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# User Innovation in Healthcare

## A perspective across developing countries

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## Abstract

The healthcare sector faces vital challenges, on the one hand the spread of chronic diseases at a global scale. On the other hand, rising delivery costs in healthcare create a necessity for innovation.

Research show patients and caregivers as one of the sources for innovation in healthcare, by self-providing treatments, therapies or medical devices to better cope with their unmet needs, imposed by health disorders commercially unattractive for medical manufacturers' investment (Oliveira et al., 2015).

Van der Boor et al. (2014) concluded that high levels of need, the existence of flexible platforms, and the access to information and communication technology, contribute to the occurrence of this phenomenon in the developing world.

Our research questions are: What are the major drivers for user innovation in healthcare, in developing countries? Which socio-economic factors influence user innovations development in these countries? Which local complementary assets affect entrepreneurship? To what extent can user solutions, created in developing countries, be adopted in developed regions?

We applied a multiple case-study method, conducting eleven semi-structured interviews and four surveys of "patient innovators" from 13 developing countries.

86.7% of the innovations were developed by users with a clear perception of the fragile conditions in the analysed countries. Reputation achieved amongst their communities was recognized by users as another major driver (46.7%). The most problematic socio-economic factor verified is healthcare, where 86.7% of user innovators reported issues. 66.7% of users rely on complementary technologies as the major complementary asset. Furthermore, 20.0% sample solutions could be adopted by developed countries.



**Keywords:** *user innovation*, *healthcare*, *developing countries*, *complementary assets*, *socio-economic factors, reverse innovation*.

## Resumo

O setor da saúde enfrenta desafios vitais, por um lado devido ao alastramento global de doenças crónicas. Por outro, devido aos aumentos nos custos da saúde, gerando-se uma necessidade de inovação.

Estudos mostram doentes e cuidadores como uma das fontes de inovação, ao criarem tratamentos, terapias ou dispositivos médicos para lidar melhor com as necessidades não atendidas, impostas por problemas de saúde comercialmente pouco atrativos para investimentos dos fabricantes médicos (Oliveira et al., 2015).

Van der Boor et al. (2014) concluiu que altos níveis de necessidade, existência de plataformas flexíveis e acesso a tecnologias da informação e comunicação, contribuem para a ocorrência deste fenómeno no mundo subdesenvolvido.

As questões de investigação são: Quais os principais fatores para a inovação de doentes utilizadores, nos países subdesenvolvidos? Que fatores socioeconómicos que influenciam o desenvolvimento de inovações por utilizadores nesses países? Que ativos complementares locais que afetam o empreendedorismo? Em que medida estas soluções, criadas em países subdesenvolvidos, poderão ser adotadas em regiões desenvolvidas?

Aplicamos um método de estudo-de-caso múltiplo, com quinze entrevistas semiestruturadas e quatro questionários de "doentes inovadores". A amostra é composta por 13 países subdesenvolvidos.

86.7% das inovações foram desenvolvidas por utilizadores conscientes das condições frágeis nos países analisados. A reputação que utilizadores inovadores adquirem nas suas comunidades é outra das motivações (46.7%). A saúde é o fator socioeconómico verificado mais problemático, 86.7% dos inovadores reportaram problemas. 60.0% dos utilizadores apostam em marketing e/ou tecnologias complementares como ativos complementares. Além disso, 20.0% destas inovações podem ser adotadas por países desenvolvidos.



**Palavras-chave:** *inovação por utilizadores*, *saúde*, *países subdesenvolvidos*, *ativos complementares*, *fatores socioeconómicos, inovação reversa*.

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*Without all of them, these pages would be empty!*

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## List of Acronyms

BRICS – Brazil, Russia, India, China and South Africa

DRC – Democratic Republic of Congo

EL – Education Level

GDP – Gross Domestic Product

GNI – Gross National Income

HDI – Human Development Index

HIC – high-income country

ICT – Information and Communications Technology

IHD – Ischemic Heart Disease

IPR – Intellectual Property Right

LIC – low-income country

OECD – Organization for Economic Cooperation and Development

pc – per capita

SMS – short message service

UK – United Kingdom

UN – United Nations

USA – United States of America

WHO – World Health Organization

# 1. Introduction

Patients constitute the largest group of stakeholders in the healthcare sector, furthermore Habicht, Oliveira and Shcherbatiuk (2012) noticed that the current services' provision often fails to meet their needs. Several studies (Greco & Eisenberg, 1993; Shortell, Bennett & Byck, 1998; Shortell et al., 2001) concluded how difficult is to change the clinicians' behaviors, the current medical practices, and the healthcare organizations, Faulkner & Kent (2001) added that, oftentimes, this happens due to regulations imposed by laws. Additionally, the rising costs on health and long-term care will continue to put pressure on public budgets over the next decades. In 2014, the percentage of Growth Domestic Product spent on public health along Organization for Economic Cooperation and Development (OECD) countries was, on average, 7.7%[i] of the total healthcare expenditure (12.4%[ii]).

Innovation is seen as a critical way of improving the health systems' ability to address the problems of aging populations and the rise of chronic diseases, while containing escalating costs (OECD, 2011b). Zaltman et al. (1973) consider innovation as a crucial component of productivity and competitive survival. As the changing global economy generates further fiscal and social pressures, additional reform approaches will be necessary (OECD, 2011a). Herzlinger (2006), after an unsuccessful exploration on the reasons behind healthcare innovations, suggested a strategy that would make healthcare better and cheaper. This strategy consists of "*breaking down*" the problems by look at the different types of innovations and forces affecting them, like policy makers, or consumers.

Von Hippel (2005) explored consumers as a source of innovation by making use of Adam Smith's statement in 1776, "*a great part of the machines made use of in those manufacturers in which labor is most subdivided, were originally the invention of common workmen (...)*". These workmen are defined by von Hippel (1976) as *user innovators*, the ones that "*invented, prototyped and field-tested instruments*".

We find this phenomenon's presence across different industries (Enos, 1962; Freeman, 1968; Riggs & von Hippel, 1996; Tietz et al., 2004; Lüthje, Herstatt, & von Hippel, 2005; Baldwin, Hienerth, & von Hippel, 2006; Oliveira & von Hippel, 2011), either in product novelties (consumer or industrial), or services. User innovators begin by developing solutions for personal use, without considering the value of them for others (Zejnilović, Oliveira, & Canhão, 2016).

One particular field where user innovation has given signs of its existence and importance is healthcare (Habicht et al., 2012; Oliveira & Canhão, 2014; Oliveira et al., 2015;

[i] http://bit.ly/2rOv3RN
[ii] http://bit.ly/2rLDVrY

Zejnilović et al., 2016; von Hippel, 2016). Patients and caregivers are the ones who know best their difficulties and challenges caused by health conditions (Habicht et al., 2012). Through a sample with 500 rare diseases patients and caregivers, Oliveira et al. (2015) observed that 8% were considered as introducers of new solutions to the world.

When looking at the geographic origin of innovations, researchers have also explored the role of users as innovators in developing countries. Van der Boor, Oliveira and Veloso (2014) verified, through a study on mobile banking services, that as users in developing markets increasingly have access to many of the same technologies, the opportunity for possible innovations expands on the user's side. The same authors (2014) even observed that three-quarters of the innovations, originated from developing countries, have already diffused to developed ones. As an example, the case of Gatorade® (Govindarajan & Trimble, 2012) prove that solutions created on the developing side can have an impact on the developed world. This liquid's recipe was created in Bangladesh to be used in cholera victims for rapid rehydration, and later on adopted by the Western world as an energy drink.

Considering need as a determinant driver for innovation and developing countries as high-need environments, this study aims to examine the extent to which patients and caregivers (*users*) innovate in these regions, the socio-economic factors that influence these innovations, and the assets these innovators acquire in order to diffuse.

It is of major importance to understand the concept of *reverse innovation*, how it occurs, and its impact. With this in mind, our research proposes to answer the following questions:

- **Research Question 1:** What are the major drivers for user innovation in healthcare, in emerging countries?
- **Research Question 2:** Which socio-economic factors influence user innovations in these countries?
- **Research Question 3:** Which local complementary assets affect entrepreneurship?
- **Research Question 4:** To what extent can user solutions, created in developing countries, be adopted by developed regions?

The structure of this dissertation is the following: the coming section comprises a review on the existent literature, which served as basis for our research. Then, we present the methodology used, including the coding used to evaluate user driven solutions. Chapter four brings the major findings, supported by evidence obtained from the sample. Lastly, we will retrieve the major outcomes, present limitations confronted during the study, and suggest recommendations for further research.

# 2. Literature Review

This section aims to inspect the current available literature that explains and supports the patient innovation phenomenon. This enables to analyse the existent theory at our disposal, to verify the academic application on this matter and provide cases of novel solutions developed by users.

First, we present an overview on the current state of the socio-economic conditions within the healthcare system, particularly addressing developing countries, and exposing the major problems amongst these regions. Subsequently, we scrutinize what to expect for this sector.

Afterwards, we introduce the user innovation concept, by giving a notion of its importance and providing evidence of its existence throughout numerous fields. Moreover, we provide literature on the user innovation process stages and the user entrepreneurial concept. Regarding the presence of this phenomenon in the healthcare system, we presented literature allowing to understanding why patients, caregivers and collaborators innovate and why this is becoming important for the academic society. Ultimately, we introduced literature on user innovation across developing countries, helping us to understand the users' major motivations, and adopted processes, to innovate. Within this, we examined and explored the reverse innovation phenomenon.

## 2.1. Healthcare System

Notwithstanding, the exponential advancements in technology that are transforming healthcare (Taylor, 2015), this sector is still consuming an escalating share of income in developed and developing nations alike. In a world where public health expenditure in OECD countries represents 6.7% from the 9.3% of total health expenditure (OECD, 2011a), major findings can help to the cost savings policy that can be followed.

There are both demographic and non-demographic reasons for these rising costs. Whilst, the demographic ones relate broadly to the age structure of the population and the evolution of its health status, the critical non-demographic driver is income (OECD, 2013). In this mode, OECD average health expenditure to GDP ratio is projected to more than double between 2010 and 2060, whereas regarding BRICS is set to more than triple (OECD, 2013).

On average, across OECD countries, about 20% of health spending is paid directly by patients, which can create barriers to healthcare access (OECD, 2015a). As an illustration, and considering the low-income households, OECD (2015a) reported that are four to six times more likely to present unmet needs for medical and dental care due to financial or other

reasons, than those with higher income.

The current healthcare system rewards innovation that prolongs life (Habicht et al., 2012). Indeed, advances in this sector have been made, still, in many countries there is room to implement best practices in acute care, further reducing mortality (OECD, 2015b). However, improvements should be done carefully and technology can be overused, if offered to patients for whom innovations provide no benefit (Bodenheimer, 2005).

OECD (2011a) advises that a structural pressure is the long-term fundamental shift of wealth creation, away from developed nations towards emerging economies, meaning that the most developed nations should attribute more funds to less developed nations.

### 2.1.1. Healthcare in Developing Countries

Many people along the developing world still live without access to healthcare, from which they could benefit greatly (O'Donnell, 2007). Akin et al. (1987) observed that, in 1983, low- and middle-income countries experienced, on average, infant mortality rates about eight times higher than the industrialized countries. Furthermore, there are large discrepancies between rich and poor in these underprivileged countries with respect to health and education outcomes (Devarajan & Reinikka, 2004). In addition, O'Donnell (2007) stated that effective healthcare interventions are underutilized across developing nations.

Additionally, incentives for effective healthcare delivery are scarce and, as the nature of health problems change, the effect on the population's overall health condition will be difficult to verify (Jack, 1999). As an example, Devarajan and Reinikka (2004) conducted a survey on primary healthcare facilities in Bangladesh and found a doctors' absenteeism rate of 74%.

Besides the efforts that are being made, such as health financing, price subsidies, and poverty alleviation programs, O'Donnell (2007) stressed that the difficulty lies on detailed policy initiatives' design, aiming to tackle root problems within severe economic, institutional, and political constraints. The vested interests that block the poor's access to better services will not be overcame, along with a limited capacity that unable the adoption of these radical changes (Devarajan & Reinikka, 2004).

Indeed, Ranck (2011) discovered that the communication gap between managers of health services, health workers at the periphery and the patient population they serve, has been a barrier to an efficient service delivery. Meanwhile, the widespread use of SMS, the least-expensive mobile phone function, offers a solution that could rapidly overcome communication weaknesses, potentially leading to improved delivery of health services and better health outcomes (Zurovac, Talisuna, & Snow, 2012). Conclusions from the study

promoted by Déglise, Suggs and Odermatt (2012) showed that text messaging seems to improve the process of care and was well accepted by both health workers and the targeted population. The majority of users and beneficiaries were familiar with mobile phones and SMS for private and professional use, and technology was reliable.

Some modern health innovations, especially technological advancements, have been inaccessible to developing countries for much of the 20th century because of both financial constraints and general lack of infrastructures. Harvey et al. (2014) noticed the change over the past decade, major healthcare companies started to look to the developing world in order to compensate slow growth in more developed nations. Consider the portable ultrasound machines' example, they were originally produced to meet urgent diagnostic needs in resource-limited war zones, but manufacturers soon recognized their potential to diagnose gaps in resource-limited settings within the developing world. Albeit small-cap ultrasound manufacturers were the first to explore this market, more recently, large-cap imaging equipment manufacturers entered this market, by offering their own portable low-cost ultrasound models (Harvey et al., 2014).

Notwithstanding, the alert given by O'Donnell (2007) for the urgent need to establish mechanisms that would increase the availability and improve the quality of healthcare in the developing world, there are many innovations in regulation of care holding promising to improve access for the most needed (Peters, 2008).

These regions have the potential to greatly improve health service efficiency, expand or scale up treatment delivery to thousands of patients in developing countries, and improve patient outcomes (Blaya, Fraser, & Holt, 2010).

For O'Donnell (2007), lowering the barrier of distance is of crucial need, although it requires either taking people to services or services to people.

### 2.1.2. Healthcare Perspectives

Innovation is seen as an important path to follow in order to increase the system's efficiency, thus lowering the costs (Robinson & Smith, 2008).

Akin et al. (1987) summarized the three main problems in the healthcare sector: firstly, the insufficient spending on cost-effective health programs, which translates into an allocation problem; secondly, poor quality public healthcare programs, reflecting inefficiency; last but not less important, an inequitable distribution of health services' benefits.

By making a comparison with the field of consumer goods, von Hippel (2016) described the possibility of complementing the traditional, expert-driven model of public health intervention development with a health intervention model that builds upon solutions

developed by the public. The same author (2016) stated this could be one of the ways to improve efficiency in a field desperate for a cost saving model.

Despite the lack of infrastructure and backup systems in resource-poor environments, well-designed e-health solutions may have a much larger impact on the quality of care than in more developed areas (Blaya et al., 2010). Thus, any new opportunity that may improve individual well-being and address to the cost issue is warmly welcomed by healthcare stakeholders (Zejnilović et al., 2016).

Examples like reliable home tests for pregnancy and HIV, administered by patients, or laparoscopic instruments that empty the hospital's operating rooms in favour of ambulatory facilities (Robinson & Smith, 2008), are two innovative examples within this field.

## 2.2. User Innovation

Amabile (1997), broadly described innovation as something novel and useful, earlier Porter (1990) stated that innovation include either new technologies or new ways of doing things. Hence, it is something new that breaks into the market or society, and defined as something original and more effective (Frankelius, 2009).

According to Bogers, Afuah and Bastian (2010), the user innovation concept started to be developed in the 1970s. Von Hippel (1976) acknowledges these users as the ones that "*invented, prototyped and field-tested instruments*", other than manufacturers. The same author (2005) distinguishes users from manufacturers, being the first "*firms or individual consumers that expect to benefit from using a product or a service*", contrasting with manufacturers that *"expect to benefit from selling a product or a service*".

Users exploiting products as inputs in their innovation processes, or using products to satisfy their personal needs, are considered user innovators (Bogers et al., 2010). This type of users, at a first stance, must have a strong unfulfilled need (Urban & von Hippel, 1988), not likely to be solved by others (Morrison, Roberts, & von Hippel, 2000), and they need to possess "*local*" and valuable information for the innovation (Lüthje et al., 2005).

Von Hippel (1986, 2005), and Urban and von Hippel (1988) go further and defined *lead users*, as the ones who find future general needs, as the marketplace face the same needs months or years after them. Lead users can provide both new product concept and design data to the market (von Hippel, 1986). Lüthje (2004) classified lead users as the ones that provide sources of new service ideas with high commercial potential. In addition, Oliveira and von Hippel (2011) classified a service innovation as user-developed if the developer expects to "*benefit from use*", and provider-developed if it expects to "*benefit from sales*".

Altogether, Enos (1962) reported that nearly all the most important innovations in oil

refining were developed by user firms; Freeman (1968) found that the most widely licensed chemical production processes were improved by final users; von Hippel (1976, 1988) noticed that users were the actual developers of 82% of all commercialized scientific instruments and 63% of all semiconductor and electronic subassembly manufacturing equipment innovations; Pavitt (1984) discovered that a considerable number of inventions by British firms were for in-house use; Shah (2000) identified that the most commercially important equipment innovations in four sporting fields have been developed by individual users.

It is becoming increasingly easier for many users to get what they want by designing it for themselves (von Hippel, 2005). Users are getting more access to tools and technologies, like cell phones and Internet, allowing them to solve problems in novel ways (Baker & Nelson, 2005), the costs for users to overcome a variety of unmet needs are greatly reduced (Van der Boor et al., 2014).

Von Hippel (2005) defends that products, services, and processes developed by users become more valuable to society if diffused to others who can also benefit from them. Oftentimes, innovators freely reveal their solutions because it is the best or the only practical option available to them, and provide innovators with significant private benefits (von Hippel, 2005). Raymond (1999) found that users who freely reveal what they have done often find that others improve or suggest improvements to the innovation, for mutual benefit, just then they diffuse either within peer-to-peer networks, or through a producer that offers the innovation in a market (Harhoff, Henkel, & von Hippel, 2003; Baldwin et al., 2006; De Jong et al., 2015).

The available literature on user innovation (Enos, 1962; Freeman, 1968; Pavitt, 1984; von Hippel, 1988; Shah, 2000) has proven this phenomenon exists across different fields. Take the following studies as examples: after studying the role of users in software development, Voss (1985) discovered the circumstances in which users lead the development of new applications; Riggs and von Hippel (1996) examined an early form of electronic home banking that utilized a telephone channel between customer and bank, relating it with the user development of novel banking services; Oliveira and von Hippel (2011), based on a sample of all important retail and commercial service innovations commercialized by banks between 1975 and 2010, built the first study on the role of user innovators in the development of new financial services.

A more recent phenomenon was reported by von Hippel (2016). *Free innovation* consists of innovations developed and given away by consumers as a "*free good*", resulting in social welfare improvements. As the author defends (2016), free innovation is not money-driven,

and incorporates two criteria: on one hand, has to be developed by consumers at private cost and during leisure time. On the other hand, can be potentially acquirable by anyone without payment. All in all, free innovators benefit from such innovations through the fun and learning from developing them.

### 2.2.1. Drivers in User Innovation

Considerable research (Franke, von Hippel, & Schreier, 2006; Urban & von Hippel, 1988) showed that individual need is often a more important driver for innovation by users, than potential market size. Following this, users may innovate if they are able and willing to pay for the development of something that is not available on the market (von Hippel, 2005). Oftentimes customer needs in a given market are heterogeneous, in addition standard products available in the marketplace repeatedly leave important needs unfulfilled (Franke & von Hippel, 2003).

As noted, transfer information from the users' side to manufacturers can be costly and it might not be accurate, known as "*sticky*" information (von Hippel, 1994). Von Hippel (1998) and Kuusisto et al. (2013) concluded it is more appropriate for users to solve their own needs instead of depending on "*manufacturer-based*" solutions.

"*Local solution information*" is another driver for user driven innovations, verified through a study on innovations from mountain bikers by Lüthje et al. (2005). Stickiness of either need or solution knowledge diminishes the opportunity to find a solution for a given problem (Kuusisto et al., 2013).

In their studies, Lerner and Tirole (2002), and Lakhani and von Hippel (2003), consider "*local technical knowledge*" as a driver for the creation of user innovations. The acquired enjoyment as users perform an innovation activity, whether by fun or to increase the required knowledge associated to the solution, constitute an incentive for users to came up with solutions (Lakhani and von Hippel, 2003). Moreover, the reputation derived from making high-quality contributions to the community is also perceived as a driver to develop user solutions (Rheingold, 1993; Constant, Sproull, & Kiesler, 1996; Raymond, 1999; Lerner & Tirole, 2002; Lakhani & von Hippel, 2003). Through a study on user innovations across the consumer goods industry, Lüthje (2004) noticed the level of experience and expertise with a solution's technicality increases the likelihood to innovate.

### 2.2.2. The process behind User Innovation

As Røtnes and Dybvik Staalesen (2009) concluded, from a study on Nordic countries, the innovation process can vary from user to user, and it goes through distinctive innovation stages.

Every process starts with a need and an identification of the problem that users face (Kuusisto et. al, 2013). Afterwards, the innovation process starts, comprising four stages: *ideation*, *specification*, *implementation*, and *diffusion* (Kuusisto et. al, 2013; Lüthje, 2004; Lüthje et al., 2005; Baldwin et al., 2006; von Hippel, 2005; Shah, 2000).

The ideation phase is characterized by the moment where users idealize a product, service, or strategy, enabling to overcome the problem, formerly identified as such. Users have the idea on their minds but do not "*drawn it up*" (Lüthje, 2004).

Moving to the following stage indicates there was a planification of the idea, such as a draw, or a model, indicating that the user has followed up the first step and is able to describe the solution and how to develop it (Oliveira, 2014). This is called specification and implies there is not yet a final product, however might have been already some experimentation.

Subsequently, we have the development of the solution, in which user innovators materialize what has been idealized in the previous stages and is ready to be used, whether as a basic or an advanced structure. Von Hippel (2005) states the solution can be something existent, used with other purpose, an incremental adaptation/innovation, something novel, or an existing solution adopting a low-cost approach. This step regards just to a personal use, meaning that no diffusion of the solution has been made (Oliveira, 2014).

Finally, and after the user experienced personally the solution, it makes an effort to communicate the novelty to others.

### 2.2.3. User entrepreneurs

Usually, after becoming innovators, users decide between selling their ideas to established manufacturers, create a venture with them, or settle a company and start selling their own products or services (von Hippel, 2005). This latest option is known as user entrepreneurship and, as von Hippel (2005) stated, after obtaining a benefit from using a developed product or service, users can opt for the commercialization of their solutions, profiting from them. This type of entrepreneurs contrast with the remaining as the latter are only focused on financial benefits derived from solutions developed (Shcherbatiuk & Oliveira, 2012).

After analysing the behaviour of user innovators in three countries, von Hippel, Ogawa and de Jong (2011) concluded that users who develop innovations do not need a superior effort to become "*casual entrepreneurs*". As these same authors (2011) defend, user driven innovations are becoming common and easier, thus they do not need to give up from their careers.

It has been studied (Shah & Tripsas, 2007; Amit, Muller & Cockburn, 1995) there is a higher probability to have users entering in industries that offer higher levels of enjoyment (regardless the economic benefit, like the case of producers) and lower opportunity costs.

We can find available literature on this topic across distinct industries: in the microcomputer and stereo components (Langlois & Robertson, 1992), within radical sports (Shah, 2000), or along the mountain bicycle business (Lüthje et al., 2005).

### 2.2.4. User Innovation in Healthcare

Goeldner & Herstatt (2016) distinguish professional users (physicians and nurses) from non-professional users (patients and relatives). Bearing this in mind, Habicht et al. (2012) characterize patient innovators as those who come up with novel treatments, strategies, and medical or non-medical equipment to help them better cope with their diseases. Within this field, user innovators face particular needs, which serve as drivers for the creation and development of solutions (Habicht et al., 2012), these drivers will be extensively covered along the methodology section.

Rare diseases' patients tend to be underserved both clinically and scientifically (Griggs et al., 2009). Aiming to find possible solutions for this problem, Oliveira and Canhão (2014) stressed that, oftentimes users "*can serve themselves*". Thus, users might be recognized as innovators in regards to services they deliver to themselves.

An enquiry (von Hippel et al., 2014; De Jong et al., 2015) estimates that 4 to 6% of US, Japan, Finland, and the UK citizens modify or create new products and services for personal use, and up to 7% of these innovations are classified as healthcare products. Furthermore, from a study with 500 rare diseases' respondents, Oliveira et al. (2015) portray that 36% of the respondents claim they have innovated, which after validation from two medical experts, 8% were considered to introduce something new to the world. These authors (2015) also reported a positive relationship between the impact of a solution on the respondents' overall quality of life, and likelihood of solution sharing. In addition, Oliveira and Canhão (2014) noted an inverted U relationship between age and solution sharing.

Although qualitative research (Frydman, 2009) found that patients and caregivers are the drivers of institutional research, Oliveira et al. (2015) concluded they have also invented countless valuable solutions in order to improve their own personal health conditions. Oliveira and Canhão (2014) described the case of Tal Golesworthy, a process engineer who, in 1992, was diagnosed with Marfan Syndrome, a rare disease resulting in a decreasing functionality and resilience of the aorta. He reached to a point when surgery was inevitable, forcing him to a lifetime anticoagulation therapy. As an engineer and with technical

knowledge, he decided to create a more suitable solution for himself, and invented the External Aortic Root Support (EARS), matching the patient's aorta and eliminating the need for anticoagulant drugs.

Many evidences of innovations by patients made a strong impact on disease related practices, some representing state-of-the-art technology (Habicht et al., 2012; Oliveira et al., 2015). However, research (Habicht et al., 2012; Oliveira & Canhão, 2014; Oliveira et al., 2015) defends this matter is not sufficiently explored, yet.

### 2.2.5. User Innovation in Developing Countries

Need is crucial towards innovation, in two ways: on one hand, high levels of need increase the number of user innovators (Urban & von Hippel, 1988; Franke et al., 2006). On the other hand, high need increases diffusion rates due to the growing potential market size (Mansfield, 1968; Geroski, 2000). Unique market needs and scarcity of alternatives can lead to valuable innovations from developing regions (Van der Boor et al., 2014).

To the best of our knowledge, just a few studies (e.g. Govindarajan & Trimble, 2012; DePasse & Lee, 2013; Van der Boor et al., 2014; Snowdon et al., 2015) have been done up to now, to understand this phenomenon in developing regions.

Van der Boor et al. (2014), from their study on mobile banking services, concluded that 85% of the innovations within this field were originated from emerging markets. By perceiving that innovations occur more often in places where need is high, corroborates the finding that the majority of innovations are stimulated by market needs, rather than technological opportunity (Utterback, 1974; Hipp, & Grupp, 2005).

If we take the study from Acemoglu and Linn's (2004) as example, we conclude that a larger potential market size for a new drug, leads pharmaceutical firms to invest more in its development. This perspective shows that investment decisions are skewed towards the most developed and rich markets, instead of addressing people and issues with higher needs (Van der Boor et al., 2014).

Studies performed previously (Schmookler, 1966; Mansfield, 1968; Mowery & Rosenberg, 1979), verify a positive relation between expected benefit from innovation and investment to innovate. After a study on the pharmaceutical industry, Trouiller et al. (2002) considered that, not only the levels of investment are lower in markets with a lower potential for profits, but the quantity of commercialized drugs for malaria is also smaller. With this description in hand, it is more likely to find a wider range of unmet needs, as well as customers who potentially create solutions to meet their own needs (Van der Boor et al., 2014). As is the case of developing markets, where the portfolio of commercially offered

products and services is typically smaller and of lower quality (Flam & Helpman, 1987; Trouiller et al., 2002).

By having as starting point the previously mentioned drugs for malaria's case, Van der Boor et al. (2014) listed the main contributors to innovations in these countries as the high level of need, the existence of flexible platforms and an increasing access to ICT.

Considering the case studied by Sternin and Choo (1999) on Vietnamese childhood malnutrition, where the innovators were the mothers of malnourished children and the consequences of their poor food regime triggered the need to innovate. Aiming to tackle their kids' problem, they changed the children's food habits and improved their quality of life. After these results, the approach to deal with the problem was diffused into other regions like Bangladesh, Bhutan, Egypt, Mali, Mozambique and Nepal. In line with this, Van der Boor et al. (2014), found that services developed by users diffused at more than double the rate of producer-innovations.

#### 2.2.5.1. Reverse Innovation

Several studies (Flam & Helpman, 1987; Grossman & Helpman, 1991) found evidence of a conversion in quality regarding North and South, across some industries. This reality, along with a lag reduction between industries in both regions, presents a higher possibility that products and services created in the South will also be new to the world (Van der Boor et al., 2014), known as *reverse innovation*.

Literature (Immelt, Govindarajan & Trimble, 2009; Govindarajan & Trimble, 2012) defines reverse innovation as a process firstly adopted in developing regions and then in the developed world.

Altogether, Van der Boor et al. (2014), observed that three-quarters of the innovations originated from emerging markets have been diffused to OECD countries. Consider the Ushahidi's case (DePasse & Lee, 2013), a crowdsourcing program used to map disaster impact and response (firstly used during the 2008 Kenyan presidential election and subsequently applied in 2010's Haitian earthquake's aftermath). After the success in these low-income countries settings, "*crossed over*" to USA (high-income country), aiming to monitor infrastructure damage during hurricanes.

Reverse innovation can be successful due to the unique characteristics of developing countries that provide powerful incentives, or "*gaps*", leading to innovation (DePasse et al., 2016).

In order to sum up this phenomenon, DePasse and Lee (2013) designed a model to be applied in the healthcare field, presented in Figure 1 (DePasse & Lee, 2013). Composed by

four steps, these authors (2013) describe them. Being the first an identification of the problem, a high-priority complication common to both low income countries and high income countries, and subject to more favourable innovation conditions in the lower-income setting. The second one consists of LIC innovators that develop and test new ideas, and then share these solutions with LIC early adopters. Thirdly, there is "*cross-pollination*" from lower- to higher-income settings. Lastly, HIC early adopters will be more likely to embrace it.

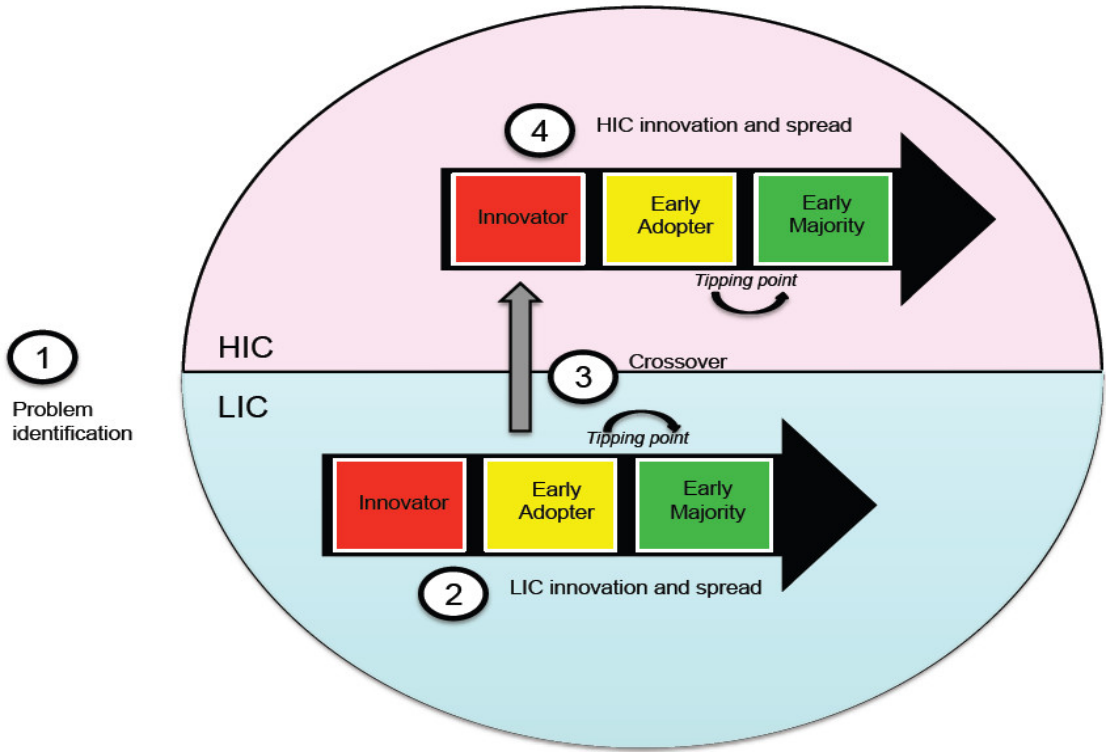



**Figure 1 - A model for reverse innovation in health care**

# 3. Research context and methods

This study was conducted through a multiple case-study method, defined by Yin (1984, 2009) as an "*empirical inquiry that investigates a contemporary phenomenon within its real-life context*". The same author (1984, 2009) recommends this approach when there is no clarity on the boundaries between phenomenon and context, and when a variety of evidence sources have been used.

Figure 2 outlines the methodology applied along the current research.


**Figure 2 - Methodology used**

## 3.1. Approach

Research (Yin, 1984; Eisenhardt, 1989; Leonard-Barton, 1990) shows the case study method is the most accurate when addressing to complex phenomena, which are not carefully studied or entirely understood. Taking into account that our research enquiry consists of "*how*" and "*why*" type of questions, Yin (1984) considers this method as the one to be applied. All in all, the presence of user innovations in healthcare, particularly in developing countries is, to the best of our knowledge, largely unexplored by user innovation theory in general. Hence, we chose this method in order to validate the current literature on this matter, or to start considering new theory that might be supported through empirical research.

This particular approach can be exploratory, explanatory, or even descriptive (Yin, 1984). The structure chosen was an exploratory one, which refers to a research handled for a problem that has not been studied clearly (Shields & Rangarjan, 2013).

The case study method can acquire either the form of single or multiple case designs (Yin, 1984), being the later preferred by having a greater capacity to be externally validated (Dul & Hak, 2007).

## 3.2. Country Selection

The list of countries under analysis was chosen taking into account the different levels of development worldwide, and whether they were accurate representatives of the developing

countries' characteristics socio-economic characteristics. Thus, we opted for using the country classification lists by the World Bank and the UN, referent to 2016. We chose not to focus just on the economic criteria but to address other conditions as well. Consequently, we followed the UN Development Programme's Country Classification System, built from the Human Development Index to capture the multifaceted nature of development (Nielsen, 2011).

Sullivan and Sheffrin (2003) considered a developing economy, or less developed country, as a nation with a relatively less developed industrial base and a lower HDI. Considering this, we decided to analyse one economic criteria and nine social indicators. A definition of each is provided on Exhibit 16.

With these measures, we have reached to a final list of 54 countries across Africa, Asia and South America (Exhibit 17).

### 3.3. Innovations Selection

We encompassed the grounded theory to collect data. Amongst all the discovered innovations, only the ones created to solve a personal need, a need of a relative or close friend, or by persons facing a general need in their community, were considered. We coded them as patients, caregivers, or collaborators, respectively, having as base the definitions provided by von Hippel (2005, 2016) and Habicht et al. (2012). Although this led to a reduced number of innovations validated, it led to more reliable findings, considering the theory on user innovation.

Our search was mainly online, through search engines like Google and DuckDuckGo, using combinations of keywords such as "came up with", "create to help", or "developed". Besides, worldwide newspapers, blogs and articles have also been consulted.

The expertise of the Patient Innovation[iii] team provided us a sound knowledge on how to find solutions, and how to identify and describe the user innovation phenomenon in healthcare. Additionally, from the pool of more than 700 solutions, we have selected three user innovations previously identified as such.

Overall, the final sample includes 36 solutions, by 38 users (since 2 of them were co-authored), from 21 developing countries (Exhibit 18).

### 3.4. Data Collection and Sample

Afterwards, we have decided to gather information through interviews, by virtue of what Eisenhardt and Graebner (2007) stated, "*interviews are a highly efficient way to gather rich,*

[iii] An online and free-access repository of open knowledge containing healthcare solutions (www.patient-innovation.com)

*empirical data, especially when the phenomenon of interest is highly episodic and infrequent*". In some cases, innovators were not available for an interview, so they agreed to answer a survey.

The available data source is a result of eleven semi-structured and extensive interviews and four surveys. All the innovators were contacted by e-mail and social networks, and the interviews were conducted via Skype and Whatsapp. The interviews followed a script (Exhibit 21), and they were recorded and conducted by a unique interviewer (the author), in order to keep consistency along the process. The answers provided by the interviewees have been entirely transcribed, resulting in 62 pages of text. The duration differed from 38 minutes to 74 minutes, with an average time of 56 minutes. The survey sent followed the script used to do the interviews and it consists in a document with a brief explanation of the study and six pages of questions (Exhibit 20).

Table 1 translates the verified sample used to perform the analysis. For each innovator information is provided regarding the country of birth and the country where the solution was firstly implemented, the innovator's type of need and its personal details (current age and gender). The code given for each solution follows Habicht et al. (2012) division regarding the different contexts in which patient innovators innovate. Group A includes all innovations that emerged from "*dead end situations*", group B contemplates innovations regarding "*strong constrains on the daily life*", and group C includes cases of innovations which occurred in "*rare conditions*" contexts. This last situation is not verified in our sample, due to the inexistence of cases comprising the characteristics of rare conditions. The following coding section explains these attributes in more detail.

The final sample consists in 15 solutions from 13 different countries, where six innovators were patients (A1, A6, A7, A8, A10, B3), five caregivers (A3, A5, B1, B2, B4), and three collaborators (A2, A9, B5). Solution A4, is the result of a collaboration between a patient and caregiver.

| Code | Country of birth | Country of innovation | Type | Age | Gender | Solution | Picture |
|---|---|---|---|---|---|---|---|
| A1 | Burundi | Burkina Faso | Patient | 39 | Male | Malaria prevention soap |  |
| A2 | Chad | Chad | Collaborator | 33 | Male | Health monitoring platform |  |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A3 | Ghana | Ghana | Caregiver | 33 | Male | Blood donation platform |  |
| A4 | Senegal and Cameroon | Senegal | Patient/ Caregiver | 24 and 23 | Male and Female | Blood donation platform |  |
| A5 | Uganda | Uganda | Caregiver | 26 | Female | Pneumonia detection shirt |  |
| A6 | Uganda | Uganda | Patient | 24 | Male | Malaria testing device |  |
| A7 | Tanzania | Tanzania | Patient | 40 | Male | Low cost water filtration system |  |
| A8 | Philippines | Philippines | Patient | 48 | Male | Blood donation platform |  |
| A9 | USA | Haiti | Collaborator | 40 and 40 | Male and Female | Reusable diapers |  |
| A10 | Nigeria | Nigeria | Patient | 51 | Male | Urine Malaria Test |  |
| B1 | Rwanda | Rwanda | Caregiver | 23 | Male | Low cost hand bike |  |
| B2 | Tanzania | Tanzania | Caregiver | 31 | Female | Malnutrition monitoring platform |  |
| B3 | India | India | Patient | 35 | Male | Chronic diseases monitoring platform |  |
| B4 | Pakistan | Pakistan | Caregiver | 23 | Male | Tremors monitoring platform |  |
| B5 | USA | Sudan | Collaborator | 47 | Male | 3D Printing Arm |  |

**Table 1 - Verified Sample of user innovators**

## 3.5. Coding

Lüthje et al. (2005) in the study of innovations developed by mountain bikers, concluded that users with a problem are compelled to develop solutions, because they possess *local need information*. In the same study, the impact of *local technical knowledge* on innovations was analysed, revealing that users already have the required knowledge to develop a technical

solution. Knowing this, we started to code the solutions accordingly to the type of need a patient had, or still has, and the knowledge a user owns to develop a solution.

Habicht et al. (2012) distinguishes among three types of situations: *dead end situations*, when patients face scenarios where there is no hope of making progress regarding their health condition (e.g., fatal diagnosis); *strong constrains on daily life*, when "*patients cannot escape their situation*", living with their health disorders permanently. At last *rare conditions*, health disorders that affect a small portion of people worldwide. Rare conditions are considered niche markets, where there are no commercial incentives, and less investment for innovation.

Two more codes were added within this coding, in order to transcribe the sub-category *Local Environment*. Firstly, the *limited professional expertise* (Dreier, 2016), meaning a user perceives the lack of knowledge given by health professionals, either to explain the condition or to treat patients in a correct manner. Secondly, we have included *characteristics of developing countries* (DePasse et al., 2016), where a user acknowledges the unique constraints within his/her community.

Afterwards, we coded our sample based upon *local technical knowledge*, encompassing the following drivers: *enjoyment of the innovation activity* (Lerner & Tirole, 2002; Lakhani & von Hippel, 2003), *enhanced reputation that may flow from making high-quality contributions* (Lakhani & von Hippel, 2003) and *greater level of experience and expertise with a given product* (Lüthje, 2004; Kuusisto et al., 2013).

Table 2 sums up the different drivers that led patients, caregivers, and collaborators to innovate.

| Category | Sub-Category | Driver | Reference |
|---|---|---|---|
| *Local need information* | Disease motivated | Dead end situations | Habicht et al. (2012) |
| | | Rare conditions | |
| | | Strong constrains on the daily life | |
| | Local environment | Limited professional expertise | Dreier (2016) |
| | | Characteristics of developing countries | (DePasse et al., 2016) |
| *Local technical knowledge* | | Enjoyment of the innovation activity | Lerner & Tirole (2002); Lakhani & von Hippel (2003) |
| | | Enhanced reputation that may flow from making high-quality contributions | Lakhani & von Hippel (2003) |
| | | Greater level of experience and expertise | Lüthje (2004); Kuusisto et al. (2013) |

**Table 2 - Coding for Drivers in user innovation**

We also have coded our findings regarding the existent complementary assets required for commercialization. According to Teece (1986), a complementary asset is what provides an innovation with the necessary services so that it can become commercialized in a successful manner. In line with this, a complementary asset is seen as a different asset from the core solution, which increases its value (Teece, 1986).

Innovations created by users generally have a narrow access to this kind of assets (Agarwal & Shah, 2014). *After-sales support*, *distribution channels*, *marketing*, *competitive manufacturing*, *human resources* and *complementary technologies* are examples of complementary assets given by Teece (1986) and Svensson (2007).

Considering this, we adopt the following line of coding to classify our sample (Table 3).

| Code | Sub-code | Reference |
|---|---|---|
| *Complementary assets* | After-sales support | Teece (1986); Svensson (2007) |
| | Distribution channels | |
| | Marketing | |
| | Competitive manufacturing | |
| | Human Resources | |
| | Complementary technologies | |

**Table 3 - Coding for Complementary Assets**

# 4. Results

In the following chapter, we present the most important drivers, the socio-economic factors that influenced the creation and development of the innovations, and the complementary assets that contributed to the commercialization of the solutions under analysis.

## 4.1. Drivers in healthcare across developing countries

### 4.1.1. Local need information

As mentioned before, and according to the literature, this driver is divided in different types of needs. For each type, we provided quotes from the interviews that supported our classification.

#### 4.1.1.1. Dead end situations

Ten solutions came from users that lived closely with near dead situations (from A1 to A10).

> "*I almost died from malaria while doing my military service in Burundi, where I was almost left for death because of malaria* (…)" (A1)
>
> "(…) *the parasite can enter in the penis and then small worms are created in the system and when people urinate came with blood. Schistosomiasis is really painful for kids when they urinate.*" (A2)
>
> "*She started with normal headaches and then started to be complicated. She started to spend the entire days in her bed and stopped doing things by her.*" (A3)
>
> "*I lost a lot of blood when I had my accident, the diagnostic was if we cannot find a blood donor, I could not move my leg, I could die.*" (A4)
>
> "(…) *after her grandmother fell ill, and was moved from hospital to hospital before being properly diagnosed with pneumonia.*" (from http://bit.ly/2klAnJG on 17.05.2017) (A5)
>
> "*I have always lived with malaria as I was growing up. But it was when I had 20 years old that suffered more severely, living with malaria for 2, 3 weeks.*" (A6)
>
> "*After the doctor diagnosed me several water-related diseases and, besides giving me medicine, I was told to wash my hands with soap. I need to change my life style* (…)" (A7)
>
> "*My platelet level was already in a critical condition, it was already 90.000 and I think the recommended platelet level is 450.000 and 500.000.*" (A8)
>
> "(…) *they are uneducated and they are living in very very dangerous situations when it comes to sanitation.*" (A9)
>
> "*Having grown up in Nigeria,* (…) *contracted malaria multiple times from a young age.*" (from http://bit.ly/2r4KrvX on 27.05.2017) (A10)

#### 4.1.1.2. Strong constrains on the daily life

Five innovations were triggered by imposed limitations throughout their lives. Two consisting in a physical disability (B1, B5) and three regarding chronic diseases (B2, B3, B4).

> "(…) *it was very hard for his uncle to leave the house because he had a wheelchair but that type of wheelchair actually needed someone to push it.*" (B1)

"*Lots of my friends and family are overweight and obese, with hypertension and diabetes. And people close to my family have babies that are undernourished.*" (B2)

"(…) *I started to understand how chronic health conditions are poorly managed in India. I realised that in our country, the chronic care management is not extended beyond the hospitals or clinics.*" (B3)

"*He did not use to move that much, he was still able to drink stuff but he had to reduce some actions and eating was a bit bad, eating bread was easy for him but eating anything like soup or like rice was a bit difficult.*" (B4)

"*Seeing this 12-year-old boy, who lost both of his arms and see this boy who would rather be dead, than live with no arms and be a burden to his family.*" (B5)

#### 4.1.1.3. Limited professional expertise

In this category, patients, caregivers and collaborators perceived the necessity to create a solution that could assist patients to receive a better treatment or a better monitoring (A2, A8, A9, B1, B3, B4). The following quotations provide examples of this driver:

"(…) (nurses) *they really do not have time to talk about the disease, they do not know how people contract the disease* (…)" (A2)

"*It is just the basic information and another thing is that there is no medicine for dengue, all they have is just to administer some injections and medicines to help you fight, or get me in a condition to be able to fight the disease.*" (A8)

"*Even if they get the disease and they go and see a doctor, the likelihood of that doctor having the proper medication is about 10%.*" (A9)

#### 4.1.1.4. Characteristics of developing countries

User innovators stated they were aware of their surrounding environments and the fragile conditions in which they live (A1, A2, A3, A4, A6, A7, A8, A9, A10, B1, B2, B3, B5).

"*My village was far away from hospitals and at night people from the village had to carry me with their own hands to the closest hospital.*" (A1)

"*In the village, they do not have a laboratory, so they did not know that he was suffering from schistosomiasis.*" (A2)

"*Here in Ghana, there was always a complaint for blood and not very much was happening.*" (A3)

"(…) *she had to go every month to a hospital to receive blood transfusions, until she stopped receiving this treatment because of a blood shortage in the hospital.*" (A4)

"*Generally, in Uganda, a person can catch malaria 2 or 3 times a year* (…)" (A6)

"*These problems are seen as a part of life, I lived with these problems since always because my parents did not have much money and in Tanzania the bottled water is very expensive.*" (A7)

"*Not all people in the Philippines know their blood type.*" (A8)

"*What is happening is that faecal matter is getting into the water or is getting into the homes, causing the deaths from water.*" (A9)

"*How do we detect malaria easily? Most rapid blood tests are difficult to use. A simple non-invasive test was critically needed.*" (A10)

"*The rural areas make so hard for the populations to get access to wheelchairs that can be used in those rural areas* (…)" (B1)

"*Many families especially in rural communities associate chronic malnutrition as shame or witchcraft so they delay seeking for medical help.*" (B2)

"*One of the things of course is that doctors in India are very busy.*" (B3)

"*I think the major driver was when I realized that Daniel was a victim of war, he was an innocent boy whose life was completely shattered for something that he had no control over.*" (B5)

### 4.1.2. Solution related knowledge

Taking into account the *stickiness* of information on the user's side, innovators increasingly depend on "*local solution information*" (Lüthje et al., 2005).

#### 4.1.2.1. Enjoyment of the innovation activity

Three user innovators stated they had performed their solutions either by fun or to increase the required knowledge associated to the solution (A3, A6, B5).

"*I love technology so I would like to use technology to solve.*" (A3)

"*I lived with this health disorder and I love technology.*" (A6)

"*Could go and helped him and print him an arm, make his life in anyway better, that was the driving force.*" (B5)

#### 4.1.2.2. Enhanced reputation that may flow

Seven user innovators highlighted how their reputation was recognized by the communities they are living in (A1, A2, A4, A5, A8, A9, A10). The following quotations serve as illustration for this driver:

> "*The winning of a national prize in 2015 from an NGO Reach for Change, that enabled us to have more recognition.*" (A4)
>
> "(…) *has been short-listed for this year's Royal Academy of Engineering's Africa Prize* (…)"
>
> (from http://bit.ly/2pX4mJt on 18.05.2017) (A5)
>
> "*Since then achieved the 2nd place at the Social Innovation Camp Asia, in Malaysia. 2nd place at Microsoft's Apps for Asia, and because of that we were able to exhibit the application back in 2013 in New Deli, India. And just recently, last December, we just received an acclamation award by our department of health, by the Philippine blood center.*" (A8)

#### 4.1.2.3. Greater level of experience and expertise

The level of experience and expertise has a positive relation with the creation of solutions by user innovators, adjustable to them or their peers (Lüthje, 2004; Kuusisto et al., 2013). We found two cases where user innovators made use of their expertise (A7, B1).

> "*I studied about nanomaterials for about seven years, and my PhD thesis focused on how to put this component on a filter* (…)" (A7)
>
> "*After completing his vocational training, he thought of something to help his community and to offer them the possibility to afford a wheelchair.*" (B1)

### 4.2. Existent socio-economic factors in developing countries

The verified socio-economic factors across the existent countries in the sample are seldom comparable with the ones observable amongst the developed nations.

#### 4.2.1. Healthcare

During the interviews, 13 user innovators made references to the fragile state of the healthcare system of the countries where innovations occurred (A1, A2, A3, A4, A7, A8, A9, A10, B1, B2, B3, B4, B5). The following quotations present examples of problems involving this socio-economic factor:

"*Hospitals are inserted in strategical areas, not accordingly with diseases, but given the terrorist attacks.*" (A1)

"*Very poor, very poor, Senegal is a poor country so there are a lot of problems in healthcare.*" (A4)

"(…) *these days the government is trying to spread. But sometimes there is just a building, there are no doctors or nurses and no medicine.*" (A7)

"(…) *it is the worst situation that I have ever seen, the medical situation in Haiti is horrible, is terrible, it is what you see on the news.*" (A9)

"*There is Abajyanama b'ubuzima (or health advisers) at every village, making easier to connect patients to first aid, but very few specialized medical personnel in Rwanda and to get in contact with them is very difficult* (…)" (B1)

"*A common problem is on the number of doctors or caregivers in relation to people available.*" (B2)

#### 4.2.1.1. Access to pharmacies

Five innovators reported the access to pharmacies, as well as the level of prices charged, constituted a major obstacle for them (A2, A6, A9, B3, B4). Examples of problems in this type of access were described in the following quotations:

"*People have good access to pharmacies, but they will not have what you need (they will have aspirins, they probably have antibiotics, but will not have medicine for specific diseases) and they cannot afford it* (…)" (A9)

"*If patients cannot afford, they will not take the recommended medicine.*" (B3)

"*Currently in Pakistan, there is not a broad access to pharmaceutical drugs for this particular disease, only one or two medicines were available, whereas on other parts of the world the range is enormous.*" (B4)

### 4.2.2. Environment

Two user innovators highlighted the sense of community, which played an important role in the innovation process (A2, B1).

"*The community was very important to the project because when we were at the villages we tested in the community.*" (A2)

"*The conversations he had with several innovators gave him the confidence he needed to develop the solution.*" (B1)

#### 4.2.2.1. Access to potable water

The lack of access to potable water is present in user innovators' statements, two solutions aim to tackle the problem of contaminated water in two different ways and countries (A7, A9).

> "(…) *even today in Tanzanian rural areas and congested cities there is a lot of struggles because of lack of clean water, among the poor communities.*" (A7)
>
> "(…) *there are accesses where they installed water systems in some communities but the majority of the water is polluted.*" (A9)

#### 4.2.2.2. Corruption

Corruption represents a relevant problem amongst these countries, and two user innovators have faced troubling situations (A8, A9).

> "*Because donors, let's say if this patient is already in this scenario where he really needs blood, so as much as possible they can actually ask let's say 10.000 pesos, you know? It is corruption.*" (A8)
>
> "*Customs in Haiti is like dealing with the IRS (laughs), there are lots of corruption. It is horrible, the people who go to try to help the country, are the same people from who they try to get advantage. And that begins with the Haitian government.*" (A9)

#### 4.2.2.3. War

One user innovator described the war climate experienced in the country and underlined this as a major obstacle (B5).

> "*You have a lot of kids like him, who can go to school but it is very difficult because of the war that is going on, and because of the bombings, and because of the general turmoil.*" (B5)

### 4.2.3. Education

Although user innovators described the difficulty of having access to a higher educational degree in their countries (A9, B2, B5), they also considered that education played an important role on their solutions (A4, A6, A8, B1), two user innovators reported problems but mentioned the importance of education (A2, B4). Descriptions of both the problems and the importance that education had for their solutions are provided in the following quotations:

"*Yes, because our studies gave us technical knowledge to build the platform without external support.*" (A4)

"*The access to a University degree from the Makerere University, in Uganda, enabled me to have a better understanding on technological software, which proved to be highly important.*" (A6)

"*High school is an honour and a privilege, it is not a right!*" (A9)

"(…) *they do have schools, Daniel is now 18 and he reads at a fourth-grade level, they do have primary schools but you have a lot of kids that are in the system intermittently.*" (B5)

#### 4.2.3.1. Access to complementary facilities

In addition to the importance of university, four user innovators benefited from other type of facilities, enabling them to develop their solutions (A4, A6, B4).

"*Yes, it is very important because at the beginning of the project we have a lot of problems in terms of money, in terms of logistics and we need good computers to build a platform.*" (A4)

"(…) *the access to a design studio to start building his idea was very helpful.*" (A6)

"(…) *I had access to one of the best laboratories here in Pakistan for the development of the hardware, but generally this is not the case.*" (B4)

### 4.2.4. Technology

Nine innovators revealed that the access to technological services proved to be fundamental throughout the stages of innovation processes (A1, A2, A4, A6, A7, A8, A9, B3, B4). Six examples of the importance and the difficulty to have access to technology, in order to develop user driven solutions:

"*Without it we could not work and contact our partners, we are using like mails, also we call people using Whatsapp or Skype* (…)" (A1)

"*It is not really possible to use high technology in Chad.*" (A2)

"*In Uganda, the price of internet is excessive and the use of smartphones by the population is low, and does not offer a good speed in relative terms.*" (A6)

"*In rural areas people do not have electricity, so do not have internet.*" (A7)

"*The access to mobile connection is great, more people have access to cell phones than they have to toilets. It is very important, for safety purposes in remote regions* (…)" (A9)

"*Internet connection is having a lot of infrastructure problems, the methods to connect are primitive, leading to a poor smartphone integration, which Indian population did not perceive yet as a user-friendly software.*" (B3)

### 4.3. Complementary assets

Organizations have an increasing need to diversify their complementary assets, due to the complexity in terms of resources and capabilities needed for commercialization (Lin & Wang, 2015). All the solutions in our sample show the presence of at least one complementary asset.

#### 4.3.1. After-sales support

The service provided by these user innovators, after the diffusion to other patients, is an essential tool to increase value for the innovation. Five user innovators provided a description of how they are providing a post-sale help (A3, A9, B1, B2, B5). The following quotations are examples to show a description of this complementary asset:

"(…) *so now we have a health call center and users leave a message and the health professionals will respond later.*" (A3)

"(…) *he is able to create wheelchairs that are able to adapt the need, he can adjust the wheels to afford the weight it can carry.*" (B1)

"*Apart from the platform that is still under development, Afya Slices organize seminars for mother, housemaids and caregivers on maternal and children optimum nutrition care and practices.*" (B2)

#### 4.3.2. Distribution channels

Three user innovators provided a description of how they benefit from having access to other channels, aiming to reach end-users (A6, A8, A9). Description examples of this complementary asset are provided:

"*Just recently the Filipino blood center contacted me to work together and to adapt Blood Donors Network to hospitals.*" and "*We were able to put in each health centers independent coordinators, responsible for a given region and his donors* (…)" (A8)

"(…) *we are looking to scale up the sale to organizations, people traveling to other countries can take DriButts with a special rate and deliver them there.*" and "*To bring DriButts to the masses they teamed up with a company called (...) to have the diapers mass produced in China.*" (from http://bit.ly/2qpCQW0 on 18.05.2017) (A9)

### 4.3.3. Marketing

Nine user innovators provided a statement showing they are already interested in promoting and/or selling the solution to other users (A1, A3, A4, A6, A7, A8, A9, B1, B4). Five examples of quotations by user innovators describe this complementary asset:

> "*We do a lot of street marketing in Senegal, like distributing flyers for presenting the platform for people.*" (A4)
>
> "(…) *we will start to export to around 20 countries* (…)" (A7)
>
> "(…) *this year will be launched in media, stakeholders, everything.*" (A8)
>
> "(…) *a diaper costs $15 and you pay $30 to give another to developing countries*." (A9)
>
> "*The solution was diffused on the KickStarter (a crowdfunding platform) webpage.*" (B4)

### 4.3.4. Competitive manufacturing

Four user innovators highlighted they had benchmarked their competitors and identified unique characteristics in their solutions, that would give them market advantage (A7, A10, B1, B4).

> "*There are filters but they do not solve the problems comprehensively, some filters remove chloride but no the bacteria and others do not have a customer service.*" (A7)
>
> "*The other solutions were not simple to use.*" (A10)
>
> *"A patient is now able to use its hands rather than the legs to move, this is the main difference from the imported wheelchair." (B1)*
>
> "*The available products have to be imported, mainly from the US, which increases the price.*" (B4)

### 4.3.5. Human resources

Seven user innovators showed involvement when choosing the adequate team for the development and commercialization of the innovation (A1, A3, A4, A8, A9, B3, B4). The following quotations are examples to show a description of this complementary asset:

> "(…) *the team is working with partners around the world.*" (A1)
>
> "*At this moment we are starting to have many ambassadors in rural areas* (…)" (A4)

"*I am working alone on this project, but I have a team of consultants to help with the development of the application, an office to work on the legal side of the application and I also have some sales consultants to help me out in regards to the commercialization of the application.*" (A8)

"(…) *we establish leaders in all the regions, in charge of managing all the contacts around the country. That person manages and educates, is responsible for all the existent diapers in one community, for proper use, to make sure they are throwing the poop to the water.*" (A9)

"(…) *the constitution of an agile team are equally important.*" (B3)

"*One of the really beneficial things was having a good team* (…)" (B4)

#### 4.3.6. Complementary technologies

The functioning of the innovation aligned with other technologies is also relevant to increase the value. Ten user innovators showed signs of incorporating this type of asset (A1, A2, A4, A5, A6, A7, A8, B1, B3, B5). Description examples of this complementary asset are provided in the coming quotations:

"*We have regular radios, but never used them for raising awareness, then they asked us if those areas have radios and after that we saw that populations use radios and started using.*" (A2)

"(…) *we also have a web platform, which do the same, we have an SMS alert to when there is an emergency, we can push an SMS for notification through our platform users.*" (A4)

"*The processed information is sent to a mobile phone app (via Bluetooth) which analyses the information in comparison to known data so as to get an estimate of the strength of the disease* (…)"(from http://bit.ly/2r7e91A on 18.05.2017) (A5)

"*That is the reason why I started to think in changing the approach and cover also the desktops.*" (A6)

"(…) *we have also developed an in-app messaging system in our solution like Facebook and Viber, so users already have the option to use one of the two systems.*" (A8)

### 4.4. Reverse Innovation

In order to study the potential of these solutions in developed countries, we asked three physicians with expertise in the patient innovation field to review and classify our sample.

We divided the classification in the following three levels (table 4):

| Level | Description | Color | Solutions |
|---|---|---|---|
| 1 | Solutions potentially adoptable by developed countries | Green | A10, B4, B5 |
| 2 | Solutions can be adopted if user innovators apply changes | Yellow | A6, B2 |
| 3 | Solutions do not have the potential to be adopted by developed countries | Red | A1, A2, A3, A4, A5, A7, A9, B1, B3 |

Table 4 - Reverse Innovation classification

In addition, exhibit 22 summarizes the excerpts from these external evaluators.

# 5. Discussion and Conclusions

To the best of our knowledge, this analysis is the first of its kind, which on one hand is the major motivation for our dissertation, but on the other hand constitutes a limitation in the sense that unable us to compare with similar literature and verify the correct applicability of the study.

Certain limitations arose during the research, either because of the nature of the study, or due to the geographical area analysed. Lastly, we provide advices on where to direct the coming research, aiming to offer a more extended available literature on this topic.

## 5.1. Hypothesis

After the conducted interviews, we started to perceive there are differences in the type of needs patients have, comparing to developed countries. Knowing this, we formulated the following hypothesis:

H1: *Despite the similarities on the user innovation process between regions with a contrasting development level, the triggers to innovate may differ.*

Our second hypothesis raising, regarding solutions developed by these users that aim to overcome a general need and not just a need of a single patient. By being close to their community, the innovator ends up fulfilling not only his need, but the needs of his community.

H2: *User innovators across these regions try to overcome not just their personal needs but to solve existent needs in their communities.*

We verified that 33.3% of user innovators participated in incubator programmes, either offered by NGOs (A2, A3, A4, B2) or by governments (B1). In addition, we verified that both private organizations and foundations, such as Microsoft and Bill and Melinda Gates Foundation, designed programmes in form of contests, to reward solutions invented by user innovators with the intent of improving the quality of life along their communities. From our sample, 60.0% of user innovators were awarded by organizations and/or foundations. This led us to another hypothesis:

H3: *Support given by organizations and foundations from the developed world are also oriented towards user innovators in developing countries, and the access to incubator programmes is seen as a useful tool to develop and promote social entrepreneurship.*

## 5.2. Outcomes

### 5.2.1. Patient innovators in developing countries

Throughout the research, we observed a strong evidence of patient innovation along developing countries. Supported by the available literature to which we had access to, we can complement our answer to the research question regarding the drivers that users have to innovate in a context of higher need, when comparing with developed nations.

Table 5 illustrates the percentage of each considered driver present in our sample, from which we can validate the findings of Hipp and Grupp (2005) and Utterback (1974), regarding innovations being stimulated by market needs, rather than technological opportunity. User innovators are triggered, in a higher proportion, by the lack of solutions available on the market.

| Category | Sub-Category | Driver | |
|---|---|---|---|
| *Local need information* | Disease motivated | Dead end situations | 10 (66.7%) |
| | | Rare conditions | 0 (0.0%) |
| | | Strong constrains on the daily life | 5 (33.3%) |
| | Local environment motivated | Limited professional expertise | 6 (40.0%) |
| | | Characteristics of developing countries | 13 (86.7%) |
| *Local technical knowledge* | | Enjoyment of the innovation activity | 3 (20.0%) |
| | | Enhanced reputation that may flow | 7 (46.7%) |
| | | Greater level of experience and expertise | 2 (13.3%) |

**Table 5 - Results for Drivers in User Innovation**

Note: In regards to the sub-category "Local environment", we verified that some user innovators had more than one driver that led them to develop a solution. In regards to the category "Local technical knowledge", some user innovators did not have this type of drivers to develop a solution. Reasons why the sum of each one is not 100%.

This partially confirms the first hypothesis raised, roughly 67% of user innovators in our sample had as trigger dead end situations and none of them faced a rare disease condition, contrasting with other studies on developed regions, like Shcherbatiuk and Oliveira (2012) and Oliveira (2014), which covered rare diseases.

In addition, we verify that 86.7% of the analysed user innovators were triggered by the state of their countries, like the distance to hospitals, inadequate hygiene habits, or lack of knowledge about the blood donations.

### 5.2.2. Socio-economic conditions

Amongst the socio-economic conditions of each environment under analysis, user innovators highlighted three of them. Firstly, healthcare conditions, where 86.7% of user innovators consider there are problems in both the delivery of healthcare services and the access to pharmacies.

The second condition regards problems accessing education and its importance, mentioned during 60.0% of the interviews. Six user innovators indicated that education was important for the development of the solutions, and two of these referred problems in this access. Another three user innovators, made a reference to the existing problems in the educational systems but did not consider education important for their solutions.

Evidence corroborates findings from Van der Boor et al. (2014), listing the major socio-economic contributors to innovations in developing countries, where access to ICT is included. In this category, 9 user solutions were studied (60.0%), 44.4% mentioned problems related with access to technologies. While, 55.6% referred the importance to have this access for their solutions.

Although a lower number of user innovators made allusion to the surrounding environment (40.0%), it is also important to analyse. The importance to have a community offering help was present in two dialogues, while other two user innovators mentioned problems in water quality. The problem of corruption was referred by two user innovators (one of these also talked about the lack of access to potable water, A9). At last, one user innovator (B5) mentioned war as one of the major existing problems.

Figure 3 displays the number of user innovators for each socio-economic factor considered relevant to mention them during the interviews and surveys. 11 user innovators mentioned more than one socio-economic factor, 3 mentioned only one (A3, B2), and a user innovator (A5) did not referred any one.

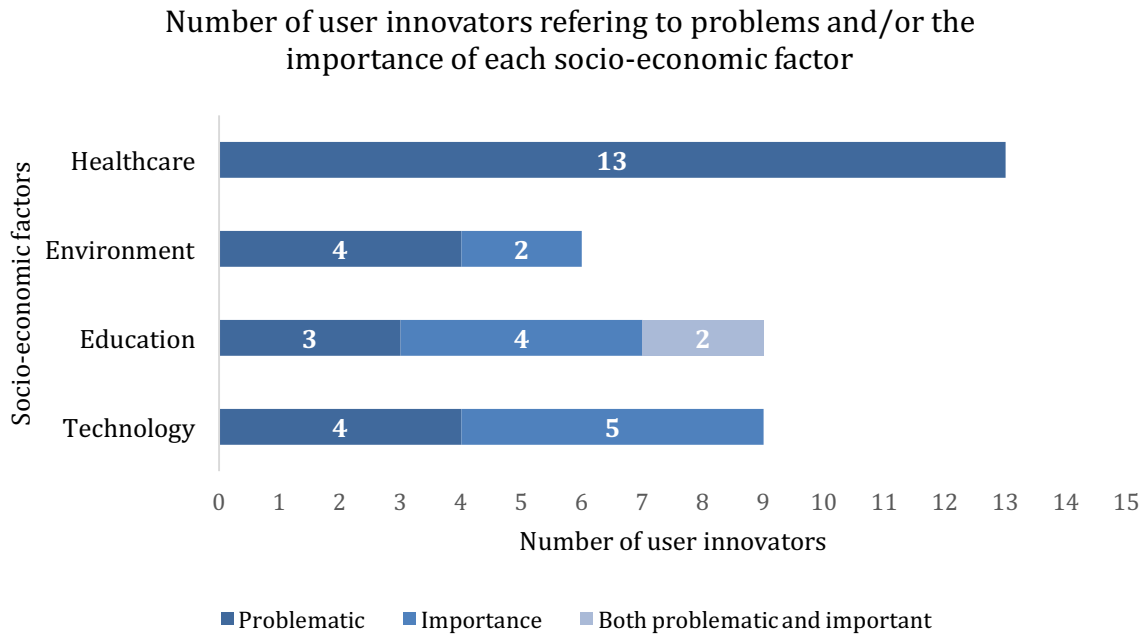



Figure 3 - Results for Socio-economic factors

### 5.2.3. Patient innovators as entrepreneurs

Through a study across organizations and industries, Helfat and Lieberman (2002) discovered that complementary assets, for new entrants, are more relevant than their core resources. Owning specialized and/or co-specialized complementary assets, enables firms to create value and prevent imitators to take profits from them (Teece, 1986).

There are two complementary assets in which user innovators invested more: complementary technologies and marketing. Complementary technologies that help increasing the solutions' value are present in 66.7% of these user driven solutions. On the other hand, 60.0% of user innovators are spending time and financial resources in marketing, to promote and sell their solutions.

With a lower relevance, 46.7% of the analysed solutions shown a concern for choosing a good team. We find solutions that benefit from having an after-sales service in 33.3% of the solutions, and others are aware of other available solutions, offering distinctive approaches (with 26.7%). Moreover, 20.0% of the sample's solutions established, or planning to establish, a distribution network to increase the value for the solution.

Figure 4 presents a summary on the complementary assets considered most important for user innovators.

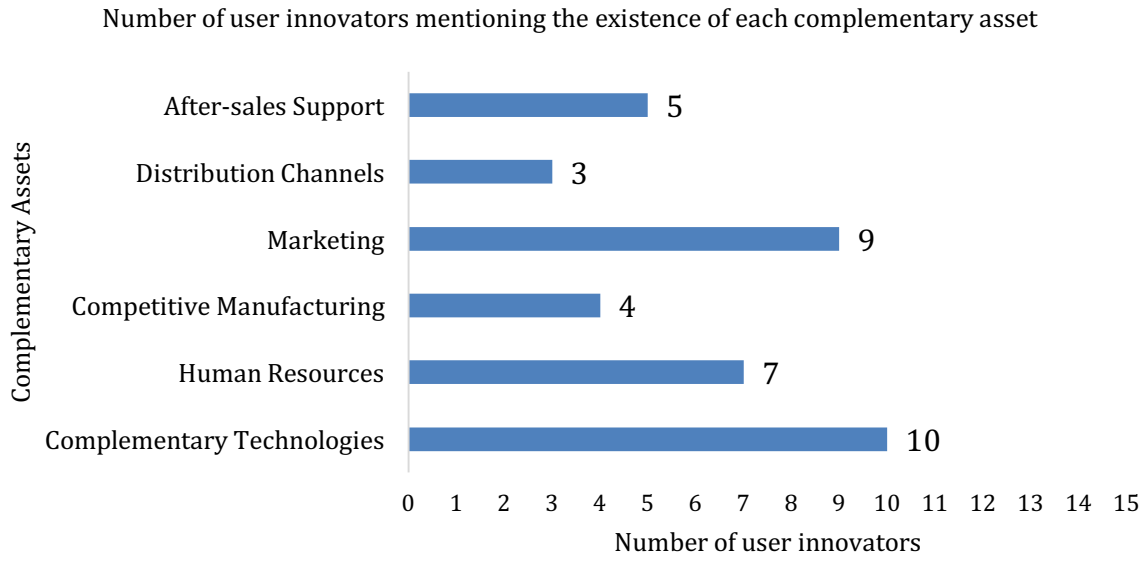



**Figure 4 - Results for Complementary Assets**

Table 6 exposes a high percentage of user innovators that decided to create their own company to take advantage of the available complementary assets and commercialize their solutions.

| | |
|---|---|
| Created company | 13 (86.7%) |
| Did not create | 2 (13.3%) |

**Table 6 - Results for creation of companies by user innovators**

Of those two user innovators that decided not to create a company, one of them was already employed in a company and decided to continue in that same company (A6).

The other user innovator could not create its company due to lack of funding (B4). This finding is important, because our sample of 15 innovators is considered limited and more users might face barriers like this, across developing countries.

> "*Basically the main issue were financials because currently there are not many investors in Pakistan that spend money on healthcare products* (…)" (B4)

Table 7 sums up the findings that support the conclusion retrieved by Lin and Wang (2015), when argued about a positive relationship between the capacity an organization has to create innovations and to have complementary assets, with the introduction of patents. Although the sample size is limited, we found 40.0% of user solutions with their IPR protected, while 26.7% are waiting for approval to protect. Moreover, there are 33.3% of user innovators that prefer not to protect their IPR. B4 terminated the project without protecting the solution.

| | |
|---|---|
| IPR protected | 6 (40.0%) |
| Waiting for approval | 4 (26.7%) |
| IPR not protected | 5 (33.3%) |

Table 7 - Results for IPR protection

## 5.3. Reverse Innovation

From the sample, we concluded that about 27% of the solutions could be adopted by developed countries, whilst other 6.7% might have use in these countries if another approach is followed. Table 8 sums up the evaluations provided by the two physicians as evaluators.

| | |
|---|---|
| Potential for adoption | 3 (20.0%) |
| Adoption might result, after changes | 2 (13.3%) |
| There is no potential for adoption | 10 (66.7%) |

Table 8 - Results for Reverse Innovation

## 5.4. Policy Implications

Healthcare stakeholders must recognize the importance of user innovations, as they are the ones facing the needs. Practitioners and policy makers across developing countries should facilitate the access to complementary assets needed by users to innovate and present new solutions to a market in need for more efficient medical devices (von Hippel, 2016).

### 5.4.1. Medical personnel

There are cases in which medical support was not provided in a clear and efficient manner. Medical professionals must be aware of this phenomenon and share it with their patients' communities, aiming to improve a sector that needs innovation, especially within these regions (O'Donnell, 2007).

Practitioners should play a more proactive role and develop a closer relation with patient innovators, in order to guide and advise them along the innovation process. Whilst, patient innovators can use feedback to improve solutions, thus increasing the possibility of being used by others with similar health conditions. At last, digital health platforms offer the necessary conditions for the improvement of these relations.

### 5.4.2. Policy makers

Oftentimes, user innovators described a lack of awareness by the populations. Investment in educational tools and healthcare venues is of major importance to tackle deeply rooted problems amongst the communities.

Digital health platforms such as Patient Innovation, contribute to patient innovators' communities, by offering the possibility to diffuse their solutions, receiving feedback from their peers. In addition, these health platforms can serve as another way to engage medical professionals and provide more pertinent feedback on the available solutions.

Another crucial policy is to offer conditions for user entrepreneurs to develop their solutions, by offering guidance to them, and favourable socio-economic environments, such as incubators and healthcare entrepreneurial contests.

## 5.5. Limitations

By applying a multiple case study analysis, our study comprises certain limitations. The case selection is included in the theoretical sample, constituting a limitation. As Eisenhardt and Graebner (2007) concluded, the cases chosen must contribute to the theory and not so much to the uniqueness of the case.

Secondly, we obtained information on the cases mainly through national newspapers. Given the developed nature of the analysed countries, there may exist other patient innovation cases, not successfully implemented, which did not call media's attention.

The fact that several articles were not data accurate, also constitute a limitation, as the story beyond the innovation could be inaccurate, especially in collaborator's cases. In line with this reasoning, some innovators initially did not understand the study's aim, leading to a misrepresentation of the sample. Take B2's example, initially she explained that created the solution because of her community, but after several messages she explained the major motivation to create it was the existence of overweight relatives. To overcome this limitation, specific questions were asked during the conversations and our focus was on facts, reducing information subjected to individual interpretations.

Our sample comprises 36 solutions' authors, of whom 32 were contacted, yet only 21 have replied (response rate of 65.6%), within these, only 15 make part of the study. A considerable number of user innovators did not reply to our contact, whilst the remaining ones scheduled interviews but were not able to conduct them. Moreover, due to the current social conditions in certain analysed countries, a call had to end up earlier because the interviewee was in an area where gunshots were being fired. In addition, during the interviews, the language used was English and sometimes this was hard to deal with. As example, there was

a user innovator who could not speak English, so we had to ask for help with the translation to a journalist.

Interviewees' bias is also considered a limitation, they may have used self-reported data, which is subjected to imprecision or misleading information. As mentioned by Eisenhardt and Graebner (2007), in a health-related context particularly, social desirability is seen as a concern, in the sense that can lead to altruism overstatements. To minimize this bias, data available from online sources, such as previous interviews given by innovators, public talks, or media reports, have been consulted to corroborate our findings, and in some cases to clarify dubious aspects.

In addition, patient innovators in these countries might not disclose their innovations, as they consider them unimportant for the community, or due to limited resources (38.9% of the analysed countries have less than 10 internet users per 100 people).

Last but not least, our research focused on health disorders selected randomly, without a specific pattern, thus with other type of health disorders the results might have been different.

### 5.6. Future Research

As other researches consider (Habicht et al., 2012; Oliveira & Canhão, 2014), this matter is not yet sufficiently explored.

These findings have been formulated having a database of 36 solutions, therefore future studies should adopt a quantitative approach across less developed countries, aiming to frame a sturdier theory.

Apart from studying the *how* and *why* patients, caregivers and collaborators innovate, it could be of great importance to inspect the role of medical personnel in the development of new products, services, or processes, within developing nations.

We suggest that further explorations on this matter should also include non-successful solutions, in order to perceive the crucial complementary assets and what sort of diffusion actions users should adopt.

The patient innovation concept and all the questions within this field have been approached from a managerial point of view. Our study also indicates organizational behaviors and psychological signs, therefore it would be of much benefit to embrace a multidisciplinary research approach, covering the psychological manifestations.

# References


Acemoglu, D., & Linn, J. (2004). Market size in innovation: theory and evidence from the pharmaceutical industry. The Quarterly Journal of Economics, 119(3), 1049-1090.

Agarwal, R., & Shah, S. K. (2014). Knowledge sources of entrepreneurship: Firm formation by academic, user and employee innovators. Research Policy, 43(7), 1109-1133.

Akin, J. S., Birdsall, N., & De Ferranti, D. M. (1987). Financing health services in developing countries: an agenda for reform. World Bank Publications, Vol. 34.

Amabile, T. (1997). Motivating creativity in organizations: On doing what you love and loving what you do. California management review, 40(1), 39-58.

Amit, R., Muller, E., & Cockburn, I. (1995). Opportunity costs and entrepreneurial activity. Journal of Business Venturing, 10(2), 95-106.

Baker, T., & Nelson, R. (2005). Creating something from nothing: Resource construction through entrepreneurial bricolage. Administrative science quarterly, 50(3), 329-366.

Baldwin, C., Hienerth, C., & von Hippel, E. (2006). How user innovations become commercial products: A theoretical investigation and case study. Research Policy, 35(9), 1291-1313.

Blaya, J., Fraser, H., & Holt, B. (2010). E-health technologies show promise in developing countries. Health Affairs, 29(2), 244-251.

Bodenheimer, T. (2005). High and rising health care costs. Annals of Internal Medicine, 142, Nr. 11, S. 932-937.

Bogers, M., Afuah, A., & Bastian, B. (2010). Users as innovators: a review, critique, and future research directions. Journal of management, 36(4), 857-875.

Constant, D., Sproull, L., & Kiesler, S. (1996). The kindness of strangers: The usefulness of electronic weak ties for technical advice. Organization Science, 7(2), 119-135.

De Jong, J. P., von Hippel, E., Gault, F., Kuusisto, J., & Raasch, C. (2015). Market failure in the diffusion of consumer-developed innovations: Patterns in Finland. Research Policy, 44(10), 1856-1865.

Déglise, C., Suggs, L., & Odermatt, P. (2012). SMS for disease control in developing countries: a systematic review of mobile health applications. Journal of Telemedicine and Telecare, 18, 273–281.

DePasse, J. W., Caldwell, A., Santorino, D., Bailey, E., Gudapakkam, S., Bangsberg, D., & Olson, K. R. (2016). Affordable medical technologies: bringing Value-Based Design into global health. BMJ Innovations, 2(1), 4-7.

DePasse, J., & Lee, P. (2013). A model for 'reverse innovation' in health care. Globalization and health, 9(1), 40.

Devarajan, S., & Reinikka, R. (2004). Making services work for poor people. Journal of African economies, 13(suppl 1), i142-i166.

Dreier, J. (2016). Exploring The Diffusion of Patient Innovations: A Multiple-Case Study. Master's thesis, Universidade Católica Portuguesa.

Dul, J., & Hak, T. (2007). Case study methodology in business research. Routledge.

Eisenhardt, K. (1989). Building theories from case study research. Academy of management review, 14(4), 532-550.

Eisenhardt, K., & Graebner, M. (2007). Theory building from cases: Opportunities and challenges. Academy of management journal, 50(1), 25-32.

Enos, J. (1962). Invention and innovation in the petroleum refining industry. The rate and direction of inventive activity: Economic and social factors, (pp. 299-322). Princeton University Press.

Faulkner, A., & Kent, J. (2001). Innovation and regulation in human implant technologies: developing comparative approaches. Social Science & Medicine, 53(7), 895-913.

Flam, H., & Helpman, E. (1987). Vertical product differentiation and North-South trade. The American Economic Review, 810-822.

Franke, N., & von Hippel, E. (2003). Satisfying heterogeneous user needs via innovation toolkits: the case of Apache security software. Research Policy, 32(7), 1199-1215.

Franke, N., von Hippel, E., & Schreier, M. (2006). Finding commercially attractive user innovations: A test of lead- user theory. Journal of product innovation management, 23(4), 301-315.

Frankelius, P. (2009). Questioning two myths in innovation literature. Journal of High Technology Management Research, 20(1), 40-51.

Freeman, C. (1968). Chemical process plant: Innovation and the world market. Nat Inst Econ Rev, 45:2957.

Frydman, G. (2009). Patient-driven research: rich opportunities and real risks. Journal of Participatory Medicine, 1(1), e12.

Geroski, P. (2000). Models of technology diffusion. Research Policy, 29(4), 603-625.

Goeldner, M., & Herstatt, C. (2016). Are patients and relatives the better innovators? The case of medical smartphone applications.

Govindarajan, V., & Trimble, C. (2012). Reverse innovation: create far from home. Harvard Business School Press, Boston.

Greco, P. & Eisenberg, J. (1993). Changing physicians' practices.

Griggs, R. C., Batshaw, M., Dunkle, M., Gopal-Srivastava, R., Kaye, E., Krischer, J., Nguyen, T., Paulus, K., & Merkel, P. A. (2009). Clinical research for rare disease: opportunities, challenges, and solutions. Molecular genetics and metabolism, 96(1), 20-26.

Grossman, G., & Helpman, E. (1991). Trade, knowledge spillovers, and growth. European economic review, 35(2-3), 517-526.

Habicht, H., Oliveira, P., & Shcherbatiuk, V. (2012). User innovators: when patients set out to help themselves and end up helping many. Die Unternehmung, 66(3), 277-294.

Harhoff, D., Henkel, J., & von Hippel, E. (2003). Profiting from voluntary information spillovers: how users benefit by freely revealing their innovations. Research Policy, 32(10), 1753-1769.

Harvey, H. B., Ahn, R., Price, D. D., & Burke, T. F. (2014). Innovating for the Developing World: Meeting the Affordability Challenge. American Journal of Roentgenology, 203(4), 835-837.

Helfat, C. E., & Lieberman, M. B. (2002). The birth of capabilities: market entry and the importance of pre-history. Industrial and corporate change, 11(4), 725-760.

Herzlinger, R. (2006). Why innovation in health care is so hard. Harvard Business Review, 84(5), 58.

Hipp, C., & Grupp, H. (2005). Innovation in the service sector: The demand for service-specific innovation measurement concepts and typologies. Research policy, 34(4), 517-535.

Immelt, J. R., Govindarajan, V., & Trimble, C. (2009). How GE is disrupting itself. Harvard Business Review, 87(10), 56-65.

Jack, W. (1999). Principles of health economics for developing countries. World Bank Publications.

Kuusisto, J., de Jong, J. P., Gault, F., Raasch, C., & von Hippel, E. (2013). Consumer Innovation in Finland: Incidence, diffusion and policy implications. Proceedings of the University of Vaasa, Reports (Vol. 189).

Lakhani, K. R., & Von Hippel, E. (2003). How open source software works: “free” user-to-user assistance. Research Policy, 32(6), 923-943.

Langlois, R. N., & Robertson, P. L. (1992). Networks and innovation in a modular system: Lessons from the microcomputer and stereo component industries. Research Policy, 21(4), 297-313.

Leonard-Barton, D. (1990). A dual methodology for case studies: Synergistic use of a longitudinal single site with replicated multiple sites. Organization Science, 1(3), 248-266.

Lerner, J., & Tirole, J. (2002). Some simple economics of open source. The journal of industrial economics, 50(2), 197-234.

Lin, J. H., & Wang, M. Y. (2015). Complementary assets, appropriability, and patent commercialization: Market sensing capability as a moderator. Asia Pacific Management Review, 20(3), 141-147.

Lüthje, C. (2004). Characteristics of innovating users in a consumer goods field: An empirical study of sport-related product consumers. Technovation, 24(9), 683-695.

Lüthje, C., Herstatt, C., & von Hippel, E. (2005). User-innovators and “local” information: The case of mountain biking. Research Policy, 34(6), 951-965.

Mansfield, E. (1968). Industrial research and technological innovation; an econometric analysis.

Morrison, P., Roberts, J. & von Hippel, E. (2000). Determinants of user innovation and innovation sharing in a local market. Management Science, 46(12) 1513-1527.

Mowery, D., & Rosenberg, N. (1979). The influence of market demand upon innovation: a critical review of some recent empirical studies. Research Policy, 8(2), 102-153.

Nielsen, L. (2011). Classifications of countries based on their level of development: How it is done and how it could be done.

OECD. (2011a). Health innovation. OECD Publishing.

OECD. (2011b). Health Reform: Meeting the Challenge of Ageing and Multiple Morbidities. OECD Publishing.

OECD. (2013). What Future for Health Spending?. OECD Economics Department Policy Notes, No. 19.

OECD. (2015a). Focus on Health Spending. OECD Health Statistics, 01/ago

OECD. (2015b). Health at a Glance 2015: OECD Indicators. OECD Publishing.

O'Donnell, O. (2007). Access to health care in developing countries: breaking down demand side barriers. Cadernos de Saúde Pública, 23(12), 2820-2834.

Oliveira, P., & Canhão, H. (2014). Users as Service Innovators: Evidence Across Healthcare and Financial Services.

Oliveira, P., & von Hippel, E. (2011). Users as service innovators: The case of banking services. Research Policy, 40(6), 806-818.

Oliveira, P., Zejnilovic, L., Canhão, H., & von Hippel, E. (2015). Innovation by patients with rare diseases and chronic needs. Orphanet Journal of Rare Diseases, 10(1), 41.

Oliveira, R. (2014). Patients and caregivers as sources of innovative ideas and solutions: A multiple case-study approach. Master's thesis, Universidade Católica Portuguesa.

Pavitt, K. (1984). Sectoral patterns of technical change: towards a taxonomy and a theory. Research Policy, 13(6), 343-373.

Peters, D. (2008). Poverty and access to health care in developing countries. Annals of the New York Academy of Sciences, 1136(1) 161-171.

Porter, M. (1990). The competitive advantage of nations. Harvard Business Review, 68(2), 73-93.

Ranck, J. (2011). Health information and health care: The role of technology in unlocking data and wellness–A discussion paper. Washington, DC: United Nations Foundation & Vodafone Foundation Technology Partnership.

Raymond, E. (1999). The cathedral and the bazaar: Musings on Linux and open source from an accidental revolutionary. O'Reilly and Associates, Sebastapol, CA.

Rheingold, H. (1993). The Virtual Community: Homesteading on the Electronic Frontier. Addison-Wesley, New York.

Riggs, W., & von Hippel, E. (1996). The Impact of Scientific and Commercial Values on the Sources of Scientific Instrument Innovation. Research Policy, 23 (4): 459-469.

Robinson, J., & Smith, M. (2008). Cost-reducing innovation in health care. Health Affairs, 27(5), 1353-1356.

Røtnes, R., & Dybvik Staalesen, P. (2009). New methods for user driven innovation in the health care sector. Oslo: Nordic Innovation Center.

Schmookler, J. (1966). Invention and economic growth.

Shah, S. (2000). From innovation to firm formation in the windsurfing, skateboarding, and snowboarding industries. Univ. Illinois, Urbana-Champaign, Working Paper, 1-45.

Shah, S. K., & Tripsas, M. (2007). The accidental entrepreneur: The emergent and collective process of user entrepreneurship. Strategic Entrepreneurship Journal, 1(1- 2), 123-140.

Shcherbatiuk, V., & Oliveira, P. (2012). Users as Developers and Entrepreneurs of Medical Treatments/Devices. The Case of Patients and their Families and Friends. Master's thesis, Universidade Católica Portuguesa.

Shields, P., & Rangarjan, N. (2013). A Playbook for Research Methods: Integrating Conceptual Frameworks and Project Management. New Forums Press.

Shortell, S., Bennett, C., & Byck, R. (1998). Assessing the impact of continuous quality improvement on clinical practice: what it will take to accelerate progress. Milbank quarterly, 76(4), 593-624.

Shortell, S. M., Zazzali, J. L., Burns, L. R., Alexander, J. A., Gillies, R. R., Budetti, P. P., Waters, T. M., & Zuckerman, H. S. (2001). Implementing evidence-based medicine: the role of market pressures, compensation incentives, and culture in physician organizations. Medical care, I62-I78.

Snowdon, A. W., Bassi, H., Scarffe, A. D., & Smith, A. D. (2015). Reverse innovation: an opportunity for strengthening health systems. Globalization and health, 11(1), 2.

Sternin, J., & Choo, R. (1999). The power of positive deviance. Harvard Business Review, 78(1), 14-15.

Sullivan, A., & Sheffrin, S. M. (2003). Economics: Principles in action. Upper Saddle River, New Jersey 07458: Pearson Prentice Hall.

Svensson, R. (2007). Commercialization of patents and external financing during the R&D phase. Research Policy, 36(7), 1052e1069.

Taylor, K. (2015). Connected health: how digital technology is transforming health and social care. London: Deloitte Centre for Healthcare Solutions.

Teece, D. J. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. Research Policy, 15(6), 285-305.

Tietz, R., Morrison, P. D., Lüthje, C., & Herstatt, C. (2004). The process of user-innovation: a case study on user innovation in a consumer goods setting. Working Papers/Technologie-und Innovationsmanagement, Technische Universität Hamburg-Harburg, No. 29.

Trouiller, P., Olliaro, P., Torreele, E., Orbinski, J., Laing, R., & Ford, N. (2002). Drug development for neglected diseases: a deficient market and a public-health policy failure. The Lancet, 359(9324), 2188-2194.

Urban, G. L., & von Hippel, E. (1988). Lead user analyses for the development of new industrial products. Management Science, 34(5), 569-582.

Utterback, J. (1974). Innovation in industry and the diffusion of technology. Science, 183(4125), 620-626.

Van der Boor, P., Oliveira, P., & Veloso, F. (2014). Users as innovators in developing countries: The global sources of innovation and diffusion in mobile banking services. Research Policy, 43(9), 1594-1607.

von Hippel, C. (2016). A 'Next Generation' for Public Health Intervention Models: The Public as Innovators.

von Hippel, E. (1976). The dominant role of users in the scientific instrument innovation process. Research Policy, 5(3), 212-239.

von Hippel, E. (1986). Leas Users: A Source of Novel Product Concepts. Management Science, 32(7), 791-805.

von Hippel, E. (1988). The Sources of Innovation. Oxford University Press.

von Hippel, E. (1994). "Sticky information" and the locus of problem solving: implications for innovation. Management Science, 40(4), 429-439.

von Hippel, E. (1998). Economics of product development by users: The impact of "sticky" local information. Management Science, 44(5), 629-644.

von Hippel, E. (2005). Democratizing innovation: The evolving phenomenon of user innovation. Journal für Betriebswirtschaft, 55(1), 63-78.

von Hippel, E. (2016). Free Innovation. MIT Press.

von Hippel, E., DeMonaco, H. J., & de Jong, J. P. J. (2014). Market failure in the diffusion of user innovations: the case of "Off-Label" innovations by medical clinicians. Science and Public Policy, 1-33.

von Hippel, E., Ogawa, S., & De Jong, J. P. (2011). The age of the consumer-innovator. MIT Sloan Management Review, 53(1), 27.

Voss, C. (1985). The role of users in the development of applications software. Journal of Product Innovation Management, 2(2), 113-121.

Yin, R. (1984). The case study crisis: Some answers. Administrative science quarterly, 26(1), 58-65.

Yin, R. (2009). Case study research: Design and methods (Fourth edition). Thousand Oaks, California: Sage Publications.

Zaltman, G., Duncan, R., & Holbek, J. (1973). Innovations and organizations. New York: Wiley, Vol. 1973.

Zejnilović, L., Oliveira, P., & Canhão, H. (2016). Innovations by and for Patients, and Their Place in the Future Health Care System. In Boundaryless Hospital, pp. 341-357.

Zurovac, D., Talisuna, A., & Snow, R. (2012). Mobile phone text messaging: tool for malaria control in Africa. PLoS Med, 9(2), e1001176.

# Exhibits

## Exhibit 1 - Gérard Niyondiko (A1)

Gérard Niyondiko was born in 1978 and he is originally from Burundi. He created Faso Soap, which was also started by Moctar Dembélé, however he left the project in 2015. Currently living in Burkina Faso, Gérard holds a University degree in Chemical Engineering, and decided to create this project while he was still a student. He dealt with malaria on several occasions, being the most severe episode when he was doing his military service. Moreover, his brother and sisters were almost left for dead due to the disease.

Aiming to reduce the number of malaria cases, he decided to create Faso Soap as a prevention tool, to be used as a complement with other available products, protecting populations from malaria. Consists of a mosquito repellent solution made with natural ingredients, providing an accessible, low-cost anti-malarial tool. This soap is made from shea butter, lemongrass oil and other ingredients. The respective tests are being made along with the Ministry of Health, providing a laboratory, and the Medicine Research Center. The team also has some partners around the world (mainly in France), aiming to increase the access to technical know-how and technologies.

The main project target consists of continuing the tests on efficacy, aiming to get the approval by the WHO (to finance the project) and, then starting the introduction in the market. Gérard mentioned the importance of finding the necessary natural raw materials. From the 214 million cases of malaria each year, 90% of them occur in Africa, accordingly to Gérard, thus the main target of the solution are these populations.

Team: Gérard Niyondiko, Lisa Barutel and Franck Langevin

**Pictures 1 – Faso Soap, by Gérard Niyondiko**

## Exhibit 2 - Didier Lalaye (A2)

Didier Lalaye is from Chad, and was born in 1984. One day in 2014, he went to visit his parents' village in Torrock (around 40kms away from his born town, in Pala) and visited a health center, where he found Simon, a 14-year-old child whose diagnostic was a urinary related disease. Simon was living with this health disorder and urinating blood for two years, and Didier discovered that schistosomiasis (spread by contact with fresh water contaminated with the parasites) affects more than 50% of children aged one to 14 months of age, and found that there are health centers without a laboratory, making it impossible to run an accurate diagnosis.

This led to the creation of DAWA Mobile Health, a mobile unit for detecting and manage schistosomiasis among rural villages (given the distance to hospitals). By setting up laboratories in health centers and contacting target groups by telephone, patients take urine samples to their doctors and request their diagnosis via SMS. Then doctors analyse them and communicate with pharmacies to prescribe medicine to patients. The results are given by SMS and those who are declared positive receive their drugs directly to their homes.

Up until 2017, DAWA Mobile Health diagnosed more than 2,500 children and treated more than 600 patients with schistosomiasis, it has also allowed the population to have access to biological tests.

**Pictures 2 – DAWA Mobile Health, by Didier Lalaye**

## Exhibit 3 - MOJA Team (A3)

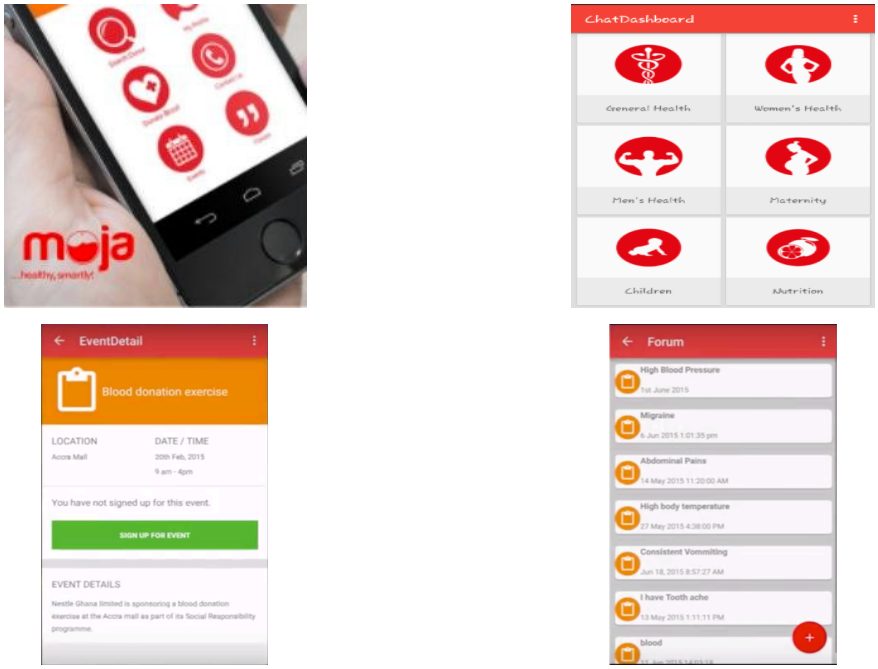
The creator of MOJA was born in the year of 1984, in Ghana. He holds a University degree in Corporate Assignments and by the time of the creation of MOJA he was a freelancer. His sister was diagnosed with cancer, and needed a considerable amount of blood, as she lived with this health disorder for three months before passing away.

The low levels of blood donation constitute a serious problem, particularly in Ghana. In 2015, only 32% of blood was collected from donors (right now this level is situated around 48%) and it is used mostly (65% in Sub-Saharan African countries) in children under-5 years and pregnant women, that is the reason why MOJA was created. With 4,000 users, the cloud based app makes possible for National Blood Service to replenish its stock and contact interested donors, who have access to a national database of volunteer donors, to search and find their match for a blood transfusion. Donors are also encouraged to recruit their friends, earning points.

After testing the app, the team realized that not a considerable size of Ghanaian population using smartphones, so they created a different approach. Medical staff is able to visit possible donors' houses and collect blood. In order to keep blood donation in top of the patients' minds, MOJA started to send health tips.

The possibility to contact personally and 24/7 health professionals has been eliminated, because the team realized doctors and nurses were not able to serve that kind of direct demand, so now there is the possibility to leave a message and health professional will respond later.

MOJA plans to cover other African areas such as, Nigeria, Liberia and Burkina Faso.




**Pictures 3 – MOJA App, by MOJA Team**

## Exhibit 4 - Jean Luc Semedo and Evelyne Ines (A4)

Jean Luc Semedo was born in Senegal in 1993. Whilst, Evelyne Ines is original from Cameroon, born in 1994. They both hold a University degree in Telecommunications, and developed HOPE: Mon Sang Pour Sauver Des Vies during their studies. When he was five years old Jean Luc suffered a car accident and he crucially needed a blood transfusion to survive (this patient spent three months recovering in a hospital). Additionally, Evelyne had a classmate back in Cameroon diagnosed with leukemia, which needed to go to hospitals to receive blood transfusions every month, until one day she went for the treatment and ended up by passing away, due to a blood shortage in the hospital.

Considered as the first digital platform in Senegal, which promotes blood banks and blood transfusion centers to mobilize their donors. Promotes blood donation by registering blood donors and encouraging them to donate. The major goal is to provide information about the existent blood banks and emergencies occurring throughout the country. The platform is available in various local languages, aiming to increase the awareness by local Senegalese populations. Moreover, there is the possibility to use the application through SMS (to inform about the next donation date and about blood banks' activities).

During its eight-month pilot, HOPE was able to acquire around 10,000 users and the main target is to switch from the pilot program to the commercialization phase. This phase involves an expansion into other countries, like Cameroon, Benin and Ivory Coast.

They plan to create an ambassador's program, to provide assistance and expand the project's mission and vision through rural areas. This enables the project to take more advantages on the local languages.


**Pictures 4 - HOPE, by Jean Luc Semedo and Evelyne Ines**

## Exhibit 5 - Olivia Koburongo (A5)

Olivia Koburongo was born in Uganda, in 1991. In June 2014, after her grandmother fell ill and being moved from one hospital to another, before being properly diagnosed with pneumonia, passed away.

With the help of a Telecommunications Engineer's friend, Brian Turyabagye (born in 1993), and a team of doctors, she developed Mama-Ope (meaning mother's hope). Nowadays, doctors simply use a stethoscope to detect pneumonia, which has the same symptoms as malaria, asthma, or tuberculosis, making difficult to come up with an accurate diagnosis. "The time lost treating those rather than pneumonia could prove deadly for their patient", as Brian mentioned during an interview.

A biomedical smart jacket, specifically designed for children ageing between 0 to 5 years old, enabling to distinguish pneumonia's symptoms, like temperature, breathing rate and sound emitted by the lungs. Health workers simply have to slip the jacket onto the child, and its sensors will pick up the symptoms. Then, information is sent via Bluetooth to a mobile app, which analyses the information in comparison to known data in order to get an estimate on the strength of the disease.

Mama-ope can diagnose pneumonia up to three times faster than a doctor and reduces human error.

**Pictures 5 – Mama-Ope, by Olivia Koburongo**

## Exhibit 6 - Brian Gitta (A6)

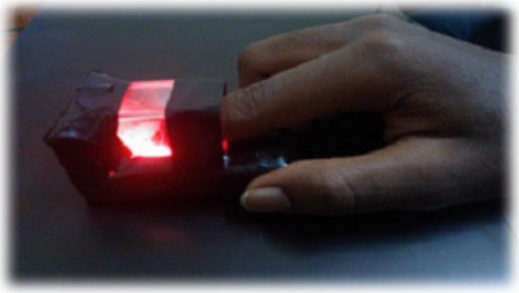
Brian Gitta is a Ugandan born in 1993, with a University degree in Computer Science, and a person with phobia of needles. He always lived with malaria as he was growing up, but it was when Brian had 20 years old that suffered more severely, he lived with this disease for two to three weeks, which decreased his life productivity. Thus, he decided to develop Matibabu while working in an engineering company.

The goal is to reduce the time for detection of malaria in a first stage (with Matibabu it takes less than three minutes, while the available products take about half an hour). Besides this, the patient wanted to change the way detection is done, avoiding the use of needles because of his fear and since it is a "*painful*" way to diagnose.

The device works with the help of a smartphone. A patient simply inserts its finger into the clipper device and selects "*start diagnosis*" on the phone. The device makes use of light and magnetism to agglomerate red blood cells and analyse the patient's blood composition, then patients just need to wait for the diagnosis.

Given the excessive price of internet in Uganda and the low use of smartphones by the general population, Brian started to think in changing the approach and also cover the desktops.

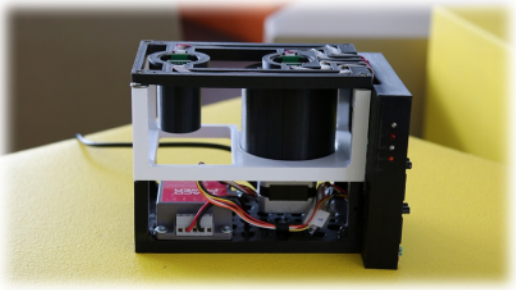
Since the beginning of the solution, four prototypes have been made and Matibabu is now in its testing phase, from the old prototype to the most recent, he decided to improve efficiency in terms of sensitivity and accuracy when running the diagnosis.



1st prototype

2nd prototype

3rd prototype



4th prototype

**Pictures 6 – Matibabu, by Brian Gitta**

## Exhibit 7 - Askwar Hilonga (A7)

Askwar Hilonga is from Tanzania and born in 1977. He holds a University Degree in Chemical Engineering from a South Korean University, where he developed an interest in nanomaterials. He lived with water related disease problems since always, because his parents could not afford bottled water, a very expensive product in Tanzania. He wanted to reduce the presence in the water of diseases like cholera, typhoid, hepatitis A and intestinal problems, as in Tanzanian hospitals 50% of diseases are related with poor water quality.

The patient studied about nanomaterials for about seven years, and his PhD thesis focused on how to put a component made of this material on a filter combined with a slow sand filter. It is an integrated water purification system, a combination of slow sands and nanomaterials.

He started by developing a prototype system in 2013, to test it amongst his community before taking it to the market. Afterwards he received financing to introduce Nanofilter® to a small-scale market.

Askwar developed the filter and started selling it to households (focusing on high and middle income ones, and also providing water stations in remote poor communities).

The changes from the first prototype have to do mainly with design, he decided to build a more attractive product and is now working with a company to come up with a more portable product. As he mentioned during our interview, water quality is the same from day 1.

Right now, a company is revolutionizing the design, and he is analysing the possibility of exporting to around 20 countries, including Colombia, Mexico, India and Sub-Saharan countries.

According with March 2017's report, the direct sales on high and middle income households were 208 and the number of water stations was 150, up to our interview.


Pictures 7 - Nanofilter®, by Askwar Hilonga

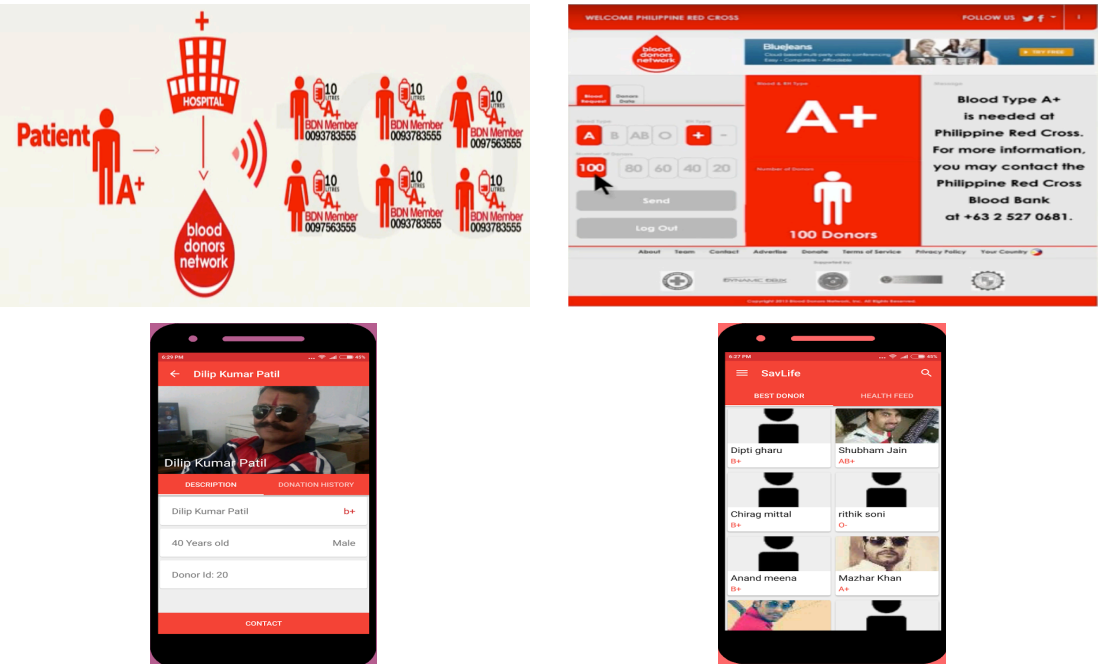
## Exhibit 8 - Joel Barquez (A8)

Joel Barquez was born in 1969 in Philippines, he is an active blood donor since 2002 (having done 43 blood donations so far). He holds a University Degree in Technology Management and the creation of Blood Donors Network was his master thesis topic.

On December 12th 1997, Joel got dengue, and the responsible doctor told him to contact friends and relatives in order to find a compatible donor for a blood transfusion. After seeking help from his close friends and relatives he discovered no one had the same blood type as his only two - three days later he has found a compatible donor, a neighbour, and was able to recover in eight to nine days.

The patient created Blood Donors Network to overcome the inexistence of a database for patients to access the availability for blood transfusions, basically have a centralized blood bank system. It is a mobile application that provides a solution to help communities meet their blood supply needs by increasing the acquisition of new blood donors and establishing a network of donors, currently with 187 active blood donors in its database.

Since its beginning the application has been pivoted, Joel does not want patients to contact directly donors because "that is where corruption comes in", as much as possible he wants this process to be voluntary and non-remunerated. Therefore, customers started to be hospitals, health centres, Red Cross, corporate and university organizations, rather than the patients. Another added feature was the location option, in which an independent coordinator is responsible for a given region and his donors, offering them the necessary care and enables health centres to manage the donors' database in an efficient way.




Pictures 8 – Blood Donors Network, by Joel Barquez

## Exhibit 9 - Michael Wahl and Starla Wahl (A9)

Michael Wahl and Starla Wahl are both North Americans and were born in 1977. Michael was a pastor and often went to do missions in Haiti, he started by helping to install water filtration systems, along the poorest Haitian areas. While Starla is a nurse in the USA.

It was during one of these missions that a mother called his attention, he looked at her holding on to her naked baby and she recognized him. As he approached, she tried to remove the faecal matter from her baby, and by seeing this Michael realised that mothers do not know how to remove deadly bacteria and parasites, and perceived the dimension of faecal related diseases in Haiti. Disposable diapers there are too expensive and mothers only use them when they leave the house to public appearances, so in 2013 Michael and Starla decided to create DriButts. "Education is what delivers the need" said him during our interview.

Made out of a polyester spandex blend for the outer shell and the inner shell is a polyester lining, finally there is an insert placed inside the diaper, made out of bamboo (naturally resistant to bacteria). The diapers are fully adjustable and fit to children up to three years old.

Problems with supplying delays, led them to sew the diapers at their kitchen table, making around 700 pairs with a help of the couple's friend, Jill Auxford. Each diaper costs $15 and they ask for $30 donations so that they can send one diaper to families in need. They are now looking to put "*DriButts centers*" within the communities they are present, and the main goal is to educate parents about simple, proper nutrition and sanitation classes (hygiene clean, wash their hands, properly dispose faecal matter). Families are also taught to wash the diapers with soap and water and hang them up to dry, which should take about 40 minutes.


**Pictures 9 – DriButts, by Michael Wahl and Starla Wahl**

## Exhibit 10 - Eddy Agbo (A10)

Eddy Agbo was born in Nigeria, in 1966. He holds a University Degree in Biotechnology and currently lives in the United States, where he created Fyodor Biotechnologies Corporation. Since his early days, he contracted malaria back in Nigeria multiple times and doctors need to inspect a blood sample with a microscope, to run the diagnosis. Besides being a costly process, which also consumes lot of time (usually 30 minutes), this country suffers from medical shortage, making it difficult to treat a patient in the right manner at the right time.

By perceiving this, Eddy created the Urine Malaria test, a simple diagnostic test that detects the presence of malaria using urine instead of blood. A "game changer in the management of malaria", as he told us in the questionnaire. It consists in a dipstick test that tells within 25 minutes if the fever is due to malaria or not. By simply dipping the test strip into the sample cup with a few drops of urine the patient can know the diagnosis. If two lines show up then it is positive, if one line shows up it is negative, and if no lines show up then the test is invalid and must be repeated. This product only costs $2 per test, while the team is planning to reduce the cost per unit as production increases (ecoomies of scale).

Eddy Agbo stated in our questionnaire that this kind of test is also very useful for travellers who visit endemic malaria countries.


**Pictures 10 – Urine Malaria Test, by Eddy Agbo**

## Exhibit 11 - Daniel Habanabakyze (B1)

Daniel Habanabakyze was born in 1994 and he is from Rwanda. After dropping out from high school he decided to enter in a vocational training center. The caregiver could not provide either his uncle's health condition or the diagnosis identified by the doctor, however his uncle was born with this type of physical disability and lived with it for about 50 years.

He lived with his uncle, who could not leave the house, because he was not able to move his legs and could not afford a wheelchair or hire a caregiver, given the affordability restrains (the existent wheelchairs are mainly imported from China, and distributed at a cost per unit of about US$1,500, while in the US costs around US$500, accordingly with Wheelchair Foundation[iv]).

Daniel designed and constructed an affordable wheelchair, which makes use of an electrical part to respond to the patients' challenges (the wheelchair can be used by the patient itself, rather than depending on a person to push it). Patients are now able to use their hands rather than the legs to move.

The caregiver started with basic tools to create a primitive electric wheelchair. Although he was not confident, he took it to the market and received valuable feedback to improve his solution. The next stage consisted mainly of adding some new features like other kind of wheels and better chains, aiming to create a faster and smoother wheelchair. Nowadays, Daniel is able to differentiate and create wheelchairs adjustable to patients' needs, which varies with their weight.

Although he still needs more funds, Daniel is planning to expand to other districts, aiming to cover the entire country. In just a year and a few months, this caregiver was able to sell almost 80 wheelchairs, mostly due to the adoption of an affordable approach.

**Pictures 11 – Low-cost hand bike, by Daniel Habanabakyze**

[iv] https://www.wheelchairfoundation.org/

## Exhibit 12 - Neema Shosho (B2)

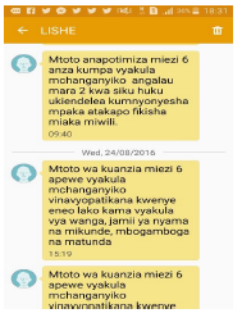
Neema Shosho is from Tanzania and was born in the year of 1986. She holds a University degree in Food and Nutrition Sciences and by the time of Afya Slices' creation she was a health nutritionist.

Lots of her friends and family are overweight, with hypertension and diabetes' problems. People close to her family have also undernourished babies. "*These kids cannot grow well, both physically and cognitively, their immune system is highly affected and, as a result, they get sick more often*", said she while filling the survey.

Afya Slices aims to address knowledge gap in nutrition in Tanzania. High prevalence of malnutrition is experienced in areas where people grow a lot of food, meaning that food availability is not necessarily translated into good nutrition. Moreover, knowledge on optimum nutrition practices, or hand washing is also very important.

Thus, she decided to develop a mobile platform that will educate communities especially parents and caregivers (with the aim of changing negative behaviours) on optimum nutrition care and practices for maternal and young children. Apart from the platform that is still under development, Neema organizes seminars for mothers, housemaids and caregivers on maternal and children optimum nutrition care and practices.

The future passes by finalizing the platform, launching it to the market, in order to make it available for malnourished populations.


Tip sent example

**Pictures 12 – Afya Slices, by Neema Shosho**

## Exhibit 13 - Raghuraj Raju (B3)

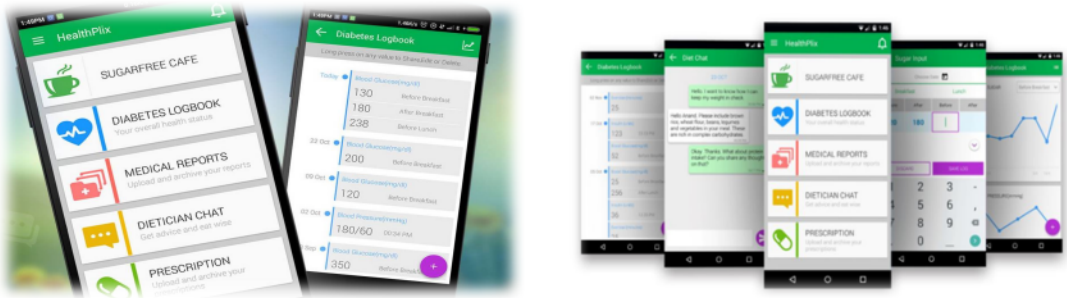
Raghuraj Raju is an entrepreneur from India, born in 1982. In 2013, he was diagnosed with hypoglycaemia, and started to perceive that chronic healthcare conditions in his country were not fully monitored by the responsible doctors (India has about 70 million patients suffering from chronic health disorders).

A year later he decided to create HealthPlix, a mobile app that connects patients to their responsible doctors in real-time messaging. Also, it enables patients to record their blood sugar, meals, activity, and insulin intake. Doctors can charge patients through the app, by paying a one-time fee based on how long and how much they will use the service. This solution also functions via SMS, however Raghuraj thinks that there is a lack of engagement in this way of approach.

Currently the mobile app has in diabetes and coronary heart diseases the majority of its users. This patient considers that feedback received and quickness to adjust to the market are the fundamental factors to success. "The need to have a good view of what is needed and the formation of an agile team" were also seen as equally important.

From the initial prototype, the patient already added to the app the possibility to integrate a patient's medical history (including the medicine a person is taking) and some analytics to the doctors (regarding treatments and their main failures) and provides them clinical insights, facilitating the doctor's work, one type of users. To the other type, the patients, Raghuraj created a more user-friendly solution, thus increasing engagement.

He plans to target more doctors and physicians treating chronic problems, and expand into other specialities such as nephrologists, dermatologists or paediatrics. Additionally, he wants to innovate and adopt artificial intelligence, creating an automatic response to users that want a doctor.




Pictures 13 – HealthPlix, by Raghuraj Raju

## Exhibit 14 - Fawad Bhatti (B4)

Fawad Bhatti was born in 1994, in Pakistan. As an electrical engineering student, he developed Trequant while studying in the University, along with Usman Shabbir, who decided to leave the project.

Although Fawad's grandfather was diagnosed with Parkinson's disease, his doctor and family were not 100% convinced of that. It was hard for him to explain to the doctor his conditions, vibrations and movements. So, Fawad wanted to solve his grandfather's health disorder by monitoring it (the different food he ate, or the different activities performed during the days that were affecting his tremors), enabling his grandfather's doctor to have access to how the he was feeling throughout the day, and not just at the moment he was visiting the hospital.

Trequant is a mobile and desktop app that aims to track and analyse tremor patterns. Designed to help doctors to understand patient's tremors by analysing its daily activities that affect the tremors, communicating this crucial information through a wearable device. It also, helps patients by offering some insights on the health disorder, providing tips on health habits, or activities to reduce the tremors, and they get notifications when it is time to take the prescribed medications. There is also the community aspect, where patients can share their problems or solutions to other people with the same health problem. It also includes the option to share the tremor intensities and collaborate in friendly challenges that motivates patients to perform daily exercises, beneficial to a tremor patient.

The project had to end, due to a lack of financing, firstly because not many Pakistani investors would be willing to invest on healthcare problems, so the caregiver adopted a crowdfunding way in order to have funds for market research and introducing the product to the market.


**Pictures 14 – Trequant, by Fawad Bhatti**

## Exhibit 15 - Mick Ebeling (B5)

Mick Ebeling is the founder of Not Impossible, a company dedicated to "technology for the sake of humanity". Currently with 46 years of age, this American is a film, television and commercial executive producer, author, entrepreneur and philanthropist.

After reading a Time Magazine article about a boy called Daniel Omar, a 15 year-old Sudanese who lost both his hands after his village had been bombed, he decided to assemble a team and, in 2013, illegally travelled towards Nuba Mountains (Sudan), a commonly know active war zone, to provide him a prosthetic arm and to teach the community to create low cost prosthetic limbs.

Daniel lost both arms while protecting himself from an aerial attack (by wrapping his arms around a tree, which enabled him to protect his body but not his arms). After this, Daniel wished he had died. Nowadays he is a double amputee, therefore he relied enormously on a caregiver, a 9 year-old child named Shaki, which had to feed him and bathe him, amongst other things.

The prosthetics arms cost $100 to produce and can be printed in about 6 hours. Daniel cannot precisely control the fingers or lift heavy objects, as the printed arm is not so sophisticated as high-end ones, but now he can do basic tasks like eat without the help of others.

After these results, Mick has established a 3D printing lab nearby a Sudanese hospital. On the other side, Daniel is now living in Kenya, after the team rescued him out of a South Sudan refugee camp, where he was living.


**Pictures 15 – 3D printing arm, by Mick Ebeling**

## Exhibit 16 - Indicators Definition

*GNI pc*: sum of value added by resident producers, plus product taxes minus subsidies (not included the output valuation, nor net receipts of primary income, compensation of employees and property income from abroad), divided by the midyear population. We choose the World Bank's Atlas Method[v] of Conversion, to smooth fluctuations in prices and exchange rates. Data referent to 2015, accordingly with World Bank.

*Population*: number of residents in a country, regardless their legal status or citizenship. This data is referent to 2015, midyear estimate, and accordingly with World Bank.

*Education level*: average mean of school years (in adults) and expected school years (in children), both expressed as an index obtained by scaling with the corresponding maxima. Data referent to 2013, accordingly with the UN.

$$EL=\frac{\sqrt{mean\ years\ of\ schooling\ index * expected\ years\ of\ schooling\ index} - minimum\ level\ verified}{maximum\ level\ verified - minimum\ level\ verified}$$

*Mortality rate, under-5*: probability per 1,000 births a newborn baby will die before reaching age 5, if subjected to age-specific mortality rates of the specified year. Data referent to 2015, accordingly with World Bank.

*Life expectancy at birth*: number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. Data referent to 2014, accordingly with World Bank.

*Multidimensional poverty*: percentage of multidimensionally poor population, adjusted by intensity of deprivations in terms of education, health and living standards. Refers to different years due to inconsistencies for some nations, accordingly with the UN.

*Population undernourished*: Proportion of population below the minimum level of dietary energy consumption. This data is referent to 2015 and accordingly with the UN.

*Human Development Index:* geometric mean of normalized indices for three dimensions: long and healthy life, knowledge and decent standard of living. Data referent to 2015, accordingly with the UN.

*Mobile phone subscriptions*: Number of subscriptions for mobile phone services (including the number of post-paid subscriptions and the number of active prepaid accounts). Data referent to 2015, expressed per 100 people, accordingly with World Bank.

*Internet users*: Population with access to worldwide network. Data referent to 2015, expressed per 100 people, accordingly with World Bank.

[v] http://bit.ly/20hZJ7K

## Exhibit 17 - Analysed Countries

| Country | Economic | Social | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GNI pc[vi] | Population ('000)[vii] | Education level[viii] | Mortality under-5[ix] | Life expectancy at birth[x] | Multidimensional poverty[xi] | Population undernourished[xii] | HDI[xiii] | Mobile users[xiv] | Internet users[xv] |
| **Africa** | | | | | | | | | | |
| Benin | $840.0 | 10879,83 | 0.414 | 100 | 60 | 0.343 (2012) | 7.5% | 0.485 | 86 | 7 |
| Burkina Faso | $640.0 | 18105,57 | 0.250 | 89 | 59 | 0.508 (2010) | 20.7% | 0.402 | 81 | 11 |
| Burundi | $260.0 | 11178,92 | 0.370 | 82 | 57 | 0.442 (2010) | n.a. | 0.404 | 46 | 5 |
| Cameroon | $1 320.0 | 23344,18 | 0.486 | 88 | 55 | 0.260 (2011) | 9.9% | 0.518 | 72 | 21 |
| Central African Republic | $330.0 | 4900,27 | 0.318 | 130 | 51 | 0.424 (2010) | 47.7% | 0.352 | 26 | 5 |
| Chad | $880.0 | 14037,47 | 0.256 | 139 | 52 | 0.545 (2010) | 34.4% | 0.396 | 40 | 3 |
| Comoros | $780.0 | 788,47 | 0.450 | 74 | 64 | 0.165 (2012) | n.a. | 0.497 | 55 | 7 |
| Congo | $2 540.0 | 4620,33 | 0.511 | 45 | 63 | 0.192 (2012) | 30.5% | 0.592 | 112 | 8 |
| Côte D'Ivoire | $1 420.0 | 22701,56 | 0.389 | 93 | 52 | 0.307 (2012) | 13.3% | 0.474 | 119 | 21 |
| DRC[xvi] | $410.0 | 77266,81 | 0.372 | 98 | 59 | 0.369 (2014) | n.s.[xvii] | 0.435 | 53 | 4 |
| Djibouti | n.a.[xviii] | 887,86 | 0.306 | 65 | 62 | 0.128 (2006) | 15.9% | 0.473 | 35 | 12 |
| Eritrea | n.a. | n.a. | 0.228 | 47 | 64 | n.a. | n.a. | 0.420 | 7 | 1 |
| Ethiopia | $590.0 | 99390,75 | 0.317 | 59 | 64 | 0.537 (2011) | 32.0% | 0.448 | 43 | 12 |
| The Gambia | n.a. | 1990,92 | 0.346 | 69 | 60 | 0.289 (2013) | 5.3% | 0.452 | 138 | 17 |
| Ghana | $1 480.0 | 27409,89 | 0.553 | 62 | 61 | 0.144 (2011) | 5.0% | 0.579 | 130 | 24 |
| Guinea | $470.0 | 12608,59 | 0.294 | 94 | 59 | 0.425 (2012) | 16.4% | 0.414 | 87 | 5 |
| Guinea Bissau | $590.0 | 1844,33 | 0.325 | 93 | 55 | 0.495 (2006) | 20.7% | 0.424 | 69 | 4 |
| Kenya | $1 340.0 | 46050,3 | 0.515 | 49 | 62 | 0.226 (2009) | 21.2% | 0.555 | 81 | 46 |
| Lesotho | $1 280.0 | 2135,02 | 0.504 | 90 | 50 | 0.227 (2009) | 11.2% | 0.497 | 101 | 16 |
| Liberia | $380.0 | 4503,44 | 0.367 | 70 | 61 | 0.356 (2013) | 31.9% | 0.427 | 81 | 6 |
| Madagascar | $420.0 | 24235,39 | 0.458 | 50 | 65 | 0.420 (2009) | 33.0% | 0.512 | 44 | 4 |
| Malawi | $340.0 | 17215,23 | 0.440 | 64 | 63 | 0.332 (2010) | 20.7% | 0.476 | 35 | 9 |

[vi] http://bit.ly/2rTj9qp
[vii] http://bit.ly/2rTKeKg
[viii] http://bit.ly/1pHdX3Q
[ix] http://bit.ly/2qfrLKZ
[x] http://bit.ly/2qj9A31
[xi] http://bit.ly/1kYwvXA
[xii] http://bit.ly/2rTvtqV
[xiii] Human Development Index (http://bit.ly/2niumB7)
[xiv] http://bit.ly/2qfrwQg
[xv] http://bit.ly/2qfmJhm
[xvi] Democratic Republic of Congo
[xvii] not significant
[xviii] not available

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Mali | $760.0 | 17599,69 | 0.305 | 115 | 58 | 0.456 (2013) | 5.0% | 0.442 | 140 | 10 |
| Mauritania | n.a. | 4067,56 | 0.352 | 85 | 63 | 0.291 (2011) | 5.6% | 0.513 | 89 | 15 |
| Mozambique | $590.0 | 27977,86 | 0.372 | 79 | 55 | 0.390 (2011) | 25.3% | 0.418 | 74 | 9 |
| Niger | $390.0 | 19899,12 | 0.198 | 96 | 62 | 0.584 (2012) | 9.5% | 0.353 | 46 | 2 |
| Nigeria | $2 820.0 | 182201,96 | 0.425 | 109 | 53 | 0.279 (2013) | 7.0% | 0.527 | 82 | 47 |
| Rwanda | $700.0 | 11609,67 | 0.478 | 42 | 64 | 0.352 (2010) | 31.6% | 0.498 | 70 | 18 |
| Senegal | $980.0 | 15129,27 | 0.368 | 47 | 66 | 0.278 (2014) | 24.6% | 0.494 | 100 | 22 |
| Sierra Leone | $620.0 | 6453,18 | 0.305 | 120 | 51 | 0.411 (2013) | 22.3% | 0.420 | 90 | 3 |
| Somalia | n.a. | 10787,1 | n.a. | 137 | 55 | 0.500 (2006) | n.s. | n.a. | 52 | 18 |
| South Sudan | $790.0 | 12339,81 | n.a. | 93 | 56 | 0.551 (2010) | n.s. | 0.418 | 24 | 27 |
| Sudan | $1 920.0 | 40234,88 | 0.306 | 70 | 63 | 0.290 (2010) | n.s. | 0.490 | 71 | 2 |
| Swaziland | $3 280.0 | 1286,97 | 0.551 | 61 | 49 | 0.113 (2010) | 26.8% | 0.541 | 73 | 30 |
| Tanzania | $920.0 | 53470,42 | 0.426 | 49 | 65 | 0.335 (2010) | 32.1% | 0.531 | 76 | 5 |
| Togo | $540.0 | 7304,58 | 0.514 | 78 | 60 | 0.242 (2014) | 11.4% | 0.487 | 65 | 7 |
| Uganda | $700.0 | 39032,38 | 0.479 | 55 | 58 | 0.359 (2011) | 25.5% | 0.493 | 50 | 19 |
| Zambia | $1 490.0 | 16211,77 | 0.591 | 64 | 60 | 0.264 (2014) | 47.8% | 0.579 | 74 | 21 |
| Zimbabwe | $860.0 | 15602,75 | 0.500 | 71 | 57 | 0.128 (2014) | 33.4% | 0.516 | 85 | 16 |
| **Asia** | | | | | | | | | | |
| Afghanistan | $610.0 | 32526,56 | 0.365 | 91 | 60 | 0.293 (2011) | 5.0% | 0.479 | 62 | 8 |
| Bangladesh | $1 190.0 | 160995,64 | 0.447 | 38 | 72 | 0.237 (2011) | 16.4% | 0.579 | 83 | 14 |
| India | $1 600.0 | 1311050,53 | 0.473 | 48 | 68 | 0.282 (2006) | 15.2% | 0.624 | 79 | 26 |
| Indonesia | $3 440.0 | 257563,82 | 0.603 | 27 | 69 | 0.024 (2012) | 7.6% | 0.889 | 132 | 22 |
| Nepal | $730.0 | 28513,7 | 0.452 | 36 | 70 | 0.197 (2011) | 7.8% | 0.558 | 97 | 18 |
| Pakistan | $1 440.0 | 188924,87 | 0.372 | 81 | 66 | 0.237 (2013) | 22.0% | 0.550 | 67 | 18 |
| Papua New Guinea | n.a. | 7619,32 | 0.376 | 57 | 63 | n.a. | n.a. | 0.516 | 47 | 8 |
| Philippines | $3 550.0 | 100699,4 | 0.610 | 28 | 68 | 0.033 (2013) | 13.5% | 0.682 | 118 | 41 |
| Solomon Islands | $1 920.0 | 583,59 | 0.405 | 28 | 68 | n.a. | 11.3% | 0.515 | 73 | 10 |
| Syrian Arab Republic | n.a. | 18502,41 | 0.553 | 13 | 70 | 0.028 (2009) | n.a. | 0.536 | 64 | 30 |
| Vietnam | $1 990.0 | 91703,8 | 0.513 | 22 | 76 | 0.026 (2011) | 11.0% | 0.683 | 131 | 53 |
| Yemen | $1 140.0 | 26832,22 | 0.339 | 42 | 64 | 0.200 (2013) | 26.1% | 0.482 | 68 | 25 |
| **South America** | | | | | | | | | | |
| Haiti | $810.0 | 10711,07 | 0.374 | 69 | 63 | 0.242 (2012) | 53.4% | 0.493 | 70 | 12 |
| Honduras | $2 280.0 | 8075,06 | 0.505 | 20 | 73 | 0.098 (2012) | 12.2% | 0.625 | 96 | 20 |
| Nicaragua | $1 940.0 | 6082,03 | 0.484 | 22 | 75 | 0.088 (2011) | 16.6% | 0.645 | 116 | 20 |

**Table 9 - Analysed Countries**

## Exhibit 18 - User Innovators Found

| Country of Innovation | Country of birth | Age | Gender | Education | Occupation | Condition | Type | Solution |
|---|---|---|---|---|---|---|---|---|
| **Africa** | | | | | | | | |
| Burkina Faso | Burundi | Born in 1978 | Male | University Degree | Entrepreneur | Malaria | Patient | Faso Soap |
| Cameroon | Cameroon | Born in 1992 | Male | University Degree | Engineer | Maternal-death | Collaborator | Gifted-Mom |
| Cameroon | Cameroon | Born in 1988 | Male | University Degree | Engineer | Heart diseases | Caregiver | CardioPad |
| Chad | Chad | Born in 1984 | Male | University Degree | Doctor | Schistosomiasis | Collaborator | DAWA Mobile Health |
| DRC | DRC | Born in 1980 | Male | Primary School | Entrepreneur | Polio | Patient | Three-wheeled wheelchair |
| DRC | DRC | n.a.[xix] | Male | University Degree | Entrepreneur | Malaria | Collaborator | PaluCheck |
| Ghana | Ghana | Born in 1984 | Male | University Degree | Entrepreneur | Cancer | Caregiver | MOJA |
| Ghana | Ghana | n.a. | Female | University Degree | Nurse | Autism | Caregiver | AACT |
| Kenya | UK | Born in 1980 | Male | University Degree | Ophthalmologist | Vision problems | Collaborator | PEEK Vision |
| Mali | Mali | n.a. | Male | University Degree | Doctor | Medical personnel shortage | Collaborator | Bogou |
| Nigeria | Nigeria | Born in 1966 | Male | University Degree | Biotechnologist | Malaria | Patient | Urine Malaria Test |
| Rwanda | Rwanda | Born in 1994 | Male | High School | Entrepreneur | Physical disability | Caregiver | Low-cost hand bike |
| Sudan | USA | Born in 1970 | Male | University Degree | Entrepreneur | Physical disability | Collaborator | 3D Prosthetic Arm |
| Sudan | Sudan | Born in 1999 | Male | High School | Student | Physical disability | Collaborator | Robotic Arm |
| Senegal | Senegal | Born in 1993 | Male | University Degree | Entrepreneur | Blood transfusion | Patient | HOPE: Mon Sang Pour Sauver Des Vies |
| | Cameroon | Born in 1994 | Female | University Degree | Entrepreneur | Leukaemia | Caregiver | |
| Uganda | Uganda | Born in 1991 | Female | University Degree | Engineer | Pneumonia | Caregiver | Mama-Ope |
| Uganda | Uganda | Born in 1993 | Male | University Degree | Engineer | Malaria | Patient | Matibabu |
| Tanzania | Tanzania | Born in 1986 | Female | University Degree | Nutritionist | Malnutrition | Caregiver | Afya Slices |
| Tanzania | Tanzania | Born in 1977 | Male | University Degree | Engineer | Water related diseases | Patient | Nanofilter® |
| **Asia** | | | | | | | | |
| Afghanistan | Afghanistan | n.a. | Male | University Degree | Doctor | Physical disability | Caregiver | Sadat Fixation Device |
| India | India | Born in 1998 | Female | High School | Student | Water related diseases | Collaborator | Water purification system |
| India | India | Born in 1984 | Male | University Degree | Doctor | Throat cancer | Caregiver | Entraview |
| India | India | Born in 1957 | Male | University Degree | Surgeon | Impossibility to speak | Collaborator | Vocalizer |
| India | India | Born in 1999 | Male | High School | Student | Physical disability | Caregiver | EEG Prosthetic arm |
| India | India | Born in 2000 | Male | High School | Student | Lack of access to vaccination | Patient | VAXXWAGON |
| India | India | Born in 1985 | Female | University Degree | Designer | Deaf at birth | Caregiver | Sohum |
| India | India | Born in 1982 | Male | University Degree | Engineer | Diabetes | Patient | HealthPlix |
| India | India | Born in 1982 | Male | University Degree | Pharmaceutic | Diabetes | Caregiver | Diabeto |
| Indonesia | Indonesia | Born in 1985 | Male | University Degree | Doctor | Lack of access to healthcare | Collaborator | ProSehat |
| Indonesia | Singapore | Born in 1993 | Male | University Degree | Doctor | Lack of access to healthcare | Collaborator | RingMD |
| Indonesia | Indonesia | Born in 1984 | Male | Secondary School | Welder | Physical disability | Patient | EEG Prosthetic arm |
| Pakistan | Pakistan | Born in 1994 | Male | University Degree | Engineer | Parkinson | Caregiver | Trequant |

[xix] not available

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Philippines | Philippines | Born in 1969 | Male | University Degree | Entrepreneur | Dengue | Patient | Blood Donors Network |
| Syrian Arab Republic | Syrian Arab Republic | n.a. | Male | High School | n.a. | Physical disability | Patient | Electric bycicle |
| **South America** | | | | | | | | |
| Haiti | USA | Born in 1977 | Male | University Degree | Pastor | Diarrhoea | Collaborator | DriButts |
| | | Born in 1977 | Female | University Degree | Nurse | | | |
| Honduras | Honduras | Born in 1995 | Male | High School | Student | Physical disability | Caregiver | EyeBoard |

**Table 10 - User Innovators found**

## Exhibit 19 - Sample

| Country of innovation | Solution | Relation with the need | Source of data | Date | Duration (min) |
|---|---|---|---|---|---|
| Burkina Faso | Malaria prevention soap | Patient | Interview | 29.03.2017 | 39 |
| Chad | Health monitoring platform | Collaborator | Interview | 13.04.2017 | 60 |
| Ghana | Blood donation platform | Caregiver | Interview | 23.03.2017 | 38 |
| Nigeria | Urine Malaria Test | Patient | Survey | 27.05.2017 | n.a.[xx] |
| Rwanda | Low-cost hand bike | Caregiver | Interview | 23.03.2017 | 74 |
| Sudan | 3D Printing Arm | Collaborator | Survey | 30.05.2017 | n.a. |
| Senegal | Blood donation platform | Patient/Caregiver | Interview | 28.03.2017 | 55 |
| Uganda | Malaria testing device | Patient | Interview | 23.03.2017 | 42 |
| Uganda | Pneumonia detection shirt | Caregiver | Survey | 04.05.2017 | n.a. |
| Tanzania | Malnutrition monitoring platform | Caregiver | Survey | 03.04.2017 | n.a. |
| Tanzania | Low cost water filtration system | Patient/Caregiver | Interview | 12.03.2017 | 41 |
| India | Chronic diseases monitoring platform | Patient | Interview | 27.03.2017 | 72 |
| Pakistan | Tremors monitoring platform | Caregiver | Interview | 27.03.2017 | 41 |
| Philippines | Blood donation platform | Patient | Interview | 20.03.2017 | 64 |
| Haiti | Reusable diapers | Collaborator | Interview | 12.04.2017 | 65 |

Table 11 - Data Gathering

[xx] non-applicable

## Exhibit 20 - Questionnaire

Dear creator,

We would like to invite you to fill out this questionnaire, aiming to obtain findings for my thesis, which focuses on solutions developed by patients, and/or their caregivers living in developing countries to overcome a problem or a need imposed by a health condition or disorder.

I am currently working in collaboration with a research project called Patient Innovation, an online and free-access repository of open knowledge containing healthcare solutions where patients and caregivers from all around the world share their knowledge and solutions with others with the same need (https://patient-innovation.com/). The biggest advantage of this platform is its network effect: the more patients or caregivers that share their solutions, more information will be available to those who are looking for answers for their problems and the higher the potential value of each solution proposed. We invite you to share your solution in our community!

We are trying to figure it out the environment in which the innovators live, their limitations in regards to healthcare support. Therefore, if your want to remain anonymous please put a cross (X) on the following question. Your information is just for research purposes only, not for commercial means.

| Do you want to remain anonymous? | |
|---|---|
| Yes | |
| No | |

---

### *(I) Information about health disorder*

1)
Which was the diagnosis for the patient's health condition?
Answer:

2)
For how long has the patient lived (or still lives) with the health disorder? When was it diagnosed?
Answer:

3)
Briefly describe the major limitations on daily activities caused by the health disorder.
Answer:

4)
Exactly which problem did you want to solve? How did you solve it?
Answer:

### *(II) Initial knowledge on the health disorder*

Please put a cross (✗) on the answer that satisfies you the most.

5)

| What is your opinion on the information given by your doctor? | |
|---|---|
| - It is clear and provided me valuable information | |
| - Provided me some basic insights but it was not enough | |
| - The responsible doctor did not explain the condition in a proper manner | |
| - It is not sufficient for a person with my health disorder | |
| - Other: | |

6)

| Did you seek for more information about the health disorder? | |
|---|---|
| - No more than what the responsible doctor told | |
| - Asked a second opinion, from another doctor | |
| - Talked with patients that have a similar health disorder | |
| - Searched. How many hours? | |
| Less than 25 hours per week | |
| Between 25 and 50 hours per week | |
| More than 50 hours per week | |
| - Other: | |

If you **searched for more information**, please answer the following questions. Otherwise you can move onto the next section.

7)

| How did you perform your search about the health disorder? | |
|---|---|
| - Searched more information about the health disorder and its symptoms | |
| - Searched for solutions created to overcome the limitations to similar specific problems | |
| - Other | |

8)

| Where did you search for that additional information? | |
|---|---|
| - Online (via social networks, websites, blogs) | |
| - Offline (via newspapers, medical journals, articles) | |
| - A company provided more information about this specific health disorder | |
| - Contacted the respective patient association | |
| - Other: | |

## *(III) Solution*

9)

At the beginning what was the major problem that you wanted to solve?
Answer:

10)

Can you briefly describe your solution? (How was the process? Any differences from the initial prototype?)
Answer:

Please put a cross (✗) on the answer that satisfies you the most.

11)

| Why did you create this solution? | |
|---|---|
| - Lack of good quality infrastructures | |
| - Lack of competent medical personnel | |
| - Lack of good accesses to medical infrastructures | |
| - Lack of information provided | |
| - Other: | |

12)

| What is your opinion about the current solutions on the market? | |
|---|---|
| - There was no alternative on the market | |
| - The current products did not satisfy my needs | |

| | |
|---|---|
| - The current alternatives on the market are too expensive | |
| - Other: | |

On a scale from 1 to 7 (being 1, irrelevant and 7, fundamental), please classify the following aspects:

13)

| How relevant were the following conditions for your creation? | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| - Access to internet connection | | | | | | | |
| - Access to mobile connection | | | | | | | |
| - Access to medical facilities and personnel | | | | | | | |
| - Access to pharmaceutical drugs | | | | | | | |
| - Household access to potable water | | | | | | | |
| - Visits from medical personnel to faraway villages | | | | | | | |
| - Lack of public healthcare policies to prevent and monitor diseases | | | | | | | |
| - Role of community (to give the idea, or help him to create) | | | | | | | |
| - Access to education | | | | | | | |
| - Access to facilities to develop the solution | | | | | | | |
| - Other: | | | | | | | |

## *(IV) Diffusion*

Please put a cross (✗) on the answer that satisfies you the most.

14)

| Did you tell anyone about the solution that you created? Who? | |
|---|---|
| - Relatives | |
| - Friends | |
| - Patients with a similar health condition | |
| - Responsible doctor | |
| - Other: | |

15)

| How did you do it? | |
|---|---|
| - Talked with friends and/or relatives, other patients, responsible doctor | |
| - Shared via online channels (social networks, websites, blogs) | |
| - Shared via offline channels (newspapers, medical journals, articles) | |
| - Other: | |

16)

| What was the feedback received? | |
|---|---|
| - All the people found it useful | |
| - Most of the people found it useful | |
| - Some people found useful and provided me feedback | |
| - Some people found useful but did not provided feedback | |
| - Most of the people did not find it useful | |
| - No one found it useful | |
| - Other: | |

17)

| Besides yourself, this solution is valuable to: | |
|---|---|
| - No one | |
| - Few others | |
| - Many others | |
| - Nearly anyone | |

18)

| Did you protect your Intellectual Property rights somehow? | |
|---|---|
| - Yes | |
| - No | |

19)
If you have answered question *18* with "**Yes**":

| Why did you do it? | |
|---|---|
| - Perceive a good commercialization opportunity | |
| - Other | |

20)
If you have answered question *18* with "**No**":

| Why did you choose not to protect? | |
|---|---|
| - It is difficult to present the product's novelty | |
| - I would like to share it openly | |
| - Did not worth the cost | |
| - Could reduce the interest from potential adopters | |
| - Other: | |

21)
What are the next steps for the solution?
Answer:

22)
Do you think this solution could be used in developed countries (like, Europe and/or in the United States of America)? Why?
Answer:

## *(V) Personal information*

23)

| Gender | |
|---|---|
| Male | |
| Female | |
| Age | |

24)
What is your country of *birth*?
Answer:

25)
What is your country of *residence*?
Answer:

Please put a cross (✗) on the answer that satisfies you the most.

26)

| What is your level of education? | |
|---|---|
| - Primary School | |
| - Secondary School | |
| - High School | |
| - University Degree | |

27)

| What was your employment status during the development of your solution? | |
|---|---|
| - Student | |
| - Employed | |
| - Unemployed | |

28)

| What is your relation with the need? | |
|---|---|
| - Patient | |
| - Friend or relative | |
| - Met the patient/community and wanted to solve its problem | |

29)

| How did you come up with this solution? | |
|---|---|
| - Did you see a commercial on TV about a similar one on another country? Which one? | |
| - Talked with a university friend? From which country? | |
| - A relative mentioned something similar in another region? | |
| - Other: | |

Your help will be an asset to my Thesis and we want to highlight that without you it would not be possible for us!

**Thank you very much for your cooperation!**

## Exhibit 21 - Interview Script

### I. Information about health disorder

a) Which was the diagnosis for the patient's health condition?

b) For how long has the patient lived (or still lives) with the health disorder? When was it diagnosed?

c) Briefly describe the major limitations on daily activities caused by the health disorder.

d) Exactly which problem did you want to solve? How did you solve it?

### II. Initial knowledge on the health disorder

a) What is your opinion on the information given by the doctor on the health disorder?

b) Did you seek for more information about the health disorder?

c) How did you perform your search about the health disorder?

d) Where did you search for that additional information?

### III. Solution

a) At the beginning what was the major problem that you wanted to solve?

b) Can you briefly describe your solution? (How was the process? Any differences from the initial prototype?)

c) Why did you create this solution?

d) What is your opinion about the current solutions on the market?

e) Could you characterize the following conditions on your country? And on a scale from 1 to 7 (being 1, irrelevant and 7, fundamental), please classify the following aspects:

i. Access to internet connection
ii. Access to mobile connection
iii. Access to medical facilities and personnel
iv. Access to pharmaceutical drugs
v. Household access to potable water
vi. Visits from medical personnel to faraway villages
vii. Lack of public healthcare policies to prevent and monitor diseases
viii. Role of community to give you the idea
ix. Role of community to help you to develop the solution
x. Access to education
xi. Access to facilities to develop the solution

### IV. Diffusion

a) Did you tell anyone about the solution that you created? Who?

b) How did you do it?

c) What was the feedback received?

d) Beside yourself, do you think this solution is valuable to anyone?

e) Did you protect your Intellectual Property rights somehow?

f) Why did you do it? (or Why did you choose not to protect?)

g) What are the next steps for the solution?

h) Do you think this solution could be used in developed countries? Why?

## V. Personal information

a) Gender

b) Age

c) What is your country of birth?

d) What is your country of residence?

e) What is your level of education?

f) What was your employment status during the development of your solution?

g) What is your relation with the need?

h) How did you come up with this solution?

## Exhibit 22 - Evaluation for Reverse Innovation

| Innovator | Physician 1 | Physician 2 | Physician 3 |
|---|---|---|---|
| A1 | "*Interesting, but the product needs to be tested in a correct manner.*" | "*It might be interesting as a tactical method as it promotes a natural product developed to protect from malaria, this aspect is crucial for the developed countries as we travel more and more* (…)" | "*Europe is a "malaria free" region, as well as USA, therefore I do not thing it is a useful solution for developed countries.*" |
| A2 | "*Useful in cases of outbreaks.*" | "*We have many ways to test in a lab… Probably it is not of a big use in developed countries, unless costs are lower.*" | "*Do not sound interesting for the reality of developed countries.*" |
| A3 | "*The approach of taking advantage of ambassadors is interesting.*" | "Fortunately, they retrieve the direct constant contact. No interest for countries like Portugal." | "*In developed countries there is already an integrated network of information and cooperation, regarding blood banks.*" |
| A4 | "*Existence of common databases.*" | "*(…) only a few types of blood are scarce enough to cause death in a developed country, nevertheless this app would definitely improve donation by constant awareness.*" | "*In developed countries there is already an integrated network of information and cooperation, regarding blood banks.*" |
| A5 | "*Good for regions without doctors, not the case of the majority of developed countries.*" | "*Interesting for educational purposes in developed countries or for a one to one use and contact with the medical doctor via telemedicine.*" | "*Do not seems interesting for our reality.*" |
| A6 | "*Important if results are proven.*" | "(…) *great for this or other diseases use. It could be interesting to commercialize in developed countries for detection and to sell as a travel kit.*" | "*Amazing! Very interesting.*" |
| A7 | "*Not health related, but interesting for countries like Portugal.*" | "*It could be transferred if it is turned into individual portable devices…*" | "*I do not think it would have applicability in developed countries.*" |
| A8 | "*Existence of common databases.*" | "*I do not see a high benefit, maybe as a model to improve national networks.*" | "*Do not seems interesting for our reality.*" |
| A9 | "*Not good for patients due to the risk of infections.*" | "(…) *it would be interesting to a small portion of society.*" | "*In developed countries there is already an integrated network of information and cooperation, regarding blood banks.*" |
| A10 | "*Interesting if cheaper and if data available.*" | "*Astronomical potential to be used as screening in both developing and developed countries. Besides, it is not a blood-dependent operator, which is a benefit.*" | "*Looks interesting, regarding the diagnosis times and the price as well. Could be adopted by developed countries.*" |
| B1 | "*Interesting the affordable approach, but very primitive.*" | "*Interesting as an "awareness marketing" tool.*" | "*I do not think it would be applicable to developed countries because it does not fit the reality in which we live.*" |
| B2 | "*Could be useful for developed populations.*" | "*It is a trend to focus on these subjects, probably as the awareness of the importance of good food* | "*There is so much available information in developed countries, I do not know the* |

| | | | |
|---|---|---|---|
| | | *choices is higher in developed countries the app would have a higher impact. Devices access is higher in developed countries.*" | *impact of this.*" |
| B3 | "*We have something like this already in developed countries.*" | "*It is similar to some new apps in the market. If well balanced and agreed between all the stakeholders with definite boundaries it would do good competition.*" | "*Sounds interesting, but I am not sure about the openness of my colleagues regarding this business model.*" |
| B4 | "*One unmet need, but needs to be clearly tested.*" | "*Due to awareness and a better Maslow Pyramid position, I guess it would have a higher impact in developed countries than in a developing one.*" | "*Interesting and applicable to developed countries.*" |
| B5 | "*Affordable approach, interesting for people who cannot go to manufacturers.*" | "*May be very interesting while children are growing and they need to change prosthetics very often (lower price, similar positive impact).*" | "*Amazing!*" |

**Table 12 - Evaluation for Reverse Innovation**

| | |
|---|---|
| Green | Solutions potentially adoptable by developed countries |
| Yellow | Solutions can be adopted if user innovators apply changes |
| Red | Solutions do not have the potential to be adopted by developed countries |