4	10.4	85.4
	6.33	8	4.9	4.9	90.2
	6.67	9	5.5	5.5	95.7
	7.00	7	4.3	4.3	100.0
	Total	164	100.0	100.0	

Table 22 – Communication Frequencies

In order to test our first hypothesis, the mean, median and mode of our Communication Index were computed (table 21) and a frequencies table was plotted (table 22). A mean of M=4.92 out of a maximum possible score of 7 (~70%) tells us that patient innovators are not communicating as well as they could be. Any value below the optimal 7 is considered to be ineffective, as potential adopters make decisions on the basis of their evaluations of an innovation's characteristics. Hence, the non-communication of even one of these characteristics hampers the decision-making process and lowers likelihood of adoption. In table 22, we can see that only 25% of all 164 solutions are considered to have a communication index of 6 or higher and that a mere 4.3% are communicated effectively (scored 7 out of 7). This proves our hypothesis that patient innovations are not being effectively communicated and shared in designated online communities, which might be the cause for the little diffusion they experience.

H2 = Radical patient innovations have a higher quality of communication than incremental ones.

- *One-way ANOVA for Radicalness (IV) and Communication (DV)*

Descriptives

COMMUNICATION

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Low	66	4.3788	1.30362	.16046	4.0583	4.6993	1.33	7.00
Medium	73	5.1827	1.02753	.12026	4.9430	5.4225	2.67	7.00
High	25	5.6012	.91868	.18374	5.2220	5.9804	4.00	6.67
Total	164	4.9230	1.22024	.09529	4.7348	5.1111	1.33	7.00

Table 23 – Radicalness (IV) and Communication (DV) Descriptives

Test of Homogeneity of Variances

COMMUNICATION

Levene Statistic	df1	df2	Sig.
2.982	2	161	.053

Table 24 – Levene's Test for Radicalness (IV) and Communication (DV)

ANOVA

COMMUNICATION

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	35.971	2	17.985	14.007	.000
Within Groups	206.735	161	1.284		
Total	242.706	163			

Table 25 – One-way ANOVA for Radicalness (IV) and Communication (DV)

Post Hoc Tests:

Multiple Comparisons

Dependent Variable: COMMUNICATION

Tukey HSD

(I) RADICALNESS	(J) RADICALNESS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Low	Medium	-.80395*	.19247	.000	-1.2593	-.3486
	High	-1.22241*	.26612	.000	-1.8519	-.5929
Medium	Low	.80395*	.19247	.000	.3486	1.2593
	High	-.41846	.26259	.251	-1.0396	.2027
High	Low	1.22241*	.26612	.000	.5929	1.8519
	Medium	.41846	.26259	.251	-.2027	1.0396

*. The mean difference is significant at the 0.05 level.

Table 26 – Tukey HSD for Radicalness (IV) and Communication (DV)

Homogeneous Subsets:

COMMUNICATION

Tukey HSD[a,b]

RADICALNESS	N	Subset for alpha = 0.05	
		1	2
Low	66	4.3788	
Medium	73		5.1827
High	25		5.6012
Sig.		1.000	.199

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 43.573.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Table 27 – Summary of Tukey HSD for Radicalness (IV) and Communication (DV)

To put our second hypothesis to the test, we conducted a one-way ANOVA to test the impact, if any, of an innovation's radicalness on its quality of communication. Hence, we defined Radicalness as our independent variable (IV), made up of 3 levels (Low, Medium, and High) and used Communication as our dependent variable (DV). In order to be able to use ANOVA and obtain valid results, 6 assumptions have to be met. Namely, the DV must be continuous (0-7), the IV should consist of two or more independent groups (3), independence of variables should be verified, there should be no significant outliers and our DV should be approximately normally distributed for our IV.

After checking for these criteria, we conducted a Levene's test (table 24) to verify homogeneity of variances. With a p-value over 0.05 (p=0.053), the null hypothesis that variances across the three levels are the same cannot be rejected, which means we can proceed with our ANOVA analysis.

Just by looking at table 23, some differences can be seen among the means of the different groups (M_{low}=4.38, M_{medium}=5.18, M_{high}=5.60), yet only in table 25 can we confirm their statistical significance. With a significance of 0.00, we can reject the null hypothesis that there is no difference in means across the levels. Furthermore, by looking at the post hoc tests in tables 26 and 27, we can verify the statistical significance of mean differences between Low and Medium radicalness (p=0.00), as well as Low and High (p=0.00), but not among Medium and High levels (p=0.25).

Overall, this ANOVA tells us that radical solutions (high radicalness) have a higher communication score than incremental ones (low radicalness), proving our hypothesis that radical innovations are better communicated than incremental innovations.

> *H3 = The quality of communication of less complex innovations is higher than the quality of communication of more complex innovations.*

- *One-way ANOVA test for Complexity and Communication Index*

Descriptives

COMMUNICATION

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Low	74	4.4416	1.26921	.14754	4.1476	4.7357	1.33	7.00
Medium	70	5.2240	1.04051	.12436	4.9759	5.4721	3.00	7.00
High	20	5.6505	.92715	.20732	5.2166	6.0844	4.00	7.00
Total	164	4.9230	1.22024	.09529	4.7348	5.1111	1.33	7.00

Table 28 – Complexity (IV) and Communication (DV) Descriptives

Test of Homogeneity of Variances

COMMUNICATION

Levene Statistic	df1	df2	Sig.
1.826	2	161	.164

Table 29 – Levene's Test for Complexity (IV) and Communication (DV)

ANOVA

COMMUNICATION

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	34.075	2	17.037	13.148	.000
Within Groups	208.631	161	1.296		
Total	242.706	163			

Table 30 – One-way ANOVA for Complexity (IV) and Communication (DV)

Post Hoc Tests:

Multiple Comparisons

Dependent Variable: COMMUNICATION

Tukey HSD

(I) COMPLEXITY	(J) COMPLEXITY	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Low	Medium	-.78238*	.18980	.000	-1.2314	-.3334
	High	-1.20888*	.28689	.000	-1.8875	-.5302
Medium	Low	.78238*	.18980	.000	.3334	1.2314
	High	-.42650	.28863	.304	-1.1093	.2563
High	Low	1.20888*	.28689	.000	.5302	1.8875
	Medium	.42650	.28863	.304	-.2563	1.1093

*. The mean difference is significant at the 0.05 level.

Table 31 – Tukey HSD for Complexity (IV) and Communication (DV)

Homogeneous Subsets:

COMMUNICATION

Tukey HSD[a,b]

COMPLEXITY	N	Subset for alpha = 0.05	
		1	2
1.00	74	4.4416	
2.00	70		5.2240
3.00	20		5.6505
Sig.		1.000	.230

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 38.561.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Table 32 – Summary of Tukey HSD for Complexity (IV) and Communication (DV)

Finally, to test our third hypothesis about the impact of innovation complexity on quality of communication, we followed a similar approach as the previous one. We believe the one-way ANOVA is the best way to put our hypothesis to the test, as our IV (complexity) is three-folded (Low, Medium, High) and our DV (Communication) is a scale from 0 to 7. All 164 observations are independent, there is an absence of significant outliers and the DV is normally distributed among the three categories of complexity. A Levene's test in table 29 also validates the homogeneity of variances, as the null hypothesis cannot be rejected with a p-value of 0.164 ($p > 0.05$).

After checking all assumptions, the ANOVA (table 30) confirms a statistically significant difference between groups ($p=0.00$). A more detailed analysis present in tables 31 and 32 illustrates that mean difference of Medium and High levels of complexity are not significant ($p=0.30$), whereas between Low and the other two levels it is ($p=0.00$).

All in all, looking at the group means and knowing their significance, we can conclude that higher complexity levels lead to higher communication indices, which rejects our hypothesis that less complex innovations are better communicated than more complex ones. In fact, this analysis proves that quality of communication increases with innovation complexity ($M_{low}=4.44$, $M_{medium}=5.22$, $M_{high}=5.65$). Further analysis should be done to investigate the reason why.

5. Conclusions

The aim of this work is to explore the diffusion process of user innovations in the medical field. As diffusion and communication go hand in hand (Rogers, 1962), we felt it was appropriate to study communication as a tool to enhance diffusion and boost adoption by others. This thesis evaluates the quality of communication of patient innovators when sharing their solutions in designated online communities. Disparities in levels of communication among different innovation types were predicted and confirmed by our results.

The applicability of user innovations in the health sector is one of great social interest and a topic we feel deserves more research focus. Given the potential of this particular type of innovators, it makes sense to have a platform designed to give them a voice and showcase their solutions. However, putting someone up on a stage is useless if they do not know how to express themselves, which is why we strongly believe the principles of effective communication play a key role in the diffusion process of patient innovations shared in an online community.

As seen in our Results section (pp. 27-28), patient developed solutions are not being effectively communicated. The biggest contributors to an average low communication index (M=4.92) are the items Relative Advantage and Trialability (table 20), as they are not being communicated at all in most cases. Both these attributes, Relative Advantage in particular, have been positively correlated with adoption (Tornatzky and Klein, 1982), meaning they are crucial in the decision to adopt, or not, an innovation. Consequently, if these characteristics are not even expressed in the description of a new solution, its potential of adoption automatically decreases.

One major issue with the diffusion of user innovations is the lack of incentives to share (Kuusisto et al., 2013; von Hippel, 2005). Users develop with the purpose of self-benefit and rarely make the effort to share their solution with others. This behaviour happens not because user innovators are not willing to freely reveal their ideas, but instead because they are unable to see value in doing so. Research has shown how valuable to others, and to society as a whole, these consumer innovations can be, as the personal problems they solve might be similar to the ones faced by other consumers in the market. Henkel and von Hippel (2005) even classify the insufficient diffusion of user innovations as a welfare loss, because not disclosing these solutions is depriving, potentially, many others of benefiting from their use.

Given the high degree of experience-based knowledge combined with more easily accessible technical knowledge, these new solutions are bound to be highly innovative. Our analysis shows that people who develop more radical innovations place more effort into communicating their solutions, so that these can be better understood by potential adopters. The same is true for solutions with higher degrees of complexity. Reasons behind this phenomenon might be related to the fact that innovators of simple solutions see them as obvious and unworthy of detailed explanation.

With this work, we wish to inspire consumers to find solutions to their problems, when these are not available or in their reach. Teaching citizens the value of their personal experience and providing them with problem-solving tools to instigate their innovative and entrepreneurial side will most likely result in not only a more accomplished society, but also in economic gains. It is key to show innovators the importance of sharing their discoveries, which goes beyond monetary compensations, and to show them how to effectively communicate their ideas.

In practical terms, this study may help contribute to the increase in traction of the Patient Innovation website as well as the diffusion of the solutions in there shared. Currently, there is a lack of guidance regarding the sharing process; users are encouraged to do it, but a set of guidelines on how to do it successfully is not provided. Having effective communication theory in mind, we think this is one way of boosting diffusion, as more people will be able to successfully receive and understand the message being transmitted. Furthermore, users should be frequently reminded of the importance of their work and incentives should be established in order to feed their innovative conduct.

5.1. Limitations

The first limitation of this study is the sample, as the categorization process left us with different-sized groups. A broader sample would have granted results of higher statistical significance. Secondly, only three people were asked to rate the solutions, which in retrospective might not have been enough to eliminate bias. More raters would likely have yielded more reliable results. Finally, no data regarding adoption measures of the shared patient innovations was available to us, which would have helped to test our hypotheses and further support our conclusions.

5.2. Future Research

Studying adoption potential should be a predictive research, meaning forecasts should be made prior to implementation in order to avoid bias. Thus, a longitudinal study would be ideal to test the hypotheses and apply the model used in this thesis. Future research should be done to evaluate the conclusions of this study, by measuring the actual adoption rates of the innovations studied based on their levels of quality of communication. Furthermore, another study should be designed to explore why complexity impacts communication quality in a positive way. Moreover, it would be interesting to study the profiles of the innovators as an explanation behind their innovations.

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