Towards the Design of Evidence-based Mental Health Information Systems: A Preliminary Literature Review

Research-in-Progress

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Abstract

Mental disorders belong to a significant and serious disease pattern with an increasing prevalence worldwide. Due to limited health personnel and financial resources, scalability of mental health services and tailored care of individuals are two key barriers for a successful treatment. Mental health information systems (MHIS) are expected to address these barriers and thus, it is of utmost importance to understand the underlying technological rules that guide the design of evidence-based MHIS interventions. However, up till now, there is no systematic literature review on the anatomy of MHIS that quantitatively tests the effects of MHIS service configurations on treatment success. We therefore conducted, as a very first step a preliminary review on MHIS in this research-in-progress. This review has not only the objective to present state-of-the-art on MHIS but also to propose a set of fine-grained evaluation criteria relevant for future work on the design of evidence-based MHIS interventions.

Keywords: Healthcare Information Systems, Mental Disorder, Review, Mental Health Information Systems

Introduction

Mental disorders such as dementia, major depression, substance abuse or mental retardation "imply the existence of a clinically recognizable set of symptoms or behavior associated in most cases with distress and with interference with personal functions." (WHO 2014 p.8) Determinants of mental disorders are manifold: personal traits such as the ability to cope with stress and emotions can play a major role in the development of mental disorders in almost the same manner as contextual factors such as the social, cultural, economic or work environment (WHO 2013a). People with mental disorders experience serious health-related consequences. In particular, they have to cope with disability and mortality to a disproportionately higher extent than those not being affected (ibid.). For example, depression alone accounts for "4.3% of the global burden of disease and is among the largest single causes of disability worldwide (11% of all years lived with disability globally), particularly for women." (ibid., p. 8) Accordingly, mental disorders are negatively related to work performance as shown by a study with more than 60.000 Australian employees (Hilton et al. 2009) and constitute the most common reason for long-term sickness absence (Henderson et al. 2011). As an economic consequence, the increasing prevalence of non-communicable diseases (i.e. non-infectious and non-transmissible among people) to which mental disorders contribute a major extent, is expected to account for a loss of US$ 47 trillion in 2030, i.e. approximately 75% of the global gross domestic product in 2010 (Bloom et al. 2011 p.6). In the US alone, health expenditures for mental disorders are projected to reach US$ 239 billion in 2014 (US$ 42 billion in 1986 and US$ 121 billion in 2003) which will represent approximately 7 % of all-health US expenditures (Levit et al. 2008).

In summary, mental disorders are today a significant and serious disease with an increasing prevalence worldwide. As a consequence, appropriate mental health strategies are needed from a top-down perspective (e.g. by implementing appropriate policies and action plans) as are particular prevention services from public health initiatives and large-scale therapeutic interventions that are tailored to individuals from the bottom-up (WHO 2006, 2012, 2013a, 2013b). However, it must be noted that mental health personnel, usually psychologists and psychiatrists with a specialized education that goes beyond both geospatial ubiquity and skills of general practitioners, are strongly required but limited due to a cost-effective resource allocation of health care budgets (Weinstein and Zeckhauser 1973; Weinstein 1990; Weinstein 1995; WHO 2006). For example, only US$ 2 (US$ 0.25 in low-income countries) are globally allocated to health care services related to mental disorders per person and year (WHO 2011) and for 50% of the world's population there is only one mental health expert responsible for 200.000 or more people (WHO 2013a).

At this challenging intersection of service scalability on the one hand and tailored care of individuals on the other hand, innovative Health Information Systems (HIS) have not only the potential to improve outcomes of preventive or therapeutic health interventions but also to reduce their costs significantly (Agarwal et al. 2010; Fichman et al. 2011; Martin et al. 2010). More precisely, a high potential of HIS has been already identified not only for electronic psychology interventions in general (Kraft et al. 2009) but also for mental heath interventions in particular (Druss and Dimitropoulos 2013; Clarke and Yarborough 2013; Mohr et al. 2013). Recent studies also suggest that MHIS can treat some pervasive mental disorders such as depression as good as traditional face-to-face therapy (Wagner et al. 2014) and moreover might be able lower the inhibition threshold to undergo mental health treatment besides the social stigma attached to it (Clement et al. 2014, Suler 2004). However, it is still an open issue which technological rules guide the design of HIS that either support existing evidence-based mental health interventions (Hedman et al. 2011) or form this sort of interventions on their own (Burns et al. 2011; Haug et al. 2013). In general, technological rules take the form of "If you want to achieve Y in situation Z, then something like action X will help." (Aken 2004). In this work, Y is a goal related to a mental health intervention (e.g. managing stressful situations), Z are everyday situations critical to a person affected by stress (e.g. the time before dinner when having an eating disorder) and X are health promotion actions that are enabled by HIS (e.g. a relaxation exercise service on a smartphone). In the following, we call this class of HIS mental HIS (MHIS) and state our overall research question as follows:

RQ: Which are the technological rules of evidence-based MHIS interventions?

In line with this question and as a very first step, this research-in-progress has two objectives:

(1) To preliminary review the current state-of-the-art on MHIS derived from both relevant fields of investigation. That is, we consider published work on MHIS from the IS field and medical outlets.

(2) To propose a set of fine-grained evaluation criteria that will help us in our future work to identify technological rules that guide the design of evidence-based MHIS interventions. Identifying these criteria enables experimental designs to analyze the causality between technical design choices of MHIS and their treatment success.

We next describe the class of mental health interventions in more detail and derive a set of dimensions that are going to be used for the literature review on MHIS. Then, the method of the review process is explained in detail. After the presentation of the resulting list of relevant articles, we briefly discuss them and outline the next steps towards the answer of our research question.

Theoretical Background

In the following two sections we briefly describe common psychological interventions that are used to treat mental disorders and present the evaluation criteria that are relevant for our literature review on MHIS.

Psychological Interventions and Mental Disorders

Common psychological interventions can be classified into acceptance and commitment therapy (ACT), cognitive behavior therapy (CBT), dialectical behavior therapy (DBT), emotion-focused therapy (EFT), family therapy and family-based interventions (FBI), Hypnotherapy (HT), interpersonal psychotherapy (IPT), mindfulness-based cognitive therapy (MBCT), narrative therapy (NT), Psychoeducation (PEDU), schema-focused therapy (SFT), self help (SH), solution-focused brief therapy (SFBT) or psychodynamic psychotherapy (PDP). For a brief description of these interventions see, for example, APS (2010). With respect to mental disorders, these psychological interventions are used to treat mood disorders (e.g. depression and bipolar disorder), anxiety disorders (e.g. panic disorder), substance use disorders, eating disorders (e.g. bulimia nervosa), adjustment disorders, sleep disorders, sexual disorders, somatoform disorders (e.g. pain disorder), borderline personality disorder, psychotic disorders, dissociative disorders or childhood disorders (e.g. attention deficit hyperactivity disorder) (ibid.).

While most of the aforementioned psychological interventions do not follow a stringent therapeutic plan but require dynamic face-to-face interactions between health care professionals and patients on a regular basis (e.g. ACT, DBT, EFT, FBI, IPT, MBCT, NT or SFBT), others can be applied with limited (e.g. PDP) or even without active involvement of the health care professional (e.g. PDP and SFT). The latter interventions, however, come along with a reduced intervention success due to low to zero interpersonal interactions (Andersson and Cuijpers 2009; Cuijpers et al. 2007; Spek et al. 2007). By contrast, CBT is a highly-structured psychological treatment (Hollon et al. 2006). It is based on the assumption that thoughts determine how we feel, behave and how we physically react. This form of intervention contains various treatments using cognitive and behavioral techniques with the assumption that changing maladaptive thinking leads to change in affect and behavior. Examples for therapeutic CBT interventions are activity scheduling, relaxation exercises, cognitive restructuring, self-instructional training or skills training such as stress and anger management (APS 2010). CBT is often regarded as the mental health intervention of choice due to its large evidence base on a variety of psychological disorders (Andersson and Cuijpers 2009; APS 2010; DeRubeis et al. 2005, 2008; Johansson and Andersson 2012; Proudfoot et al. 2004; Ruwaard et al. 2009; Spek et al. 2007). Moreover and with regard to its structure it seems suitable for implementation in digital interventions (Kraft et al. 2009; Martin et al. 2010; Riley et al. 2011). Due the aforementioned reasons, we restrict the current literature review on MHIS to CBT-based interventions.

Evaluation Criteria

In line with prior work on behavioral interventions that are supported by individual services HIS such as a relaxation exercise service delivered via a website or smartphone (Kraft et al. 2009; Mohr et al. 2013), we use the following evaluation criteria for our literature review:

(1) *Type of Disorder*

(2) *Channel of service delivery:* (a) offline delivery; this includes any intervention program, not requiring Internet connection to deliver interventions ("The Wellness Workshop", (Levin et al. 2011)); (b) Internet-based delivery; this channel is used to offer intervention services over the internet using e.g. interactive websites to deliver intervention ("MoodGym" (Christensen et al. 2004), "ODIN" (Clarke et al. 2005)) or online self-help forums ("PsychFrums.com", (Nimrod 2012)); (c) smartphone delivery; this channel is used to provide interventions using a native smart phone application. This ranges from simple message passing ("MEMO", Whittaker et al. 2012) to feature rich multi media interventions ("Virtual clinic – The Get happy Program", (Watts et al. 2013)).

(3) *Tailoring:* This criterion considers MHIS services for customization of interventions to meet patients' individual needs and to optimize the delivered intervention. Studies on a range of mental health interventions suggest that tailoring may improve their effectiveness (Johansson et al. 2012). Tailoring is either implicit, e.g. an intervention program enables the therapist to tailor electronic intervention modules to the patients' needs (Carlbring et al. 2011) or explicit, e.g. if the program automatically adapts the intervention plan according to the patients development or feedback throughout the intervention (Meglic et al. 2010).

(4) *Peer support:* This criterion considers MHIS services such as discussion boards (Robinson et al. 2010; Titov et al. 2010a), anonymous group chats (van der Zanden et al. 2012) or the option to share experience of intervention modules on a virtual pin board (Sharry et al. 2013). A wide range of studies showed that peer support interventions improved the effect of the treatments significantly (Dennis et al. 2009).

(5) *Subsidiary support:* This criterion lists all MHIS services provided in addition to the core intervention in order to improve the effect on the treatment outcome. This can be explicit, e.g. by supporting a patient via telephone, chat or eMail to discuss therapy progress (Mohr et al. 2013), or implicit, e.g. by using regular eMail or reminders via telephone to improve adherence (Christensen et al. 2010).

(6) *Gamification service:* This criterion evaluates MHIS interventions with regard to the degree of game elements that are included. Such interventions use game elements in non-game environments, displaying a persuasive intent. This ranges from mini games (Christensen et al. 2004) to game-like elements, such as digital awards for completing interventions (Sharry et al. 2013) or playful graphical content (Watts et al. 2013), aiming at positive effects on motivation and adherence. In fact, recent studies suggest positive effects of game elements on treatment adherence and intervention success (Mohr et al. 2013; Dennis and O'Toole 2014).

Search Process

To make the search process as transparent as possible we followed guidelines for systematic literature reviews (Okoli and Schabram 2010; Webster and Watson 2002). Consistent with prior work (Okoli and Schabram 2010), we first included the top ten IS journals which are the AI Magazine, Communications of the ACM, Decision Science, Decision Support Systems, European Journal of Information Systems, Information Systems Research, Journal of Management Information Systems, Management Information Systems Quarterly and Management Science. The relevant time range was set from 2004 to 2014 (including March).

In our interdisciplinary research team, we have collaboratively developed a set of keywords describing potential review work on MHIS. The title was restricted to at least one of the following keywords: 'mental health', 'e-mental health', 'ehealth' or 'mhealth'. The abstract had to include at least one of each of the following subgroups made up of the keywords 'intervention', 'effect*' or 'review' and 'computer', 'internet', 'web', 'mobile phone' or 'smartphone'. Surprisingly, no relevant articles were identified. Based on this insight, we turned away from IS outlets and continued our review with a focus on medical and psychological outlets.

Consultation of domain experts placed our focus on the interdisciplinary databases PsycINFO, a source of psychological literature (www.apa.org/psycinfo) and Public Med Central, a database from the US National Library of Medicine (www.nlm.nih.gov/). This selection of databases is also consistent with reviews conducted in related fields (Andrews et al. 2010; Barth et al. 2013). The databases were systematically

searched with another set of keywords that were iteratively developed to target distinct studies of interest. The changes we made to the keywords are due to the fact that we were specifically aiming at clinical trials from the medical domain. In the keyword set used for the IS domain we focused on keywords describing a general view on MHIS. Table 1 shows the final keyword combinations included in our search. In this first prescreening on the topic we incorporate several limitations to narrow down the scope of this preliminary literature review.

Besides the general terms 'mental health' and 'mood disorder' we included the two most common mental disorders 'depression' and 'anxiety' in the title search. From the two groups of keywords to be searched in the abstracts, at least one has to be included respectively. As a final full text criterion we utilize the keywords 'rct' and 'randomized control trial' to limit our results to randomized control trials to guarantee a high validity of studies (APS 2010). After removing duplicates our research basis contained 199 papers for further qualitative screening.

Table 1. Included keyword combinations.

Title (OR)		*Abstract 1 (OR)*		*Abstract 2 (OR)*		*Full text (OR)*
'mental health', 'mood disorder', depression, anxiety	(AND)	intervention, support, therapy, treatment, cbt	(AND)	computer, internet, web, 'mobile phone', smartphone, ehealth, mhealth	(AND)	rct, 'randomized controlled trial'

In the next step we validated the relevancy of the 199 articles based on title, abstract, keywords and the full text (in this order). For this preliminary review, we only included studies meeting the following criteria. Studies had to at least utilize one ICT component, target a major mood disorder such as depression, had been peer-reviewed and published in a journal, featured at least one CBT component, analyzed the effectiveness of the intervention and presented a positive result. Additionally, we include trial protocols as they have the potential to show possible future directions of MHIS interventions potentially resulting in a more fine-grained subset of evaluation criteria. Review papers and meta-analyses were excluded from further consideration. Further we excluded studies focusing on very targeted minority patient groups, e.g. veterans, infants or patients with severe physical disorders such as brain damage. If several studies covered the exact same ICT component, only one was included for further analysis. After several rounds of screening our research basis was left with 30 papers meeting our final criteria.

Results

Table 2 shows the results of our literature search as outlined in the former section.

Table 2. Results of the literature review process

Note: *Mental disorders:* general anxiety disorder (GAD), major depressive disorder (MDD), social anxiety disorder (SAD), panic disorder (PD), substance abuse (SA); *Subsidiary support:* Therapist (T), eMail reminder (EMR), eMail Support (EMS), Telephone reminder (TR), Telephone support (TS); *Peer Support:* discussion board (DB), Experience Exchange (EE); *Game:* graphical motivation (GRMO), achievement (ACHI); Attention modification program (AMP); Therapist (T)

Article	**Mental disorder treated**	**Comment**	**HIS Channel**	**HIS service configuration**			
				Tailored	**Subsidiary support**	**Peer Support**	**Game**
(Amir and Taylor 2012)	GAD	AMP / CBT	Offline	no	no	no	no
(Boettcher et al. 2013)	SAD	interactive attention training website	Web-based	no	no	no	no
(Ebert et al. 2014)	MDD	guided self-help, audio/video/text	Web-based	Tailored module selection	TS via online system	no	no

(Carlbring et al. 2011)	GAD	eMail retrieval of modules and assignments	Web-based	Tailored module selection	EMR + EMS by T	no	no
(Christensen et al. 2004)	MDD/GAD	"MoodGYM" website, workbook + assesements	Web-based	no	no	no	Game
(Christensen et al. 2006)	MDD	Websites	Web-based	no	TR	no	Quiz
(Christensen et al. 2010)	GAD	"E-couch" Website	Web-based	no	EMR	no	no
(Farrer et al. 2011)	MDD	"BluePages" / "MoodGym"	Web-based	no	TR	no	Quiz
(Gosling et al. 2014)	Insomnia	"SHUTi" interactive website	Web-based	tailored modules	no	no	no
(Griffiths et al. 2010)	MDD	"E-Couch" website + "WellBeing Board"	Web-based	no	no	DB	no
(Hedman et al. 2011)	SAD	Online homework submission	Web-based	no	EMS by T	no	no
(Johansson et al. 2012)	MDD	Website	Web-based	Tailored plan for each subject	EMS by T	DB	no
(Johnston et al. 2011)	GAD	"Anxiety Program" Website	Web-based	no	TS/CHAT/ EMS by T	EE	no
(Kelly et al. 2012)	MDD/SA	"SHADE" CBT App	Offline	no	no	no	no
(Levin et al. 2011)	MDD	"Wellness Workshop" app	Offline	no	no	no	no
(Lindner et al. 2013)	SAD/PD	Smartphone delivered ICBT / website	Smart-phone app	no	SMS support by T	no	no
(Lopez-del-Hoyo et al. 2013)	MDD	"Smiling is fun" website	Web-based	no	EMR	no	no
(Meglic et al. 2010)	MDD	"Improvehealth" website	Web-based	automatic detection of problems and support	EMS	DB, social profile, message system	no
(Mohr et al. 2013)	MDD	moodManager website/ telecoach	Web-based	no	Weekly TS	no	no
(Nordgren et al. 2012)	GAD	Web submission	Web-based	Simple module selection by T	15 min Weekly TS	no	no
(Robinson et al. 2010)	GAD	Worry program websites	Web-based	no	TS / EMR	DB	no
(Sharry et al. 2013)	MDD	"Mind Balance" program website	Web-based	Personalized profile, own info-share management	TS via online system	Profile page, rating of intervention	ACHI
(Titov, Andrews, Davies, et al. 2010b)	MDD	"Sadness program" website	Web-based	no	EMR	DB	no
(Titov, Andrews, Johnston, et al. 2010)	GAD	"Anxiety Program"	Web-based	no	eMail within platform	DB	no

(Titov et al. 2013)	MDD/GAD	"Wellbeing Course" Website	Web-based	no	EMR	no	no
(van der Zanden et al. 2012)	MDD	"Master Your Mood"	Web-based	no	chat	Anonymous group chat	no
(Watts et al. 2012)	MDD	ICBT Website	Web-based	no	contact twice with T / EMR	no	GRMO
(Watts et al. 2013)	MDD	"Get Happy Program"	Smart-phone app	no	EMS/ TS by T	EE	no
(Whittaker et al. 2012)	MDD Prevention	"MEMO"	Smart-phone app	no	no	no	GRMO
(Williams and Andrews 2013)	MDD	"Sadness Program" website	Web-based	no	no	no	no

Figure 1 gives a quantitative overview on the distribution of the evaluation criteria we investigated throughout this preliminary review. Figure 1a depicts the distribution of disorders addressed within the studies. Here the majority focused on major depressive disorder (63%) followed by general anxiety disorder (30%) and social anxiety disorder (10%). Figure 1b shows the distribution of HIS channels analyzed. The majority of studies delivered interventions through the Internet (80%). Native smartphone applications and offline interventions each account for 10% of the studies. Quantitative results of the HIS service analysis are presented in Figure 1c). Most of the MHIS interventions featured at least one level of subsidiary support accounting for 77% of all studies, here eMail and phone reminders as well as eMail and phone support by a therapist are almost equally present, therapist chat support was only present in two of the studies. One third of the MHIS interventions utilized peer support services where discussion boards were the most present accounting for almost half of the peer supported interventions followed by experience exchange modules such as online pin boards accounting for around 30% of peer supported modules. Social network features such as a personal profile page and anonymous chat rooms were only present two times and one time, respectively. Gamification and tailored intervention modules occurred almost equally frequent with 20% and 23% of the times, respectively.

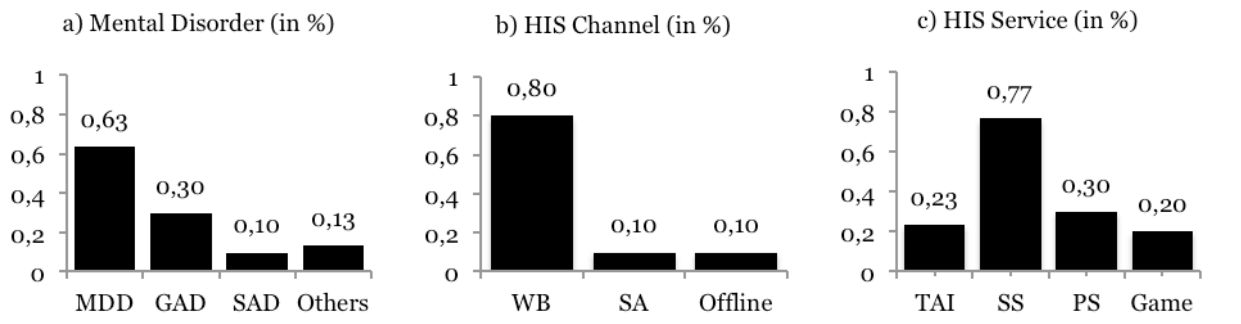

Figure 1. Overview of descriptive results.

Note: The numbers may not add up to 100% for (a) and (c) as the criteria are not mutually exclusive
Note (a): general anxiety disorder (GAD), major depressive disorder (MDD), social anxiety disorder (SAD)
Note (b): web-based (WB), smartphone app (SA)
Note (c): tailored (TAI), subsidiary support (SS), peer support (PS)

Discussion

With regard to the first objective of this research-in-progress, Table 2 presents the current state-of-the-art of MHIS interventions that are based on CBT. All interventions succeed to some degree in delivering CBT by using modern technology to treat a range of mental disorders. The fact that no relevant articles were found in top IS outlets leads us to the conclusion that the IS community is just at the beginning of this

kind of IT-supported mental health research and that there is a high potential of future work, in particular with regard to the investigation of technological rules within each group of mental disorders and applicable treatments that guide the design of evidence-based MHIS interventions.

While pursuing the first research objective to analyze the proposed evaluation criteria we found that there is a range of enclosed sub-sets of criteria (targeting our second research objective), which can be further clustered by their specific type of service within the enclosing service group. Almost all of the interventions utilizing instances of the HIS service groups fail to draw detailed conclusions on the impact of a specific sub-criteria on treatment success. The motivation of these articles usually only addresses the prevalence of success in literature of the enclosing criteria group. This asks for further detailed analyses of sub-sets of identified evaluation criteria and their effect on intervention success. As a consequence, we propose this following list of fine-grained evaluation criteria (with subsets) featuring all identified components present in the scope of the current review for our future research: *(1) delivery channel*: interactive online platform, static website, eMail, smartphone application, short messages; (2) *peer support*: online discussion boards, patients experience exchange, social networks limited to the scope of intervention, chatrooms; (3) *subsidiary support*: eMail reminder, telephone reminder, eMail support, telephone support, chat support; (4) *gamification*: digital awards / achievements, playful computer graphics, quizzes, interactive mini games.

Summary and Future Work

In this research-in-progress we have briefly outlined the determinants and consequences of mental disorders, a serious class of non-communicable diseases with an increasing prevalence worldwide. Due to limited personnel and financial resources, scalability of mental health services and tailored care of individuals are two key barriers for a successful treatment of those being affected. The class of mental Health-IS (MHIS) is expected to overcome these barriers. Because no systematic literature reviews exist that describe the technological rules of successful MHIS, a preliminary literature review was conducted which focused solely on interventions structured along the principles of cognitive behavior therapy (CBT) and which included study protocols to account for the latest developments in the anatomy of MHIS. Results indicate that in combination with CBT, major depressive disorders are treated with Internet-based MHIS support with a particular high degree (77%) of subsidiary support. Furthermore, a fine-grained subset of evaluation criteria was identified that is going to be used as a next step in our research.

Thus, we will now reuse the results of this work to conduct a complete literature review that has not only the objective to broaden the scope beyond CBT-based psychological interventions but also to discuss the findings with regard to a research agenda for MHIS. In particular, we will add further relevant evaluation criteria such as effect size measures for empirically validated mental health interventions that allow us to conduct quantitative statistical analyses on the relationship between HIS service configurations (as they are listed in Table 2) and the degree of intervention success. In the scope of the proposed review further details on the nature of the MHIS (e.g. the specific psychological content) will be of importance to proper statistical analysis of the impact of identified HIS Services on MHIS performance. These analyses will bring us much closer to a point from which our research question can be answered.

For that purpose, trial protocols will be excluded whereas articles on completed RCTs and meta-analyses on mental health interventions will be considered instead. Consistent with prior work (APS 2010) and in addition to the PsycINFO and MEDLINE databases we will also consider the Cochrane Library, an evidence-based healthcare database of the Cochrane Collaboration (www.cochrane.org). Moreover, articles will be classified independently against our coding scheme by three judges and appropriate inter-rater reliability measures such as the raw agreement and Cohen's Kappa will be reported (Moore and Benbasat 1991). The next steps outlined above will not only reveal the state-of-the-art of MHIS and a corresponding research agenda but they will bring us one step further towards the design of empirically validated MHIS, which, hopefully, results in a decrease of mental disorders over the course of the next two decades.

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