IDENTIFYING OPPORTUNITIES FOR FUTURE DESIGN RESEARCH FOR MHEALTH FOR MENTAL HEALTH

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IDENTIFYING OPPORTUNITIES FOR FUTURE DESIGN RESEARCH FOR MHEALTH FOR MENTAL HEALTH

Complete Research

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Abstract

Mobile health (mHealth) improves health care by leveraging mobile technology to reach out to patients above and beyond traditional medical interventions. Unfortunately, mHealth progress is still lacking for one of the most prevalent disorders worldwide – depression. mHealth for mental health (mH²) needs to deal with specific challenges such as sensitivity of patient information and traditional nature of conversation-based treatment. Nevertheless, mH² has the potential to improve care through engaging patients in treatment, providing confidentiality and motivating patients to perform their “homework” in-between therapies. Our research is the first comprehensive study of mH² applications for depression from one major app store. In this research paper we survey the progress of mH² for depression by applying and extending a previously developed conceptual framework. We derive research opportunities for designing mHealth for mental health and analyze 124 iPhone applications for depression in order to derive the gaps in their functionality and propose actions for fuller usage of their potential. Consequently we propose a comprehensive analysis method for future design research for mHealth for mental health.

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

1 Introduction

mHealth (mobile health) is used to improve health-related services by using mobile and wireless technologies (Mitchell et al., 2013). Mobile devices can be used by both patients and medical professionals in order to track, manage, and improve health (Mitchell et al., 2013). In 2013 U.S. Food and Drug Administration predicted that around 500 million people would use mobile medical applications by 2015 (FDA, 2013). In 2015 the recent research showed that the fast development of this market is proven by the number of applications worldwide: 5% of all apps are mHealth apps (research2guidance, 2015).

However, not all health care areas are equally fast in applying new mobile technologies. Some lag behind the average pace of mHealth adoption. For example, innovations are not always integrated very quickly in the area of mental health. This is caused by the traditional nature of treatment and a large share of one-on-one interactions between patients and medical professionals (Castelnuovo et al., 2003). Another discouraging factor is the highly sensitive nature of information where mentally ill patients can be discriminated as a result of data leaks (Ennis et al., 2011; Callard and Wykes, 2008).

In spite of these peculiarities, mHealth for mental health care may help to overcome entry barriers to health care and to provide opportunities for remote diagnosis, monitoring, and treatment (Farrington et al., 2014). Patients may be able to access care services in their own environment (Blaya et al., 2010) which corresponds to the latest developments in terms of decentralization of care and low-threshold solutions. mHealth can thus help to deinstitutionalize and scale up the provision of mental health care (Farrington et al., 2014).
Multiple factors – both economical and organizational – influence the need for innovation-driven change in mental health care provision. The prevalence of mental disorders and substance abuse influences sick leave and unemployment and thus poses an economic burden on companies and governments (Harnois and Gabriel, 2000). Modern technologies, such as mobile technology can provide opportunities for innovation and cost saving in this health care area (Farrington et al., 2014; Donker et al., 2013). Another incentive for improvement in mental health care provision is the shift from centralized care within large mental health institutions towards decentralization of care provision. This change enables the reduction of hospitalization and more intensive prevention (Hardstone et al., 2004; Wisdom et al., 2008). Care is thus provided via multiple channels and engages multiple actors such as hospitals, psychotherapists, communities etc. (Hardstone et al., 2004). This urges for stronger integration of actors which can be enabled by mHealth. Also low-threshold care can be provided by patient-centered mobile apps as such a type of care requires stronger involvement and engagement of patients (East and Havard, 2015).

mHealth for mental health – mH² – was first introduced by Farrington et al. (2014). This area of mobile health can engage patients in treatment because it is portable, can be applied in real-time, can provide live interaction, and can continuously collect and monitor data (Heron and Smyth, 2010). Additionally the confidentiality and privacy of mHealth can reduce shame and can enable treatment at individualized pace (Juarascio et al., 2015). mH² may address multiple limitations of current psychiatric treatments. It motivates and encourages patients to do their “homework” in between therapies, perform self-monitoring, and even take part in live interventions (Juarascio et al., 2015).

Previous analysis of mH² literature revealed a huge lack of IS research in this mHealth area. It lags behind the market development that can be observed in major app stores or on startup platforms (Tokar et al., 2015). This research aims to discover the potential for mH² in terms of its functionality and capabilities to leverage care. A framework is applied in order to analyze mHealth applications for mental health. This framework was derived from our previous research (Tokar et al. 2015) and was originally conceptualized and applied to mH² applications that were described in previous research papers. The current research paper revises this framework and applies it in order to conduct a comprehensive analysis of existing applications in practice. Our study uses the examples of depression-oriented applications for iPhone and is aimed to discover gaps in existing solutions and to define recommendations for future design-oriented research in the area of mHealth for mental health.

The paper is structured as follows. First, we describe the conceptual foundation for our analysis by using the framework for analyzing patient-centered mH² applications. Then we describe the methodology of the search and identification of relevant mH² applications for depression. We omit irrelevant apps based on predefined criteria. We categorize and summarize selected results using the proposed and revised framework. The Results section also describes exemplary apps that comprise pre-defined best-practice criteria for each cluster of the framework. Finally, the conclusion part provides discussion of the results, their implications, derives conclusions and outlines future research opportunities.

2 Theoretical Framework

Considering mobile health solutions in general, one can argue that mHealth offers diverse advantages enabled by mobile technology. It can remove physical barriers in healthcare provision by bridging patients with the preventive medicine and diagnostics (Yetisen et al., 2014). For medical professionals mHealth provides a tool to diagnose patients off-site providing a possibility to access clinical data anytime and wherever they need it (FDA, 2013). For payers, such as insurance companies, mHealth can lower administrative costs, improve access to personalized information and promote better health for customers through better involvement in care (PWC, 2014).

mH² (mobile health for mental health) is defined as any psychological or mental health intervention, which is enabled by mobile technology (Clough and Casey, 2015). mH² uses the advantages of mobile technologies such as mobility, wide distribution, constant connection etc. in order to provide medical...
intervention for individuals suffering from mental disorders and in order to support their families (Boschen and Casey, 2008; Ly et al., 2012; Tokar et al. 2015).

Based on the capabilities of mobile health mH2 is able to enhance the assessment of mental health conditions, leverage the intervention proposition, offer a variety of treatment options, and even provide treatment (Clough and Casey, 2015). This is crucial for mental health care as in this medical area patients are characterized by high resistance to treatment. At the same time mental health care urges for treatment tools which are integrated into daily life (Juarascio et al., 2015).

Our research aims to leverage the efficient usage of mH2 and to find the gaps that inhibit the full utilization of the advantages of mH2. Therefore, the purpose of this analysis is to define gaps in the functionality of mH2 applications. The basis of this analysis is the framework for analyzing patient-centered mH2 applications (Tokar et al. 2015) that was developed referring to the directions of Agarwal et al. (2010) and previous works on mH2 functionality (Clough and Casey, 2015; Price et al., 2013; Hermano et al., 2014).

This study aims to analyze patient-centered apps and to eliminate apps that are used only by clinicians. It draws onto the concept of patient-centeredness where patient-centered care establishes a partnership among medical professionals, patients, and their relatives. This type of care guarantees that the wants, needs and preferences of patients are respected and can influence the decision-making and participation in their own care (Hurtado et al., 2011). Patient-centered mH2 applications are thus developed for treating mental disorders or supporting the treatment of mental diseases at the level of health care consumer. This is the level where the patient is an active participant and a co-creator of own care (Hurtado et al., 2011).

In this section we describe and refine the framework derived in our previous publication (Tokar et al. 2015). The framework is illustrated in Figure 1. It considers two views: one view deals with applications aimed to treat single mental disorders and the second view deals with applications aimed to treat multiple (comorbid) mental disorders. Comorbid disorders are the ones that accompany the primary disease. The comorbidity view shows the linking potential for mobile applications which can deal with several disorders and can be used across different health care systems. This enables a stronger integration of different actors and channels in order to treat multiple disorders simultaneously. For patients it means fewer interventions and simpler solutions for several disorders at the same time.

Three functional clusters derived in Tokar et al. (2015) are based on previous research of mH2 functionality. The first functional cluster – “Intervention cluster” – indicates how the application can screen patient’s condition, monitor patient’s progress, provide treatment or counseling, etc. In sum, this cluster shows the traditional health care services that can be provided by a mobile application (Clough and Casey, 2015; Price et al., 2013; Hermano et al., 2014). The second cluster – “Social engagement” – indicates how patients engage with medical professionals, peers, self-help groups, own family members etc. This cluster shows whether an application uses its connecting potential to bring different care participants together (Price et al. 2013). Finally, the third cluster – “Data handling” – shows the technical side of the app whether the application is able to collect data, store it, analyze it, transfer, etc. (Tokar et al. 2015, Luxton et al. 2011). In sum, the first two clusters help to analyze mH2 from the medical point of view, whereas the third cluster allows to analyze the IS side of same medical applications. Therefore, our framework allows to integrate both medical and IS views in order to understand the interdisciplinarity of applications based on the premises of two different communities: medical and IS.

Although the framework proposes a division into three functional clusters, the functions across those clusters can be interconnected and interrelated to each other. For example, data collection and storage allow to perform self-assessment and self-tracking, whereas the data output from self-tracking can be used for diagnostics and monitoring and can be shared with doctors or peers. Nevertheless, distinguishing between separate clusters can help to identify gaps in the functionality of mH2 applications according to each particular cluster.
Our current research refines the previously derived framework with its three clusters and the comorbidity view by adding a quality view onto mH². Because the market for mHealth applications has strongly grown (Mitchell et al., 2013) the variety of offerings is overwhelming and it becomes hard to distinguish good and bad quality apps or to evaluate their potential (Stoyanov et al., 2015). Several attempts to analyze existing mHealth applications have been made. Handel (2011) reviewed mHealth apps based on user ratings of usability, reliability, quality, information scope, and design. Khoja et al. (2013) described evaluation criteria based on the app’s life-cycle: development, implementation, integration, and sustained operation. Besides these described methods there are ratings of applications in diverse app stores, whereas those are often non-transparent or insufficient in order to determine the quality of the app.

Figure 1. A framework for analyzing patient-centered mH² applications (derived from Tokar et al. 2015).
Some researchers have attempted to analyze mH2 applications specifically. For example, Riley et al. (2011) reviewed mHealth behavior interventions and concluded that most of them were one-way interventions with only data input or informational output. Few of them have leveraged mobile technologies to provide live and interactive interventions and few were able to adjust interventions. In their research on mHealth for bipolar disorders Nicholas et al. (2015) concluded that few apps have been developed with reference to evidence-based practice or involved medical professionals whereas health care consumers have a positive attitude towards evidence and professional involvement (Proudfoot et al., 2010).

Our paper adds a quality view on mH2 applications within the previously derived framework (Tokar et al. 2015). It adds this view to the framework using the notion of Proudfoot et al. (2010) and Nicholas et al. (2015) about the importance of evidence and professional involvement and defines high quality applications. This means that applications are evidence-based, are recommended by medical professionals (or others) or were at least co-developed by medicals, peers or pharmacists. This work uses the framework and evaluates patient-centered mental health applications in practice. It is expected to show that only few existing apps draw on evidence-based techniques. The research paper addresses this issue and proposes recommendations for more comprehensive usage of evidence in mH2 apps.

In sum, the revised framework for analyzing patient-centered mH2 applications allows analyze each application from both medical and IS view. It enables the evaluation of medical functions in terms of treatment, connecting functions in terms of engagement with other actors and also data handling capabilities of solutions. The views on comorbidity and quality help to analyze the comprehensiveness of apps in terms of quality and breadth of their offerings. The previous version of the framework has been applied to mH2 applications described in previous research works. In this paper the revised version of the framework will be applied onto applications found in open mobile ecosystems such as app stores. It is aimed to leverage the understanding of mH2 functions, functional gaps and potential for mobile health for mental health.

3 Methodology

3.1 Search and data description

This research is based on the analysis of patient-centered mH2 applications for depression. The reason for choosing depression is the highest prevalence of this disease worldwide. According to Whiteford et al. (2003) depression is the most disabling disorder worldwide and counts for the most years lived with disability among all mental disorders. Depressive disorders contribute most of the non-fatal burden followed by anxiety, drug abuse, and schizophrenia.

For our comprehensive analysis we conducted a search of iPhone apps for depression. We chose apps that directly address depression as a disorder. iPhone apps were chosen because Apple is one of the largest leaders on the mHealth market (research2guidance, 2015). We looked for relevant mH2 applications using the AppShopper platform because it offers convenient navigation functions and is one of the largest directories for iPhone applications search (AppShopper, n. d.). The search of relevant applications was documented and refined via several validation steps.

In this research the keyword “depression” was used and a list of apps was generated via AppShopper search (search date: 21.09.2015). Because we focused on apps and not ebooks or games, only two categories of apps: “Health & Fitness” and “Medical” were considered for analysis. The search generated 394 apps in the category “Health & Fitness” and 271 apps in the category “Medical”. Those are 665 apps in total.

In order to refine the list of results several criteria were defined and our research team performed further refinement. Two researchers analyzed the generated search results. Each researcher was responsible for one app category and screened the full list from each category. After the screening was finished, each researcher validated the analysis of the other team member.
We described apps from the assigned categories using an Excel chart. The chart included different characteristics of each application. The group “General information” contains data provided by AppShopper for each application. The group “Framework related characteristics” indicates how each application corresponds to the functional clusters derived in the theoretical framework. All groups of characteristics were used as classification columns in an Excel chart. These columns were filled out using the app description from AppShopper, iTunes, and the website of app developers. The Excel chart contained multiple characteristics for each application that are presented in Table 1.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Description</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General information</strong></td>
<td>Android version</td>
<td>The app has an Android version.</td>
</tr>
<tr>
<td>Average rating</td>
<td>Average rating on iTunes.</td>
<td>Number of “stars”</td>
</tr>
<tr>
<td>Release/ Update</td>
<td>The data on app’s first release and last update.</td>
<td>Date</td>
</tr>
<tr>
<td>Disorders</td>
<td>The app is aimed to provide help/treatment for particular mental or general disorders.</td>
<td>Depression, eating disorders, diabetes, etc.</td>
</tr>
<tr>
<td><strong>Framework-related characteristics</strong></td>
<td>Patient-centeredness</td>
<td>The app is either patient-centered or professional (for clinicians or medical professionals).</td>
</tr>
<tr>
<td>Co-developed</td>
<td>The app was developed/co-developed by medical professionals, experienced peers etc.</td>
<td>Doctors/peers/pharmacists/hypnotherapists etc.</td>
</tr>
<tr>
<td>Evidence</td>
<td>Evidence on treatment/assessment techniques used by the app.</td>
<td>Research data, links to research articles etc.</td>
</tr>
<tr>
<td>Recommended</td>
<td>The app is recommended by medical professionals, institutions or others.</td>
<td>Names of the institutions, funds, doctors etc.</td>
</tr>
<tr>
<td>Intervention</td>
<td>The app provides care by means of diverse interventions.</td>
<td>Self-assessment, self-tracking, counseling, etc.</td>
</tr>
<tr>
<td>Social engagement</td>
<td>The app connects users/patients to other actors.</td>
<td>Sharing/feedback with doctors, peers, family, etc.</td>
</tr>
<tr>
<td>Data handling</td>
<td>The app is able to perform diverse data handling functions in terms of data output, data collection, data analysis and data transfer.</td>
<td>Videos output, recording talkabouts, input of symptoms, sending data reports.</td>
</tr>
<tr>
<td>Comorbidity</td>
<td>The app provides help for individuals suffering from multiple disorders.</td>
<td>Multiple mental disorders/plus general disorders.</td>
</tr>
</tbody>
</table>

Table 1. Apps characteristics that were used for app analysis.

### 3.2 Identifying and selecting relevant apps

Within each app category three types of apps were defined – this helped to perform further refinement of data. The apps of the first type were marked as “irrelevant”, because they did not address depression at all. They mostly addressed general stress, other health issues (e.g. weight loss and training) or used the word “depression” as an advertising slogan without dealing with the depressive disorder directly. The second type of apps was called “relevant” and included mobile apps for depression that either involved medical professionals or peers directly or allowed patients to communicate with those via app. The third type – “potentially relevant” were the apps dealing with depression, but lacked evidence of their intervention techniques at the first sight.

Overall, 175 relevant and potentially relevant applications were considered for further analysis. Duplicates were removed. “Lite” versions and “another language version” were also excluded from the list.
As our focus concerned patient-centered applications, all professional apps aimed only at clinical usage or usage by medical professionals had to be removed.

After these steps were completed, the researchers came back to “relevant” and “potentially relevant” apps in order to define the final list of relevant apps among those. The following criteria based on the quality view from the framework (derived from Proudfood et al. 2010 and Nicholas et al. 2015) were used to define relevant apps for the final analysis. At least one of these criteria had to be met in order to include the app in the final analysis:

- The application uses evidence-based intervention techniques or medical scales
- The application is developed or co-developed by medical professionals, peers or pharmacists
- The application is recommended by insurance companies, doctors, medical institutions, etc.

The evaluation of these criteria was based on screening of different information sources for each app. E.g. the description of an app in the app store, developer website or other sources were used in order to find scientific evidence provided for an app – research articles, conference publications on app efficacy, clinical trials etc. Same information sources were used in order to find information on whether an app was developed/co-developed or recommended by professionals.

The sorting of irrelevant apps showed that many components of existing apps are not empirically supported, do not draw onto evidence-based principles or do not involve any professionals or peers in their development as proposed by Juarascio et al. (2015). Even though some of these components (e.g. positive affirmations, yoga, etc.) may be useful or at least not harmful – they were excluded from the future analysis. Overall, 124 apps were considered as relevant for our analysis and are presented in the Results section.

4 Results

4.1 Functional clusters of mH² applications

The analysis framework was applied onto 124 mH² applications and final results are presented in Table 2 and Table 3. In order to evaluate the functions from each cluster we relied on the description of analyzed applications. As our focus lies on patient-centered applications, many functions contain the prefix “self-“, such as self-assessment, self-training, etc.

Table 2 is structured as follows. The first column – cluster – represents the functional clusters from the framework: intervention, social engagement and data handling. For each cluster we specify different functions. In the intervention cluster there are self-assessment, self-tracking, self-training, self-management (in terms of self-planning and self-organizing), psychoeducation, counseling and treatment. In the social engagement cluster there are functions of sharing with either doctors or peers (and other actors). There is also a function of both sharing and feedback with doctors or peers as well. In the data handling cluster we included data collection, data analysis and transfer.

Table 2 provides the number of apps that perform selected functions. First, the number of apps from the total list of apps (out of 124) and the share of apps in percent is provided. In the comorbidity column we present the data on apps that are able to engage with other disorders. In this column mental comorbidity stands for comorbidity with other mental disorders except for depression – those are 91 apps in total. “Mental + general comorbidity” indicates apps that can deal with depression, other mental disorders and other general disorders. Those are 36 apps in sum. Therefore, the shares of apps in the comorbidity columns indicate how many apps (in percent) perform each function from the framework.
Table 2. Functional analysis of the mH apps for depression (own representation; Appshopper, n.d.; iTunes, n.d.).

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Functions</th>
<th>All apps</th>
<th>Apps with comorbidity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Intervention</td>
<td>Self-assessment</td>
<td>70</td>
<td>56%</td>
</tr>
<tr>
<td></td>
<td>Self-tracking</td>
<td>50</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>Self-training</td>
<td>49</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>Self-management</td>
<td>33</td>
<td>27%</td>
</tr>
<tr>
<td></td>
<td>Psychoeducation</td>
<td>29</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>Counseling</td>
<td>24</td>
<td>19%</td>
</tr>
<tr>
<td></td>
<td>Treatment</td>
<td>37</td>
<td>30%</td>
</tr>
<tr>
<td>Social engagement</td>
<td>Doctors</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sharing</td>
<td>29</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>Sharing + Feedback</td>
<td>20</td>
<td>16%</td>
</tr>
<tr>
<td></td>
<td>Peers/...</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sharing</td>
<td>15</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>Sharing + Feedback</td>
<td>9</td>
<td>7%</td>
</tr>
<tr>
<td>Data handling</td>
<td>Collection</td>
<td>98</td>
<td>79%</td>
</tr>
<tr>
<td></td>
<td>Analysis</td>
<td>98</td>
<td>79%</td>
</tr>
<tr>
<td></td>
<td>Transfer</td>
<td>61</td>
<td>49%</td>
</tr>
<tr>
<td>Total applications</td>
<td></td>
<td>124</td>
<td>91</td>
</tr>
</tbody>
</table>

The results in the intervention cluster indicate that many applications are able to provide self-assessment (56%) and self-tracking (40%) features as part of health tests. Nevertheless, a gap was detected where many apps provide only assessment without using the feature of data tracking over time (the difference between larger share of self-assessment and lower share of self-tracking). 40% of all apps enable self-training for users where users can practice to improve their mood, their overall condition, etc. Most of these apps enable this feature by providing guided exercises using images, videos, audio, gaming etc. This allows to use different interactive capabilities of mobile technologies in order to provide training in a flexible way – anywhere and anytime. The same can be applied to psychoeducation which also uses different interactive mobile tools but is mostly more conservative and often provides only texts with psychoeducative information. Nevertheless, reading on a smartphone can be very convenient as it is possible to restart reading later, save the progress, etc.

Less than one third of all applications provide self-management in terms of self-planning where users can schedule appointments, plan their treatment, and perform other tasks in terms of self-organization (27%). This function is often enabled by calendars and reminders. Whereas our research proposes that more applications should have provided this function as it is necessary for diverse types of help and intervention in general. 19% of the mH solutions provide counseling and 30% provide treatment opportunities. The first ones enable counseling mostly through connecting to medical professionals and ability to share and receive feedback from other actors or institutions. Apps that enable treatment are also mostly connected with medical professionals or institutions or can provide mobile cognitive behavioral therapy (CBT). The usage of CBT is not unusual as this therapy method can be easily translated into computerized interventions (Musiat and Schmidt, 2010). Nevertheless, we found that only 15 out of 124 applications are CBT based whereas many others could also apply this therapy method in a mobile version and thus provide evidence-based treatment technique.

23% of all applications offer a possibility to share with doctors and 16% allow to receive feedback from them. Only 12% and 7% can enable users to share with other users, peers or family or and to receive feedback from others. In both cases – whether doctors or peers – most of the engagement occurs
unilaterally. Therefore, patients can share some information or their progress in a one-way matter. And only in few cases, mH can enable feedback loops and interactive communication from both sides of the health care system.

Almost 80% of all applications are able to collect and analyze data. Most of the time users type in their data or symptoms and the app can evaluate this information in order to diagnose or recommend treatment or other intervention. Many apps are able to show graphical representations of data analysis either as a snapshot or analyze development over time. Only half of the applications give an opportunity to transfer the data by means of the application itself. Most of the apps transfer data via email by connecting to email apps installed on the smartphone. We found that only 11 out of all 124 applications have an in-app data transfer function that connects app users with other actors. This indicates at insufficient usage of data transfer capabilities whereas these capabilities can be provided by an app itself without using other email programs, etc.

Table 3 shows how many apps and how many comorbidity-related apps (in percent) are able to perform several functions and not just a single function. In order to examine the thesis that mHealth leverages the proposition of treatment (Clough and Casey, 2015) several functions were put in combinations. The results show that very few applications out of all 124 can provide multi-tasking rather than concentrate only on e.g. self-assessment or only on data collection. For example, only three apps can provide a comprehensive package of self-help intervention functions plus counseling or treatment. Several apps are able to support sharing or/and feedback with both doctors and peers. Better results were gathered for the data handling cluster. 40% of all applications are able to perform all main functions of data handling: collection, analysis and transfer. The important gap is, however, the difference between performing all three functions and performing collection plus analysis. This indicates that many apps that gather and analyze data can still improve and enhance their data handling functionality in terms of data transfer.

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Combinations of functions</th>
<th>All apps</th>
<th>Apps with comorbidity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>Mental comorbidity</td>
</tr>
<tr>
<td>Intervention</td>
<td>Self-assessment, -tracking, -training, -management</td>
<td>12</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>Self-assessment, -tracking, -training, -management, PS-education, + counseling or treatment</td>
<td>3</td>
<td>2%</td>
</tr>
<tr>
<td>Social engagement</td>
<td>Sharing with doctors + peers</td>
<td>7</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>Sharing + feedback with doctors + peers</td>
<td>4</td>
<td>3%</td>
</tr>
<tr>
<td>Data handling</td>
<td>Collection + analysis</td>
<td>93</td>
<td>75%</td>
</tr>
<tr>
<td></td>
<td>All data handling</td>
<td>49</td>
<td>40%</td>
</tr>
<tr>
<td>Total applications</td>
<td></td>
<td>124</td>
<td>91</td>
</tr>
</tbody>
</table>

Table 3. Combinations of functions performed by the mH applications for depression (own representation; Appshopper, n.d.; iTunes, n.d.).

Also, the analysis of all functions throughout three functional clusters was performed for the apps that are concerned either with several mental disorders or with both mental and general disorders. Most of the numbers correlate with the numbers for all apps – concerning individual functions and combinations. Interestingly, the apps dealing with comorbidity are the ones that offer more counseling and treatment from established health care institutions or counseling offices. These apps also are able to
perform data transfer. Especially, this concerns apps that offer help for both mental and general disorders. Therefore, apps that deal with depression only or with mental disorders only use more offline interventions and offer fewer counseling, treatment and therefore less opportunities for data transfer. This can result from specifics of each mental disorder or from complex integration, which is required for such comprehensive apps. Based on this notion, this study proposes that mH can enhance the treatment of comorbid disorders and that this issue has to be strongly considered for future mH apps.

The summary of major gaps and opportunities derived from the results is provided in Table 4.

<table>
<thead>
<tr>
<th>Gap in functionality</th>
<th>Opportunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance of assessment-only functions</td>
<td>Apps that assess data can also provide data tracking and analysis over time.</td>
</tr>
<tr>
<td>Few apps provide self-management functions</td>
<td>More self-management can enable users to plan and control their treatment.</td>
</tr>
<tr>
<td>Few CBT-based applications</td>
<td>More CBT-based apps could leverage the provision of care by reaching out to more patients.</td>
</tr>
<tr>
<td>Most of the engagement occurs unilaterally.</td>
<td>Both patients and professionals can benefit from the combination of sharing and feedback.</td>
</tr>
<tr>
<td>Data sharing occurs mostly by means of external tools (email etc.)</td>
<td>An app-integrated sharing feature can inhibit the data diffusion to other external sources.</td>
</tr>
<tr>
<td>Few apps provide multi-tasking.</td>
<td>The provision of comprehensive packages can leverage care offered by one provider.</td>
</tr>
</tbody>
</table>

Table 4. Major gaps and opportunities derived from the analysis.

4.2 mH² examples

The following section selects and describes several examples of mH² applications for depression. These applications were selected because they provide an overview on how multiple mH² functions can be empowered by mobile technologies. These state of the art examples comprise several functions from each of the three clusters and comorbidity as well. These apps represent very good examples for each functional cluster and comorbidity. This section describes three examples from the category “Health & Fitness” and one example from the category “Medical”.

Table 5 provides an overview of four examples. It shows the functions that each app performs per selected cluster. It also provides basic information such as application name and app category.

Example “Intervention”. Anti-Depression (first release February 2014)

Anti-Depression was developed in collaboration with a medical professional and comprises a personal depression management program. It is also able to perform other functions besides self-management – such as self-assessment, self-tracking, self-training, psychoeducation and treatment. This application does not provide any social engagement capabilities. It is able to collect and analyze data but does not allow transfer of data. An interesting feature includes playing the recorded messages of the doctor that provides an action plan for the treatment (iTunes, n.d.; www.moodmaster.co.uk, n.d.).


This application is recommended by health providers, it deals with multiple mental disorders, and allows users to assess, track, train, and manage themselves and their health. The app gives an opportunity to share with the medical professional and receive feedback if the latter uses the CohesiveSelf online platform. It is also possible to share and communicate with other people via integrated Twitter-, Facebook-sharing or email. Although this app has been developed by doctors and is recommended by medical professionals – it does not provide any evidence on the therapy methods used in this solution (iTunes, n.d.; www.cohesiveself.com/, n.d.).
Example “Data handling”. Health Ally (first release February 2015; latest update June 2015)
Health Ally is a personal medical assistant that deals with diverse mental and general disorders. It can be used for self-assessment, self-tracking, self-training, self-management, psychoeducation and counseling. This app allows users to share and receive feedback and it integrates multiple data handling functions. The app collects profile entries and symptoms. Evaluations can be performed weekly and results are shown by diverse graphs and presentations. Health Ally has an integrated contact function where patients can contact their doctors via “in-app” connect function. This application does not provide any particular information on the evidence of its therapy methods either (iTunes, n.d.; www.osiamedical.com).

Example “Comorbidity”. Activity and Mood Diary by Ginsberg (first release March 2015; latest upgrade March 2015)
The app was developed within a collaborative project of The Scottish Government, UK National Health Service and New Media Scotland. It is a free modular app for tracking mood and physical activity which can be synchronized with other health and fitness apps and wearable devices. It is reported to reduce mild depression and anxiety. This app also has positive effects on behavior change and provides support for general fitness and health. The Ginsberg app uses evidence-based techniques of Mindfulness-Based Stress Reduction, NHS approved measurement scales and World Health Organization’s methods of wellbeing evaluation. Ginsberg does not provide an opportunity to share or receive feedback from doctors, peers or others (iTunes, n.d.; www.ginsberg.io, n.d.).

<table>
<thead>
<tr>
<th>Cluster / comorbidity</th>
<th>Functions</th>
<th>Application</th>
<th>App category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention</td>
<td>Self-assessment, self-tracking, self-training, self-management, psychoeducation, treatment.</td>
<td>Anti-Depression</td>
<td>Health&amp; Fitness</td>
</tr>
<tr>
<td>Social engagement</td>
<td>Sharing and feedback with medical professionals and peers.</td>
<td>CohesiveSelf</td>
<td>Medical</td>
</tr>
<tr>
<td>Data handling</td>
<td>Data collection, analysis and transfer.</td>
<td>Health Ally</td>
<td>Health &amp; Fitness</td>
</tr>
<tr>
<td>Comorbidity</td>
<td>Other mental disorders and general disorders</td>
<td>Activity and Mood Diary by Ginsberg</td>
<td>Health &amp; Fitness</td>
</tr>
</tbody>
</table>

Table 5. Four mH² examples for each functional cluster and comorbidity (own representation; Appshopper, n.d.; iTunes, n.d.).

The selected examples show how the functions from each cluster of the analysis framework can be used. All of the examples are successfully and actively used solutions that were selected as relevant based on the quality criteria. Nevertheless, none of the examples is able to perform the maximum of functions from all functional clusters plus cover the comorbidity at the same time. This indicates that the advantages of mobile technologies are not imposed upon even very good solutions at full. Surely, it is understood that not every mH² application has to comprise all functions. But an effective combination of high quality and evidence with mobile innovations can leverage care and provide patients with all-inclusive solutions.

5 Conclusion
This research paper is the first comprehensive study of mH² applications for depression. In parts it confirms the findings of our previous research paper, but this time it analyzes the entire set of available mH² apps for iPhone available on the open market. Additionally it shows new gaps and thus significant opportunities for design research of mHealth in mental health.
The comprehensive analysis of patient-centered mH² applications for depression was performed by means of the previously derived analysis framework. In this paper the framework was revised in order
to be able to analyze high quality applications. This enabled a systematic selection of relevant applications in a very dynamic and often unclear ecosystem of the mHealth market. As a consequence, this research contributed to the enhancement of systematic analysis of patient-centered mH² applications available for download and usage.

In this paper the notion on quality leveraged the selection process of relevant apps and provided a solid evidence to the data. The selection process also showed that the majority of existing apps did not draw on any evidence-based techniques, recommendations or did not engage medical professionals or others for the development of applications. As Jurascio et al. (2015) proposed that mHealth can improve treatment if it combines both evidence-based principles and recent advances in technology we can summarize that many solutions are still not capable of providing this combination in full.

The analysis of the functional clusters for 124 apps revealed several important gaps. Some of those corresponded with the previous research, and some were newly discovered. Many applications provided assessment functions but not all of them used the tracking feature in order to analyze the assessment-data over time. Also, the lower share of self-management in all applications presents the insufficient usage of mobile capabilities as the usage of calendar, reminders and other management tools can enhance the usage of mH² applications. The scarce usage of cognitive behavioral therapy as a treatment basis is another important gap. Especially the fact that this method can be easily computerized and may be offered as a mobile solution shows that there is a strong potential for higher involvement of such methods in mH² solutions.

Some results in terms of data handling and social engagement correspond with the results from previous research. In this paper we additionally differentiated the social engagement with doctors and peers and provided a more detailed analysis of data handling functions including the data collection. The analysis of these clusters also revealed significant gaps with these functions being provided poorly and insufficiently.

The comprehensive analysis of functional combinations revealed that many apps gather and analyze data but do not use mobile capabilities to share or transfer data in full. It can be concluded that much data remains stored on a mobile device and is rarely transferred. Especially, it is rarely transferred by means of in-app communication tools as those are characteristic for few applications. Also many applications are mostly concerned with single or few functions, but rarely provide functional combinations inspite of their potential capabilities. This urges for broader expansion of functional capabilities of mH² solutions.

Moreover, an interesting result was found concerning the comorbidity. The applications that are devoted to both mental and general disorders use more online intervention and often offer counseling and treatment with different opportunities for data transfer. This can be explained by the nature of such solutions as many of them are aimed at video conferencing and virtual doctor visits. Nevertheless, this study proposes that this potential can be also used by the applications that focus on depression only or on different mental disorders. This can enable the virtual face-to-face communication between patients and mental health professionals.

Overall, our findings summarize the high potential of mH² solutions to combine therapy techniques and medical evidence with advances in technology in order to improve care provision. Up to date this capability has been used insufficiently. This is supported by diverse gaps derived from the analysis. It can be concluded that using the revised framework for analyzing patient-centered mH² apps enabled the definition of such gaps and potential. Therefore, our framework can be recommended to both IS and medical researchers engaged with the topic of mHealth for mental health.

6 Implications and Limitations of Research

This paper addressed the gap derived from our previous research. The previous paper analyzed only mH² applications from published studies, but omitted the dynamic space of open mobile ecosystems. The current research paper also focused on patient-centered apps only and urges for future research on
mH² functionality for clinical or clinician-oriented mH² applications. Also the analysis of common interface between patient-centered and clinical apps should be useful.

The revised version of the framework is considered to be very useful for the comprehensive analysis of mH² applications. This can be utilized for the future design-oriented IS and medical research on mH². Additionally, it has a practical implication for those who plan to develop mH² solutions. The framework can help to identify the potential, recommend the closure of important gaps and leverage the importance of integrated solutions for multiple comorbid disorders.

This research is limited to the analysis of mH² functions independently from one another. A further step could be the evaluation of the connection and correlation between different sets of functions from same and different clusters combined with the comorbidity topic.

Overall, our research has implications for different stakeholders and areas: medical professionals and institutional stakeholders from health care, IS researchers focused on mHealth research from the IS community and application developers on the mHealth market. It can be concluded that future design-oriented research by means of comprehensive analysis tools such as our framework can leverage the understanding of mH² functionalities and its potential. The results of this research can influence all of the stakeholders mentioned in order to fully use the potential of approved treatment techniques and mobile innovations combined together.

References


