A Framework for Analyzing Patient-centered Mobile Applications for Mental Health

Full paper

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Abstract

Mobile health (mHealth) is a key innovation area in health care. mHealth promises new capabilities for data collection, interactions between patients and healthcare professionals, and self-help. Despite the potential, research on mHealth innovation is in its infancy in mental health, whereas the increasing prevalence of mental illnesses worldwide urge for better care solutions. mHealth for mental health (mH2) can support the delivery of patient-centered and decentralized care. Despite more than a decade of the existence of mobile technology, there is a lack of research on adoption of mH2 as clinics, governments and insurance companies require evidence in order to transfer mH2 into regular care. We therefore propose a framework for analyzing patient-centered mH2 applications. This can help to indicate gaps for future design research, to leverage mHealth for patient engagement and to serve patients who suffer from additional diseases that accompany primary mental disorders in a better way.

Keywords

mHealth, mental health care, mental health information systems, mH2.

Introduction

Health information systems (IS) have recently been an area of an intense research and innovation development in the most areas of health care (Agarwal et al. 2010). Especially, the use of mobile healthcare technologies has witnessed a fast pace development in the recent years (Boudreaux et al. 2014). Yet, with regards to IS some areas of health care have witnessed less progress. Mental health care is one of these areas that lag behind other medical areas (such as general medicine, cardiology etc.) with regard to IS adoption (Drake et al. 2005) and especially to adoption of mobile IS (Luxton et al. 2011). This gap stands in strong contrast to the need for innovation in mental health care. Whereas such innovation can be provided by mobile IS that has a huge potential to generate significant impacts on mental health care provision and to lower its costs (Farrington et al. 2014).

The importance of improving mental health care and lowering its costs is driven by the increasing prevalence of mental illnesses in both rich and low-income countries as mental health has substantial influence on sick leave and unemployment. This explains the recent focus of the World Health Organization as well as other global institutions on mental health care along with such major burdens as AIDS or diabetes (Harnois and Gabriel 2000). Therefore, mental disorders pose an economic burden on companies, organizations and governments and require considerable funding for mental health care (Harnois and Gabriel 2000). The gap between funding and mental health needs calls for better delivery of mental health care services (Farrington et al. 2014), whereas modern information technologies and particularly mobile IS provide extensive opportunities for innovation in this space (Donker et al. 2013).
Another incentive for the improvement in mental health care provision other than costs is the significant change of mental health care organizations over the last decades. Lately, mental health care systems have witnessed a shift from large mental health institutions towards decentralization of care provision in order to reduce hospitalization and intensify prevention (Hardstone et al. 2004; Wisdom et al. 2008). This means to provide care via multiple channels and to engage multiple actors such as hospitals, psychotherapists, nurses, communities or self-help groups as well as to leverage the role of low-threshold services in health care (Hardstone et al. 2004). Care provision via multiple channels urges for stronger integration of actors. Especially, mobile IS may be a powerful facilitator for such integration. At the same time, low-threshold care can be also supported by patient-centered and user-friendly mobile solutions as this type of care builds on stronger involvement and engagement of patients (East and Havard 2015).

However, the adoption of mobile IS in mental health care may face different challenges. Mental health care has several peculiarities compared to other health care areas in terms of technology use. Castelnuovo et al. (2003) state that mental health is not that quick to integrate innovations due to the traditional nature and superior role of one-on-one doctor-client interaction. According to Ennis et al. (2011) mental health care is also characterized by a highly sensitive nature of information. For example, electronic information storage and sharing is potentially unsafe in terms of discrimination of mentally ill patients (Callard and Wykes 2008). With a larger number of users that have access to sensitive information there is a greater risk that information could potentially be dispersed amongst unauthorized personnel (Callard and Wykes 2008). In spite of these risks, the usage of IT (information technology) and mobile IT in mental health care may help overcome entry barriers to health care, especially for remote and poorer populations, and may offer potential for remote diagnosis, monitoring, and treatment (Farrington et al. 2014). Patients may be able to access care services in their own environment without dealing with judgment and barriers (Blaya et al. 2010). This corresponds to the latest developments in terms of decentralization of care and low-threshold solutions. If tailored according to local needs and integrated into wider global efforts mobile health solutions can help to deinstitutionalize and scale up the mental health care provision (Farrington et al. 2014). In order to do so, mobile health for mental health care should overcome the adoption barriers especially in terms of information usage. This can be done by different way that protect against security risks – both in terms of technology and legislation (Hall and McGraw 2014; Luxton et al. 2011).

In our work we analyze the potential of mobile solutions to leverage mental health care and refer to the abbreviation of mobile health for mental health care as mH² (as introduced by Farrington et al. 2014). We propose that mH² applications developed for mental health are becoming more and more popular in major app stores (Donker et al. 2013). Also multiple emerging startups (e.g. ginger.io, Lantern, CohesiveSelf) and startup platforms (e.g. angel.co, rockhealth.com, Inc.5000) provide innovative mH² solutions. We searched within several startup platforms and the Apple App Store for mH² applications and found 130 apps performing different functions such as psychoeducation (e.g. phobias, fix-depression), disease management (e.g. proact OSI Connect: OSI Clinic Network), self-assessment (e.g. depressioncheck, imindmood), treatment (e.g. mevoked, PsychologyOnline) etc.

With regards to different functions of mH² solutions our findings are consistent with the prior work of Hermano and Stewart (2014). They classified and described diverse functions of mH² such as reference, assessment, awareness, reminder and coaching. In our study we refer to their classification of the mH² functions as well as to classifications of other authors (Clough and Casey 2015; Price et al. 2013). Therefore, the purpose of our paper is to extend existing classifications of mH² functionality to propose a framework for analyzing patient-centered mH² applications. In our work we also discuss the comorbidity (additional disorders to the primary disease) in order to show the linking potential for mobile applications, which can deal with several disorders and can be used across different health care systems. This can be of high value for the treatment of comorbid disorders as they require a stronger integration of different actors and channels in order to treat multiple disorders simultaneously. The focus of our study is driven by the high prevalence of the comorbidity in mental health care (Kane and Blank 2004; Morse et al. 2006). Overall, with our framework we seek to define functional clusters of patient-centered mH² applications, to analyze the comorbidity focus of existing mH² applications, to define gaps within these clusters and comorbidity referral in order to identify fruitful areas for future research.

Our research is structured as follows. First, we outline the conceptual foundation for our analysis by proposing our framework for analyzing patient-centered mH² applications. Then we describe the method.
used for searching, identifying and analyzing relevant publications and omitting irrelevant ones. We categorize and summarize selected research works using the proposed framework. Based on this analysis, we derive conclusions and outline future research opportunities.

**Conceptual Foundation**

**mH² and Functions of mH² Applications**

Our research applies the definition of mH² provided by Clough and Casey (2015). They state that mH² is defined as “any psychological or mental health intervention that is delivered or supported by the use of mobile technology”. Clough and Casey (2015) also describe such functions of mH² as providing further treatment, enhancing assessment, leveraging the intervention proposition and offering a wide choice of treatment materials and activities.

Boschen and Casey (2008) and Ly et al. (2012) discuss many advantages that are provided by mobile technology. These advantages include following:

- mobility
- acceptance of mobile technology in the society
- relatively low price and ongoing maintenance costs of mobile devices
- worldwide distribution
- almost constant connection
- capability of interacting with other users etc.

Those advantages may offer opportunities for mH² to leverage mental health care. According to Price et al. (2013), mH² helps to prepare and engage patients in treatment. It can be used as a communications medium for psychotherapy, as an extension of psychotherapy or as psychosocial intervention using innovative monitoring approaches (Chan et al. 2014). Educating patients and assigning homework are other important tasks of mH² applications due to their mobility and portability (Price et al. 2013). The premature termination or nonattendance of face-to-face therapy sessions can be avoided by using mH² in between therapeutic sessions (Clough and Casey 2015). mH² can also help to deal with the situation after the intervention. It can provide a continuous access to interventions that were started with a therapist or other activities strengthening and sustaining previous therapy results (Price et al. 2013).

In our paper we will discuss patient-centered mH² applications, by reaching for the classic definition of patient-centered care. Hurtado et al. (2011) defined patient-centered care as “health care that establishes a partnership among practitioners, patients and their families (when appropriate) to ensure that decisions respect patients’ wants, needs and preferences and solicit patients’ input on the education and support they need to make decisions and participate in their own care”. We will examine different mobile applications that were developed for treating mental disorders or supporting mental health at the patient-centered level. In our research we will refer to the outcomes of the applications, which include patient-centered low-threshold and decentralized mental health care services.

**Analysis Framework**

Despite more than a decade of existence of mobile technology, few research works have been devoted to a systematic evaluation of mH² applications (Donker et al. 2013). The gap between research and market inhibits the adoption of mH², as clinics, governments and insurance organizations require decisive results for their transfer into standard care (Free et al. 2013).

In their recent analysis of mental health care information systems Wahle and Kowatsch (2014) show that IT solutions for mental health are mostly analyzed within medical clinical trials and much less in the IS area. This is also applicable for mH² solutions that were also included in their research. In our work we focus on mH² and develop an analysis framework, which can be used by both medical and IS researchers to analyze the functionality of mH² applications. This will help to detect gaps in the functional clusters in order to leverage the utilization of mH² and fully apply all advantages provided by mobile technology.
In our work we refer to Agarwal et al. (2010). They defined three directions of opportunities in IS health care research:

- an opportunity for better understanding of implementation, design, and usage of information systems in healthcare,
- an opportunity for deeper knowledge and better measurement of financial and non-financial impact of health IT, and
- an opportunity for leveraging IT innovation in order to expand the boundaries of traditional health IT.

We build our framework on the directions of Agarwal et al. (2010) and propose a systematic method for analyzing the functionality of mH². Our framework is derived from the previous works on mH² functions such as of Clough and Casey (2015), Price et al. (2013) and Hermano et al. (2014). Additionally to their proposals we add an IS view onto mH².

The proposed framework for analyzing functions of patient-centered mH² applications is illustrated in Figure 1. We propose a twofold view on specific mH² applications. In our framework we consider applications for treating isolated mental diseases as well as mental diseases combined with comorbid disorders. We do not distinguish between comorbid mental illnesses and comorbid physical illnesses (e.g. diabetes, heart diseases etc.). Figure 1 shows two areas: the first one for single mental diseases and the second one for mental diseases combined with comorbid disorders. Each of these areas includes all three functional clusters.

Applications perform diverse functions within the three clusters. An input can be provided and updated by patients using the application in a patient-centered setting. This input includes demographics, information on lifestyle situation, symptoms etc. The application itself uses these data and performs diverse types of functions. According to Clough and Casey (2015), Price et al. (2013) and Hermano et al. (2014) those functions include support of intervention and social engagement of patients with other actors participating in intervention. Therefore, an application can support the intervention by helping to screen the patient's condition, monitor his ongoing condition, support traditional clinical treatment etc. ("Intervention cluster"). The second functional cluster ("Social engagement") is allocated in an extra category. The reason is the specific role of patient-centered mH² applications for engaging patients in intervention and connecting them with other actors (Price et al. 2014). This includes the patient's connection and interaction with professionals, other patients, peers, social networks, self-help groups and many others. Those functions cannot be supported by an application without certain data handling capabilities. The application can collect data, store data, process, analyze, provide outputs of processed data, send it to professionals for their evaluation etc. ("Data handling cluster"). Distinguishing the latter function helps to pose an IS view of the mH² functionality. Although, we propose a division into three main functional clusters, we agree that all functions within the model are interconnected, support each other and cannot be perfectly isolated. Nevertheless, a distinguished categorization of the functions can help to identify gaps in the main clusters.
Therefore, the developed framework allows a systematic analysis of mH² applications by engaging both medical and IS view. This framework will be used in our paper and applied to diverse research papers on mH² applications. The analysis of up-to-date research of mH² applications’ functions will enable deriving gaps and propositions for future research.

Methodology

This paper is based on previous studies that explored, tested or described mobile applications for mental health care. The search of relevant articles and books was documented and screened using the guidelines of vom Brocke et al. (2009), who argue that the process of literature search must be explicitly described. This allows readers to gain a deep understanding of the thoroughness of the analysis. According to vom Brocke et al. (2009) the review scope and conceptualization of the topic must be defined prior to literature search. We performed and documented those steps in order to define most relevant search criteria and keywords that were further used for the literature search.

First, we conducted the search in IS, business and medical databases. We searched within AIS Electronic Library, ABI/INFORM Complete, PsycInfo, Psynex and PubMed databases. The databases within different areas were systematically searched with a set of keywords adapted to the database focus. For
example, the usage of the keyword “mobile” was appropriate in AIS Electronic Library, but generated many irrelevant entries in medical databases (mobile teams or mobile help instead of mobile technology).

We developed a set of keywords combining both areas of interest: mental health care and mHealth. For the search in the mental health area we used synonyms such as psychiatric, psychological, behavioral etc. as well as the names of most prevalent mental health disorders. The list of these disorders was generated by Whiteford et al. (2013) and is based on the 2010 World Health Organization study estimating the burden of disease in terms of disability-adjusted life years. Within the mHealth topic we used different keywords such as mobile phone, smartphone, app etc. Therefore, the usage of keywords differed amongst databases due to their different foci. Our scheme of search criteria is represented in Table 1.

<table>
<thead>
<tr>
<th>General mental health keywords</th>
<th>Specific mental disorders keywords</th>
<th>mHealth keywords</th>
</tr>
</thead>
</table>

Asterisk * was used for marking main part of the keyword.

Table 1. Keyword Combinations

Due to the late emergency of the topic and a descent number of entries we used the keywords for searching both in abstract and full text. After completing the database search 113 articles were found and were screened for their relevancy. We also conducted a forward and backward search in order to broaden our search output. Two researchers performed the screening based on (1) title, (2) abstract, (3) keywords and (4) full text of each paper. A paper would be considered for future analysis if it deals with both mental disorder (plus eventual comorbid disorders) and mHealth in terms of a specific mobile application. Papers that deal with mHealth in general were excluded from further analysis, because they did not examine any particular application. Also papers that deal with the usage of smartphones in terms of calling, sms-texting, recording or participating in an electronic research survey via smartphone were also omitted, as the research objects were mobile applications and not standard mobile phone functions. Because of our patient-centered focus we excluded the applications used uniquely by professionals. After the screening was completed we performed a detailed analysis of 48 articles that will be discussed in the “Results” section.

Results

We applied the proposed framework onto 48 research papers on specific mH2 applications. Each paper deals with a minimum of one mH2 application, developed for a smartphone or both smartphone and tablet. No tablet-only applications were found. For each application we gathered all detailed information on three types of functional clusters. We also looked for comorbidity capture within each application and created a detailed overview table for all 48 articles. Overall, 40 different applications (named or not named) were found in those works.

For example, the article of Gonzalez and Dulin (2015) on location-based monitoring and intervention application for alcohol use disorders described the usage of their application for comorbid disorders (other substance abuse). Their application performed following functions, which were allocated to the corresponding clusters:

- “Intervention cluster”: self-assessment, treatment, psychoeducation, coordination,
- “Social engagement”: identification of non-drinking activities, sharing results with others,
- “Data handling”: data transmission to a back-end server, data analysis.
Therefore, our framework categorizes the information for each functional cluster and comorbidity per mH² application. It also helps to detect the gaps within the functional clusters and to set a stronger focus on accompanying disorders for each application. The results of applying the proposed framework are presented in Table 2. The first column indicates the authors that were dealing with a specific application (authors, year of publication and eventually the name of an application). The following three columns include the results of allocating the functions in each cluster. Because all authors were mainly focused on the “Intervention cluster” – we only specify the intervention type in this column in order to provide an overview on diverse intervention types that can be performed by mH² apps. The column “Social engagement” provides information on whether any function within this cluster has been performed or not. The functions within this cluster were grouped with regards to their unilateral or bilateral engagement. The engagement could be only in terms of sharing: unilateral sharing, e.g. sharing symptoms, feelings etc. (“Sharing”). Or it could be bilateral: sharing and feedback, e.g. sharing the improvement results and regular feedback from the therapist (“Feedback”). The column “Data handling” does not provide an overview on obvious functions that were typical for each application (such as data collection etc.), but indicates whether the data was both analyzed and transferred by means of an application. The last column “Focus on comorbidity” indicates whether the comorbid issues were a focus of the research, were only mentioned (“an application may also support accompanying disorders”) or were not mentioned at all.

<table>
<thead>
<tr>
<th>Authors (year) / application</th>
<th>mH² functions</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Intervention cluster (intervention type)</td>
<td>Social engagement cluster; S (Sharing) F (Feedback) N (None)</td>
</tr>
<tr>
<td>Ahtinen et al. 2013 / Oiva</td>
<td>Psychoeducation, training of stress-management</td>
<td>N</td>
</tr>
<tr>
<td>Ben Zeev et al. 2013 / FOCUS</td>
<td>Self-assessment, illness-management, treatment</td>
<td>S</td>
</tr>
<tr>
<td>BinDhim et al. 2014 / Depression Monitor</td>
<td>Self-assessment</td>
<td>N</td>
</tr>
<tr>
<td>Boyer et al. 2012 / iHeal</td>
<td>Monitoring, treatment, self-assessment</td>
<td>N</td>
</tr>
<tr>
<td>Brouillette et al. 2013 / NA*</td>
<td>Diagnostics</td>
<td>S</td>
</tr>
<tr>
<td>Burns et al. 2011 / Mobilyze!</td>
<td>Self-assessment, monitoring, self-management, training</td>
<td>S</td>
</tr>
<tr>
<td>Burns et al. 2013 / NA*</td>
<td>Self-assessment, psychoeducation, coordination</td>
<td>S</td>
</tr>
<tr>
<td>Bush et al. 2013 / Mobile Screener</td>
<td>Self-tracking</td>
<td>N</td>
</tr>
<tr>
<td>Chih et al. 2014; McTavish et al. 2012 / A-CHESS</td>
<td>Treatment, self-monitoring</td>
<td>F</td>
</tr>
<tr>
<td>Application</td>
<td>Functionality</td>
<td>A</td>
</tr>
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<td>-------------------------------------------------</td>
<td>---------------------------------------------------</td>
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<tr>
<td>Depp et al. 2010 / Myexperience</td>
<td>Self-assessment, self-management</td>
<td>N</td>
</tr>
<tr>
<td>Faurholt-Jepsen et al. 2013, 2014 / MONARCA</td>
<td>Self-monitoring</td>
<td>S</td>
</tr>
<tr>
<td>Fletcher et al. 2011 / NA*</td>
<td>Monitoring</td>
<td>S</td>
</tr>
<tr>
<td>Gaggioli et al. 2012, 2013 / PsychLog</td>
<td>Self-tracking, coordination, treatment</td>
<td>N</td>
</tr>
<tr>
<td>Gaggioli et al. 2013 / BeWell</td>
<td>Self-tracking, coordination</td>
<td>F</td>
</tr>
<tr>
<td>Gaggioli et al. 2013 / Interreality</td>
<td>Self-tracking, treatment</td>
<td>N</td>
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<tr>
<td>Gaggioli et al. 2013 / T2 Mood Tracker</td>
<td>Self-tracking</td>
<td>S</td>
</tr>
<tr>
<td>Gajjecki et al. 2014 / Promillekoll</td>
<td>Self-monitoring, psychoeducation</td>
<td>N</td>
</tr>
<tr>
<td>Gajjecki et al. 2014 / PartyPlanner</td>
<td>Self-monitoring, psychoeducation</td>
<td>N</td>
</tr>
<tr>
<td>Gay et al. 2013 / CaptureMyEmotion</td>
<td>Self-tracking, treatment, psychoeducation</td>
<td>S</td>
</tr>
<tr>
<td>Gonzalez and Dulin 2015 / Step Away</td>
<td>Self-assessment, treatment, psychoeducation, coordination</td>
<td>F</td>
</tr>
<tr>
<td>Gorini et al. 2010; Riva et al. 2009 / NA*</td>
<td>Monitoring, treatment</td>
<td>N</td>
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<tr>
<td>Hasin et al. 2014 / HealthCall-S</td>
<td>Self-tracking, coordination</td>
<td>S</td>
</tr>
<tr>
<td>Jones et al. 2014 / NA*</td>
<td>Treatment</td>
<td>S</td>
</tr>
<tr>
<td>Kuhn et al. 2014b / PTSD Coach</td>
<td>Self-assessment, self-management, psychoeducation, coordination</td>
<td>S</td>
</tr>
<tr>
<td>Lanata et al. 2015 / PSYCHE system</td>
<td>Self-assessment, monitoring</td>
<td>N</td>
</tr>
<tr>
<td>Lindner et al. 2013 / NA*</td>
<td>Self-tracking, self-assessment, treatment, self-management, psychoeducation</td>
<td>F</td>
</tr>
<tr>
<td>Ly et al. 2012 / NA*</td>
<td>Treatment, psychoeducation</td>
<td>N</td>
</tr>
<tr>
<td>Maier et al. 2011 / NA*</td>
<td>Self-monitoring, self-management</td>
<td>S</td>
</tr>
<tr>
<td>Morris et al. 2010 / NA*</td>
<td>Self-assessment</td>
<td>N</td>
</tr>
<tr>
<td>van Os et al. 2014/ mROM</td>
<td>Self-tracking, self-assessment, self-management, treatment</td>
<td>F</td>
</tr>
<tr>
<td>Patterson 2013 / ARSA</td>
<td>Self-management, self-focus</td>
<td>S</td>
</tr>
</tbody>
</table>
Table 2. Results: mH² Functions and Comorbidity Focus in Previous Research

**Intervention Cluster**

By summarizing the functions within this cluster we used the wording of the authors. It was obvious that high level of patient integration in this cluster results in multiple usage of the word “self-“. Self-assessment, self-tracking, self-management and others are the functions that are used to support the intervention process and engage patients in observing their health condition. Some authors also described psychoeducation and training functions. In these cases a smartphone was used as an interactive reader for confidential education on such sensitive topic as mental disorders. Surprisingly, only few applications within this cluster comprised typical clinical functions such as treatment, monitoring and diagnostics. Those are the functions that allow mental health systems to displace even typical clinical functions into the patient’s environment in order to provide low-threshold and decentralized health care services.

**Social Engagement and Data Handling Clusters**

Within the “Social engagement cluster” 17 applications did not describe any function with regards to patient engagement with other actors. 18 applications included the function of unilateral sharing: patients inform the therapist about their social interaction, one-way sharing symptoms with the doctor etc. Of course some researchers described the feedback performed by means of other tools such as email, personal conversation or phone call. However, in this case the functionality of the mobile application was not used at its maximum. Only five applications from Table 2 indicate the usage of active and regular feedback by means of an application itself.

On the other side, the “Data handling cluster” includes many contributions that deal with both analysis and data transfer. The examples within this cluster include sending patient data to the therapist, sending assessment-reports to the medical professional etc. Here, too, the quality or exact definition of this transfer is questionable. In many cases it deals with a one-way transmission of patient data and very scarce exchange. Although, the same applications may implicit a data transfer function from the “Data handling cluster” – in most cases they still give a simple opportunity for one-way data sharing or transmission. This mostly occurs without a constant interaction between patients and professional caretakers, peers or other patients.
Dealing with Comorbid Disorders

The last column of Table 2 includes three kinds of results. Previous research was whether focused on comorbidity, only mentioned the comorbidity or did not mention it at all. The authors that focused on comorbidity were dealing with combinations of several mental disorders or with mental disorders accompanied by a physical disease. The combinations of mental disorders included psychosis and schizophrenia, depression and anxiety disorders, posttraumatic stress and substance abuse etc. The combinations of mental and physical diseases included depression and diabetes, HIV and alcohol abuse etc. Most of the papers were not primarily focused on comorbidity or were not focused on it at all (23 papers in total). These results stand in contrast with the high prevalence of comorbidity in mental health.

Conclusion, Implications and Limitations of Research

IS Research on mH^2

The search for the mH^2 literature reveals a huge lack of IS research on mH^2. For example, the AIS Library contained only two papers that analyzed specific mH^2 applications, whereas several other papers from the IS domain delivered only general information on mH^2. This was no surprise as another research on general health IT conducted by Wahle and Kowatsch (2014) showed similar result. Therefore, we can conclude that the research on mH^2 within the IS domain is at the very beginning of its development and has a big potential for improvement. It lags much behind the evident existing mH^2 applications that can be found in major app stores or at the startup platforms that have emerged lately.

Functional Clusters of mH^2

The application of the proposed framework proved to be beneficial to detect important gaps within each functional cluster. For example, the scarce implementation of typical clinical or professional functions such as treatment, monitoring and diagnostics means that most of the mH^2 applications are still immature when performing these functions or there are barriers for their implementation. Filling of this gap could help to provide more low-threshold, decentralized treatment within the patient’s environment.

Surely, not every application requires functions from the “Social engagement cluster”. But those applications that do – often perform simple unilateral sharing with other actors. This one-way sharing and eventually later feedback by means of other tools (email, telephone etc.) indicates the limited usage of the advantages of mobile technology. This also indicates a further gap. Only five applications within our results indicated a full usage of both bilateral sharing and feedback, whereas others should consider the option of complementing current sharing by adding the feedback function via application. The bilateral engagement can be implemented in combination with available data analysis and transfer features from the “Data handling cluster”. Our analysis proved that the majority of the applications had both capabilities, which were still mostly used only for one-way data transfer. Therefore, both latter functional clusters are very important in terms of broader usage of the advantages provided by mobile technology. They can utilize flexibility, portability, connectedness and other advantages in order to overcome typical mental health problems: barriers in communication, limited outreach, information sharing requirements etc.

Overall, we can conclude that the interconnection between those three clusters is very close and it is difficult to draw a distinct border between them. Nevertheless, the framework proved that it can analyze the main functional clusters of mH^2 and that it can detect further functional gaps.

Comorbidity in mH^2 Applications

Not all applications within our research had a comorbidity focus or even mentioned comorbid disorders. We consider that capabilities of mH^2 may be of great advantage to provide an integrated care for multiple disorders simultaneously, which is normal and even crucial for mental health issues, but sets a big challenge for health care systems. This potential of mH^2 must be included into the research agenda, which poses a next question of how to integrate the standalone mH^2 applications into multi-functional mH^2 platforms or at least allow their interoperability. The combination of different independent solutions may be problematic due to the different development methods and no common standards. Therefore, we call
for more research on utilization of multiple mH² applications or for a better standardization of their interoperability. A further gap concerns the lack of differentiation between comorbidity within mental health and comorbid physical diseases parallel to mental issues. This requires integration of functions from different health care areas and poses another superior challenge: mH² to support comorbid physical diseases.

**Practical Implications and Limitations of the Research**

We propose that our framework may be beneficial for both IS and medical practitioners. By planning the development of an application and consulting our framework, practitioners can identify opportunities for mHealth innovation in mental health with greater precision. Our framework can also raise the awareness of practitioners in terms of using mH² for comorbid disorders.

Our study has several limitations. First of all, we consider patient-centered mH² applications, whereas a further analysis of professional mH² applications can surely complement and leverage the research. Secondly, our review focuses only on published studies on mH² applications and does not consider the highly dynamic space of mH² applications in open mobile ecosystems such as app stores. Future research should also integrate findings from this area.

So far the analysis of mH² applications lags behind their dynamic emergence and development. This calls for more research of mH² applications from the IS communities. This future research can leverage the understanding of mH² functions and the functional gaps as proposed in this paper. The results of such research can convince health care stakeholders to make a better use of these applications on their way to more patient-centered low-threshold and decentralized health care services.

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