

Adaptive Element in Architecture of Internet-Delivered Treatments systems to improve user adherence: Systematic Review

Suresh Kumar Mukhiya^{a,*}, Jo Wake^b, Yavuz Inal^c, Yngve Lamo^a, Svein-Ivar Lillehaug^a, Violet Ka I Pun^{a,d}

^aWestern Norway University of Applied Sciences, Bergen, Norway

^bNORCE Norwegian Research Centre, Bergen, Norway

^cUniversity of Bergen, Bergen, Norway

^dUniversity of Oslo, Norway

Abstract

Background Internet-Delivered Psychological Treatments (IDPT) are built on evidence-based psychological treatment models, such as Cognitive Behavioral Therapy (CBT), and are adjusted for online delivery through the Internet. The use of Internet technologies has the potential to accelerate access to evidence-based mental health services for a far-reaching population at a lower cost. However, despite extensive evidence that Internet Interventions can be effective means in mental health morbidities, user adherence towards such Internet programs are sub-optimal.

Objective The aim of this review was to i) inspect and identify the adaptive elements of Internet-Delivered Psychological Therapy (IDPT) for mental health morbidities, ii) examine how adaptation influences the efficacy of IDPT in mental health, iii) identify the design elements, processes and adaptive elements for implementing these interventions for mental health illness, and iv) use the findings to create a conceptual framework that provides better user adherence and adaptiveness in IDPT for mental health issues.

Methods A systematic literature review was performed. The Cochrane Database of Systematic Reviews, and Cochrane Central Register of Controlled Trials, EMBASE, MEDLINE, CINAHL, and PsycINFO were searched for studies dating from January 2000 through to October 2019. Based on predetermined selection criteria, data was extracted from eligible studies. Methodological quality of the studies was assessed using an adapted version of the Cochrane Collaboration Back Review Group checklist.

Results and conclusion will have to be updated later after survey is completed.

Results

Conclusions : Based on the results, we envision developing a conceptual framework that provides adaptive Internet based interventions to mental health patients.

© 2019 The Authors. Published by Elsevier B.V.

This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

Peer-review under responsibility of the Conference Program Chairs.

Keywords: Cognitive Behavioral Therapy; IDPT; Adaptive treatment; Internet-based treatment; adaptive system; mental health; literature review; architecture centric development; Tailored Internet interventions; flexible mental health Internet interventions

This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

Peer-review under responsibility of the Conference Program Chairs.

1. Introduction

Research statistics reveals IDPT¹ as an effective therapeutic tools [1] with increase potential to provide evidence-based mental health interventions for far-reaching population at lower cost [2, 3]. However, the actual user adherence to such interventions are low [4, 5, 6, 7, 8]. These results raise a critical question in IDPT: *how can these IDPT be effective if the user adherence is sub-optimal?* Therefore, it is relevant to focus on the factors associated in enhancing user adaption towards such interventions. Several studies have been conducted with an attempt to reduce user dropout rates. To our knowledge, some of the attempts taken to increase user adherence to IDPT are as follows:

1. **Therapists contact for online support during interventions:** Some studies claimed providing therapists contact for online guidance and support during interventions duration has been found to increase adherence and effect sizes [7, 9, 10].
2. **Reminder telephone calls and postcards from therapists:** Clarke et al. added telephone calls and postcard reminders from therapist with an aim to increase user adherence [11]. The study concluded by discovering no significant difference between intervention groups with or without reminders. However, a similar study done by Farrer et al. [12] to evaluate effectiveness of a six week IDPT for depression with and without telephone interaction concludes that IDPT is effective both with and without tracking for reducing depression. This indicates the success of specific interventions are associated to the settings in which they are performed.
3. **Increasing frequency of emails from therapists:** Klein et al. [13] conducted a study to examine if the frequency of therapists contact (from one e-mail per week to three e-mails per week) make a difference in user adherence. The study concluded that the effectiveness of IDPT may be independent of the frequency of therapist support.
4. **Providing choice of treatment course, timing and varying economic cost:** Hilvert-Bruce et al. [14] conducted a study with an aim of inspecting if dropouts of users in IDPT is because of lack of efficacy; can change in adding choice of treatments, reminders and financial cost improve adherence; and finally if addition of clinical contact improves user adherence. The results obtained in this study claims adding reminders; the choice of treatments, cost and timing; contact of clinicians improves the user adherence.

The above statistics illustrates the baseline predictors of adherence vary between different research studies. A systematic review by Christensen et al. [7] discovered *disease diversity*, *treatment length* and *chronicity* predicted are important factors contributing to user adherence in IDPT. Similarly, *clinical severity* has also been indicated as one of the important factors contributing to user adherence in web-based interventions targeting problematic drinking [15]. Similar factors have been identified as the most prominent factors in user adherence towards IDPT. However, only few studies discusses why the target group choose not to adhere. The most common reasons for non-adherence elaborated on state-of-art studies are:

1. **Sufficient progress:** A meta analysis by Vandereycken et al. [16] elaborates the target groups choose not to adhere in the eating disorder treatment because they believed they achieved sufficient progress. However, the lack of progress is not related to non-adherence according to several other studies [7, 13].
2. **Too much content without much flexibility:** According to a survey done by Johansson et al. [17], participants chose not to adhere as they were unable to perceive compatible correlation between the length of weekly text modules and the conditions in their personal life. Moreover, the participants found the content to be a tiresome

* Corresponding author. Tel.: +47-94430044
E-mail address: skmu@hvl.no

¹ Web-based Internet-Delivered Psychological Treatments

burden because of the length of the text modules and time consumed to go through it. Furthermore, the fixed format of the content sent to the participants each week were perceived as inflexible for some participants.

3. **Treatment being too difficult:** Content complexity was perceived as difficult to comprehend and process by individuals participating in interventions [17, 8] especially when these individuals consider themselves as having attention problem or limited reading and writing skills.
4. **Users expectations and trust:** Participants' knowledge and expectations about the treatment process have known to influence user trust and hence adherence [18]. Johansson et al. [17] outlined in their study that participants mentioned they were grateful for being offered the treatment but not all of them appeared to be fully aware of the treatment and its significance. Similar conclusion has been drawn in the study by Alaoui et al. [19] indicating higher treatment credibility as the strongest prognostic factor for user adherence.
5. **Lack of therapists feedback:** Feedback have thought to increase user adherence [15] for sixty-five percent of intervention participants. Contrary to this, no face-to-face therapist during the interventions were perceived as the therapist not caring about their personal issues [17]. In addition to this, some participants outlined they never prioritized on their own personal development as they were aware face-to-face meeting was not required.
6. **Lack of personalization:** Recent study on mental health indicates that compliance failure can result from lack of personalization [8]. A study done by Doherty claims to have improved user compliance with the IDPT system by focussing on user personalization [20].

Most of the researches examining the causes for declining user adherence towards IDPT discovered the patients personal reasons [7]. More than about the diagnosis and problem severity, it is about personal and interpersonal competencies, and resources. Moreover, it is about the patient's intrinsic motivation to change, his self-relatedness, and receptivity to change. Levey et al. [21] characterizes this reason as *patient variable*. Considering this reason for premature termination of interventions indicate the need to further investigate the reasons and circumstances for non-adherence. Specifically, this indicates a gap in the literature concerning the in-depth exploration of the subjective reasons for non-adherence in online psychological interventions. In general, the factors affecting premature termination of participants from IDPT, as outlined by Johansson et al. [17], be characterized by interaction between the *participant perception of the treatment* (Content complexity, therapists feedback, information about significance) and the *participants' personal situations* (awareness about the treatment, availability, daily routines, treatment expectations, perceived language skills). Analogously, a report by WHO [22] distinguishes five interacting dimensions affecting adherence to medication, therapies and healthcare in general: *socio-economic factors, therapy-related factors, patient-related factors, condition-related factors, and health system/health care team-factors*. The same report justifies relatively limited research has been done on the effects of health care team and system-related factors on adherence.

We hypothesise in this paper that in addition to these two factors (perception of treatment and personal situations), third factors is contributing to user adherence - adaptive Information Architecture (IA) in IDPT. There are two perspective here: *adaptiveness* and *information architecture*. First, IA is associated with how people cognitively process information and enhances the ability of the participants to find information. Second, adaptiveness refers to an ability system that changes its behavior with response to its environmental changes. The former perspective makes information presented in IDPT comprehensible and discoverable, while the latter makes the IDPT more personalized. In this paper, we argue that both adaptiveness and IA are important factors that contributes to user adherence in IDPT. Hence, we aim to investigate following research questions from this literature review:

1. **RQ1:** What are the most relevant choices of IA chosen in existing IDPT systems? What are the main rationale behind such architecture?
2. **RQ2:** What are the main adaptive elements in such IDPT systems? How does these elements contribute in enhancing user adherence and interventions outcomes?
3. **RQ3:** How can we use generalized results to create a conceptual framework that can be used in creation of adaptive IDPT for mental health interventions?

To our knowledge only few studies, if any, have examined experience of non-adherence in IDPT system based on IA and adaptiveness as affecting factors. In this study, we focus on reviewing the adaptive element and IA in the current IDPT system used for the treatment of mental health disorders.

2. Methods

We conducted the review according to the PRISMA guidelines [23]. We used the P.I.C.O.S. (Population, Interventions, Comparators, Outcomes, and Study Design) framework to identify relevant studies. Our focus was on adult (> 18 years) mental health patients receiving IDPT (P), interventions that were delivered via the Internet (I) compared to standard care or other active intervention (C-Comparison) and their adherence to the interventions (O-Outcomes).

2.1. Search Strategy

We searched the databases recommended by Cochrane [24] including Medline (PubMed), ACM Digital Library, PsycINFO, EMBASE, CINAHL and Cochrane to identify studies. In addition to this, we hand searched the reference list of the selected publications to retrieve other relevant publications. The search string included Adaptive, OR Flexible, OR Tailored, AND Internet, AND Interventions, AND Mental Health. Each term included medical subject headings (MeSH) and the search was done on full text papers. The search was limited to all papers published in English from January 2000 to October 2019. The database searches, and subsequent review were performed by two of the authors independently in a double-blind process.

2.2. Eligibility Criteria

We included those studies in which the articles met the following inclusion criteria (IC): (1) an intervention delivered through Internet (Both web or mobile based); (2) attempts to provide adaptive (dynamic, tailored, flexible) interventions by using adaptive strategies; (3) delivered for mental health disorders including depression, social anxiety, bipolar disorder, dementia, schizophrenia, suicidal tendencies, Obsessive Compulsive Disorder, PTSD, social phobias, panic disorder, ADHD, eating disorder, borderline personality disorder and stress; and (4) published between 2000 and 2019. No data restrictions were imposed. The following exclusion criteria (EC) were used: (1) not written in English language, (2) not having a full text or was published in the form of a conference paper or an abstract; (3) designed as non-empirical findings such as opinion papers, reviews, editorials, letters or study protocols; (4) the paper dealt with adaptive technology in any domain other than mental health, or (5) was not about adaptive technology.

2.3. Review Procedure

The selection of studies took place in three phases based on title, abstract and full publication. Title and abstract screening was done blinded for author, journal and date of publications. Any doubtful paper were included for the next phase and disagreement were resolved using discussion. After identifying 913 relevant papers through the initial database search, 207 duplicated papers were removed and 706 unique papers remained. In the screening step, the resulting list of 323 papers were reviewed independently by the same two authors according to inclusion and exclusion criteria. By reviewing the title, abstract, and keywords, all 109 eligible papers were retrieved. Full texts were evaluated to determine the eligibility of the remaining papers. The full texts of all identified articles were assessed independently by the same authors. Articles upon which both authors agreed were included. Any discrepancies between the authors regarding the selection of the papers were resolved through discussion. In total, 84 papers were excluded in this round, and the selection process lead to the inclusion of 17 papers as depicted in Figure 1. The most common reason for exclusion in this phase was that the publications were not using Internet to deliver intervention. Other publications were excluded because they focused on other type of healthcare interventions without clear information about IA, user adherence, and adaptive strategies. In addition to this, several publications used the term "adaptive" to oversell their research papers. On a critical review of those research papers, it was not clear how interventions were adapted.

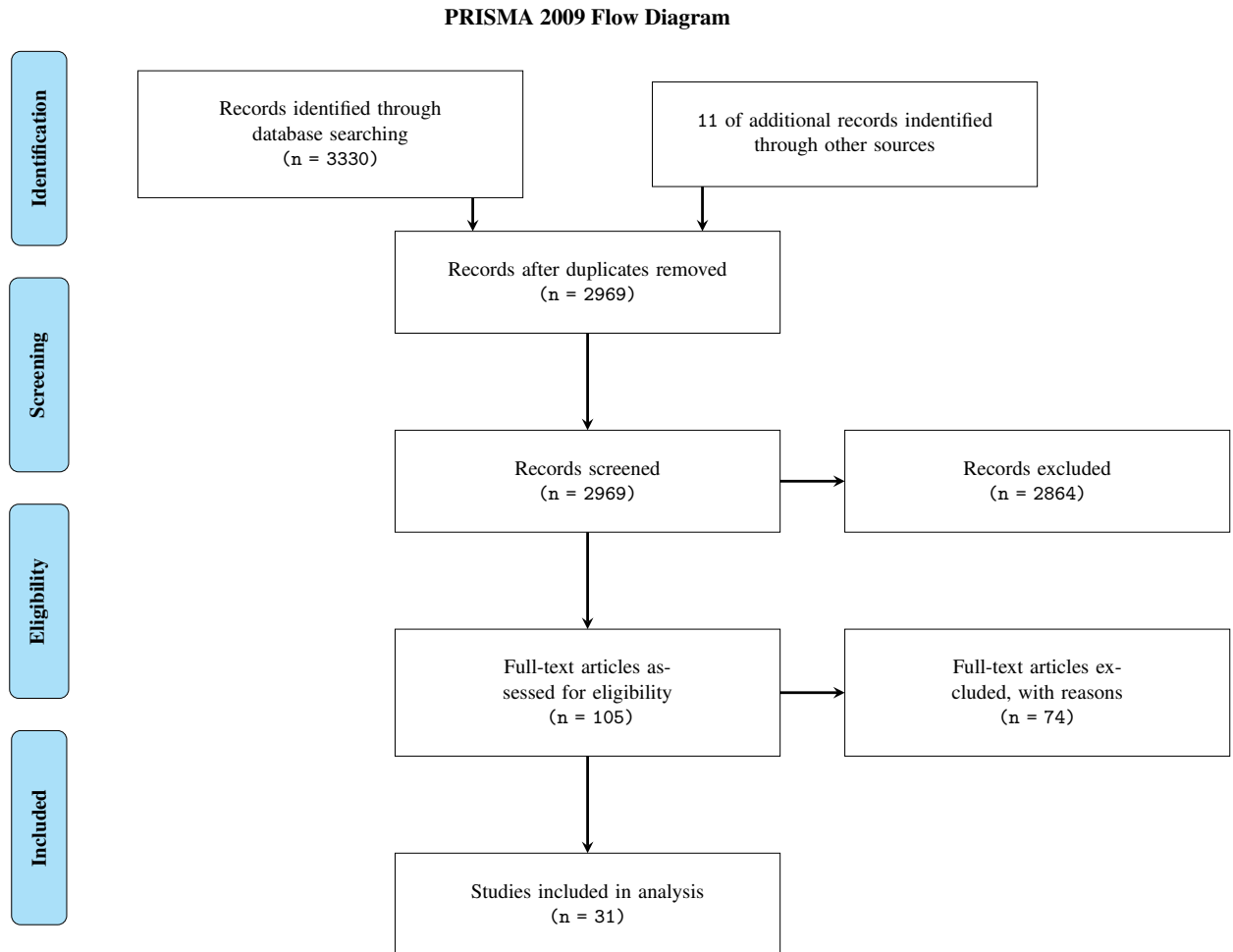


Fig. 1: PRISMA information architecture

2.4. Data Extraction and Synthesis

Data from the included studies were extracted by a team of reviewers and then verified and tabulated for review by title, abstract and full description of the research paper. Potential literature related to increasing user adherence, enhancing treatment outcomes and using adaptive strategies were included for study. We chose to list related studies (Table 1), studies attempting to increase user adherence through RCT (Table 2) and most relevant studies including adaptive strategies (Table 3).

3. Results

3.1. Taxonomy challenge

Our review shows that several different terms are used to describe similar Internet delivered psychological treatments. The interventions involving Internet as delivery mechanism are referred as *web-based treatments*, *web-based interventions*, *online treatment*, *computerized psychotherapy*, *e-therapy*, *Internet-based cognitive behavioral therapy (ICBT or iCBT)*, *digital interventions*, *web-application based psychotherapy treatments*, *therapeutic web-based interventions*, *eHealth interventions* [25], and others. Analogously, other variations include creation of technical plat-

forms such as *Interapy* [26], *Deprexis* [27], *ULTEMAT* [28], dBCIs (digital behaviour change interventions) [29], smartphone-based applications with specific brand names [30]. The absence of any taxonomic preferences and professional ontology make the field of IDPT inconsistent and ambiguous. The use of multitude terms and labels to describe similar health interventions make it difficult to search the results of the study. To be consistent, we chose to use the term *Internet Delivered Psychological Treatments* (IDPT), as suggested by Andersson et al. [31].

3.2. Mode of Delivery

The medium used to administer Internet delivered interventions to the patients falls under five categories: *robotics*, *Virtual Reality (VR)* [32] and *Augmented Reality(AR)*, *conversational agents* or *chatbots* [33], web applications (Table 2), and *mHealth* or *mobile applications*. [34] As depicted in figure 2, the higher is the block in chain, the higher is the computational complexity involved and lower is the prevalence. Conversely, the lower is the block in the chain, the lower is the computational complexity but higher is the prevalence. An interesting observation from the literature study made was, most of the IDPT are delivered using mobile applications [34] and web-based applications. One explanation for this is smartphones contain a plethora of sensors and other data sources that can inform aspects of users well being, context, activities, behaviors, or intentions. However, fewer attempts have been made to deliver IDPT using conversational agents [33], VR and AR applications.

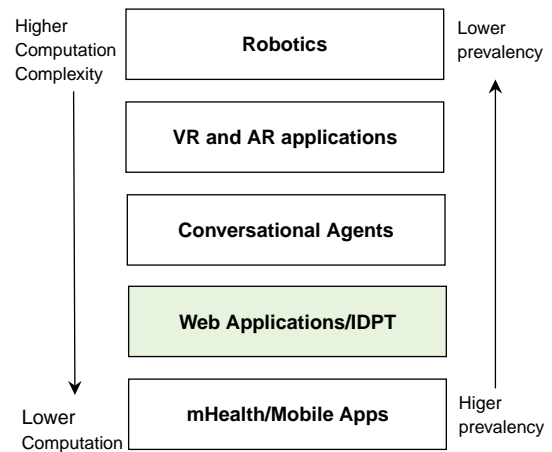


Fig. 2: Mode of delivery for Internet delivered interventions. Most of the IDPT falls under web-based applications.

3.3. Authors credentials category

We evaluated educational background of the first author of the included papers. 66.7% of the authors were from computer science background while remaining 33.3% of the authors were from healthcare domain. The most common occurrence was summative evaluations carried out by authors with a computer science background. When healthcare scientists are involved in the IDPT development, it is in collaboration with scientists from computer science background.

Reference	Year	Objective	Main findings
Brian <i>et al.</i> [35]	2005	Review the roles of considering IA designs for effective web-based interventions	Encourage adoption of a multidisciplinary perspective IA for presenting content of behavior change interventions.
Jillian <i>et al.</i> [36]	2018	Find relationship between IA and its effect on health outcomes	No clear relationship found between IA and health outcomes, given the limited evidence in the literature.
Webb <i>et al.</i> [37]	2010	Investigate which characteristics of IDPT best promote health behavior change	a) IDPT incorporating more behavior change techniques have larger effects on outcomes. b) Additional communication with participants using SMS, email, messages increases adherence.
Van Ballegooijen <i>et al.</i> [38]	2014	Compare adherence to guided ICBT vs face-to-face CBT	Adherence to guided ICBT was found to be adequate and could be equal to adherence to face-to-face CBT.
Christensen <i>et al.</i> [7]	2009	Review adherence with respect to IDPT and investigate the rates of dropouts and compliance in RCT for anxiety and depression	Main predictors of adherence include disease severity, treatment length and chronicity. Very few studies examined the actual reasons for dropout.
Gerhard Andersson <i>et al.</i> [31]	2019	Literature review arguing ICBT can be viewed as a vehicle for innovation	Detailed review in several directions including effectiveness of IDPT, implementation paradigm, predictors and future works.
Kelson <i>et al.</i> [39]	2019	Examine the therapeutic impact of Internet-delivered acceptance and commitment therapy(iACT) on all anxiety conditions.	Results indicate iACT to be efficacious and acceptable treatments.
Jokste <i>et al.</i> [40]	2017	A systematic review to about rule-based adaptation to discover types of rules applied, application domains, and performance measures	a) Results indicate widely adopted in medicine related system, adjustable system for people with disabilities and others. b) Categorized three forms of semantic rules: event-condition rules (if-else), association rules and RuleML based behavior rules.
Karyotaki <i>et al.</i> [41]	2006	Examine the predictors of dropout in an individual patient data meta-analysis	a) Dropout can be predicted by several variables and is not randomly distributed. b) Understanding such variables can help to adapt IDPT to prevent dropout in identified groups at risk.
Rogers <i>et al.</i> [42]	2017	(a) discover the range of health-related topics that are addressed through Internet-delivered interventions, (b) generate a list of current websites used in the trials, and (c) identify gaps in the research that may have hindered dissemination.	Wide range of IDPT are available for health-related behavior. However, most of the IDPT found to be efficacious in RCT do not have website for general use.
Brouwer <i>et al.</i> [43]	2011	Identify (a) which potentially exposure-promoting methods and strategies are used in existing IDPT, b) which objective measures are used to measure exposure to IDPT, c) which methods are associated with better exposure.	Feedback, interactive elements, and email/phone contact were mostly used methods and strategies to increase treatment outcomes. No clear conclusion drawn due to diversity of intervention methods used and inconsistency in reporting.
Arnberg <i>et al.</i> [44]	2014	Evaluate whether IDPT for mood and anxiety disorders are efficacious, non-inferior to established treatments, safe, and cost-effective for children, adolescents and adults.	IDPT is a viable treatment option for adults with depression and some anxiety disorders who request this treatment modality.

Table 1: List of related review papers.

Reference	Year	Country	Size	Target group	Methods	Main findings
Forsell <i>et al.</i> [45]	2019	Sweden	251	Insomnia	At-risk patients (assessed by a semi-automated algorithm) were randomly assigned to continue standard ICBT or adapted ICBT	a) A semi-automated algorithm was used to assess risk of treatment failure early in treatment in 251 patients and at-risk patients were given adapted ICBT. b) Concludes that an adaptive treatment can increase treatment effect for at-risk patients and reduce the number of failed treatment.
Zita Hilvert-Bruce <i>et al.</i> [14]	2012	Australia	2107	Depression, Anxiety	6 online lessons in the form of a story with homework at the end	a) Adding reminders, choice of course, timing, financial cost and clinician contact support increase adherence, b) adherence is an important determinant of effectiveness.
Olof Johansson <i>et al.</i> [17]	2015	Sweden	7	GAD	8 weeks modules of text, audio, illustration and assignments	The process of non-adherence is described by interaction between patient factors (daily routines, perceived language, expectations) and treatment factors (workload, text-content complexity, treatment process).
Danaher <i>et al.</i> [46]	2006	Sweden	2523	Tobacco cessation	Enhanced condition web (interactive, tailored, rich-media content) and basic condition web (static, text-based)	The process of non-adherence is described by interaction between patient factors (daily routines, perceived language, expectations) and treatment factors (workload, text-content complexity, treatment process).
Rik Crutzen <i>et al.</i> [47]	2012	Dutch	668	Hepatitis A, B, and C virus	Three groups randomly exposed to tunneled version with less control, a higher control and not exposed to web	Increased website use in the tunneled version of the web indicating higher effectiveness of guided interventions
Bridgette M. Bewick <i>et al.</i> [15]	2008	UK	506	Alcohol misuse	Personalized feedback and social norms information using IDPT to randomized group self-reporting alcohol consumption	Personalized feedback proved to be effective in reducing alcohol intake.
Walter Vandereycken <i>et al.</i> [15]	2010	Belgium	21	Eating disorder	Both patients and staff reported the reasons for dropout using Likert Scale	patients were satisfied with the therapy so did not expect further benefits in continuing.
Hurling <i>et al.</i> [48]	2006	UK	75	Obesity	10-weeks interventions to two groups - interactive group (interactive web) and control group (less interactive web)	Interactive version was more engaging and hence has better user retention.
Alfred Lange <i>et al.</i> [26]	2003	Netherlands	69	PTSD	IDPT for people with mild to relatively severe post-traumatic stress	More than fifty percent of participants showed improvements.
Lappalainen <i>et al.</i> [49]	2015	Finland	39	depressive symptoms	Comprised home assignments, assessment questionnaire, and online feedback over a 7-week intervention period, and automated email-based reminders.	Significant effects were observed in favor of the Internet-delivered acceptance and commitment therapy group on depression symptoms.

Alnanith <i>et al.</i> [50]	2013	Saudi Arabia	10	-	a mobile application that can adapt user interface based on context and pre-defined rules	Adaptation of mobile user interface based on context and rules showed improved productivity and task efficiency.
Samir El Alaoui <i>et al.</i> [19]	2015	Sweden	764	SAD	Rates of symptomatic change during treatment and adherence were analysed using multilevel modeling. Variables examined: (a) socio-demographic; (b) clinical characteristics; (c) family history; and (d) treatment-related factors	Credibility of IDPT is the strongest prognostic factor. Early screening of ADHD-like symptoms may help clinicians identify patients who might need extra support. Therapist behaviours that promote adherence.
Soucy <i>et al.</i> [51]	2017	North America	116	Anxiety	Patients with elevated anxiety were randomly assigned to medication, CBT and IDPT in order to investigate patients perception about Internet delivered treatments.	Medication and CBT were preferred over IDPT. In order to increase access of IDPT, several user preference options are required.
Andersson <i>et al.</i> [52]	2012	Sweden	101	OCD	Patients with OCD were randomly given 10 weeks IDPT with therapist support or an attention control condition. Outcome was measured with Yale-Brown Obsessive Compulsive Scale (YBOCS) psychometric test.	IDPT proved to an efficacious treatment for OCD. The proportion of participants showing clinically significant improvement was 60% in the IDPT group compared to 6% in the control condition.
Johnston <i>et al.</i> [34]	2011	Australia	131	GAD, social phobia or panic disorder, depression	Compare three groups: clinically supported (CL), coach-supported (CO) and wait list control. 8 lesson, 10 weeks IDPT program with weekly contact from a clinician or a coach and a follow up at 3-months post-treatment.	Outcomes for the pooled treatment groups (CL, CO) were superior to the control groups. 74% and 76% of CL and CO participants completed the program respectively.
Jermelov <i>et al.</i> [53]	2012	Sweden	133	Insomnia	Parallel randomized three groups with and without therapist support, and waiting list was given six weeks IDPT. Assessment before and after treatment with 3 months follow up	Participants showed significant improvements. Therapist supported group has considerable more effective than other groups.
Zwerenz <i>et al.</i> [54]	2019	Germany	229	Depression	Participants randomized to web-based self-help or an active control group for 12 weeks. Follow-up was performed 6 months after study intake.	Participants of web-based self-help program showed significant improvements. Residual symptoms at discharge from inpatient treatment and utilization of the Web-based self-help were the major predictors of depressive symptoms at follow-up.
Lutz <i>et al.</i> [55]	2017	Germany	409	Depression	Applied piecewise growth mixture modeling (PGMM) to identify different latent classes of early change in individuals with mild-to-moderate depression	Web-based interventions outcome and adherence can be predicted by patterns of early change, which can inform treatment decisions and potentially help optimize the allocation of scarce clinical resources.

Table 2: List of papers using Randomized Control Trial to increase treatment outcomes and user adherence

We shall use this page.. Table 3:

Reference	Year	IA	What is adapted	Dimensions	Adapter	Adaptive Strategy	Outcome
Cruzen <i>et al.</i> [56]	2009	NC	Design, skeleton, structure	UP, CPP	SA	User needs and site objectives (GB)	Non-evaluated conceptual framework.
Pugatch <i>et al.</i> [36]	2018	GEN	Design, skeleton, structure	UP, CPP	-	User needs	No clear conclusion about the relationship between IA and health outcome.
Mukhiya <i>et al.</i> [57]	2018	NC	Content	UP, CPP, PT	A	ML	Not evaluated
Wallert <i>et al.</i> [58]	2018	NC	-	UP, CPP, PT	A	ML	Predictors for adherence were cardiac-related fear, sex, and the number of words used to answer the first assignment.
Forsell <i>et al.</i> [45]	2019	NC	TF, CP, CC, treatment format	UP, CPP	SA	RB, and user needs	Adapted IDPT for at-risk patients were significantly more successful in reducing symptoms compared to standard IDPT.
Danaher <i>et al.</i> [25]	2015	GEN	Information, design, structure	UP	-	-	Unevaluable
Gonul <i>et al.</i> [59]	2019	GEN	Intervention components' timing, frequency and content	UP, CPP, PT	SA	RB and ML based reinforcement learning supported by transfer learning for cross-individual knowledge transfer.	The personalization algorithm is capable of adapting intervention delivery strategies for simulated real-life conditions.
Lindgren <i>et al.</i> [60]	2016	NC	Feedback message, assessment tests, intervention component	UP, Goals, Abilities and motives	SA	RB based on user model	Presents a method for computer-supported assessment for tailoring agent-based assistive technology in a multi-intervention perspective. While the evaluation was not conclusive, further research is required in the direction.
Rough <i>et al.</i> [61]	2014	NC	NC	Goals	NC	RB	Not evaluated.
Pejovic <i>et al.</i> [29]	2014	NC	Behavioral activities	User context	NC	ML	Not evaluated.
Uyumaz <i>et al.</i> [62]	2019	NC	-	User sleep data	NC	Predictive algorithms	An interactive mockup was designed and evaluated with some participants.
Beun <i>et al.</i> [63]	2013	NC	Information and sleep exercises	UP, CPP, location, knowledge	SA	Goal based	Conceptual model presented. Not evaluated.

Kop <i>et al.</i> [64]	2014	NC	Interventions	User needs	SA	Learning algorithms	Personalization can be achieved by predictive algorithms and more research is required in this direction.
Ven <i>et al.</i> [28]	2017	NC	Reminder messages, Questionnaire requests	User context, location	SA	RB	Personalization can be achieved by predictive algorithms and more research is required in this direction.
Rachuri <i>et al.</i> [65]	2010	NC	Reminder messages, Questionnaire requests	User context, location	SA	RB	Personalization can be achieved by predictive algorithms and more research is required in this direction.

Table 3: List of papers considered for review. IA = Information Architecture(NC = Not Clear, GEN = Mentioned but very generic, NM = Not mentioned), What is adapted(TF = Therapist feedback, CP = Content presentation, CC = Content Complexity), Dimensions (UP = User preferences, CPP = Content presentation preferences, PT = Psychometric tests), Adapter(Actor who is actually doing adaptation, A=Automatic, SA = Semi-automatic, M = Manual), Adaptive strategy (RB = Rule based, GB = goal oriented, ML= Machine Learning based)

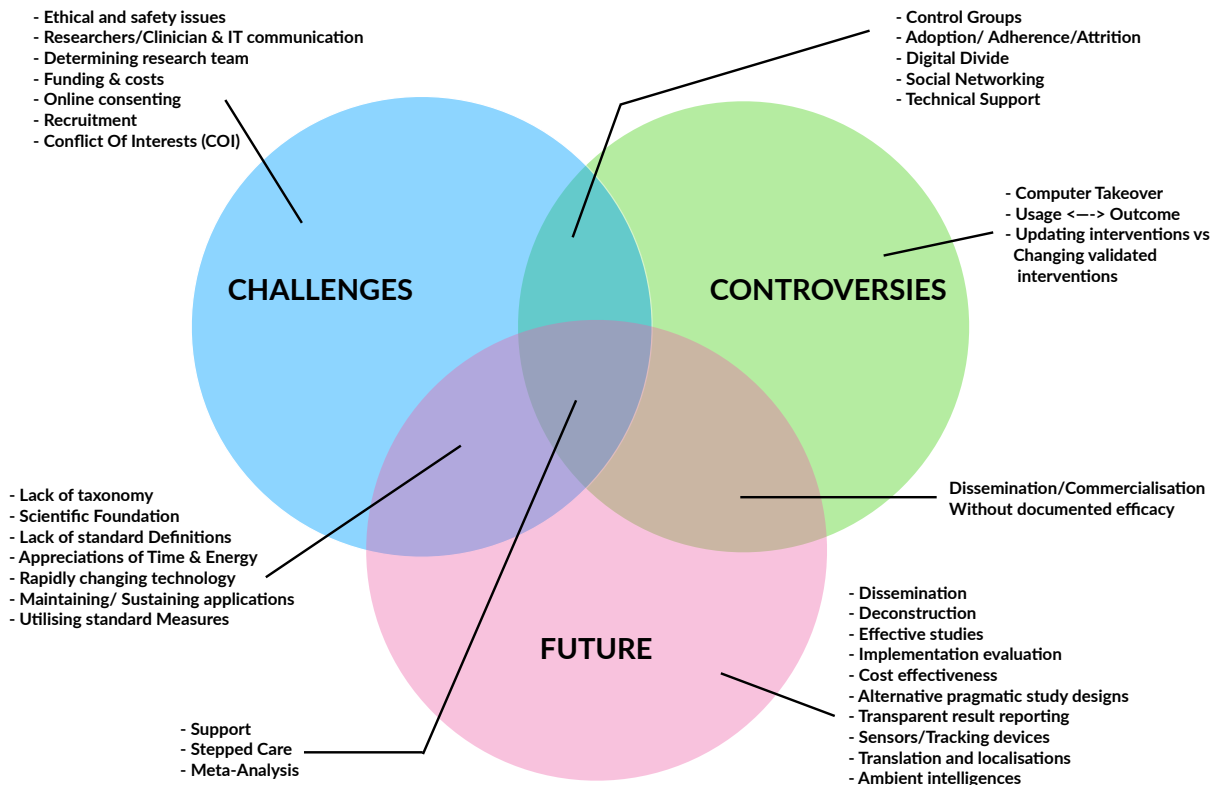


Fig. 3: The Venn Diagram model illustrates challenges, controversies and the futures of developing, evaluating and implementing Internet Delivered Psychological treatments

4. Discussion

- Two important concepts: adaptive vs self-adaptive
- Adaptation actors: Who is adapting?
- What is adapted?
- Does it have effect on the outcomes?
- The results of the first part of this study suggest the presence of user needs that largely remain implicit and unaddressed [66].

Our review shows that several different terms are used to describe similar Internet delivered psychological treatments. Similar conclusions were drawn in the study by Barak et al. [67] in 2009.

4.1. Principal Findings

Personalization and user-profiling: The main aim of adaptation is personalization which is one of the important dimensions in P4 Medicine []. The focus of personalization is tailoring of psychological interventions to match one's relevant traits like cognitive processing skills. Such tailoring can be achieved by maintaining users profile at different levels - historical evidence, personal preferences, goals, availability, and current assessment of issues. One strategy for accumulation of such information is to allow users to self-report such relevant traits. With time and dynamism

of associated health issues, such user-driven data collection is burdensome nonetheless. In addition, it is infeasible for individuals to capture the amount and granularity of information required to generate a comprehensive behavioral profile. Moreover, such self-reporting is problematic for some context such as when self-assessment is involved. Alternative to *user-driven data* collection, *system-driven data* collection is getting popular. Such system-driven system passively measures and models individual characteristics from behavior trace data. Such procedure incorporates ambient intelligence capabilities that are powered by sensors. Given the wealth of available user-specific biological markers data, and considering the effort required to accumulate them, this method can be computationally expensive and involve more data-driven approach.

4.2. Adaptability to the needs of users

An adaptive IDPT system has two types of users: a) patients who interact with the adaptive system, and b) the therapists who create the interventions. For the patients, the adaptive system should create a personalized experience based on their needs, cognitive skills, and historical performance. For the therapists who involve in designing, monitoring patients, and evaluating the adaptive IDPT system, the adaptive system should provide an adaptive dashboard to track and assess the performance of patients and adapt interventions based on their progress.

4.3. Design Features and content for the interventions

4.3.1. Challenges

1. **Privacy, Ethical and safety challenges:** Personalization requires the storage of several biological markers health data sets, including location, physical activities, co-locations, emotions, together with other personal health data. Misuse and leaking of such information can have severe consequences. Hence, it is essential to ask who owns the health data, and what information can be extracted from the data of an individual?
2. Researcher/Clinicians and IT communication
3. Funding and costs
4. Online consenting
5. Recruitment
6. Conflict of Interests

4.4. Implementation Process

4.5. Limitations

Given that health ICT literature is quite diverse and extensive, the current study focused exclusively on Internet-delivered interventions for mental health morbidities. Notwithstanding this limitation, the current paper highlights the significance of the continued study of this intervention method. Another limitation is that our literature exploration only encompasses articles in English; therefore, it is plausible that some researches carried in other parts of the world in other languages were missed. A third limitation pertains to IDPT applications developed by industry which are not accessible for review. Hence, we have less knowledge about the adaptive elements involved in their architecture.

4.6. Implications and recommendations for future research

5. Conclusion

Evidence from this literature review also indicated that almost all studies received positive feedback from their participants who found the evaluated tools useful. However, further research is required to investigate the effects of usability levels of mobile mental health applications on outcomes of an intervention. As many of the studies described using an adapted version of a standard usability questionnaire, there is a need to develop a standardized mobile health usability questionnaire, which is a goal for future research.

Acknowledgement

This publication is a part of the INTROducing Mental health through Adaptive Technology (INTROMAT) project, funded by Norwegian Research Council (259293/o70). INTROMAT is a research and development project in Norway that employs adaptive technology for confronting these issue.

References

- [1] D. B. Portnoy, L. A. J. Scott-Sheldon, B. T. Johnson, and M. P. Carey, “Computer-delivered interventions for health promotion and behavioral risk reduction: a meta-analysis of 75 randomized controlled trials, 1988–2007.,” *Preventive medicine*, vol. 47, pp. 3–16, 7 2008.
- [2] I. M. Marks, K. Cavanagh, and L. Gega, “Computer-aided psychotherapy: Revolution or bubble?,” 12 2007.
- [3] E. Emmett, K. Wallin, L. Psych, S. Mattsson, E. Martin, and G. Olsson, “The Preference for Internet-Based Psychological Interventions by Individuals Without Past or Current Use of Mental Health Treatment Delivered Online: A Survey Study With Mixed-Methods Analysis,”
- [4] G. G. Bennett and R. E. Glasgow, “The delivery of public health interventions via the Internet: actualizing their potential.,” *Annual review of public health*, vol. 30, pp. 273–92, 2009.
- [5] G. Eysenbach, “The law of attrition,” 1 2005.
- [6] T. L. Dunn, L. M. Casey, J. Sheffield, P. Newcombe, and A. B. Chang, “Dropout from Computer-based interventions for children and adolescents with chronic health conditions,” 2012.
- [7] H. Christensen, K. M. Griffiths, and L. Farrer, “Adherence in internet interventions for anxiety and depression,” 2009.
- [8] A. Konrad, V. Bellotti, N. Crenshaw, S. Tucker, L. Nelson, H. Du, P. Piroli, and S. Whittaker, “Finding the adaptive sweet spot: Balancing compliance and achievement in automated stress reduction,” in *Conference on Human Factors in Computing Systems - Proceedings*, vol. 2015-April, pp. 3829–3838, Association for Computing Machinery, 4 2015.
- [9] G. Andersson, “Using the Internet to provide cognitive behaviour therapy,” *Behaviour Research and Therapy*, vol. 47, pp. 175–180, 3 2009.
- [10] V. Spek, P. Cuijpers, I. Nyklicek, H. Riper, J. Keyzer, and V. Pop, “Internet-based cognitive behaviour therapy for symptoms of depression and anxiety: A meta-analysis,” 3 2007.
- [11] G. Clarke, D. Eubanks, E. Reid, C. Kelleher, E. O’Connor, L. L. DeBar, F. Lynch, S. Nunley, and C. Gullion, “Overcoming depression on the internet (ODIN) (2): A randomized trial of a self-help depression skills program with reminders,” *Journal of Medical Internet Research*, vol. 7, 4 2005.
- [12] L. Farrer, H. Christensen, K. M. Griffiths, and A. Mackinnon, “Internet-based CBT for depression with and without telephone tracking in a national helpline: Randomised controlled trial,” *PLoS ONE*, 2011.
- [13] B. Klein, D. Austin, C. Pier, L. Kiropoulos, K. Shandley, J. Mitchell, K. Gilson, and L. Ciechomski, “Internet-based treatment for panic disorder: Does frequency of therapist contact make a difference?,” *Cognitive Behaviour Therapy*, 2009.
- [14] Z. Hilvert-Bruce, P. J. Rossouw, N. Wong, M. Sunderland, and G. Andrews, “Adherence as a determinant of effectiveness of internet cognitive behavioural therapy for anxiety and depressive disorders,” *Behaviour Research and Therapy*, vol. 50, pp. 463–468, 8 2012.
- [15] B. M. Bewick, K. Trusler, B. Mulhern, M. Barkham, and A. J. Hill, “The feasibility and effectiveness of a web-based personalised feedback and social norms alcohol intervention in UK university students: A randomised control trial,” *Addictive Behaviors*, vol. 33, pp. 1192–1198, 9 2008.
- [16] W. Vandereycken and K. Devidt, “Dropping out from a specialized inpatient treatment for eating disorders: The perception of patients and staff,” *Eating Disorders*, vol. 18, pp. 140–147, 3 2010.
- [17] O. Johansson, T. Michel, G. Andersson, and B. Paxling, “Experiences of non-adherence to Internet-delivered cognitive behavior therapy: A qualitative study,” *Internet Interventions*, vol. 2, pp. 137–142, 5 2015.
- [18] W. H. Sledge, K. Moras, D. Hartley, and M. Levine, “Effect of time-limited psychotherapy on patient dropout rates,” *American Journal of Psychiatry*, vol. 147, no. 10, pp. 1341–1347, 1990.
- [19] S. E. Alaoui, B. Ljótsson, E. Hedman, V. Kalso, E. Andersson, C. Rück, G. Andersson, and N. Lindefors, “Predictors of symptomatic change and adherence in internet-based cognitive behaviour therapy for social anxiety disorder in routine psychiatric care,” *PLoS ONE*, vol. 10, 4 2015.
- [20] G. Doherty, D. Coyle, and J. Sharry, “Engagement with Online Mental Health Interventions: An Exploratory Clinical Study of a Treatment for Depression,” in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI ’12, (New York, NY, USA), pp. 1421–1430, ACM, 2012.
- [21] K. N. Levy and J. F. Clarkin, “The influence of client variables on psychotherapy,” *Bergin and Garfield’s handbook of psychotherapy and behavior change*, pp. 194–226, 2004.
- [22] World Health Organization 2003, “ADHERENCE TO LONG-TERM THERAPIES: Evidence for action,” in *ADHERENCE TO LONG-TERM THERAPIES: Evidence for action*, p. 211, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland, 2003.
- [23] D. Moher, L. Shamseer, M. Clarke, D. Ghersi, A. Liberati, M. Petticrew, P. Shekelle, L. A. Stewart, M. Estarli, E. S. Barrera, R. Martínez-Rodríguez, E. Baladia, S. D. Agüero, S. Camacho, K. Buhning, A. Herrero-López, D. M. Gil-González, D. G. Altman, A. Booth, A. W. Chan, S. Chang, T. Clifford, K. Dickersin, M. Egger, P. C. Götzsche, J. M. Grimshaw, T. Groves, M. Helfand, J. Higgins, T. Lasserson, J. Lau, K. Lohr, J. McGowan, C. Mulrow, M. Norton, M. Page, M. Sampson, H. Schünemann, I. Simera, W. Summerskill, J. Tetzlaff, T. A. Trikalinos, D. Tovey, L. Turner, and E. Whitlock, “Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement,” *Revista Espanola de Nutricion Humana y Dietetica*, vol. 20, no. 2, pp. 148–160, 2016.

- [24] V. Pennick, A. D. Furlan, and V. Pennick, "2009 Updated Method Guidelines for Systematic Reviews in the Cochrane Back Review Group 2009 Updated Method Guidelines for Systematic Reviews in the Cochrane Back Review Group," *Spine*, vol. 34, no. September 2009, pp. 1929–1941, 2016.
- [25] B. G. Danaher, H. Brendryen, J. R. Seeley, M. S. Tyler, and T. Woolley, "From black box to toolbox: Outlining device functionality, engagement activities, and the pervasive information architecture of mHealth interventions," 3 2015.
- [26] A. Lange, D. Rietdijk, M. Hudcovicova, J. P. Van de Ven, B. Schrieken, and P. M. Emmelkamp, "Interapy: A controlled randomized trial of the standardized treatment of posttraumatic stress through the internet," *Journal of Consulting and Clinical Psychology*, vol. 71, pp. 901–909, 10 2003.
- [27] B. Meyer, T. Berger, F. Caspar, C. G. Beevers, G. Andersson, and M. Weiss, "Effectiveness of a novel integrative online treatment for depression (Deprexis): Randomized controlled trial," *Journal of Medical Internet Research*, vol. 11, 4 2009.
- [28] P. van de Ven, H. O'Brien, R. Henriques, M. Klein, R. Msetfi, J. Nelson, A. Rocha, J. Ruwaard, D. O'Sullivan, and H. Riper, "ULTEMAT: A mobile framework for smart ecological momentary assessments and interventions," *Internet Interventions*, vol. 9, pp. 74–81, 9 2017.
- [29] V. Pejovic and M. Musolesi, "Anticipatory mobile computing for behaviour change interventions," in *UbiComp 2014 - Adjunct Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, pp. 1025–1034, Association for Computing Machinery, Inc, 2014.
- [30] T. Donker, K. Petrie, J. Proudfoot, J. Clarke, M. R. Birch, and H. Christensen, "Smartphones for smarter delivery of mental health programs: A systematic review," 11 2013.
- [31] G. Andersson, N. Titov, B. F. Dear, A. Rozental, and P. Carlbring, "Internet-delivered psychological treatments: from innovation to implementation," *World Psychiatry*, vol. 18, pp. 20–28, 2 2019.
- [32] N. Kang, W. P. Brinkman, M. B. Van Riemsdijk, and M. A. Neerinx, "Internet-delivered multi-patient virtual reality exposure therapy system for the treatment of anxiety disorders," in *ECCE 2011 - European Conference on Cognitive Ergonomics 2011: 29th Annual Conference of the European Association of Cognitive Ergonomics*, pp. 233–236, 2011.
- [33] K. K. Fitzpatrick, A. Darcy, and M. Vierhile, "Delivering Cognitive Behavior Therapy to Young Adults With Symptoms of Depression and Anxiety Using a Fully Automated Conversational Agent (Woebot): A Randomized Controlled Trial," *JMIR Mental Health*, vol. 4, p. e19, 6 2017.
- [34] L. Johnston, N. Titov, G. Andrews, J. Spence, and B. F. Dear, "A RCT of a transdiagnostic internet-delivered treatment for three anxiety disorders: Examination of support roles and disorder-specific outcomes," *PLoS ONE*, vol. 6, 11 2011.
- [35] B. G. Danaher, H. G. McKay, and J. R. Seeley, "The information architecture of behavior change websites," 4 2005.
- [36] J. Pugatch, E. Grenen, S. Surla, M. Schwarz, and H. Cole-Lewis, "Information Architecture of Web-Based Interventions to Improve Health Outcomes: Systematic Review," *Journal of medical Internet research*, vol. 20, no. 3, p. e97, 2018.
- [37] T. L. Webb, J. Joseph, L. Yardley, and S. Michie, "Using the Internet to promote health behavior change: A systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy," *Journal of Medical Internet Research*, vol. 12, 1 2010.
- [38] W. Van Ballegooijen, P. Cuijpers, A. Van Straten, E. Karyotaki, G. Andersson, J. H. Smit, and H. Riper, "Adherence to internet-based and face-to-face cognitive behavioural therapy for depression: A meta-analysis," *PLoS ONE*, vol. 9, 7 2014.
- [39] J. Kelson, A. Rollin, B. Ridout, and A. Campbell, "Internet-Delivered Acceptance and Commitment Therapy for Anxiety Treatment: Systematic Review," 1 2019.
- [40] L. Jokste and J. Grabis, "Rule based adaptation: Literature review," in *Vide. Tehnologija. Resursi - Environment, Technology, Resources*, vol. 2, pp. 42–46, Rezekne Higher Education Institution, 2017.
- [41] E. Karyotaki, A. Kleiboe, F. Smit, D. T. Turner, A. M. Pastor, G. Andersson, T. Berger, C. Botella, J. M. Breton, P. Carlbring, H. Christensen, E. De Graaf, K. Griffiths, T. Donker, L. Farrer, M. J. Huibers, J. Lenndin, A. Mackinnon, B. Meyer, S. Moritz, H. Riper, V. Spek, K. Vernmark, and P. Cuijpers, "Predictors of treatment dropout in self-guided web-based interventions for depression: An 'individual patient data' meta-analysis," *Psychological Medicine*, vol. 45, pp. 2717–2726, 10 2015.
- [42] M. A. Rogers, K. Lemmen, R. Kramer, J. Mann, and V. Chopra, "Internet-delivered health interventions that work: Systematic review of meta-analyses and evaluation of website availability," 3 2017.
- [43] W. Brouwer, W. Kroeze, R. Crutzen, J. De Nooijer, N. K. De Vries, J. Brug, and A. Oenema, "Which intervention characteristics are related to more exposure to internet-delivered healthy lifestyle promotion interventions? A systematic review," *Journal of Medical Internet Research*, vol. 13, 1 2011.
- [44] F. K. Arnberg, S. J. Linton, M. Hultcrantz, E. Heintz, and U. Jonsson, "Internet-delivered psychological treatments for mood and anxiety disorders: A systematic review of their efficacy, safety, and cost-effectiveness," 5 2014.
- [45] E. Forsell, S. Jernelöv, K. Blom, M. Kraepelien, C. Svanborg, G. Andersson, N. Lindefors, and V. Kaldø, "Proof of concept for an adaptive treatment strategy to prevent failures in internet-delivered CBT: A single-blind randomized clinical trial with insomnia patients," *American Journal of Psychiatry*, vol. 176, pp. 315–323, 4 2019.
- [46] B. G. Danaher, S. M. Boles, L. Akers, J. S. Gordon, and H. H. Severson, "Defining participant exposure measures in web-based health behavior change programs," *Journal of Medical Internet Research*, vol. 8, no. 3, 2006.
- [47] R. Crutzen, D. Cyr, and N. K. De Vries, "The role of user control in adherence to and knowledge gained from a website: Randomized comparison between a tunneled version and a freedom-of-choice version," *Journal of Medical Internet Research*, vol. 14, no. 2, pp. 75–84, 2012.
- [48] R. Hurling, B. W. Fairley, and M. B. Dias, "Internet-based exercise intervention systems: Are more interactive designs better?," *Psychology and Health*, vol. 21, pp. 757–772, 12 2006.
- [49] P. Lappalainen, S. Langrial, H. Oinas-Kukkonen, A. Tolvanen, and R. Lappalainen, "Web-Based Acceptance and Commitment Therapy for Depressive Symptoms With Minimal Support: A Randomized Controlled Trial," *Behavior Modification*, vol. 39, pp. 805–834, 11 2015.

- [50] R. Alnanih, O. Ormandjieva, and T. Radhakrishnan, "Context-based and rule-based adaptation of mobile user interfaces in mHealth," in *Procedia Computer Science*, vol. 21, pp. 390–397, Elsevier B.V., 2013.
- [51] J. N. Soucy and H. D. Hadjistavropoulos, "Treatment acceptability and preferences for managing severe health anxiety: Perceptions of internet-delivered cognitive behaviour therapy among primary care patients," *Journal of Behavior Therapy and Experimental Psychiatry*, vol. 57, pp. 14–24, 12 2017.
- [52] E. Andersson, J. Enander, P. Andrén, E. Hedman, B. Ljótsson, T. Hursti, J. Bergström, V. Kaldø, N. Lindefors, G. Andersson, and C. Rück, "Internet-based cognitive behaviour therapy for obsessive-compulsive disorder: A randomized controlled trial," *Psychological Medicine*, vol. 42, pp. 2193–2203, 10 2012.
- [53] S. Jernelöv, M. Lekander, K. Blom, S. Rydh, B. Ljótsson, J. Axelsson, and V. Kaldø, "Efficacy of a behavioral self-help treatment with or without therapist guidance for co-morbid and primary insomnia -a randomized controlled trial," *BMC Psychiatry*, vol. 12, 1 2012.
- [54] R. Zwerenz, C. Baumgarten, J. Becker, A. Tibubos, M. Siepmann, R. J. Knickenberg, and M. E. Beutel, "Improving the Course of Depressive Symptoms After Inpatient Psychotherapy Using Adjunct Web-Based Self-Help: Follow-Up Results of a Randomized Controlled Trial," *Journal of Medical Internet Research*, vol. 21, p. e13655, 10 2019.
- [55] W. Lutz, A. Arndt, J. Rubel, T. Berger, J. Schröder, C. Späth, B. Meyer, W. Greiner, V. Gräfe, M. Hautzinger, K. Fuhr, M. Rose, S. Nolte, B. Löwe, F. Hohagen, J. P. Klein, and S. Moritz, "Defining and predicting patterns of early response in a web-based intervention for depression," *Journal of Medical Internet Research*, vol. 19, no. 6, 2017.
- [56] R. Crutzen, J. De Nooijer, W. Brouwer, A. Oenema, J. Brug, and N. K. De Vries, "A conceptual framework for understanding and improving adolescents' exposure to Internet-delivered interventions," 9 2009.
- [57] S. K. Mukhiya, F. Rabbi, K. I. Pun, and Y. Lamo, "An Architectural Design for Self-Reporting E-Health Systems," pp. 1–8, Institute of Electrical and Electronics Engineers (IEEE), 9 2019.
- [58] J. Wallert, E. Gustafson, C. Held, G. Madison, F. Norlund, L. Von Essen, and E. M. G. Olsson, "Predicting adherence to internet-Delivered psychotherapy for symptoms of depression and anxiety after myocardial infarction: Machine learning insights from the U-CARE heart randomized controlled trial," *Journal of Medical Internet Research*, vol. 20, 10 2018.
- [59] S. Gonul, T. Namli, S. Huisman, G. B. L. Erturkmen, I. H. Toroslu, and A. Cosar, "An expandable approach for design and personalization of digital, just-in-time adaptive interventions," *Journal of the American Medical Informatics Association*, vol. 26, no. 3, pp. 198–210, 2019.
- [60] H. Lindgren, J. Baskar, E. Guerrero, J. C. Nieves, I. Nilsson, and C. Yan, "Computer-supported assessment for tailoring assistive technology," in *DH 2016 - Proceedings of the 2016 Digital Health Conference*, pp. 1–10, Association for Computing Machinery, Inc, 4 2016.
- [61] D. Rough and A. Quigley, "An end-user interface for behaviour change intervention development," in *Proceedings of the Workshop on Advanced Visual Interfaces AVI*, pp. 377–378, Association for Computing Machinery, 2014.
- [62] B. Erten-Uyumaz, M. Ahuja, T. Vacaretu, M. D. Rama, S. Overeem, T. Visser, J. Hu, and L. Feijs, "Design and evaluation of a negotiation-based sleep scheduler app for insomnia treatment," in *ACM International Conference Proceeding Series*, pp. 225–233, Association for Computing Machinery, 5 2019.
- [63] R. J. Beun, "Persuasive strategies in mobile insomnia therapy: Alignment, adaptation, and motivational support," *Personal and Ubiquitous Computing*, vol. 17, pp. 1187–1195, 8 2013.
- [64] R. Kop, M. Hoogendoorn, and M. C. Klein, "A personalized support agent for depressed patients: Forecasting patient behavior using a mood and coping model," in *Proceedings - 2014 IEEE/WIC/ACM International Joint Conference on Web Intelligence and Intelligent Agent Technology - Workshops, WI-IAT 2014*, vol. 3, pp. 10–15, Institute of Electrical and Electronics Engineers Inc., 10 2014.
- [65] K. K. Rachuri, M. Musolesi, C. Mascolo, P. J. Rentfrow, C. Longworth, and A. Aucinas, "EmotionSense: A mobile phones based adaptive platform for experimental social psychology research," in *UbiComp'10 - Proceedings of the 2010 ACM Conference on Ubiquitous Computing*, pp. 281–290, 2010.
- [66] M. R. Scholten, S. M. Kelders, and J. E. Van Gemert-Pijnen, "Self-guided Web-based interventions: Scoping review on user needs and the potential of embodied conversational agents to address them," 11 2017.
- [67] A. Barak, B. Klein, and J. G. Proudfoot, "Defining internet-supported therapeutic interventions," 8 2009.

Appendix A. Abbreviations

List of Abbreviations

ACD	Architecture-Centric Development
ADHD	Attention Deficit Hyperactivity Disorder
AUI	Adaptive User Interface
CBT	Cognitive Behavioral Therapy
GAD	Generalized Anxiety Disorder
IA	Information Architecture

ICT Information Communication Technology

IDT Internet-Delivered Treatments

OCD Obsessive Compulsive Disorder

PRISMA Preferred Reporting Items for Systematic Reviews and Meta-Analyses

RCT Randomized Controlled Trial

YBOCS Yale–Brown Obsessive Compulsive Scale

Appendix B. Search Terms

[website* OR "information system" OR "information architecture" OR "web application" OR "web-based" OR "internet" OR "internet-delivered" OR "internet interventions" OR "mobile-phone" OR "user-centered application" OR "person-based approach" OR "persuasive design" OR "web-architecture" OR "architecture" OR "adaptive architecture" OR "self-adaptive architecture" OR "adaptive system" OR "adherent system"] AND ["behavior change" OR "behavioral interventions" OR "behavioral treatment" OR "adaptive treatment" OR "adherence" OR "health interventions" OR "patient education" OR "mHealth" OR "online treatment", "self-help" OR "self-care" or "depression" OR "social anxiety" OR "schizophrenia" OR "eating disorder" OR "bipolar disorder" or "ADHD" OR "dementia"] AND ["mental health" OR "mental issues" OR "mental OR neurological problems" OR "neurological" OR "issues" OR "therapies"]