

Adopting Health Apps, What's Hinderering Doctors and Patients?

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Received 8 July 2014; revised 25 August 2014; accepted 9 September 2014

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Abstract

There are high expectations for Mobile Health to transform health into a sustainable and prevention-based system. Unfortunately it has not reached its scale of adoption many had hoped for, due to the existence of adoption barriers. More insight into these barriers fosters adoption of mHealth and the innovation it can bring to worldwide healthcare. This study investigates the main barriers in the adoption of mHealth, their underlying causes and their breakthrough possibilities. All the data are gathered from an international and multi-stakeholder point of view. First of all we tried to identify the main barriers by doing an international literature study. Second of all we asked Dutch mHealth Key Opinion Leaders (KOLs) to rank the barriers to importance. These KOLs were from different stakeholder groups; policy-makers, users and developers. At last we asked the KOLs in interviews for underlying causes and breakthrough opportunities of the barriers. Eventually twelve main adoption barriers emerged. According to literature and to the KOLs the most important barriers are *"Integration and interoperability"* and *"Business case"*. An underlying cause for the barrier *"Integration and interoperability"* might be the active closed power system of technology suppliers, which exists in the Netherlands. Furthermore there seems to be a difference in the importance of the barriers *"Privacy and security"* and *"Conservative culture"* when perceptions of Dutch KOLs and international literature are compared. Within the stakeholders-groups, the KOLs think differently about the importance of the barriers *"Visionless development"* and *"Competing payment mechanism"*. The Dutch healthcare insurers could take a more leading role in the fragmented landscape of mHealth in the Netherlands, by strategically funding new initiatives that use open standards and deliver better value for end-users. Other chances might lie in the international cooperation between countries to overcome certain barriers.

Keywords

Mobile Health, Adoption Barriers, Health Innovation

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1. Introduction

Over the past decade a higher need for new innovations in healthcare has emerged, especially for developed countries. These countries face a crisis in their current healthcare systems, because healthcare costs are soaring at an unsustainable rate [1]. This is partially due to an aging population, coupled with rising incidence of chronic conditions and a shortage of healthcare workers [1] [2]. That is why innovation in healthcare is needed. The healthcare sector has always been characterized by innovation aimed at enhancing life expectancy, quality of life, diagnostic and treatment options [3]. In the last decades the need has also shifted to efficiency and cost effectiveness in healthcare. Health Information Technology (health IT) can play a vital role in this. Buntin (2011) showed that 92 percent of the recent articles on health IT reached positive conclusions, with most positive outcomes in effectiveness and efficiency of care [4].

In healthcare innovation a new trend is visible within the parameters of eHealth. eHealth is a more recent term for health IT, which has been introduced since 1999 and predominantly refers to the use of Internet in healthcare practice [5]. With the rapidly growing adoption of mobile phones all over the world, at the moment over 6 billion people own one, a new field has evolved in eHealth, known as mHealth [6] [7]. The term mHealth implies using mobile communications—such as PDAs and mobile phones—for health services and information [8]. High expectations for mHealth exist; it is seen as an enabler of change in the healthcare sector shifting the care paradigm from crisis intervention to promoting wellness, prevention and self-management [9]. In 2011, the US Secretary of Health and Human Services Kathleen Sebelius referred to mHealth as “the biggest technology breakthrough of our time” [10].

Unfortunately, mHealth failed to reach the scale of adoption that many stakeholders have hoped for [11] [12]. This can be attributed to a variety of factors. Explanations range from macro-level systemic barriers (such as lack of enabling healthcare policy) to micro level individual barriers (such as perceived complexity and resistance from physicians) [13] [14]. According to Norris (2009) the health sector in itself is a notoriously late adopter of information technologies, especially mHealth as a disruptive innovation faces a difficult and slow adoption in healthcare [15] [16]. Also, concerns to the perceived quality of services and lack of evidence are mentioned [7] [9] [17]. Wu (2011) suggests more studies on adoption of mobile devices by medical professionals are needed to effectively promote the use of such devices in hospitals [12].

To date, however, few studies have focused on the adoption barriers of mHealth from a multi-stakeholder point of view. Most of the studies are physician-centered and study micro-level individual barriers for adoption. Furthermore, they were designed to evaluate the perspective of stakeholders in the US. Different studies suggest future research should have a larger size of participants, should include non-US data for a more global context and have a multi-stakeholder perspective [13] [18] [19]. Tomlinson (2013) and Gruber (2009) suggest programmers and health insurers should also be included in studies so they can leverage future policy and investments in mHealth [17] [20]. Vishwanath (2007) suggests the importance and relationship of barriers are also desirable information [13], since at this moment no ranking was given on the importance of barriers. Norris (2009) proposes a more top-down view to match and encourage bottom-up innovation by healthcare practitioners [15]. Better understanding of barriers to mHealth supports faster adoption of mHealth in the healthcare sector.

There is limited amount of academic research dedicated to quantifying barriers and ranking them according their importance [21]. Our research aims to identify these barriers in the adoption of mHealth, as experienced by different key opinion leaders (KOL) in the Dutch healthcare sector. These KOLs represent all the relevant stakeholders in the mHealth industry. Data were generated from a literature review, survey and interviews, and provided insight into the importance and differences of the barriers from an international and multi-stakeholder point of view. Relationships between the barriers, causes and breakthrough opportunities are also given. This paper presents knowledge that can be used for new policy by governmental institutions, hospitals and patient organizations to foster the innovation of health through mHealth.

2. Background Information

2.1. State of mHealth

Over the past decades, mHealth has seen a substantial growth. This is mainly due to the exponential growth of mobile phones. Currently, the number of mobile subscribers worldwide is expected to have reached over 7 billion, of which 1 billion are smartphones with mobile broadband connections [16] [22]. Almost all developed countries and even some developing countries have mobile penetration greater than 100% [23]. This has been

fueling the interest in mHealth solutions as a game changer for global health [7].

There are high expectations for mHealth for both developed and developing regions in the world. According to the Economist Intelligence Unit (2012), mHealth can increase access to care in emerging markets and transform the developed world's costly healthcare burden into less expensive, prevention-based and patient-focused systems [16]. The driving force of the advancement of mHealth in the hospital is, besides general healthcare needs such as increasing productivity, capacity and patient service, more specifically the clinician's needs for providing the right care to the right patient at any time in any place [24]. If these needs are met, mHealth has the potential to save the EU 99 EUR billion in healthcare costs in 2017 and help 185 million patients lead healthier lives [25].

Different classifications of mHealth solutions are mentioned in earlier studies. MHealth has roughly three types of technologies: devices, sensors, and applications and other software [26]. Mobile apps, which work without external devices, can be classified as applications and other software. The target group of mHealth is classified into healthy people, hospital patients and chronically ill individuals [15]. The solutions mHealth can bring can be targeted at four domains: wellness and prevention; diagnosis; treatment and monitoring; and stronger healthcare systems [15] [23] [25]. Stronger healthcare systems focus on enhancing clinical decision-making and improving the utilization of physical and human healthcare resources by providing the system and staff more information and analysis. These different classifications are visualized in **Figure 1**.

There is a rising call for more evidence about the efficacy and effectiveness of mHealth. Over the last couple of years hundreds of proof-of-concept projects have been done, which failed to translate or scale into health systems, leading to criticisms of "pilotitis" [7]. Most randomized trials of mHealth interventions have employed text message reminder systems [17]. According to Free (2013) these have modest benefits and may be appropriate for implementation [27]. Many investigators call for more high quality trials, for more evidence [7] [17] [27]. Labrique (2013), however, claims the evidence base for mHealth continues to be strengthened, but sees challenges due to the disruptive character of mHealth.

According to Research2Guidance (2013), mHealth has currently left the initial trial phase and entered the commercialization phase of the market [28]. Currently, more than 97,000 mHealth applications are listed in the different app stores. The general sophistication of these applications, however, is low to medium, and provides limited benefit for patients, doctors and health interested smartphone users [28]. Researchers all agree the market revenue of mHealth is going to grow exponentially, which is currently between 1.3 and 4.5 billion dollar [22] [23]. Between 2017 and 2018 the revenue is expected to reach 10.2 billion dollar according to Ruder Finn (2013), 23 billion dollar according to PwC (2012) and 26 billion dollar according to Research2Guidance [22] [23] [28]. While the US has been at the forefront of mobile health deployments in the world at this moment, Europe and Asia Pacific are expected to each have about 30% market share of the global mHealth market in 2017, closely followed by the developed markets of North America with 28% market share [23]. Furthermore, mHealth could add 93 billion EUR to the EU GDP in 2017 if its adoption is encouraged [25].

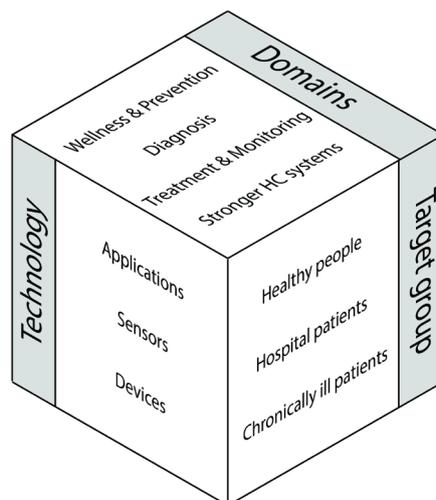


Figure 1. Classification model for mHealth solutions.

2.2. Dutch Healthcare System

Just as in other developed countries, the Netherlands faces the same challenges on the increasing burden on the healthcare system. It is estimated that over 4 million people will be 65 years or older in 2030, almost a quarter of the total population [29]. Since the fundamental reform in 2006 of the Dutch health care, the role of the national government changed from directly steering the system, to safeguarding the proper functioning of the health markets [30]. Responsibilities have been transferred to providers, insurers and patients. Since then insurers negotiate with healthcare providers on price and quality and patients choose the providers they prefer and join a healthcare insurance policy. The principle behind it was to introduce a market system with competition between providers, to cope with the future challenges [31]. This market orientation implies that insurers are key in agreeing on healthcare arrangements with health care providers, such as to reimburse innovation programs like eHealth and mHealth, for providers [32].

The Netherlands is internationally recognized as an early adopter for eHealth, but there are no nationwide implementations of interoperable eHealth solutions [32]. The healthcare sector is lagging behind in implementing ICT innovations and solutions, compared to other branches [30]. The use of electronic health records among general practitioners, however, is among the highest in the world [33]. But in 2011 the Dutch Senate vetoed the rollout of a nationwide electronic health record, due to privacy concerns [32]. While the government stimulates eHealth innovation and its implementation, it does not take a leading role. That is why many players exist in implementing eHealth programs. Current developments in eHealth are too fragmented and hardly based on standards that can enable wider implementation [32]. This leads to a lack of evidence for eHealth, which withholds insurance companies from reimbursing programs. The Dutch healthcare sector can be characterized as traditional, medical specialists and nurses are often resistant to new innovations [32].

The use of smart phones and tablets by healthcare professionals, however, is high, 64% uses them for professional work [34]. According to the same research, one on every six Dutch doctors has prescribed an app to a patient. Healthcare professionals highly trust that mobile technology will improve the communication and cooperation between them. But also Dutch patients are highly willing to use the Internet to get into contact with their healthcare provider [30].

2.3. Stakeholders

According to Herzlinger (2006) six forces can help or hinder efforts in innovation: industry players, funding, public policy, technology, customers, and accountability [35]. Omachonu (2010) defines these forces for healthcare innovation into the following stakeholders: physicians; patients; organizations; innovator companies and regulatory agencies [3]. When looked to specific interests, needs and expectations of them, we sum up the following stakeholders: regulators, providers, funders, technology suppliers, patients and healthcare organizations [1] [11]. Healthcare regulators (e.g. ministries), healthcare organizations (e.g. hospitals) and healthcare funders (e.g. health insurers for the Netherlands) have the same role when implementing mHealth; they formulate policy from a top-down view [1]. They are mainly interested in cost-effectiveness and efficacy of mHealth. Healthcare providers and patients are the users of the mHealth solutions; they are mainly interested in clinical outcome. The technology suppliers and the innovation companies are the developers of the mHealth solutions and are mainly interested into profitability and improved outcomes. The different stakeholders and their different roles in the mHealth industry are plotted in **Table 1**.

Table 1. The stakeholders in the mHealth industry and their expectations.

Stakeholders	Who	Expectations
Policy-makers	Healthcare regulators	Cost-effectiveness
	Healthcare organizations	
	Healthcare funders	Efficacy
Users	Healthcare providers	Clinical outcome
	Patients	
Developers	Technology suppliers	Profitability
	Innovation companies	Improved outcomes

2.4. Barriers to Innovation

Innovation is a complex phenomenon and studying barriers to innovation provides insight into the dynamics of innovation, which simultaneously is a first step in the process of overcoming them [21]. A barrier to innovation is any factor that negatively influences the innovation process. Barriers to innovation can be grouped into endogenous and exogenous barriers. Endogenous barriers may arise due to organizational routines, lack of technical expertise, resource related or human nature related e.g. risk-adverse top managers [36]. Exogenous barriers may include financial barriers e.g. reluctance of investors, governmental barriers e.g. policies and regulations, and collaboration barriers e.g. differences in objectives between players [36]. Also, barriers can be further classified into general or relative barriers. General barriers are affecting all types of companies, while relative barriers selectively affect companies in specific sectors [21]. It is estimated that if the current barriers on adoption of mHealth persist, the potential benefits of it in the EU will be limited [25]. With only 10% of the total potential adoption, the total healthcare cost saving will not be 99 EUR billion but 6.6 EUR billion, and the added GDP will be 6.5 EUR billion instead of 93 EUR billion. That is why research into these barriers could encourage stakeholders to adopt mHealth into its full potential. The focus of the present research lies on studying barriers associated with the adoption of mHealth applications for hospital patients and chronically ill patients in the developed world. The barriers studied will be relative exogenous barriers, since these results in a cross-industry perspective

3. Methodology

Data for the current research was generated in different stages. In the first stage a literature study was done to find the main adoption barriers for mHealth in an international context. In the second stage KOLs from multiple stakeholder groups were asked in a questionnaire to quantify these barriers according to importance. In the last stage KOLs were interviewed to get more knowledge about the relations, causes and breakthrough opportunities of the barriers. All together this generated a top-down view on what is hindering mHealth adoption, how important it is and how it can be overcome.

3.1. Literature Study

In this stage barriers were found from multiple articles of peer-reviewed journals and reports of international research institutes. PubMed and Google Scholar were used to find these articles and reports. The keywords, which were searched for, were: “mobile health adoption”, “adoption barriers”, “innovation barriers” and “e-health adoption”. Only articles and reports that were published from 2007 were taken into account. The context of the articles and reports had to be about the use of mobile techniques for health in the developed countries. Only the barriers that were mentioned at least three different times in articles or reports were taken into account for analysis. It was thus possible to identify the main barriers from an international perspective. These barriers were then used as input for the barrier prioritization process questionnaire.

3.2. Participant Selection

The participants for the questionnaire and the interviews had to be a “Key Opinion Leader” within the broader context of mHealth. A KOL ought to have extensive experience in either the policymaking process, usage or development of mHealth applications in the hospital and chronic care in the Netherlands. They were found via different methods. Two expert-meetings about mHealth were attended. Others were contacted directly online via a search for experts that had been a keynote speaker at a congress or symposium about mHealth. The online questionnaire was also shared on a (private) LinkedIn group for Mobile Doctors (245 members) that was administered by a large Dutch healthcare provider association, and a (private) platform about eHealth from the Dutch institute for Health IT (100 members). The snowball technique was used to find more participants, every participant was asked for other KOLs that could be contacted for this research. Participants, who were not contacted beforehand directly, were opposed to a selection afterwards on their scale of experience as a KOL. The KOLs were divided into three stakeholder groups: policy-makers, users and developers. All participants were asked for their names and e-mail addresses to ensure the reliability of the online questionnaire; unfinished questionnaires and names, which were not familiar or searchable on LinkedIn, were filtered out of the results.

3.3. Questionnaire

An online questionnaire was made with the online web survey program Survey Monkey. This was embedded in a simple (mobile) website specifically made for this research. A brief explanation of the research and the definitions of all the barriers were explained on this website. 98 KOLs were contacted directly via phone, e-mail or twitter and another 245 KOLs were reached through the two online platforms. To increase response rates, KOLs that did not respond to the initial request, received a follow up e-mail one week later.

In the questionnaire the KOLs were asked to do a weighted-ranking exercise with the list of barriers created in the first stage, so a prioritization of the main barriers could be made. Weighted-ranking is a tool used to quantify the opinions on a set of pre-determined elements by capturing the associations between core factors and the degree they are assessed as barriers [37]. KOLs were asked to rank their personal top-four and indicating its importance weight by distributing hundred points over the four factors selected. Fifty points could be distributed over number one, thirty over number two and ten under number three and four. Participants also had the possibility to introduce a new barrier, which was not mentioned earlier and on the list, and allocate points to it. The following formula was used to calculate the relative weighted rank per barrier:

$$WR_{ab} = \frac{\sum((n_{r_1} * 50) + (n_{r_2} * 30) + (n_{r_3} * 10) + (n_{r_4} * 10))}{\sum((n_{r_1} * 50) + (n_{r_2} * 30) + (n_{r_3} * 10) + (n_{r_4} * 10))_{HRB}} \bigg/ \frac{\sum(\text{Allratedbarriers})_{KOL\ group}}{\sum(\text{Allratedbarriers})_{total}}$$

WR: weighted ranking; *ab*: adoption barrier; HRB: highest rated barrier; *n*: number of times; $r_{1/2/3}$ = rank_{1/2/3}; KOL group: total points allocated in a KOL group; total: total points allocated by all participants (Adopted from [37]).

Differences in size of KOL groups are removed with this formula. Subsequently the relative weighted ranks were aggregated according to the different KOL groups. The results were supplemented by a one-way ANOVA for the statistical variance between the perceptions of each KOL group.

3.4. Semi-Structured Interviews

In the last stage semi-structured interviews were undertaken with nine KOLs, to identify the relations, underlying causes and the breakthrough opportunities for the barriers. All participants of the questionnaire could indicate if they would like to participate in an interview. From all the participants that were willing to do an interview, nine were selected which were mentioned the most as a KOL by other participants. The participants equally represented the different stakeholder groups. The interview questions were prepared by asking for underlying causes and breakthrough possibilities for the barriers found during the literature review and other questions emerged from the results of the questionnaire. All interviews were recorded, transcribed and analyzed according to the root-cause analysis.

4. Results

4.1. International Barriers Ranking

An initial forty-four barriers were found in five research reports of prominent research firms and five academic articles of peer-reviewed journals. All of them were published between 2007 and 2013. Subsequently these barriers were grouped in overlapping and corresponding main barriers. Barriers that were only mentioned twice or less in the references and could not be grouped were excluded. Eventually forty-one initial barriers were grouped into twelve main barriers. In **Table 2** the corresponding barriers that are ranked according to their references are displayed.

4.2. Weighted Ranking Exercise

Eighty-six KOLs completed the online questionnaire. Twenty-nine KOLs did not respond at all. After a selection based on their scale of experience as a KOL, nine participants were excluded, which resulted in seventy-six remaining participants for the questionnaire that were taken into account for analysis. The participants equally represent the different stakeholder groups: twenty-four represented policy-makers, twenty-four the users and twenty-eight the developers. Three participants did not complete the questionnaire completely by not distributing all the hundred points to the different barriers. Only one participant introduced a novel barrier, which was

Table 2. Literature barrier ranking [6] [14] [16] [18] [19] [25] [38]-[41].

Ranking	Barriers Themes	References	WHO [6]	Li <i>et al.</i> [14]	EIU [16]	Mirza <i>et al.</i> [18]	Whittaker [19]	PwC [25]	Vodafone [38]	GSMA [39]	Clark <i>et al.</i> [40]	Shieh <i>et al.</i> [41]
1	Integration & Interoperability	10	x	x	x	x	x	x	x	x	x	x
2	Business case	10	x	x	x	x	x	x	x	x	x	x
3	Privacy & Security	9	x		x	x	x	x	x	x	x	x
4	Technological obstacles	9	x	x	x	x	x		x	x	x	x
5	Lack of access for patients	8	x	x	x		x	x	x	x	x	
6	Legislation	8	x	x	x	x	x	x		x		x
7	Not adapted for physician	8	x	x		x	x	x	x	x	x	
8	Lack of governance	7	x	x	x	x	x	x				x
9	Lack of Evidence	5	x				x	x	x	x		
10	Conservative culture	5			x	x			x	x	x	
11	Competing payment mechanism	3			x		x	x				
12	Visionless development	3	x				x			x		

further not mentioned by other participants and so not taken into account for further analysis. It is therefore assumed the list of barriers reflect the twelve most important barriers on the adoption of mHealth. In **Figure 2** the differences in perceived value of the barriers on the adoption of mHealth by the different stakeholder groups is plotted.

Results indicate a significant internal validity of KOL group responses. Additionally, the ANOVA analysis revealed no significant variance between the KOL groups. Only the barrier visionless development showed significant variance between the KOL groups. In **Table 3** the Anova analysis results are plotted.

4.3. Data Integrations

By mapping the results in a decision matrix configuration, similarities and differences between the perceived importance of barriers according to the international literature and the Dutch KOL responses are visualized. The international literature barrier ranking is taken as a reference (**Figure 3**).

The following decision matrix configuration visualizes the similarities and differences between the KOL responses. The policy-makers opinion is taken as a reference, to which the users and developers are compared (**Figure 4**).

4.4. Relations, Causes and Breakthrough Opportunities

Nine KOLs were invited for a semi-structured interview. During the root-cause analysis of the transcripts of the interviews, an initial fifty-one causes and fifty-one breakthrough opportunities were found. Subsequently they were grouped in overlapping and corresponding main causes and breakthroughs. The ones that were mentioned by two or less KOLs and the ones that could not be grouped were excluded. Eventually eleven causes and nine breakthrough opportunities remained and the relationships between them were identified. It is believed these represent the most important causes and breakthroughs opportunities for the corresponding barriers. Integrating all the outcomes of this research, results in an overview that visualizes which main barriers are impacting mHealth adoption, their relationships, the main underlying causes and which main breakthrough opportunities exist in overcoming them. Since barriers usually mutually reinforce their impact on each other, the identification of the causes and breakthrough opportunities of the adoption barriers may assist in their elimination or reduction [21]. This overview can be seen in **Figure 5** and the explanation of the different definitions can be found in **Table 4**.

Table 3. Anova analysis for significant effect between the weighted ranking values and KOL group membership.

Anova Analysis	df	F	P-value	F crit
Integration & Interoperability	2	0.978	0.3808	3.122
Business case	2	0.467	0.6290	3.122
Conservative culture	2	2.688	0.0748	3.122
Visionless development	2	3.863	0.0254	3.122
Not adapted for physician	2	0.219	0.8041	3.122
Privacy & Security	2	0.544	0.5825	3.122
Lack of Governance	2	0.843	0.4344	3.122
Lack of Evidence	2	1.293	0.2807	3.122
Competing payment mechanism	2	2.239	0.1138	3.122
Legislation	2	0.377	0.6875	3.122
Lack of access for patients	2	0.392	0.6773	3.122
Technological obstacles	2	1.125	0.3301	3.122
KOL group	2	0.002	0.9984	3.008

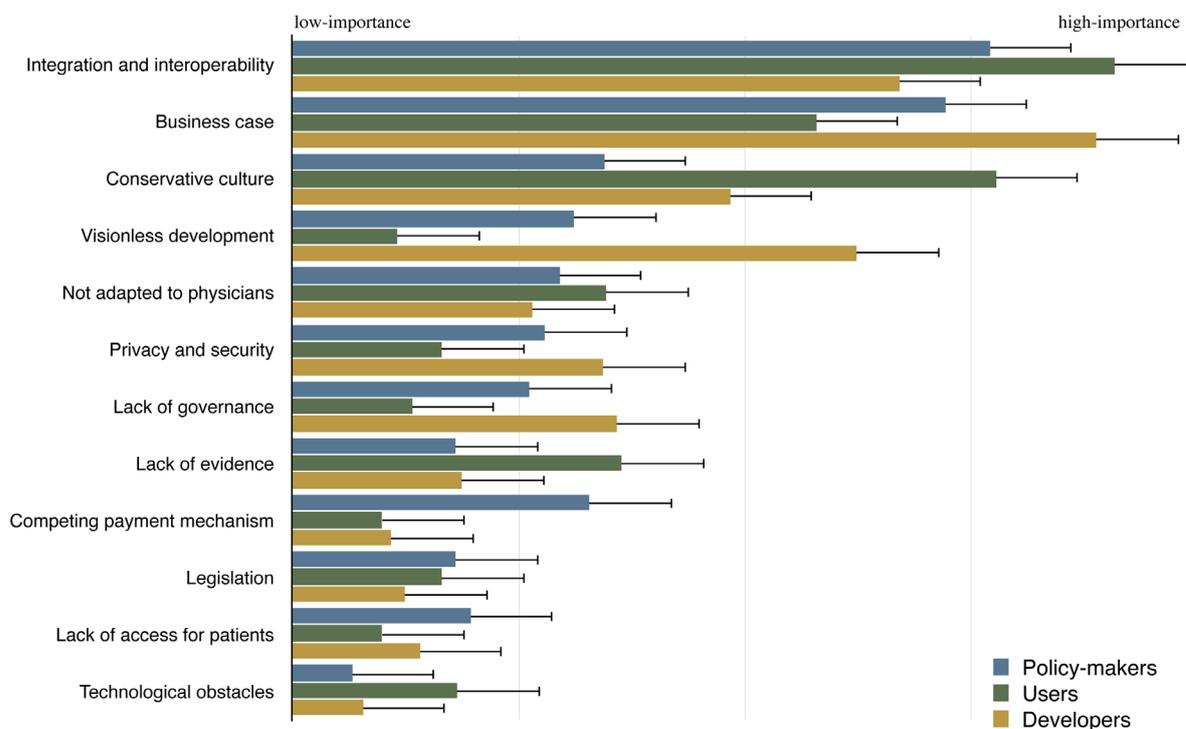


Figure 2. Stakeholders' barrier ranking.

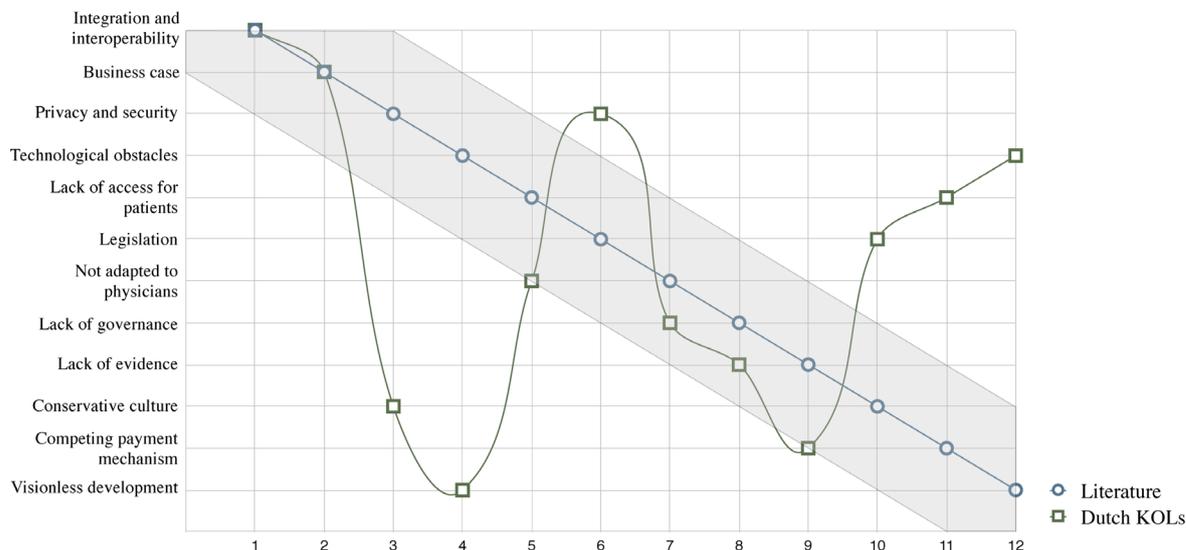


Figure 3. Barrier ranking matrix international literature and Dutch KOLs.

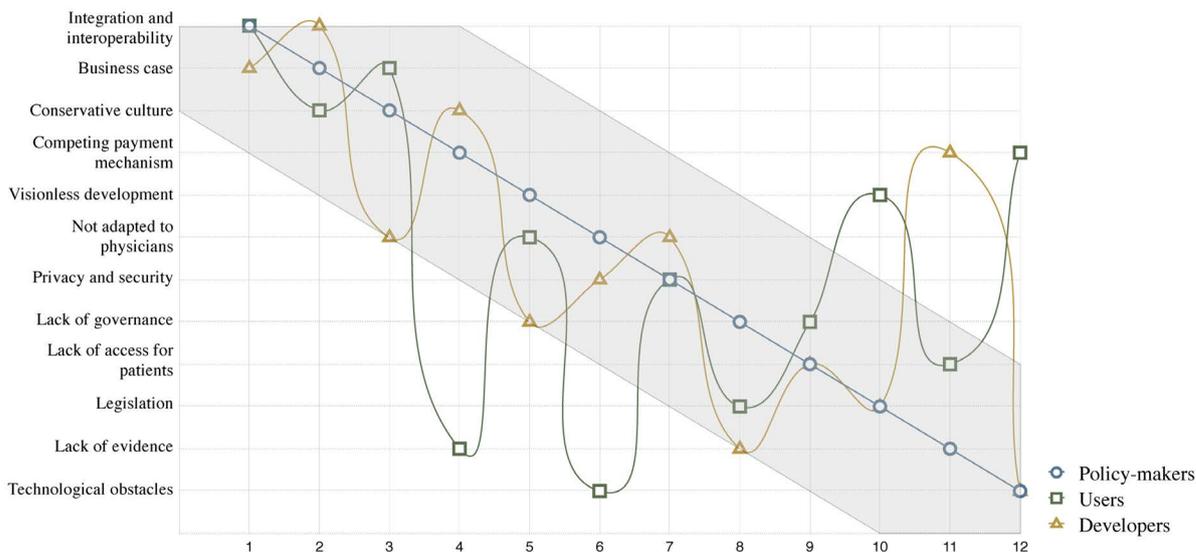


Figure 4. Decision matrix stakeholder groups.

5. Discussion

The developed world has high expectations of transformative health innovations such as mHealth, since they are severely needed to cope with future challenges in the healthcare system. To date, however, mHealth has not achieved its promise, due to a lack of large-scale adoption. There is little knowledge on the underlying barriers that exist and what their impact is on adoption. Our research aims to quantify these barriers and rank them according to their importance from a multi-stakeholder point of view. The most important barriers are “Integration and interoperability” and “Business case”. A different and more strategic role of funding by healthcare insurers might have a positive role on the elimination of these barriers.

The present study shows the importance of “Integration and interoperability” and “Business case” as barriers according to international literature and according to different stakeholders in the Dutch healthcare system. An important underlying cause for “Integration and interoperability” is the active closed power system of technology suppliers. In the Netherlands only a few big suppliers exist, and for them it is not lucrative to make use of open standards and APIs. With the fragmented developments in mHealth and a non-leading role of the Dutch Government on mHealth deployment, only the healthcare insurers might be able to break this closed system

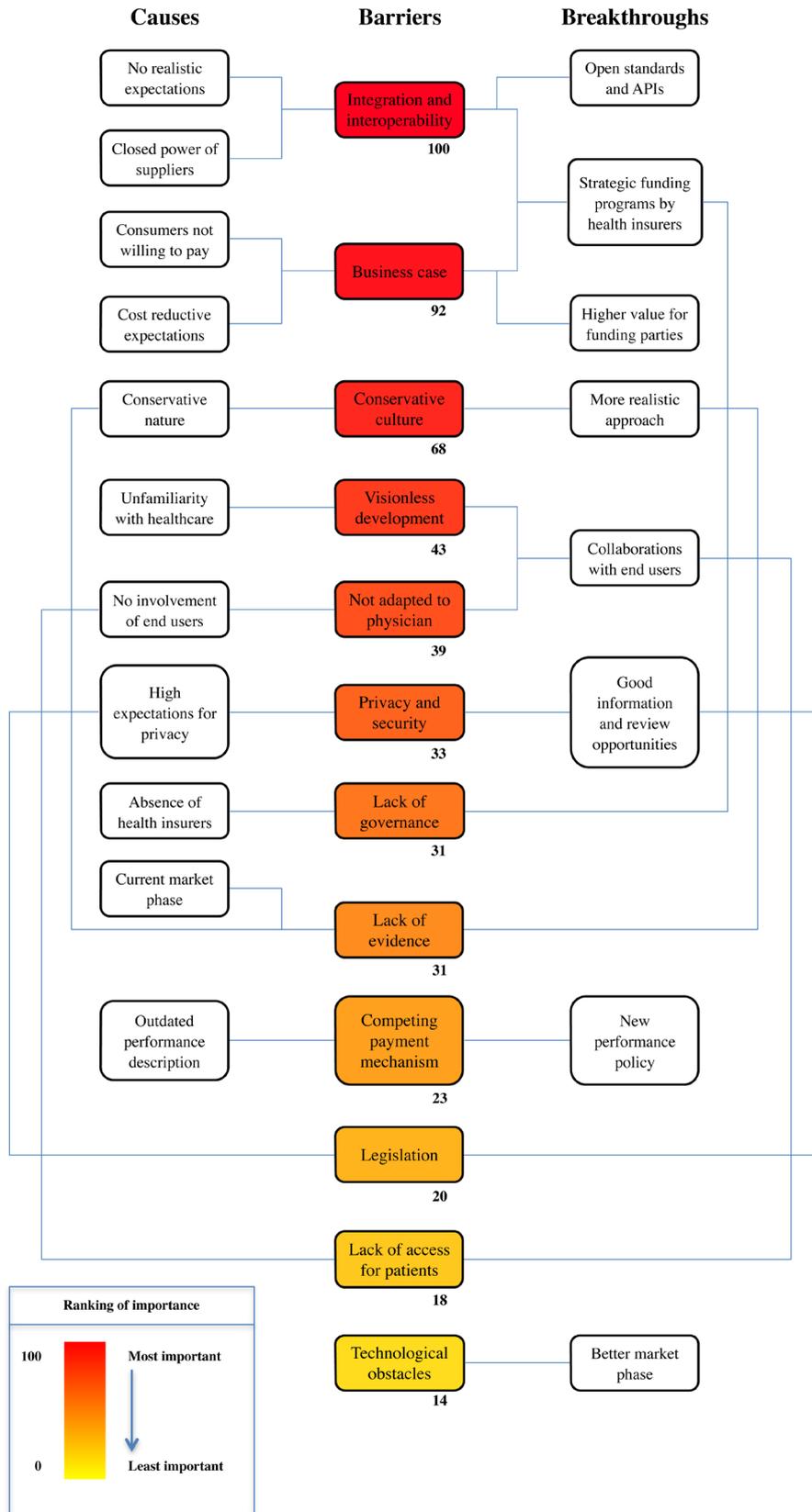


Figure 5. Relations, underlying-causes and breakthrough opportunities.

Table 4. Explanation Figure 5; Barriers, relations, causes and breakthroughs opportunities.

Integration and interoperability	Difficult for mHealth apps to be integratable in current health IT systems and their lack of connectivity with other technology solutions	Consumers not willing to pay	Consumers expect all applications to be free or low-priced, just as in the different app-markets
Business case	High risk investment needed in unsure market	Conservative nature	Healthcare is traditionally conservative due to the importance of personal contact and risk averse behavior
Conservative culture	Existence of a conservative culture among healthcare professionals for new technologies	Unfamiliarity with healthcare	Developers are mostly new in the healthcare market and possess insufficient health knowledge
Visionless development	Current developments of mHealth applications miss focus and vision for added value	No involvement of end users	Physicians and patients are insufficiently involved during the development phase
Not adapted to physicians	Difficult for physician to adapt new technologies in their current work-environment	High expectations for privacy	The general population has high standards for privacy preservation
Privacy and security	High expectations for proper security with privacy sensitive information	Absence of health insurers	Health insurers are not taking the lead where they should, due to the non leading role of the government
Lack of governance	Not enough central control and steering from the government	Open standards and APIs	Open standards and APIs make integration easy and possible on a high systemic level
Lack of evidence	Insufficient evidence of clinical outcomes, effectiveness and efficiency	Strategic funding programs by health insurers	Health insurers should strategically fund initiatives that are integratable from start and deliver value on the long-term
Competing payment mechanism	Current pay-per-performance is outdated and not compatible with mHealth's prevention focus	Higher value for funding parties	New initiatives should better match the needs of funding parties and collaborate with them on an early basis
Legislation	National and international legislation about medical devices is unclear, to strict and outdated	More realistic approach	Realistic approach and more focus on the end-results, such as efficiency and digitalization
Lack of access for patients	Use of mHealth applications asks for a high degree of (technological) knowledge and is to costly	Collaborations with end users	Better collaborations with end users and stakeholders, such as doctors and patients
Technological obstacles	Current solutions are too complex. Furthermore connectivity and battery lacks performance	Good information and review opportunities	The government should provide guidelines and review opportunities for new initiatives
No realistic expectations	Too high and unrealistic expectations of integration and interoperability of all technological devices	New performance policy	New policy about performance funding for healthcare professionals, where health results should be the measuring tip
Closed power of suppliers	Limited amount of health IT suppliers with a closed power system	Better market phase	Waiting for a better market phase which is more sophisticated and developed

by strategically funding technology developments that use open standards and APIs from start. Healthcare insurers can have a similar role in funding new mHealth initiatives that face a problem with their business case. While mHealth can lead to cost reductions on the long run, this cannot be expected and surely should not be a goal from a transformative innovation on the short term. Since healthcare insurers will reap the benefits of a healthier population, it is expected they should strategically fund new initiatives where users are not willing to pay, and guide developers to deliver higher value solutions. For other countries where the government is the main funding party, the same role is expected from them.

This study further shows a difference in the ranking of importance of some barriers found in literature and perceived by Dutch KOLs. “*Conservative culture*” and “*Visionless development*” are perceived as more important to Dutch KOLs than according to international literature. As explained earlier the Dutch healthcare system is characterized as traditional [32], which might be an explanation for the higher importance of “*Conservative culture*” as a barrier to adoption. A cause for the high ranking of “*Visionless development*” might be the fragmented landscape of eHealth and mHealth developments in the Netherlands. On the other hand, our research

shows that some barriers seem to be less important according to Dutch KOLs than according to international literature. While the Dutch Senate vetoed the rollout of a nationwide electronic health record due to privacy concerns, “*Privacy and security*” together with “*Legislation*”, “*Lack of access*”, and “*Technological obstacles*” are perceived as less important barriers. An underlying cause for this difference might be the fact that the mHealth market in the Netherlands is less advanced as in the US, where most of the studies are done and is at the forefront of mobile health deployments [23]. Several KOLs pointed out during the interviews these barriers might become more important in the future, when the mHealth market in Netherlands will be more advanced. Since Europe is expected to have the largest market share in 2017 [23], the importance of these barriers should not be underestimated.

Other findings show stakeholders have different perceptions among each other, on the importance of some barriers. “*Lack of evidence*” and “*Technological obstacles*” are perceived as more important to users than to policy-makers and developers. A possible explanation for this is that the users face the liability question. This is specifically the case for doctors, who have to prescribe the mHealth solutions to patients, and for patients who have to weigh up the risks of using them. The “*Competing payment mechanism*” is a much-heard barrier when KOLs are speaking about the transformation of a treatment focused healthcare system to a prevention based health system. However, users and developers rank the importance lower than policy-makers. This might be since users, such as doctors, benefit from the current payment mechanism; consequently they might not perceive it as an important barrier.

Our study provides unique findings that contribute to the knowledge about mHealth adoption in the developed countries. The multi-stakeholder point of view gives unique insight into the differences and similarities of stakeholder’s perceptions on the importance of barriers. The inclusion of developers and policy-makers as stakeholders is scarce in the mHealth research. Furthermore this study gives a unique international comparison on how barriers impact mHealth adoption globally. The Netherlands can be taken as a reference for other Western-European countries. A limiting factor for this research is the starting phase where mHealth is currently in. In some parts research about eHealth and Telehealth, which were about practices closely linked to mHealth, were taken into account as mHealth practices. KOLs, who participated, were in the same way not always experts on mHealth merely, but experts on the broader field of eHealth. Furthermore a limited amount of patients participated in this research. It was difficult to find patients with extensive experience in mHealth. Though this research included KOLs, the amount of participants makes it difficult to represent all stakeholders in the Dutch healthcare industry.

The results of this research imply which barriers exist, how important they are, what their underlying causes are and which breakthrough opportunities exist. It provides practical knowledge for policy-makers, doctors, patient-organizations and developers where to change policy and improve solutions. The research suggests that health funders in the Netherlands, such as health insurers, could play a new and more strategic role to deal with the two most important barriers, “*Integration and interoperability*” and “*Business case*”. Since they are also perceived as important according to international literature, the most successful breakthrough possibilities might also lie in the international context. Especially for the European Union, where major opportunities lie when mHealth is successfully adopted [25], cooperation between countries might result in better uptake of mHealth. It is advised for all stakeholders to be prepared for a change in importance of barriers, when the market phase further advances.

Future research should provide more knowledge on the underlying causes and breakthrough opportunities of the mentioned barriers. Case-study research on successful large-scale rollouts of mHealth strategies could give new information on how barriers have successfully been overcome. When the current market of mHealth is further advanced, new barriers might arise and the importance of others might change. More knowledge about barriers on mHealth adoption in developing countries might give new insight, since adoption in some developing countries is increasing more rapidly than developed countries [16].

This research has given new knowledge on how mHealth adoption can be improved. The writers believe when keeping them in mind during the development of new policies and mHealth initiatives, a larger rate of adoption can be met. All stakeholders should actively contribute in removing these barriers. So one day, mHealth can meet its promise and transform global healthcare into a more sustainable system.

Acknowledgements

The authors gratefully acknowledge the participants in this study for generously helping of this research.

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