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Smartphone applications for depression: a systematic literature  
review and a survey of health care professionals' attitudes towards  
their use in clinical practice

Dissertation

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## Summary

Depression is one of the most common mental disorders. Despite the high prevalence of depression, only part of those affected receive adequate treatment. In order to improve mental health care, the interest in e-mental health interventions has increased considerably in recent years. E-mental health describes the use of information and computer technology in mental health care. In this field, the use of mobile applications (apps) is gaining increasing attention due to the immense and growing number of smartphone users worldwide. App-based interventions have the potential to lower treatment barriers and to improve the access to mental health care. The effectiveness of these interventions as well as the acceptance of their therapeutic application are important prerequisites for a successful implementation in mental health care.

Therefore, the aim of this study was to examine the evidence on the efficacy of apps in the treatment of depression and to investigate health care professionals' attitudes towards their use in clinical practice. This study focused on therapeutic mobile applications containing active treatment components as opposed to pure information provision or data collection apps.

In the scope of this study, a systematic literature review on the clinical efficacy of treatment apps for depression was conducted. The included studies of the systematic review showed that app-based interventions can reduce symptoms of depression. The results of these studies thus indicate that smartphone applications may be effective in the treatment of depression. However, large-scale research trials are needed to confirm these results and to investigate medium to long-term effects.

In addition to the systematic review, an online survey on health care professionals' attitudes, awareness and experience concerning treatment apps for depression was conducted. Survey participants had overall positive attitudes towards the use of these interventions in the treatment of depression. Benefits were seen mostly in terms of accessibility to psychotherapeutic services in mental health care. Concerns were related to data security and privacy protection of patients. Significant differences were found between the amount of technology experience and the extent to which health care professionals would consider the use of therapeutic apps for depression. In this context, study participants with much technology experience (e.g., with computers or smartphones) expressed more willingness to use treatment apps in clinical practice. Overall, the respondents had limited knowledge and experience with therapeutic mobile applications for depression.

Similar results regarding health care professionals' limited awareness and experience related to e-mental health interventions have also been shown in other studies. Education and training of health care professionals can help to increase awareness and knowledge of the therapeutic potential of e-mental health interventions and apps in the treatment of depression.



## Zusammenfassung

Die Depression gehört zu den häufigsten psychischen Erkrankungen. Trotz der hohen Prävalenz wird nur ein Teil der Betroffenen adäquat behandelt. Um die Versorgung zu verbessern, hat in den letzten Jahren das Interesse an E-Mental Health stark zugenommen. E-Mental Health beschreibt die Nutzung von Informations- und Computertechnologie in der Behandlung und Vorbeugung von psychischen Erkrankungen. In diesem Feld gewinnt der Einsatz von mobilen Smartphone-Anwendungen (Apps) aufgrund der weltweit immensen und wachsenden Anzahl von Smartphone-Nutzern zunehmend an Aufmerksamkeit. App-basierte Interventionen haben das Potenzial, Behandlungsbarrieren zu senken und den Zugang zur psychotherapeutischen Versorgung zu verbessern. Die Wirksamkeit dieser Interventionen sowie die Akzeptanz ihrer therapeutischen Nutzung sind dabei wichtige Voraussetzungen für eine erfolgreiche Implementierung im Gesundheitswesen.

Ziel der vorgestellten Studie war es deshalb, die Evidenz zur Wirksamkeit von Apps in der Depressionsbehandlung zusammenzufassen und zu bewerten sowie die Einstellungen von an der Versorgung beteiligten Berufsgruppen gegenüber deren Anwendung in der klinischen Praxis zu untersuchen. Der Fokus dieser Studie lag dabei auf therapeutischen Apps, die aktive Behandlungskomponenten enthalten im Gegensatz zu Apps, die z.B. der reinen Informationsvermittlung oder der Verwaltung gesundheitsbezogener Daten dienen.

Im Rahmen dieser Studie wurde eine systematische Literaturrecherche zur Wirksamkeit von therapeutischen Apps in der Depressionsbehandlung durchgeführt. Die in dieser systematischen Übersichtsarbeit eingeschlossenen Studien zeigten, dass depressive Symptome durch den Einsatz der App-basierten Intervention reduziert werden können. Die Studienergebnisse deuten demnach auf eine mögliche therapeutische Wirksamkeit dieser Apps hin. Größere Langzeitstudien sind jedoch notwendig, um die Wirksamkeit zu bestätigen und auch über längere Zeiträume zu untersuchen.

In einer Online-Umfrage wurden darüber hinaus die an der therapeutischen Versorgung beteiligten Berufsgruppen zu Kenntnis, Erfahrung und Einstellungen gegenüber dem Einsatz therapeutischer Apps in der klinischen Praxis befragt. Bei den Teilnehmenden der Umfrage zeichnete sich ein eher positives Bild zum Einsatz von Apps in der Depressionsbehandlung ab. Vorteile wurden vor allem bezüglich der Zugänglichkeit zu therapeutischen Angeboten im Gesundheitswesen gesehen. Bedenken gab es hinsichtlich der Datensicherheit und dem Schutz der Privatsphäre. Es zeigten sich signifikante Unterschiede zwischen der Technikerfahrung und dem Maß, in welchem die Teilnehmenden die Nutzung von Apps in Erwägung ziehen würden. Teilnehmende mit viel Technikerfahrung (z.B. mit Computern oder Smartphones) zeigten eine höhere Bereitschaft therapeutische Apps in der Praxis zu nutzen. Insgesamt hatten die Befragten eher wenig Kenntnis und wenige eigene Erfahrung mit mobilen Anwendungen in der therapeutischen Versorgung von depressiv Erkrankten.

Ähnliche Ergebnisse bezüglich begrenzten Wissens und Erfahrung wurden auch in anderen Studien zu computerbasierten therapeutischen Interventionen bei psychischen Erkrankungen gezeigt. Schulungen und praktische Fortbildung können dazu beitragen, Kenntnisse zu verbessern und das therapeutische Potenzial von E-Mental Health in der Depressionsbehandlung aufzuzeigen.

## Index of abbreviations

<b>ADHD</b>	Attention deficit hyperactivity disorder
<b>App</b>	Mobile application
<b>BA</b>	Behavioral activation
<b>BDI</b>	Beck Depression Inventory
<b>CBT</b>	Cognitive behavioral therapy
<b>cCBT</b>	Computerized cognitive behavioral therapy
<b>DALY</b>	Disability-Adjusted Life Year
<b>DSM</b>	Diagnostic and Statistical Manual
<b>e-health</b>	Electronic health
<b>e-mental health</b>	Electronic mental health
<b>GPS</b>	Global Positioning System
<b>ICD</b>	International Classification of Diseases
<b>ICT</b>	Information and communication technology
<b>m-health</b>	Mobile health
<b>MINI</b>	Mini-International Neuropsychiatric Interview
<b>NHS</b>	National Health Service
<b>NICE</b>	National Institute for Health and Clinical Excellence
<b>PHQ</b>	Patient Health Questionnaire
<b>PTSD</b>	Posttraumatic stress disorder
<b>SIGN</b>	Scottish Intercollegiate Guidelines Network
<b>TAM</b>	Technology Acceptance Model
<b>UTAUT</b>	Unified Theory of Acceptance and Use of Technology
<b>WHO</b>	World Health Organization

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# 1 Introduction

## 1.1 Background

Mental disorders are highly prevalent with around 29% of the global population being affected by a common mental disorder across their lifetime [1]. Approximately 38% of the European population suffer from a mental disorder every year [2]. Mental disorders are not only very prevalent but also very disabling conditions which lead to a high burden for individuals, families and society [2]. The most common mental disorders include depression, anxiety and substance use disorders [1]. Depressive disorders account for most of the overall disease burden [3]. The global burden of disease caused by mental disorders continues to grow and poses an enormous challenge for health systems [4].

Despite the high prevalence and substantial burden that these disorders cause, treatment rates are low [3]. For Europe it is estimated that only one out of two affected individuals has ever received professional treatment [2]. If treatment is provided, it is often delayed several years after the disorder began [3].

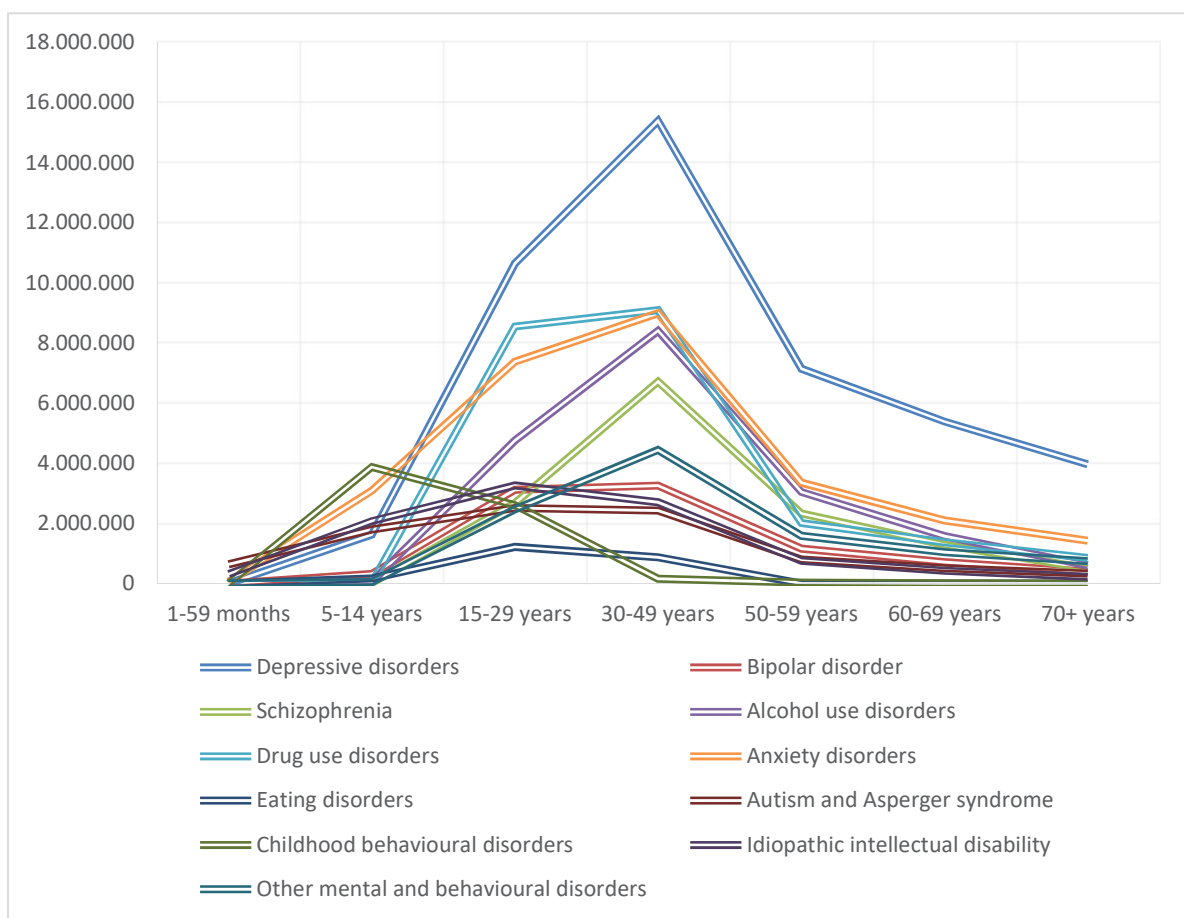
The improvement of unmet treatment needs and the access to mental health care are major issues in public health [5]. Therefore, innovative treatment concepts using information and communication technologies (“e-health” and “e-mental health”), have gained increasing attention in recent years. In particular smartphones and the use of mobile applications (apps) are of interest due to the large and increasing number of users worldwide [6]. These new therapeutic interventions have the potential to contribute to improved health care provision by offering easily accessible and cost-effective treatment [5]. Recently, the World Health Organization (WHO) even concluded that universal health coverage cannot be achieved without the support of e-health [7].

## 1.2 Depression

### 1.2.1 Epidemiology and course of illness

Depression belongs to the most common mental disorders with more than 300 million individuals affected worldwide [4]. It is the leading cause of disability and a strong contributor to the global burden of disease [8]. Figure 1 shows Disability-Adjusted Life Years (DALYs) for mental and substance use disorders indicating the highest disease burden for

depressive disorders for most age groups. The disorder affects individuals at any age but often starts in the teen years with a peak in the third life decade [9]. Depression often has a recurrent or chronic course of illness. Most of those affected have a depression more than once in their lifetime and 15-30% of the cases have a chronic course [10]. Comorbidity with other mental disorders, such as anxiety disorders, addictive disorders or personality disorders, is common. Women are more often affected than men with a lifetime prevalence of 25% compared to 12% in men [9]. Due to the risk of suicidality, depression can be described as a potentially life-threatening condition [9].



**Figure 1: Global Disability-Adjusted Life Years (DALYs) by age for mental and substance use disorders.**

Source: own figure based on WHO Global Health Estimates Data 2016 [11].

### 1.2.2 Symptoms and diagnosis

The symptoms of depression include persistent sadness or low mood, loss of interests or pleasure, fatigue or low energy, and can be accompanied by additional symptoms of disturbed sleep, poor concentration or indecisiveness, low self-confidence, poor or increased appetite, agitation or slowing of movements. In severe cases, depression can lead to suicidal thoughts and acts [4]. Symptoms need to last at least two weeks in order to fulfill the criteria for a diagnosis of a depressive episode according to international classification systems [12, 13]. Depending on the number and intensity of these symptoms, a depressive episode can be categorized as mild, moderate or severe [12–14].

The diagnosis of a depressive episode is made according to specific diagnostic criteria which are outlined in disease classification systems. The most established systems are the International Classification of Diseases (ICD), currently in version ICD-10 and in revision for ICD-11, published by the World Health Organization, and the Diagnostic and Statistical Manual for Mental Disorders (DSM), currently in version DSM-5, published by the American Psychiatric Association [12, 13, 15]. Symptoms, severity and course of a depressive episode according to both classification systems are shown in Table 1.

The classification systems allow for an international comparability of diagnostics and treatment and build the foundation for coherent research [16]. In addition, standardized interviews and rating scales for the diagnosis of mental disorders have been developed. These are frequently used in research and clinical trials. The MINI-international neuropsychiatric interview is a short and structured method of clinical diagnosis assessment, which is commonly used by researchers [17]. The Beck Depression Inventory (BDI) in contrast is a self-reported scale consisting of 21 questions filled out by the study participant or client [18]. Another self-report questionnaire is the Patient Health Questionnaire (PHQ), which exists in a longer version with nine questions (PHQ-9) and a shorter version with two questions (PHQ-2) [19, 20]. These scales are very commonly used assessment tools for depression in research as will be seen in further chapters of this dissertation.

DSM-5	ICD-11
<b>Symptoms</b>	
<p>At least 5 of the following symptoms, present nearly every day during the same two-week period (at least one symptom is depressed mood or diminished interest or pleasure):</p> <ul style="list-style-type: none"> <li>depressed mood most of the day, almost every day</li> <li>significantly decreased interest or reduced pleasure in (almost) all activities</li> <li>significant weight loss without a diet or weight gain or decreased or increased appetite</li> <li>insomnia or hypersomnia</li> <li>psychomotor agitation or retardation</li> <li>fatigue or loss of energy</li> <li>feelings of worthlessness or inappropriate guilt</li> <li>diminished ability to think or to concentrate or indecisiveness</li> <li>recurrent thoughts of death, recurrent suicidal ideation, actual attempted suicide or precise planning of suicide</li> </ul>	<p>Almost daily depressed mood or diminished interest in activities lasting at least two weeks accompanied by other symptoms:</p> <ul style="list-style-type: none"> <li>difficulty concentrating</li> <li>feelings of worthlessness or excessive or inappropriate guilt</li> <li>hopelessness</li> <li>recurrent thoughts of death or suicide</li> <li>changes in appetite</li> <li>changes in sleep</li> <li>psychomotor agitation or retardation</li> <li>reduced energy or fatigue.</li> </ul>
<b>Severity</b>	
<ul style="list-style-type: none"> <li>mild</li> <li>moderate</li> <li>severe</li> <li>with psychotic symptoms</li> </ul>	<ul style="list-style-type: none"> <li>mild</li> <li>moderate*</li> <li>severe*</li> <li>unspecified</li> </ul> <p>*additional: with psychotic symptoms</p>
<b>Course</b>	
<ul style="list-style-type: none"> <li>single episode or recurrent (at least 2 months between episodes)</li> <li>in partial remission</li> <li>in full remission</li> <li>not specified</li> </ul>	<ul style="list-style-type: none"> <li>single episode or recurrent (at least 2 episodes separated by several months)</li> <li>in partial remission</li> <li>in full remission</li> <li>unspecified</li> </ul>

**Table 1: Symptoms, severity and course of a depressive episode in Major Depression according to DSM-5 and a depressive episode according to ICD-11.**

Source: own table based on diagnostic criteria for a depressive episode as outlined in the Diagnostic and Statistical Manual of Mental Disorders, DSM-5, 5th edition [12] and the World Health Organization ICD-11 for Mortality and Morbidity Statistics, Online-Version 04/2019 [13].

### 1.2.3 Treatment

For the treatment of depression, clinical guidelines recommend pharmacotherapy and psychotherapy alone or in combination [21, 22]. Often, therapy is grounded on a multidimensional approach [16]. Psychotherapy is an alternative or addition to pharmacotherapy. Research of the last decades has shown that psychotherapy is effective in the treatment of mental disorders [23]. Behavioral and cognitive approaches are established techniques in the treatment of depression [10].

Behavioral approaches are rooted in learning theories and the assumption that learned behaviors can be modified [24]. An example for a behavioral approach is behavioral activation (BA). It aims at increasing pleasant activities and consequences as well as the development of social skills to reinforce potentially supporting experiences and improve mood. Behavioral activation has shown its efficacy in several research trials and is also a recommended therapy for depression according to clinical guidelines [25].

Cognitive therapies focus on dysfunctional thinking patterns and feelings. They often include a process of cognitive restructuring and aim at the evaluation and modification of irrational thoughts, beliefs and assumptions about the self and others [26]. Cognitive-behavioral therapy (CBT) tries to understand the connection between thoughts, feelings and behavior. Moods and behavior are changed by replacing maladaptive thought patterns by healthier ones [24]. Cognitive behavioral approaches are very widely used and belong to the group of psychological treatments with most comprehensive empirical support [27]. In the recent development phase of cognitive behavioral approaches, techniques such as mindfulness-based exercises or acceptance of dysfunctional thoughts gained increasing interest. These types of interventions focus more on the relationship that a person has with these thoughts and emotions rather than their content [27].

Both pharmacotherapy and psychotherapy have shown their efficacy for the treatment of depression [25, 26, 28, 29]. The major types of psychotherapy do not differ significantly from one another in their efficacy [23, 30]. Research has shown the efficacy with effect sizes of approximately 0.8 for different psychotherapeutic approaches which means that about 65% of patients are treated successfully [23]. As will be seen in the further chapters of this work, these psychotherapeutic approaches often build the basis for e-mental health interventions.

#### **1.2.4 Relevance of depression in the public health context**

Mental disorders belong to the most disabling medical conditions due to their high prevalence and the impairments that are associated with them [2, 3]. In addition to the considerable burden for the individual, the economic burden for health systems and society is substantial. Mental disorders cause very high indirect costs, for example by sick leave or early retirement, compared to other somatic disorders, which account for more direct costs



linked to diagnostics and treatment [2]. The global economic costs due to production losses and mental health care expenditures are rising and expected to reach up to 2.5 trillion US-dollar by the year 2030 [31]. Despite the availability of established therapeutic interventions, only a fraction of those in need receive adequate treatment. The difference between the number of individuals affected and the number of individuals that receive treatment is called “treatment gap” [32]. The global treatment gap for depression is about 56%, which means that more than half of those in need do not receive adequate treatment [32]. For Europe this number is slightly lower with a treatment gap of 45.4% [32]. Numerous reasons for the treatment gap in mental disorders have been identified. These include the scarcity or unequal distribution of available resources as well as their inefficient use [3]. In addition, individual reasons, such as the belief that treatment is not effective or the wish to deal with the issue without professional help, contribute to the treatment gap [32]. The stigma of mental illness is another prominent barrier to mental health services [34]. Although acceptance has increased over the decades, mental health problems including depression still evoke shame in many individuals which hinders the use of adequate treatment. The use of e-mental health interventions may contribute to close the treatment gap in depression and lower access barriers to mental health care [7].

### **1.3 E-mental health**

The aim of e-health (or “eHealth”) is the improvement of information flow and the support of health services delivery and the management of health systems [35]. Multiple definitions have been proposed to describe the term “e-health” and there is no consensus on one single definition [5]. According to the World Health Organization, e-health is “the use of information and communication technologies (ICT) for health” [35]. It includes the delivery of health care via the internet using different electronic devices [36].

A sub-category of e-health is “e-mental health” which specifically refers to the application in mental health [5]. The National Health Service Confederation defines it as “the use of information and communication technologies to support and improve mental health, including the use of online resources, social media and smartphone applications” [37]. Riper et al. [38] describe e-mental health as “a generic term to describe the use of information and communication technology (ICT) – in particular the many technologies related to the internet – when these technologies are used to support and improve mental health condi-

tions and mental health care, including care for people with substance use and comorbid disorders” [38].

Both e-health and e-mental health can be applied to all phases of disease management. This includes screening, health promotion, prevention, treatment and rehabilitation. E-health also comprises those technologies that improve the provision of health care (e.g., the digital patient record, hospital communication tools and systems), the training and education of professionals (e.g., e-learning programs) or the provision of information (psychoeducation) or peer-support for anyone affected by a mental disorder [40, 41].

The spectrum of e-mental health is very broad and there are different attempts to classify the various approaches. Klein et al. [42] propose the grouping of e-mental health interventions according to the following characteristics:

- Phase of disease management (e.g., prevention, treatment, aftercare)
- Type of technology (e.g., web-based, mobile-based)
- Presentation of content (e.g., text, video, audio)
- Amount of therapist contact (e.g., self-management, remote-therapy)
- Underlying therapeutic approach (e.g., cognitive-behavioral therapy, behavioral activation)

Available therapeutic e-mental health interventions for patients mainly comprise interactive self-help programs, serious games (psychological training via computer games), prompting and memory interventions that target certain behavior or thoughts, monitoring and tracking programs, and virtual reality interventions supported by devices such as computers, smartphones, tablets and phone- or wearable sensors [43]. The focus of the present study lies on those interventions that are used in the treatment phase of depression using a mobile-based technology (smartphones and apps).

Therapeutic e-mental health interventions are often based on cognitive behavioral therapy and use structured and standardized techniques to target behavior and thoughts. However, other therapeutic methods, such as mindfulness-based treatment, acceptance and commitment therapy or psychodynamic techniques are incorporated in e-mental health interventions as well [43]. These interventions aim at the alteration of cognitive, emotional or behavioral processes and support the user to integrate acquired skills with the help of psychotherapeutic techniques in their everyday lives [44].

The degree of human support in e-mental health interventions may range from no support (“self-management”) to integration into a medical/psychological treatment plan (“blended treatment”) [42]. In between, there is a continuum of guidance, support and communication provided by health care professionals [42]. In the scope of this work, the role of human support in mobile-based interventions will be further examined.

### **1.3.1 Mobile mental health**

Mobile mental health (“m-health”) is a sub-category of e-mental health and describes the use of mobile and wireless electronic devices, such as smartphones, tablets or wearables, for medical and public health purposes [6]. These mobile devices aim at the creation, storage, retrieval and transmission of data in real-time between end users [45].

Smartphones and wearables became increasingly relevant over the recent years. Wearables are small electronic devices that are worn closely to the body. They are usually connected to a smartphone app or other program that transfers, processes and edits the data [46]. Sensors in these wearables accumulate a variety of health parameters and submit the information for interpretation. In general, biosensors can collect various data (e.g., blood glucose, heart rate, blood pressure) that are monitored and interpreted for different purposes. Data of these bodily functions are also called “objective data” because they can be gathered automatically and the individual can hardly influence these parameters [46]. Commonly known health wearables are fitness watches that collect data on movement, rotation and position and translate this information into measures of exercise, activity or sleep [47]. Sensors are not only integrated into wearables but also into smartphones.

In mental health, sensors can be used to gather passive user data to provide information on the patient’s mental health status. Passive data collected by the Global Positioning System (GPS), accelerometer or call logs of a smartphone may give information on mental health measures such as social engagement [48]. An advantage of passive data is the potential greater adherence and the collection of more objective information compared to self-reports [49]. However, the evidence on passive data collection for mental health purposes is limited up to now [48, 50].

Smartphones and apps play a main role in mobile health. An overwhelming number of health apps are available in the Apple Store and Google Play Store, the two most common

app marketplaces [51]. Many of these apps focus on lifestyle, diet and fitness and only a smaller proportion focuses on specific diseases although the latter number is rising [52].

Within the disease-specific apps, mental health apps make the greatest share of all therapy areas with 28% of apps being for mental health. Apps for diabetes and the heart- and circulatory system rank second and third behind the mental health applications [47]. Within the sub-group of mental health apps, depression is one of the most commonly addressed health issues [47].

Health apps may be used for a multitude of purposes and target groups. They can assist professionals in disease diagnosis, drug referencing, medical calculating (e.g., drug dosing), literature search, clinical communication or medical training [53]. There are apps related to hospital information systems and health care provision. Furthermore, there are apps that are used for disease management and focus on symptom or diagnosis assessment, symptom monitoring and treatment [48]. This study focuses on treatment apps that are used for disease management. According to the IMS Institute for Health Care Informatics [52], the dimensions of app functionality for disease management apps include:

- Information provision (via text, video, photo)
- Instructions to the user
- Recording of entered user data
- Display of entered user data (graphics, text)
- Guidance to the user based on the entered data
- Reminding or prompting the user
- Communication between health care providers and users

Many of the commercial apps have limited functionality and focus on information provision [52]. Most of them are free of charge [52]. In addition, there are those apps that have been tested in research. A part of these apps may also be available on the commercial app markets.

Like other e-mental health interventions, therapeutic mobile applications for depression and other common mental disorders may be based on techniques of cognitive behavioral therapy or other methods as described earlier [46]. An example of such a treatment app is the behavioral activation app developed by Ly et al. [54]. In a study, the authors compared

participants diagnosed with depression who used either a behavioral activation (BA) app or a mindfulness app [54]. These apps were developed by the researchers [54]. The BA treatment consisted of a web-based psychoeducation (including information on depression as well as the theoretical basis of behavioral activation) and a step-by-step behavior program that was delivered through the app. The aim of the app was to increase everyday activation and contained a database of behaviors from three categories [54]:

- **Everyday structure:** e.g., “Get out of bed when the bell rings in the morning”, “Clean a part of my home”, “Take a brisk walk for 10 min”
- **Social behaviors:** “Call a friend and ask what the situation is”, “Meet a friend in the evening and ask how your day was”, “Cooking with someone”
- **New activities:** “Buy or borrow a book I wanted to read”, “Spend at least 30 min of physical activity”, “Write down at least two good things that happened around me”

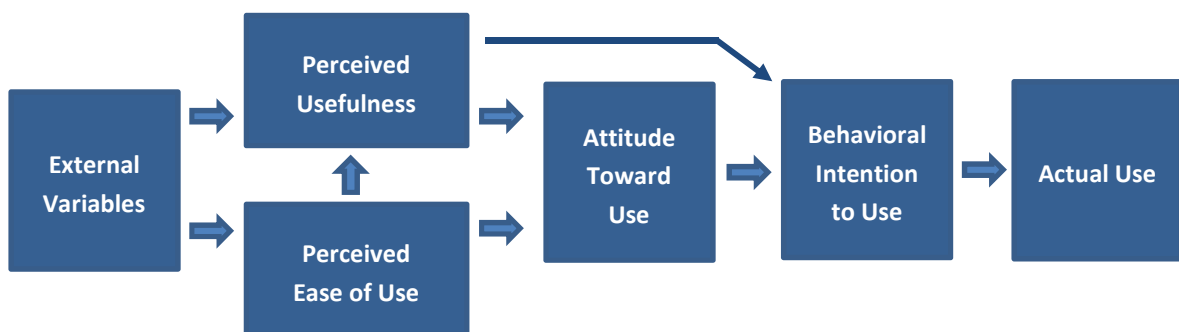
In addition, the participants could expand the list with their own suggested tasks. When one of the listed activities was completed, the participant logged it into the app including personal reflections on them. The app presented the participants with summaries and statistics of these behaviors and reflections. The intervention was supported by a therapist who was able to see the activity summaries and who then gave encouraging feedback via text messages to the participant [54].

### 1.3.2 Attitudes and technology acceptance

An individual’s attitude is “a feeling, belief, or opinion of approval or disapproval towards something” [24]. Positive attitudes are crucial for implementation of new health care interventions, because the approval of a technology leads to its use and adoption [55–57]. This is true for both health care providers and users [55].

Acceptance can be described as a process from attitude to successful experience [58]. In the literature, some authors differentiate between acceptance and acceptability. In this context, acceptability refers more to the willingness to use a tool beforehand and acceptance is constructed subsequently when the tool has been used successfully [57]. However, these two terms are also used interchangeably.

Technology acceptance has been defined with the help of different theoretical models. The “Technology Acceptance Model” (TAM) describes perceived usefulness and ease of use as predictors of attitude towards using a technology [59]. Attitude leads to a certain behavioral intention which finally leads to actual technology use as shown in Figure 2 [59]. This model is grounded on the “theory of reasoned action” which is one of the most influential theories in psychology and describes attitude as predictor of behavioral intention [60].



**Figure 2: Technology Acceptance Model (TAM)**, adapted with permission from Davis FD, Bagozzi RP, Warshaw PR [59].

Another more recent model for technology acceptance is the “Unified Theory of Acceptance and Use of Technology” (UTAUT) [60]. This model includes four main positive predictors of behavioral intention [60]:

- Performance expectancy (the belief that the technology will provide benefits)
- Effort expectancy (belief about the ease of use related to the technology)
- Social influence (the belief of important others related to the technology)
- Facilitating conditions (beliefs about the organizational and technical infrastructure)

In addition to these predictors, four moderating aspects are added to the model: gender, age, experience and voluntariness of use [60].

A model specifically tailored to the health care context is proposed by Sekhon et al. [55]. According to the authors, acceptability of health care interventions is constructed by a variety of factors, including [55]:

- Attitude (the feelings and beliefs about the intervention)
- Burden (the perceived effort to use the intervention, e.g., time, expenses)
- Ethicality (the fit with the value system of the individual)
- Intervention coherence (the extent to which the individual understands the intervention)
- Opportunity costs (the amount of benefits, profits or values that need to be given up to use the intervention)
- Perceived effectiveness (the extent to which the intervention is perceived as successful)
- Self-efficacy (the individual's confidence to being able to perform the requirements of the intervention)

The acceptance of a technology by its users is crucial for its success. As e-mental health interventions are often provided with human support, both user and provider acceptance are needed for the uptake of an intervention [55]. Health care professionals influence patient adoption by guiding their patients. They serve as primary advisors in the process of disease management [55]. Therefore, the present study focuses on the attitudes of health care professionals towards mobile mental health interventions (via smartphones and apps) in the treatment of depression. Within this thematic scope, health care professionals are defined as those professionals who are actively involved in mental health care (e.g., medical practitioners, psychotherapists, nurses or other therapeutic professions).

## 1.4 Context of current research

The application of e-mental health interventions is considered a promising option to reduce access barriers in mental health care [44]. These interventions are used increasingly to support existing health care provision [44]. With the rapidly growing impact of smartphones over the recent years, the interest in these mobile interventions has increased vastly. Due to their accessibility, mobility, ease of use and comparably low cost, mobile interventions have the potential to contribute to the improvement of mental health care [61, 62].

Much research has been done on e-mental health interventions that are computer-based. Studies have shown that computer-based CBT is equally effective as face-to-face therapy for depression [46, 63–67]. Research on mobile interventions for depression is increasing and therefore will be systematically reviewed in the scope of this study.

A few studies on user acceptance of e-health interventions have been published. These studies focus on e-mental health interventions in general but not exclusively on mobile mental health interventions. Research has shown that computer-based CBT for depression is mostly evaluated positively by patients [58]. Studies on health care professionals are less consistent in their findings compared to acceptance research with patients [56, 68–73]. Therefore, the attitudes of health care professionals will be further investigated in the scope of this study.

## **1.5 Aims of this study**

The overall aim of this work is to systematically review the evidence on the efficacy of therapeutic mobile applications for depression and to explore health care professionals' attitudes towards the use of these apps in clinical practice. This study focuses on therapeutic mobile applications with active treatment components (“treatment apps”) as opposed to pure information provision or data collection apps.

The evidence on treatment apps for depression is evaluated in a systematic literature review regarding the following aspects:

- Efficacy of treatment apps in reducing symptoms of depression
- Underlying treatment approach of these apps
- Type or severity level of depression addressed by these apps
- User adherence to the app-based interventions and, if provided, measures on acceptance of treatment apps
- Amount of human support in app-based interventions

The attitudes of health care professionals towards the use of treatment apps in clinical practice are assessed in an online-survey, which focuses on the following thematic components:



- Experience with the use of technology and apps in general
- Awareness and knowledge of apps for depression
- Experience with apps for depression
- Attitudes related to apps for depression

The survey has an explorative character. However, an analysis of group differences regarding age, gender and country of residence of the participants is included because these factors might influence attitudes towards treatment apps as suggested by literature [56, 60, 70].

## **1.6 Ethics approval**

In the scope of this study, an anonymous online survey among health care professionals was conducted. The survey included questions on personal data and attitudes of the healthcare professionals as outlined in Appendix II. Further information on the respondent was not collected or saved. All data were collected completely anonymously and no data was given to third parties. The ethics committee of the Medical Faculty of the Heinrich-Heine University Düsseldorf approved the study on 20 April 2017 (Study number: 5769).

- 2 Smartphone applications for depression: a systematic literature review and a survey of health care professionals' attitudes towards their use in clinical practice, Kerst A, Zielasek J, Gaebel W, *European Archives of Psychiatry and Clinical Neuroscience*, 2019, doi: 10.1007/s00406-018-0974-3 (Epub ahead of print)**



# Smartphone applications for depression: a systematic literature review and a survey of health care professionals' attitudes towards their use in clinical practice

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## Abstract

Smartphone applications (“apps”) may contribute to closing the treatment gap for depression by reaching large populations at relatively low costs. The general public seems open towards the use of apps for mental disorders but less is known about the attitudes of health care professionals. Therefore, the aim of this study was to examine the available evidence on the effectiveness of apps for depression and to explore the attitudes of health care professionals towards their use in practice. A systematic literature search was performed aimed at studies utilizing smartphone applications for depression. In addition, a survey was conducted to explore health care professionals' attitudes towards using these treatment apps in clinical practice. Twelve articles were identified in the systematic literature review. All included trials reported a decline in depressive symptoms after the intervention periods. In the survey, 72 health care professionals participated. Significant differences were found between the level of technology experience and how much the health care professional would consider the use of mobile applications in clinical practice. Survey participants reported openness towards therapeutic app use but very little knowledge and experience in the field. Apps appear to be a promising self-management tool for reducing depressive symptoms. Despite some concerns, health care professionals' attitudes towards the use of smartphone applications in clinical practice are quite positive. The provision of information on the potential benefits of e-health interventions as well as the training of professionals in the application of new technologies may increase health care professionals' awareness and knowledge about mobile apps for the treatment of mental disorders.

**Keywords** e-Mental health · Depression · Smartphone applications · Mobile health · mHealth · Apps

## Introduction

Depression is one of the most common mental disorders with more than 300 million people affected worldwide. It is a major contributor to the overall global burden of disease and the leading cause of disability [1]. Although depression is a highly prevalent and disabling disease, only a part of affected individuals receives adequate treatment

[2]. The median untreated rate for depression is estimated to be more than 50%, even though these rates vary per region in the world [3]. This treatment gap is a growing public health concern and the improvement of access to mental healthcare is one of the major issues in this field [4]. Numerous barriers to treatment have been identified to explain this shortcoming in mental health care provision. These include the lack of available facilities and trained professionals, the cost of treatment, stigma, structural barriers and lack of perceived need for treatment [3, 5]. Because the prevalence of depression is so high and not likely to decrease in the near future, it appears doubtful that the traditional ways of providing mental healthcare alone will be able to meet the demands [6]. Scaling up mental health care may need to make use of innovative treatment approaches. In this context, the interest in e-mental health interventions has grown substantially in recent years. Digital technologies have strongly advanced

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during the last decades and the current developments in this field are very promising [7]. The new technologies may enhance the provision of mental healthcare, contribute to closing the treatment gap and may lead to improved cost-effectiveness because large populations may be reached at relatively low cost [8]. Especially smartphone-based approaches and the use of mobile applications (apps) gain increasing attention due to the immense and expanding number of smartphone-users worldwide. It is estimated that in 2020 there will be more than 6 billion individuals worldwide using smartphones, representing 70% of the global population [9]. Thus, mobile interventions are considered to play a major role in future healthcare provision [8]. They can be incorporated in all stages of disease management (prevention, treatment, aftercare) and target different functions, for example symptom assessment, patient education, communication or treatment adherence [7]. Furthermore, there are treatment apps which are based on already established treatment methods, for example, cognitive behavioral therapy or behavioral activation [5].

Among the disease-specific apps, mental health applications play a considerable role and depression is one of the most commonly addressed mental health conditions [10]. Studies suggest that the general public is open towards these interventions for the treatment of mental disorders [11]. Health care professionals' attitudes towards app use in clinical practice are examined to a much lesser extent. However, there are studies that investigated health care professionals' acceptance towards general e-mental health interventions and these studies report varying degrees of openness [12–19]. Despite the fast pace of technological advances and the large number of health related apps on the market, research in this field is still in its infancy. Existing reviews on mobile interventions include groups of mental disorders or do not focus solely on treatment apps. Our aim was to examine the available evidence on the effectiveness of treatment apps for depression. In addition, we sought to explore the attitudes of health care professionals towards the use of these apps because they play a key role in the implementation of new technologies and represent the link between research and practice [15].

## Methods

### Systematic literature search

A systematic literature search was conducted in three databases: Medline (Pubmed), the Cochrane Library and Scopus (Elsevier). Studies were selected according to predefined inclusion and exclusion criteria.

Inclusion criteria:

- The study assesses treatment apps, defined as smartphone applications that contain active treatment components (e.g., based on cognitive behavioral therapy, behavioral activation).
- The smartphone application targets depression in a clinical or subclinical population.
- One main outcome measure is symptoms of depression.
- The study is written in English or German language.

Exclusion criteria:

- The app is solely used for symptom monitoring, assessment, data collection, medication/therapy adherence or prevention.
- The app is solely used for lifestyle change (e.g., diet, exercise).
- The app is a pure text-messaging or videoconferencing app.
- The app is a virtual reality or gaming app.
- The app is designed only for health care professionals.
- The study is a protocol, manual, conference abstract or opinion paper.

The search algorithm included a combination of the following terms with the asterisk indicating a truncation: *intervention\**, *app\**, *blended*, *mhealth*, *e-health*, *e-mental health*, *mobil\**, *depression*, *major depressive disorder*, *mood disorder*.

No further limits were set to the databases. The selection process followed the inclusion and exclusion criteria above as well as a quality assessment using quality checklists. These checklists contained information on study quality, study characteristics and an overall assessment.

### Survey design and development

A questionnaire was developed with the aim to explore health care professionals' attitudes toward using treatment apps in clinical practice. As operationalized in the systematic literature search, apps were defined as smartphone applications that contain active treatment components and target depression. The target group of the survey was mental health care professionals. This group was defined as professionals who are actively involved in mental health care, like psychiatrists, psychologists, (psychiatric) nurses, social workers, occupational therapists or others.

The content of the questionnaire was built based on the results of the literature search described above as well as additional searches related to acceptance of mobile technologies in mental health care. The survey contained 25 questions covering different thematic components: demographic information about the respondent (gender, age, country of residence, profession and professional experience), general



technology use (experience with technologies in general, smartphone ownership and app use) and experience and attitudes related to app use in clinical practice (awareness related to apps, expectations of treatment outcomes with apps alone and their use in a combined treatment approach, professional support and the availability of apps). Finally, a number of facilitators and barriers for the use of treatment apps were included to be rated for their relevance. All ratings were performed on five-point or four-point Likert scales. The questionnaire has been validated by a number of test-runs with mental health care professionals. They checked the questionnaire for comprehensibility (in form and content), completeness and technical functionality before the data collection started. Feedback was used to adapt the questionnaire accordingly.

### Data collection and analysis

The survey was administered with the scientific online survey platform *SurveyMonkey*. Data collection was initiated via email lists and online-platforms of these supporting organizations: *Arq Foundation* (Diemen, The Netherlands), *Mental Health Reform* (Dublin, Ireland), *Etablissement Public de Santé Mentale Lille-Métropole* (Lille, France) and *Aktionsbündnis Psychische Gesundheit* (Berlin, Germany). The organizations are active in mental health and represent a variety of professional groups in this field. They are all interested in e-mental health and were selected from existing contacts. The mentioned organizations were the ones that agreed to support the distribution of the survey. The link to the survey was sent via email (e.g., in newsletters) and put online on associated webpages. Due to the anonymous and open access character of the survey as well as the unknown number of web page visitors, it was not possible to estimate a response rate for the survey.

Data analyses were performed in IBM SPSS version 22. Descriptive and explorative analyses were conducted. A Wilcoxon–Mann–Whitney test was performed to identify gender differences in the scoring for consideration of app use as well as the scoring for concern about app use. Kruskal–Wallis tests were conducted to identify differences in age, country of residence or the amount computer experience and how much one would consider the use of apps or how much concern one has about the use of apps in clinical practice.

## Results

### Literature search

The search yielded 141 documents including ten duplicates, which were removed. After screening titles and

abstracts of these 131 studies, 25 full texts were acquired. Eight additional full texts were included from cross-references of the obtained studies or from hand searches. Thirty-three studies met the eligibility criteria and were selected for full text review and quality assessment. Twenty-one studies were then excluded due to low quality or irrelevant content. Finally, twelve studies were selected for the review. The article selection process is shown in Fig. 1.

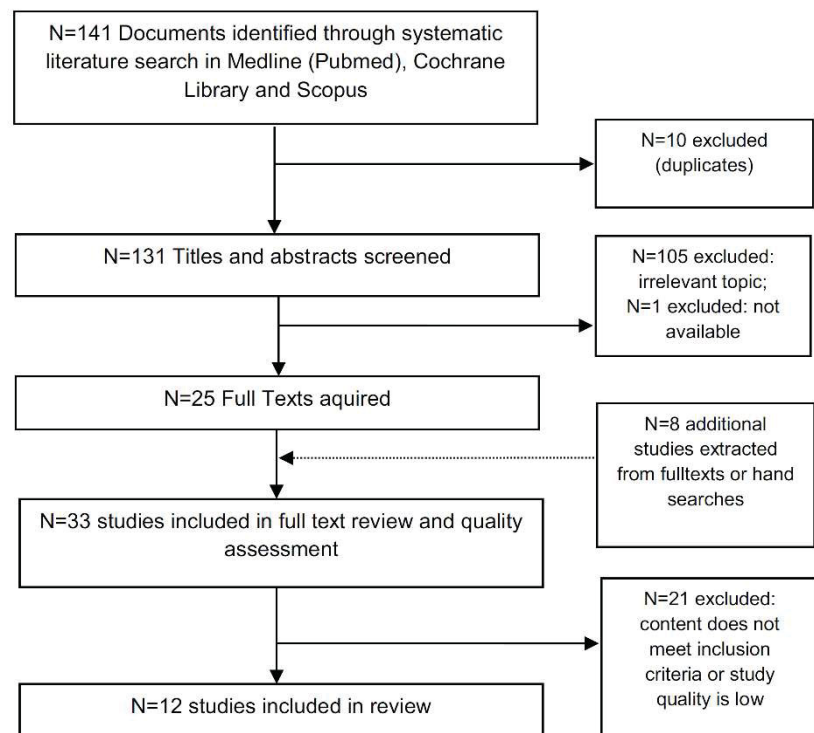
### Characteristics of included studies

All reviewed studies are summarized in Tables 1 and 2. Eligible studies included three randomized controlled trials (RCTs), two pilot-RCTs, two single arm pilot trials, one prospective cohort study, three review articles and one meta-analysis. Sample sizes of the included trials varied from 24 to 626 participants. Most trials included samples with clinical levels of depression as determined by the Patient Health Questionnaire (PHQ) or the Beck Depression Inventory (BDI) [20–23]. The remaining trials focused on sub-clinical levels of depression [6, 24, 25]. The symptom assessment was done online [21, 24] or by a (phone-) interview [6, 20, 23]. One study did not report the method of initial assessment [25]. In two studies, the diagnosis was administered by a clinician and the sample was drawn from a clinical setting [22, 26]. The remaining studies recruited their participants from the general population. From the studies that used a control condition, most of these were active control conditions providing another intervention. Two of the included RCTs used a waitlist–control condition [23, 24]. Some trials were underpowered or did not give information on the statistical power. Overall, the level of evidence of the included studies was very heterogeneous.

Therapeutic approaches of apps used in the trials included cognitive behavioral therapy (CBT), acceptance and commitment therapy, behavioral activation (BA), mindfulness-based treatment and behavioral strategies like targeting emotional regulation or cognitive reframing. Interventions were supported by clinicians in most trials. Two trials had only minimal clinician support and one intervention was conducted without any support by a clinician. Details are given in Table 1.

Eligible studies also included three review articles and one meta-analysis. The meta-analysis focused on smartphone-apps for depressive symptoms [27]. The other review articles focused on a broader scope of mobile interventions and mental disorders but they included relevant evidence on depression [5, 11, 28]. For the purpose of completeness these studies are included and presented separately (Table 2).

**Fig. 1** Flow of studies retrieved in the systematic literature search



### Intervention effects, adherence and user satisfaction

The maximum length of an intervention in the included trials was 12 weeks [22, 25]. Other trials conducted interventions of 8 weeks [6, 20, 23, 26] and 4 weeks [21]. Adherence rates to the respective interventions as conducted in each study varied between 70% up to 94% [20, 22, 23, 25, 26]. Two studies had lower rates between 22% and 35% of participants adhering during the intervention period [21, 24]. Furthermore, high participant satisfaction as well as acceptability of the mobile interventions was reported [22, 23, 25]. In the study by Watts et al. [23], all participants were either very satisfied or somewhat satisfied with the intervention. In another study by Schmädeke and Bischoff [22], one-third of an eligible participant group declined to engage in the intervention which the authors evaluated as an acceptance problem. However, participants who engaged in the study reported high satisfaction with the intervention [22]. All included trials reported a decline in the PHQ-9 or BDI-scores after the intervention periods. Effect sizes were not reported in all trials but when reported they ranged from medium to large effects, depending on the comparison. Details on the main outcomes of the interventions are outlined in Table 1.

### Survey

#### Participants

Out of 72 individuals who filled out the survey questionnaire, 15 had to be excluded from the analyses because they did not belong to the target group of health care professionals. Included professionals were medical practitioner/psychologists/psychotherapists ( $n=33$ ), other therapeutic professions like, e.g., occupational therapists ( $n=13$ ), nurses ( $n=7$ ) and social workers ( $n=5$ ). From the included individuals, 31.6% ( $n=18$ ) were male and 64.9% ( $n=37$ ) were female. Two participants did not report their gender. The mean age was 43 years ( $SD=12.3$ ) with an age range of 21–74 years. Participants came from France ( $n=2$ ), the Netherlands ( $n=4$ ), Ireland ( $n=14$ ) and Germany ( $n=37$ ). Participants had a mean professional experience of 14.8 years ( $SD=12.2$ , range 1–42 years).

#### App use and technology experience

The vast majority of participants (93%,  $n=51$ ) owned a smartphone and stated to have “a lot” (29.8%,  $n=17$ ) or “quite a lot” (52.6%,  $n=30$ ) experience with computer technologies. The remaining 17.5% ( $n=10$ ) of the

**Table 1** List of included studies and details on design and main outcomes

References	Type of study	Study sample	Design	Clinician support	Relevant primary outcome measure	Main findings
Arean et al. [24]	RCT	626 Participants with mild-to-moderate symptoms of depression as determined by a PHQ-9 score $\geq 5$ , or if their score on item 10 was $\geq 2$ ; recruitment through web-based advertising sources	12 Weeks "EVO" (cognitive control app) vs. "iPST" (problem solving therapy app) vs. "Health Tips" (Information Control)	Minimal participant contact through email or SMS; sending of reminders if the participants had 3 consecutive days of missing data	PHQ-9	Differential treatment effects were present in participants with a baseline PHQ-9 score of more than 10. The cognitive training and problem-solving apps resulted in greater effects on mood than the information control app in participants with baseline PHQ-9 score $> 10$ ( $\chi^2 = 6.46$ , $p = 0.04$ )
Lappalainen et al. [25]	Pilot RCT	24 Male participants with self-reported stress and mood problems; recruitment through local newspaper advertising; no BDI cut-off for inclusion reported	12 Weeks "P4Well" (CBT and acceptance & commitment therapy-based intervention) and 3 group meetings vs. waitlist control	3 Psychologist-assisted group meetings	BDI	Depressive symptoms decreased more in the intervention group compared to the control group. There was a slightly significant group by time-interaction effect for the BDI ( $p = 0.072$ ). In the treatment group the mean BDI score decreased with more than eight scores (CI 4.92–11.99) compared to four scores (CI 0.62–7.38) in the control group. A medium effect size ( $d = 0.57$ ) was found between groups in favor of the intervention group. Post- and follow-up BDI were significantly lower than pre-intervention in the intervention group (BDI: $d = 1.11$ , $p < 0.001$ )



Table 1 (continued)

References	Type of study	Study sample	Design	Clinician support	Relevant primary outcome measure	Main findings
Ly et al. [20]	RCT	81 Participants diagnosed with MDD as defined by the Statistical Manual of Mental Disorders (DSM-IV); assessed by a diagnostic interview; patients scoring $\geq 5$ on the PHQ-9 were included; recruitment via mass media and newspaper advertising	8 Weeks behavioral activation (BA) versus mindfulness-based guided self-help treatment administered through a smartphone application	Minimal therapist contact via text messaging and email (max. 20 min per participant per week)	BDI-II, PHQ-9	Significant improvements of BDI were found in both treatment conditions. BA treatment was more effective among participants with higher initial severity of depression from pretreatment to the 6-month follow-up (PHQ-9: $F(1, 362.1) = 5.2$ , $p < 0.05$ ). The mindfulness treatment worked better for participants with lower initial severity of depression from pretreatment to the 6-month follow-up (PHQ-9: $F(1, 69.3) = 7.7$ , $p < 0.01$ ); BDI-II: $F(1, 53.60) = 6.25$ , $p < 0.05$ )
Mantani et al. [26]	RCT	164 Patients with major depression as defined by DSM-V and antidepressant-resistant as indicated by a BDI-II score $\geq 10$ ; PHQ-9 scores were assessed by telephone; recruitment among patients in 20 psychiatric clinics and hospitals	8 Weeks medication switch alone vs. medication switch plus smartphone CBT app "Kokoro" (including self-monitoring, behavioral activation, and cognitive restructuring)	Weekly congratulations emails to participants on their progress; telephone interviews to assess PHQ-9 in weeks 0, 1, 5, 9, and 17	PHQ-9, BDI-II (secondary outcome measure)	Added smartphone CBT was more effective than treatment by medication change alone. Of the total sample, patients allocated to the CBT app scored 2.48 points (95% CI 1.23–3.72, $p < 0.001$ , 0.4) lower on PHQ-9 and 4.1 points (95% CI 1.5–6.6, $p = 0.002$ ) lower on BDI-II than those who were not. Of the per-protocol sample, the intervention group scored 1.72 points (95% CI 0.25–3.18, $p = 0.02$ ) lower on PHQ-9 and 3.2 points (95% CI –0.01–6.3, $p = 0.05$ ) on BDI-II



Table 1 (continued)

References	Type of study	Study sample	Design	Clinician support	Relevant primary outcome measure	Main findings
Mohr et al. [6]	Single-arm pilot trial	99 Participants with elevated symptoms of depression or anxiety (score > 10 on PHQ-9); assessed by a phone interview and web-based questionnaire; recruitment from a variety of sources (internet, print advertisement, clinical research registries)	8 Weeks of coaching on the use of "IntelliCare" (skills focused app selection to reduce symptoms of depression and anxiety)	Coaching via one initial phone call of 30–45 min and text messaging (1–2 texts per week)	PHQ-9, GAD-7	Participants showed substantial reductions in the PHQ-9. Significant reductions in symptoms of depression were found in the entire sample (PHQ-9: $d=1.4$ ; $p<0.001$ )
Schmäddeke & Bischoff [22]	Prospective control group study	92 Inpatient aftercare patients with an ICD-10 unipolar affective disorder; diagnosis administered by a clinician	3 Months of eATROS smartphone supported cognitive behavioral rehabilitation aftercare vs. ambulant post inpatient aftercare	Support via telecoaching and emergency contacts	BDI	Patients in the intervention group were more capable to maintain the rehabilitation-induced improvement of the depressive symptoms. A medium effect was found (partial $\eta^2=0.07$ ). Patients of the intervention group were significantly less depressed than the control group at post intervention (BDI: $F=6.76$ , $p<0.01$ )
Wahle et al. [21]	Single-arm pilot trial	126 Clinically depressed participants (PHQ-9 $\geq 11$ ) assessed by an online-screening survey; recruited from the general public through advertising	4 Weeks of using the CBT-smartphone app "MOSS" (Mobile Sensing and Support)	No clinician support	PHQ-9	Subjects who used the app for a prolonged time-frame showed significant reduction in self-reported symptom severity. For subjects with PHQ-9 $\geq 11$ at baseline and adherence $\geq 8$ weeks, the score on PHQ-9 dropped significantly ( $p=0.01$ )

Table 1 (continued)

References	Type of study	Study sample	Design	Clinician support	Relevant primary outcome measure	Main findings
Watts et al. [23]	Pilot RCT	35 Participants diagnosed with MDD as defined by DSM-IV and assessed by the PHQ-9 and Mini International Neuropsychiatric Interview Version 5.0.0 (MINI); the interview was done by phone	8 Weeks of app-based CBT vs. computer-based CBT ("Get Happy Program")	Clinician support via email or phone calls until session two of the intervention	PHQ-9, BDI-II	Significant symptom reduction was found in both groups, PHQ-9 Pre- to follow-up within group measurement for the mobile group: ( $F [3, 73.6] = 28.4, p \leq 0.001$ ); BDI-II ( $F [2, 47.09] = 60.1, p \leq 0.001$ )

participants described to have "a little" experience with computer technologies. Daily use of their smartphone apps was reported by 75.4% ( $n = 43$ ) of the respondents. On average, the participants used seven apps on their smartphone on a regular basis ( $SD = 7.5$ ). Less than half of the respondents (45.6%,  $n = 26$ ) stated that they did not know apps for mental disorders. Knowledge of apps for mental disorders was reported by 42.1% ( $n = 24$ ) of the participants. For applications that are specifically used for depression, 59.6% ( $n = 34$ ) of the respondents stated that they did not know any of these apps and 31.6% ( $n = 18$ ) stated that they knew apps for depression. With regard to their own use of apps in clinical practice, 70.2% ( $n = 40$ ) of the participants replied that they had never used apps in clinical practice before. Only 21.1% ( $n = 12$ ) stated that they had used treatment apps before.

### Attitudes

Of those, who had never used treatment apps before, 40.3% ( $n = 23$ ) would consider their use "a lot" or "quite a lot". Another 33.3% ( $n = 19$ ) of the respondents would use treatment apps "a little" or "very little". Only 3.5% ( $n = 2$ ) stated that they would not use apps at all in their practice. Regarding the helpfulness for different levels of depression, the respondents were asked to rate each level according to their opinion. Most participants considered apps most helpful for individuals with sub-clinical levels of depression (68%,  $n = 34$ ) followed by mild-to-moderate depression (52%,  $n = 26$ ) and finally for severe depression (10%,  $n = 5$ ). The majority of the respondents (64.9%,  $n = 37$ ) found that apps should be freely available to anyone. Concerning the use of treatment apps with the support of a health care professional, 45.6% ( $n = 26$ ) of the respondents voted against and 42.1% ( $n = 24$ ) voted in favor of app use only with support of a health care professional. Apps were rated more helpful in a combined treatment approach than as a stand-alone intervention. The majority of the respondents (66.0%,  $n = 33$ ) expected treatment outcomes to be "better" or "much better" when apps are added to the treatment of depression. Negative attitudes of therapists towards digital treatment, lack of therapist contact, limited security of personal data and privacy protection and limited suitability for certain patient groups were the most named barriers for therapeutic app use. Easy access to treatment, increased availability of therapy anytime and anywhere, and the reach of certain patient groups received strongest agreement as facilitators of therapeutic app use (Table 3).

Kruskal–Wallis tests showed no significant differences between age groups or the country of residence and the scoring for consideration of app use as well as the concern about app use. Significant differences were found in the levels of computer experience and how much one would

**Table 2** List of included reviews with details on study purpose, sample and relevant findings for the treatment of depression

References	Type of study	Study purpose	Study sample	Relevant findings
Donker et al. [11]	Systematic review	Review on the efficacy of mental health apps for mobile devices	227 Participants across 8 included studies using apps for depression, stress and substance use	The review found promising results for evidence-based mental health apps in reducing depressive symptoms. Included studies on depression showed a significant reduction of depressive symptoms
Firth et al. [27]	Meta-analysis	Review on the efficacy of smartphone-based mental health interventions for depressive symptoms	18 RCTs included with data from 3414 participants with depression, bipolar disorder, social anxiety, insomnia, PTSD, ADHD, suicidal thoughts	Smartphone apps had a significant effect on reduction of depressive symptoms compared to control conditions ( $g=0.38$ , 95% CI: 0.24–0.52, $p<0.001$ ). A moderate effect was found in comparison to inactive control conditions ( $g=0.56$ , 95% CI: 0.38–0.74). Only a small effect was found in comparison to active controls ( $g=0.22$ , 95% CI: 0.10–0.33)
Menon et al. [28]	Systematic review	Review on psychotherapeutic applications of mobile phone-based technologies	24 Articles were included with apps related to anxiety, substance use, depression, bipolar disorder, schizophrenia, psychotic disorders and attempted suicide	In general, apps were found to be feasible and acceptable. Effectiveness trials are scarce. Apps for depression lead to a reduction of depressive symptoms in the included studies
Van Ameringen et al. [5]	Review	Review on the current state of mobile applications for DSM-5 obsessive-compulsive disorder, posttraumatic stress disorder and mood disorders	Five studies exploring the efficacy of treatment-based smartphone apps for MDD were included	Studies show some promise in relieving symptoms of depression. MDD treatment apps have suggested efficacy in controlled settings. In naturalistic settings, effects become less pronounced

**Table 3** Number of respondents (in %) rating facilitators and barriers for therapeutic app use

	Strongly agree	Agree	Disagree	Strongly disagree
<b>Facilitators</b>				
Easy access to treatment	37.2	49.2	13.6	0.0
Availability 24/7	37.2	49.2	13.6	0.0
Availability anywhere	44.1	44.1	11.8	0.0
Reach certain patient groups (e.g., young individuals)	37.3	52.5	10.2	0.0
<b>Barriers</b>				
Negative attitudes of therapists towards digital treatment	34.0	46.0	16.0	4.0
Lack of therapist contact	42.0	44.0	14.0	0.0
Limited security of personal data and privacy protection	54.0	24.0	20.0	2.0
Apps are not suitable for all patient groups (e.g., older individuals)	34.0	42.0	24.0	0.0

Rating on a four-point Likert scale: 1 = “strongly agree” to 4 = “strongly disagree”.  $N=59$

**Table 4** Mean values for “consideration of app use” as well as “concern about app use” regarding gender, age, country of residence, and amount of computer experience

	Consideration of app use			Concern about app use		
	Mean	SD	<i>p</i>	Mean	SD	<i>p</i>
Gender			0.43			0.76
Male	3.6	1.2		3.1	1.0	
Female	3.3	1.0		3.2	0.9	
All	3.4	1.0		3.2	1.0	
Age group			0.42			0.44
Age 21–29	3.7	1.5		3.1	0.4	
Age 30–39	3.7	0.6		3.1	0.8	
Age 40–49	3.2	1.3		3.5	1.0	
Age 50–59	3.4	0.7		2.8	1.2	
Age 60–74	3.3	1.0		2.8	1.1	
All age groups	3.4	1.0		3.2	0.9	
Country			0.68			0.38
IE	3.3	1.3		3.2	1.2	
DE	3.6	0.9		3.2	0.8	
NL/BE/FR	2.8	1.3		2.7	0.8	
All countries	3.4	1.0		3.2	0.9	
Computer experience			<b>0.03</b>			0.57
“A little”	3.3	1.0		3.4	0.5	
“Quite a lot”	3.2	0.9		3.1	1.0	
“A lot”	4.0	1.2		3.1	1.0	
All levels	3.4	1.0		3.2	0.9	

Statistically significant value is in bold ( $p < 0.05$ )

*P* significance level of Wilcoxon-test (gender) or Kruskal–Wallis-test (age, country, experience)

Consideration of app use rated on a five-point Likert scale: 1 = “not at all” to 5 = “a lot”;

Concern about app use rated on a five-point Likert scale: 1 = “no concern” to 5 = “a lot”

DE Germany, IE Ireland, NL The Netherlands, BE Belgium, FR France

Computer Experience rated on a five-point Likert scale: 1 = “none” to 5 = “a lot”

SD standard deviation

consider using apps in clinical practice (Table 4). The Wilcoxon Mann–Whitney test did not show gender differences in how much one would consider the use of apps in clinical

practice or how much concern one had about the use of apps in clinical practice. Mean values and standard deviations for age, country of residence, gender, the amount of computer



experience and the consideration of app use as well as concern about app use are shown in Table 4.

## Discussion

App-based interventions lead to a reduction of symptoms of depression in all reviewed studies. These results appear promising and are in line with previous reviews on other e-mental health interventions [4, 5, 11, 27–31]. The adherence and user satisfaction were good in more than half of the included trials which may provide a link to their acceptability, indicated by these two factors [29]. Acceptability of an intervention among patients is an important factor for sustainability and successful implementation in practice [32]. The vast majority of the studies included some sort of clinician support during the intervention periods, which makes it difficult to completely isolate the intervention effects due to the new technologies [5]. Using apps in a combined treatment approach might be the preferred method of their application. Previous research has also shown that clinician support improves adherence and outcomes [6, 33]. Health care professionals play a vital role when it comes to the application of new and effective therapeutic approaches [32]. They are the primary advisors to patients and directly influence their attitude formation towards a treatment method [34]. When acceptability is low, the overall effectiveness of an intervention may be hampered [32].

Despite the promising findings of the reviewed studies, it needs to be pointed out that the evidence base is still limited. In addition, the quality of the evidence in the selected studies differed widely and included a number of small-scale pilot trials and single arm trials with no comparator. Some of the studies that used a control group, compared to an active control condition which was not an established treatment approach in all cases. The effects of the interventions may be smaller compared to active controls than to inactive control groups which has also been shown previously [27]. The interpretation of the results should thus be made carefully.

Overall, survey respondents' attitudes towards app use in the treatment of depression were quite positive. Similar positive attitudes of health care professionals towards technology use have also been reported in other studies [15–19]. The health care professionals in the survey reported a good understanding of technology and regular use of smartphones. But only a few participants had knowledge about app-based interventions or actual experience with them in the treatment of depression or other mental disorders. Awareness of existing therapeutic technologies seems to be quite low. One of many reasons for this might be the fact that validated and reliable apps are often not freely available because they were designed for study purposes [35]. In most countries,

apps or other e-health technologies are not yet integrated into standard health care provision.

A considerable number of respondents were open towards app use and would consider using them a lot in clinical practice. Participants regarded apps as most suitable for sub-clinical levels of depression followed by mild levels of depression. That apps were considered to be more suitable for mild-to-moderate symptoms than for severe symptoms was also found in previous studies [5, 13, 27]. Our survey participants expected app use in combination with face-to-face treatment to be more effective than the stand-alone app treatment. A combined treatment approach thus appears to be the preferred treatment option by health care professionals. Guidance and professional support are supposedly key factors in the use of e-health interventions [33, 36]. As indicated above, a combined treatment approach might not only be more effective for patients but also more acceptable for professionals and by this easier to implement in practice.

We found significant differences between the levels of computer experience and how much one would consider app use in clinical practice. Thus, more familiarity with technology positively influences the attitude towards apps and the expectation of their therapeutic benefits. Accordingly, prior experience with (health-) technologies is an important facilitator for acceptance of e-health interventions which has also been reported in other studies [15, 34, 37]. The acceptance and willingness to use these interventions could be improved by education and training in the field. In a study by Perle et al. (2013), the majority of included psychologists stated that they were more willing to use e-health interventions with additional training and education [38]. In another study by Titzler et al. (2018), the necessity of providing educational and training sessions to become familiar with new technologies was pointed out by participating psychotherapists who were asked about their perspectives on blended therapies including internet- and mobile-based interventions [39]. Exposure through demonstration of an intervention and the provision of information material may also positively influence attitudes as has been shown in studies on computerised cognitive behavioral treatment [40]. The distribution of evidence-based information as well as the provision of training sessions, seminars and workshops for e-health could be used to positively influence attitudes and uptake of web- and mobile-based interventions.

Studies have found that male health care professionals show higher acceptance of e-health interventions than female health care professionals [15, 34, 41]. Younger age may also positively influence acceptance of e-health interventions [15, 34, 38, 40]. Our analyses could not confirm these previously reported gender or age differences. Effects in our analyses were small-to-moderate without reaching significance level. However, a post hoc power calculation revealed that age and gender would have reached significance level in a sample of



150–200 participants, whereas the obtained sample size was sufficient to ensure the large effect for “computer experience” and “consideration of app use” as reported.

The participants in our survey considered the lack of therapist contact, negative attitudes of therapists towards digital treatment and limited data and privacy protection as the biggest drawbacks in app use. Especially the concerns about data protection are a frequently cited problem [10, 13, 39, 42, 43]. Given the enormously growing app market, it is difficult to select those apps that are reliable and effective [43]. In fact, there are no regulations or mandatory guidelines for quality or data protection to date. Many apps fail to provide accurate privacy policies [10]. This barrier is increasingly recognized by stakeholders and there are now attempts to develop guidelines and quality criteria including data protection for internet interventions [7, 10, 44].

## Limitations

This study has several limitations. The number of included studies in the review was small and the quality varied widely. The limited amount of available research may lower the generalizability of the presented results. In addition, the intervention periods were relatively short with a maximum of 3 months. The sustainability of effects and long-term adherence needs to be confirmed in studies over a longer period of time. Furthermore, only two studies recruited the sample from a clinical setting with an actual clinician-administered diagnosis. The remaining studies recruited from the general population and partly used self-assessment tools for inclusion. This may limit the meaning of the results in relation to real disease. The apps that were used in the included trials varied and it is not yet clear which components of the interventions are effective and which mode or frequency of use is most beneficial for adherence and outcomes. As the field of research on mobile interventions is relatively new, these aspects need to be addressed in future research. The review focused especially on treatment apps for depression which might have excluded other good internet interventions that have been studied. In addition, the outcomes of our study may not be applicable to other types of mobile interventions or other mental disorders.

Our survey results should be interpreted with caution. Despite all recruitment efforts, the number of responding health care professionals was small. Furthermore, the majority of our respondents were female and German, which may limit the generalizability of the results. Finally, most of the respondents did not have any experience with smartphone applications in clinical practice. Thus, participants replied from a more theoretical point of view, which needs to be taken into account in the interpretation of the results.

## Conclusion

Apps appear to be a promising self-management tool for reducing depressive symptoms and seem to be acceptable for both app users and professionals. Despite some concerns, health care professionals’ attitudes towards the use of mobile interventions in clinical practice are rather positive. Therapeutic benefits of apps are seen especially in their application in combination with other treatment methods and for mild-to-moderate levels of depression. Positive attitudes are necessary for future implementation. However, health professionals lack knowledge and experience related to app use in the treatment of mental disorders. The provision of information on the potential benefits of e-health interventions as well as the training of professionals in the application of new technologies may increase health care professionals’ awareness and knowledge about mobile apps for the treatment of mental disorders.

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## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical standards** The survey was approved by the ethics committee of the Medical Faculty of the Heinrich-Heine University Düsseldorf.

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## 3 Discussion

The aim of the present study was to systematically review the literature on therapeutic mobile applications for depression and to provide insights into health care professionals' attitudes towards the use of these treatment apps in practice. In the following paragraphs, the results of the study are briefly summarized and discussed in more detail.

### 3.1 Systematic literature review on treatment apps for depression

#### 3.1.1 Overall evidence on treatment apps

All trials included in the present systematic review reported a reduction of depression symptoms [74]. Effect sizes, if reported, were medium to large, depending of the comparison [74]. Research on non-mobile e-mental health interventions for depression and anxiety found comparable effects and high efficacy was reported in many studies [43]. Strongest evidence exists for e-mental health interventions for anxiety and mood disorders [43, 63, 75–77]. Several studies and meta-analyses have shown that computer-based CBT (cCBT) is comparable to face-to-face therapy in terms of efficacy [46, 63–67]. E-mental health interventions have also been studied in the scope of the treatment of somatic disorders. Studies have shown that these interventions can reduce depressive symptoms in cancer, heart-disease or diabetes patients [44, 78]. There is also evidence for the clinical efficacy of e-mental health interventions for other mental disorders, e.g., psychotic disorders or posttraumatic stress disorder (PTSD), that indicates the potential of these approaches [5, 43, 61, 79].

Within the field of mobile interventions, there are comparably more studies on depression than on other common clinical conditions, such as diabetes or anxiety disorders [80]. The findings of this systematic review indicate that treatment apps may provide comparable effects to other therapeutic e-mental health interventions, e.g., computer-based CBT. Other review articles and meta-analyses on general mental health apps showed that the use of these apps can reduce symptoms of depression as well [48, 80–82]. Most of these studies included a variety of mental health conditions (e.g., anxiety, stress, insomnia, memory

complaints, PTSD or attention deficit hyperactivity disorder (ADHD)) and various types of apps (e.g., mood monitoring, cognitive training, symptom assessment).

Research on mobile interventions and apps for depression is less advanced than research on cCBT, which became evident in the systematic literature review of this study [74]. There are fewer research studies available and methodological limitations are reported [74]. This has implications for the generalizability of the results of the studies. The studies included in the systematic review varied in their duration and sample sizes. Some studies had small samples and the maximum duration of the trials was three months. Given the relatively short duration of most trials, it needs to be investigated if the apps also provide medium to long-term effects on depression symptoms [83]. Not all trials used a control group or a waitlist-control condition [74]. The use of active versus passive control groups may influence the effect sizes of a trial. Effect sizes with passive controls may be greater compared to active controls [74]. In this systematic review, two studies used a waiting-list control condition. However, the non-provision of a potentially beneficial intervention in a study is not recommended from an ethical perspective [84]. Long-term studies on a larger scale are needed to confirm the results of present studies [74]. Given the interest in mobile applications for the treatment of mental disorders, scientific evidence for clinical efficacy of these interventions is claimed increasingly [83, 85]. On the other hand, some authors argue that current evidence on the clinical efficacy of mobile applications under controlled circumstances does not necessarily exclude the usefulness of these interventions for the everyday reality of users [86].

### **3.1.2 Underlying therapeutic approaches and depression severity**

Treatment apps for depression used in the studies of this systematic review were based on evidence-based therapeutic techniques including additional elements of psychoeducation [74]. The apps were applied in treatment and rehabilitation. They were based on CBT, acceptance and commitment therapy, behavioral activation, mindfulness-based treatment, emotional regulation or cognitive reframing [74]. These therapeutic methods were, for example, incorporated into step-by-step plans that the participant had to follow and included additional interactive elements like reminders to promote the fulfillment of the given tasks [87]. Most of the current online interventions are built this way. Often, they are based on well-structured treatment manuals that are transferred to the e-mental health intervention

[88]. Firth et al. [80] tried to isolate the effects of the underlying therapeutic approaches of various apps for depression but they found no difference in their efficacy. This is in line with evidence that shows that the established therapeutic techniques are more or less equally effective, as mentioned earlier [30]. It is not yet clear which frequency of app-based interventions is most beneficial. Studies on cCBT suggest, that more intense use of e-mental health interventions as well as a longer duration of use improve treatment outcomes [89, 90].

The samples of the included studies of the systematic review were mostly convenience samples recruited via a variety of channels [74]. Most samples in those studies were chosen according to certain cut-off points on the PHQ-9- or BDI-scales. The cut-off points differed per study and included participants ranging from mild to moderate symptoms of depression [74]. Due to the broader range of inclusion criteria, it is difficult to apply the results to one specific level of depression severity. Very severe levels of depression or suicidality were often an exclusion criterion. In contrast, non-mobile approaches have also proven their efficacy in severe cases of depression [30]. This has yet to be shown for smartphone applications or other mobile interventions. The present systematic review on treatment apps gives insight into the efficacy for mild to moderate depression.

Only two studies from the included trials had drawn their sample from a clinical setting with a clinician-administered diagnosis [74]. Most studies included in the present systematic review relied on self-reports of their participants as opposed to a clinician-administered diagnosis according to DSM- or ICD-criteria. Thus, the relation to clinically assessed depression needs to be considered in the interpretation of the presented results [74]. Self-reports are often criticized for being not as objective as external assessment. However, in mental health, self-reports are more commonly used than in other fields of medicine. In mobile health, there are attempts to use sensors in smartphones or wearables to collect passive mental health data (“objective data”) [46]. This approach is also called “ecological momentary assessment”. Some researchers describe this approach as a new possibility for more objective diagnosis assessment or patient monitoring [46]. Based on passive data, these interventions could also provide tools in instant need. There are only a few studies on this topic, but their results are comparable to other e-mental health interventions [48].

### 3.1.3 Human support

Most studies in this review included some kind of clinician support [74]. The interventions can most likely be described as “guided self-help”, which means that clinicians guide and support their patients in the self-reliant application of therapeutic techniques [43]. In most interventions, human support has the main aim of strengthening adherence to the intervention [44]. There are studies that describe limited adherence to e-mental health interventions as a problem [44, 84, 91, 92]. This was not the case in the included studies of this systematic review [74]. Adherence rates varied between 70-94% [74]. A possible explanation could be the provided human support, which is effective in improving adherence to e-health interventions as has been shown in other studies [30, 43, 82, 93, 94].

Human support in the studies included in this systematic review was provided via text messaging, group meetings or phone calls. Communication in mobile health can be synchronous or asynchronous, which means that either the communication is held in real-time (phone calls, chats, videoconferencing) or with delay (e-mail, text- or voice messaging) [42]. The included studies provided both types of communication, mostly for guidance or to improve adherence rather than to provide further therapeutic content. Guidance by clinicians or other health workers usually focuses on improving comprehension, providing feedback or encouragement [43]. No matter which type of support, e-mental health research has shown that human support is very beneficial, if not crucial, for the success of the intervention [30]. Effects of e-mental health interventions are greater when human support is provided as a meta-analysis on computer-based psychological treatments for depression has shown [95]. It is argued, that the mode or underlying therapeutic approach is not as essential as professional guidance [30]. But it is not yet clear which amount of human support is most beneficial. In contrast to many other studies, Firth et al. [80] found that apps without human support or integrated feedback were more effective than those with feedback and support. There are a few other studies that report no difference between supported versus non-supported interventions as well [43]. As this is contrary to research that emphasizes the role of human support, the authors reason that stand-alone apps might have a more comprehensive design than supported apps [80]. It is also assumed that human support is not equally important for all interventions or disorders. For depression, human support seems to play a major role [43]. As most included trials provided human support, it is difficult to completely isolate the effect of the app alone and the amount of human support in the intervention [74].

## 3.2 Health care professionals' attitudes

### 3.2.1 Overall attitudes

Health care professionals in the present study expressed overall positive attitudes towards the use of smartphone applications for depression [74]. However, respondents had very little knowledge and actual experience with smartphone applications for depression or other mental disorders [74]. They replied from a more theoretical perspective than from a well-informed position which indicates acceptability as a prerequisite for final acceptance according to the acceptance models discussed previously.

When looking at the health care technology acceptance model by Sekhon et al. [55], respondents' replies as outlined in the present study [74] can be positively connected to "attitude", "perceived benefits", "perceived burden", "experience", "self-efficacy" and "ethicality". Participants had positive beliefs about smartphone applications for depression, especially for mild-to-moderate levels of depression and in a combined treatment approach ("attitude" and perceived "effectiveness"). Availability anytime and anywhere as well as easy access to treatment were the highest rated facilitators for treatment apps ("perceived benefits" and "perceived burden", e.g., time and effort). Respondents also presented themselves as being very familiar with technology and willing to use smartphone applications in clinical practice (perceived "self-efficacy"). Lack of therapist contact and limited security of personal data and privacy protection belonged to the frequently named drawbacks for therapeutic app use [74]. The therapeutic relationship as well as the privacy protection of the individual were a value that respondents showed in their replies ("ethicality").

Considering the existing evidence on technology acceptance, several studies on health care professionals' attitudes towards e-mental health interventions have been published [56, 68-73]. These studies focus on computer-based CBT or e-mental health in general but not exclusively on mobile health. Vigerland et al. [69] conducted a survey on attitudes towards cCBT among Swedish mental health professionals. In line with the results of the present study, participants had little knowledge of cCBT but they were positive about its use in prevention and for mild-to-moderate depression. More skepticism was shown related to cCBT for severe depression [69]. Similar results were presented in another survey among mental health care professionals in Germany [56]. Most of the participants had largely pos-

itive attitudes towards e-mental health for depression and anxiety. However, participants felt minimally informed about available e-mental health interventions and had concerns about data safety and privacy protection [56]. Very similar results were also shown in a survey by Stallard et al. [68] who investigated clinicians' attitudes towards cCBT with children and adolescents. Respondents were positive about the interventions for mild-to-moderate symptoms but more concerned for more severe symptoms [68].

In contrast to the rather positive attitudes of the present survey and the above-mentioned studies, there is also some evidence on lower acceptance of e-mental health. For example, a study by Hennemann et al. [70] explored health professionals' acceptance and adoption of e-mental health in routine care. Most participants reported only low-to-moderate acceptance of e-mental health interventions [70]. Another study showed that some psychotherapists experienced e-mental health as a threat, were more skeptical and had a lower belief in benefits than individuals affected by depression [72]. Based on current evidence, it is assumed that attitudes of care providers towards e-mental health are not as positive as those of health care users [96].

### **3.2.2 Awareness and experience**

In the present survey, participants' actual knowledge and experience with mental health apps were low [74]. Around 60% of participants did not know any apps for depression and only around 20% of the whole sample had experience with them [74]. The feeling of being uninformed was also shown in other studies that investigated health care professionals' attitudes towards e-mental health interventions [56, 68, 69, 97]. In a study by Gun et al. [97], 77% of the respondents replied that they would like to learn more about internet-based treatments and their application. A survey among German mental health care professionals showed that respondents did not feel well informed about e-mental health interventions although they were interested in the field [56]. Interview participants in a study by Sinclair et al. [98] also reported a lack of exposure to online treatment during their training. A reason for the low awareness of e-mental health approaches could be the still very limited number of available interventions that are integrated into the health care system. In Germany, for example, only some of the major statutory health insurance companies offer self-management online-interventions for depression [88]. Apps that are available via



health insurance companies mainly focus on service provision or general health promotion and not on treatment [99].

### **3.2.3 Influence of sociodemographic factors and technology experience**

As mentioned earlier, theories on acceptance also include sociodemographic factors (e.g., age and gender) as well as experience with the intervention as part of the facilitating factors for technology acceptance [70, 100]. In this study, significant differences were found between the amount of technology experience and the consideration of using therapeutic apps for depression [74]. Those participants that reported much experience with technology (e.g. smartphones or computers) also reported more likely consideration of app use in clinical practice [74]. User experience thus positively affects the willingness to use a new therapeutic approach or technology which was also shown in other studies [56, 70, 97, 101]. For example, in a study by Hennemann et al. [70], acceptance rates of e-mental health interventions were significantly higher in those participants with prior experience with these interventions. Similar results were shown in a study by Gun et al. [97]. Respondents who reported experience with e-mental health treatment showed significantly higher acceptance [97]. In another survey, health care professionals who were more experienced with technology, showed higher interest in using e-mental health, believed more in the benefits and had less concern about negative effects of these interventions [56]. Another study by Donovan et al. [101] found that more knowledge of cCBT was associated with fewer perceived drawbacks of it. These study results are in line with acceptance models that include knowledge, literacy and experience as facilitators for e-health acceptance [55, 60]. The engagement in an e-health intervention, its content and the perceived or actual effectiveness impact the users' acceptability [55].

Gender is another factor that is associated with acceptance. It is assumed that male participants are more likely to express higher acceptance than female participants [70]. Although the present study could not confirm these group differences, other studies have found indications for these assumptions. In a survey by Surmann et al. [56], female mental health care professionals expressed less interest and felt less informed about e-mental health. In addition, they had more concerns and feared a negative impact on the doctor-patient relationship more than male participants [56]. In another study by Hennemann et al. [70], male

health professionals' acceptance ratings of e-health interventions were significantly higher than female health professionals' ratings.

It is proposed that the age of the individual may influence the acceptance of e-mental health interventions [56, 70, 72]. The results of this study could not confirm an influence of the age group on the attitudes of health care professionals. In contrast, a study by Surmann et al. [56] showed that older health care professionals may associate e-mental health with more extra effort and expense than younger aged health care professionals. In another study by Schröder et al. [72] older age was associated with reduced confidence in the effectiveness of internet interventions.

In the case of e-mental health, the country of residence could also play a role because some countries belong to the group of early adopters of e-health while other countries express less openness and integration of these technologies [88]. Australia and the Netherlands, for example, belong to the early adopters and have already integrated some e-mental health interventions in standard health care provision [88]. The present study could not confirm any group differences related to the country of residence [74]. A reason for this finding could also be the present study's small sample size [74].

### **3.2.4 Perceived benefits and concerns about treatment apps**

The respondents of the survey were presented with a number of potential benefits and drawbacks of treatment apps that they were asked to rate according to their opinion [74]. The three aspects that were rated most beneficial were availability anytime and anywhere as well as easy access to treatment [74]. All these perceived benefits are linked to health care provision and access rather than benefits associated with the treatment itself. These results relate to current problems in mental health care, e.g., long waiting times, limited number of therapists or other barriers like stigma. Thus, health care professionals are aware of the high treatment gap for mental disorders and see e-mental health as a potential solution for these problems. In fact, the facilitation of access to care is one of the main promises of e-mental health interventions [7]. Professionals in other studies on e-mental health interventions reported similar attitudes in terms of advantages [68, 69, 97]. Access-related benefits of cCBT also received strongest agreement among Swedish mental health professionals as reported in a study by Vigerland et al. [69]. This included the possibility of using

these interventions at home, at any given time and in rural areas where health care provision is usually more limited [69]. Earlier access to treatment was one of the most frequently rated benefits in a study by Stallard et al. [68]. Long waiting times for therapy are a problem for timely mental health treatment. The use of mobile mental health could help to bridge waiting times until treatment is available. Mobile health has the potential to provide more flexibility and reduce the treatment gap in mental health care [44].

One of the most frequently perceived disadvantages in the present study was the potentially limited suitability for certain patient groups, such as older patients [74]. Another study by Surmann et al. [56] reported a comparable finding. Health care professionals rated e-mental health interventions as more suitable for adolescents and adults compared to children and elderly persons [56]. Older patients might not be as familiar with technologies and probably tend to rely more on human support compared to younger generations. However, research has shown that elderly individuals catch up on internet and technology use [102]. In older age groups, the use of these technologies including smartphones and other devices has increased continuously over the past years [102]. About 48% of the age group over 65 use the internet [84].

Another most frequently rated disadvantage was a lack of therapist contact when using smartphone applications for depression [74]. This finding was also reported in a study on cCBT in which health care professionals had most concern related to the potential lack of a therapeutic relationship and the limited therapist contact [68]. However, most current internet-based treatments include human support and many studies have shown that this improves adherence and the effects of the intervention [43]. Nonetheless, the therapeutic relationship has changed with the rise of the internet and e-health technologies. The doctor-patient relationship is shifting from a paternalistic to a more patient-centered perspective [103]. Rather than just an advancement of technology alone, this development represents a cultural change in mental health care [36]. New technologies may lead to greater patient empowerment by supporting the patient in psychoeducation and self-management of mental conditions [41]. They enable patients to increase control and treatment choices related to their disorder [36]. Self-management may also increase the effects of a treatment provided by a practitioner [41]. The British National Institute for Clinical Excellence (NICE) Guideline for depression recommends CBT-based self-management interventions as a part of treatment [21]. However, some health care professionals may see new technologies as a

threat to their profession [70] and self-help in general may not be seen very positively by some professionals [104]. The provision of information and training to health care professionals could help to raise awareness of potential benefits of e-mental health interventions and reduce misinformation and fear of these technologies [74]. The knowledge about the potential and limitations of technology and practical experience are prerequisites for uptake. This needs support by an enabling environment. In order to create a facilitator for e-mental health implementation, the teaching and training of professionals could be integrated into medical education [102].

Another most frequently rated potential drawback was limited security of personal data and privacy protection [74]. Other studies among health care professionals have reported these concerns in varying degrees as well [68–70, 73, 105]. Data safety and privacy protection in mobile health are broadly discussed. Despite the growing number of available mental health apps, there are few resources of evaluation of these technologies [106]. Most available apps are developed on the commercial market and outside the health care system. These apps may lack adequate privacy policies and may fail in securing the users' data by encryption [107]. The appropriate data collection, handling, storage and safe access are crucial for data protection [108]. Especially sensitive mental health data needs to be protected as it is the case in regular health care provision [106]. There are regulations on national and European level to protect data privacy. Recently, the European General Data Protection Regulation has been enacted and is legally binding. However, to date, there is no universal regulation for the requirements that apps have to fulfill in the field of mental health. The security rules that apply to regular health care provider-patient relationships are not applicable to interactions via mobile technologies [107]. The discussion about finding agreement on the confidentiality and security in mobile health are ongoing and several stakeholders have published position papers or have started to develop frameworks for e-mental health evaluation [106, 109]. The British National Health Service (NHS), for example, has developed an open app library in which NHS approved apps can be found [110]. The library also contains a section for mental health in which only safe and secure apps are listed. The library includes ten apps for mental health including apps that target depression [110].

### 3.3 Additional factors influencing the uptake of e-mental health

The efficacy of apps as well as positive attitudes of health care professionals are important prerequisites for successful uptake in practice. Beyond that, there are additional factors that may hinder or facilitate the implementation of e-mental health. These factors include availability, affordability and reimbursement, service quality and legal regulations.

Availability and resources are important enabling factors for e-mental health implementation. To date, in most countries, e-mental health is not incorporated into standard care or reimbursement schemes [43]. In Germany, the provision of e-health interventions differs per health insurance company [99]. Some insurance companies provide e-mental health interventions or reimbursement for certain programs which other companies do not provide [99].

For availability, e-mental health interventions also need technological infrastructure (e.g., wireless network coverage) and integration into existing workflow systems of the health care system in order to be taken up [52]. Ideally, there is information interoperability which enables the exchange of data between systems [45].

From publicly available apps in stores, only a minority is evidence-based [48]. Evaluations of apps for depression have shown that the quality of the provided information and recommendations vary profoundly [84]. E-mental health interventions do not yet underlie a standardized quality assurance process like it is the case with health technology assessments for medical devices. Thus, there is a need for reliable evaluation procedures for e-mental health interventions [41]. Moreover, app developers need to be equipped with guidance on how to develop an intervention according to the demand of regulatory authorities [41].

There are also legal regulations that might hinder the implementation of e-mental health. Due to the technological developments in the health sector, there are now discussions to change existing regulations with the purpose of facilitating the integration of e-mental health into care. In Germany, for example, the professional code for psychotherapists has recently been changed to allow the application of remote therapy [111]. However, a fully remote psychotherapy without any personal contact is still not permitted. [43]. Diagnostics and patient information still need to be done in person. The professional code for doctors

has been changed a step further so that fully remote treatment via phone, text messaging, e-mail or online-chat is permitted [112]. An enabling political and operational environment is key to encourage innovation. However, regulations still need to be restrictive enough to protect a high standard of care [45].

### **3.4 Limitations**

A defined and systematic search strategy was used in three major scientific databases. Nonetheless, the possibility of missed studies for the systematic review cannot be excluded completely. Studies written in English and German language were included so that relevant trials written in other languages were neglected. This language bias also includes the tendency that studies with significant results are more often published in English and the interpretation of effects may be overestimated in this way.

This study focused on peer-reviewed scientific publications. Grey literature was only included by hand searches and cross-references if these were considered relevant for the research questions of this dissertation. A general limitation of systematic reviews is publication bias which describes the tendency to publish more positive results than negative ones. Publication bias may have led to an overestimation of the effects of smartphone applications for depression. Relevant studies that never have been published nor were accessible in scientific databases were not included in this review. Included studies had heterogeneous study designs and measures (e.g., number of control conditions or active vs. passive control groups) so that the conduction of a meta-analysis was not considered feasible. The methodological constraints of the included studies of the systematic review are illustrated more deeply in the discussion section of this dissertation.

The number of survey participants was limited and the sample included comparably more female participants than male participants and more participants from Germany compared to the other countries [74]. This aspect may compromise the generalizability of the results as well as the statistical power to identify factors influencing the attitudes of health care professionals.



## 4 Conclusion and outlook

This study systematically reviewed the literature on therapeutic mobile applications for depression and conducted a survey on health care professionals' attitudes towards the use of these treatment apps in practice. The literature on treatment apps for depression is promising but in comparison to the evidence-base for computer-based e-mental health interventions for depression, research on mobile apps is less advanced. However, available studies indicate that smartphone applications may be effective in reducing symptoms of depression although large-scale trials are needed to confirm these results and to investigate medium to long-term effects. Open questions still remain related to the most beneficial components of those interventions, the best mode and frequency of treatment as well as the amount of human support for optimal effectiveness.

Health care professionals in this study had positive attitudes towards using apps in clinical practice, which is in line with many other studies. However, the evidence on service provider acceptance is mixed and there are also studies that showed rather negative attitudes. Knowledge and experience are important facilitators for e-mental health acceptance. In line with other studies, health care professionals in this study had limited knowledge and experience with e-mental interventions and therapeutic apps. Education and training can help to increase awareness and knowledge of the therapeutic potential of e-mental health interventions and promote their acceptance.

E-mental health interventions have the potential to contribute to improved health care provision and may provide easily accessible and cost-effective treatment for depression. The field is comparably new and brings along many opportunities and challenges. A problem of current research is, that it is very difficult to keep pace with the speed of technological developments [82, 113, 114]. There is a huge gap between technological advances on the commercial market and the creation of scientific evidence on those techniques. Very quickly, technologies are outdated and it is one challenge for the future to bring those two developments closer together.

The successful implementation of e-mental health is a societal challenge where different fields, such as research, policy, care providers and care users, are involved [84]. In addition to effectiveness and acceptance research, the integration of e-mental health into existing infrastructure, the implementation in routine care as well as the development of regulatory,

security and privacy standards will be major challenges for e-mental health implementation. When these challenges are tackled adequately, e-mental health has the potential to contribute to the further improvement of mental health care.

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## 6 Appendix I. Example of quality checklist used in the systematic literature review

The following table gives an example of the quality checklist used for the evaluation of the studies included in the systematic review (Table 2). The checklist was adapted from the Scottish Intercollegiate Guidelines Network (SIGN) templates [115]. The checklist consists of three parts: internal quality, description of the study and an overall assessment.

<b>Article (Authors, Title, Source)</b>	Ly KH, Trüschel A, Jarl L, Magnusson S, Windahl T, Johansson R, Carlbring P, Andersson G (2014) Behavioural activation versus mindfulness-based guided self-help treatment administered through a smartphone application: a randomized controlled trial. <i>BMJ Open</i> 4(1):e003440.				
<b>Evaluated by</b>	AK				
<b>Decision: Include in review?</b>			<b>Yes</b>		
<b>Evidence Level I</b>					
<b>Section 1</b>	<b>Internal Quality</b>				
<b>Topic</b>	<b>Yes</b>	<b>No</b>	<b>Can't Say</b>	<b>Does not Apply</b>	<b>Comment</b>
The study addresses an appropriate and clearly focused question.	X				Evaluation and comparison of the effectiveness of two smartphone-delivered treatments: one based on behavioral activation (BA) and other on mindfulness.
A description of the methodology used is included.	X				Parallel randomized controlled trial
The statistical methods used are appropriate for the study type and reported in sufficient detail	X				SPSS analysis using various measures: independent t tests and $\chi^2$ tests, mixed effects models, interaction effects of group and time; between group differences
Potential confounders are identified and taken into account in the design and analysis		x			No confounders reported
Are conflicts of interested reported?	Yes				App development for the open market is declared



<b>Section 2</b>	<b>Description of the study</b>	<b>Comment</b>
How many participants were included?	81 participants were randomized	-
What are the main characteristics of the participants?	Participants diagnosed with major depressive disorder	-
What comparisons are made in the study?	Depression symptoms measured on Beck Depression Inventory-II (BDI-II) and the nine-item Patient Health Questionnaire Depression Scale (PHQ-9) for the behavioral activation app compared to mindfulness app from pre-treatment to post-treatment or from pre-treatment to the 6-month follow-up	-
How long were participants followed-up?	6 months	-
What is the main result of the study?	Significant improvements of BDI was found in both treatment conditions The two interventions did not differ significantly from one another	-
What size of effect is identified in the study?	Significant improvements of BDI were found in both treatment conditions. BA treatment was more effective among participants with higher initial severity of depression from pretreatment to the 6-month follow-up (PHQ-9: $F(1, 362.1)=5.2, p<0.05$ ).  The mindfulness treatment worked better for participants with lower initial severity of depression from pretreatment to the 6-month follow-up (PHQ-9: $F(1, 69.3)=7.7, p<0.01$ ); BDI-II: ( $F(1, 53.60)=6.25, p<0.05$ ).	-
How was the study funded?		

<b>Section 3</b>	<b>Overall Assessment</b>	<b>Comment</b>
How well was the study done to minimize bias	Randomized Controlled Trial; no further report on bias	-
Size and selection of the study group was representative	Study was underpowered as indicated in limitations section; participants were recruited nationally through mass media and advertisements and not from a clinical setting	-
All relevant results are measured in a standard, valid and reliable way	Detailed description of analysis and results	-
Information about non-responders to survey invitations, drop outs in surveys with sequential questionnaires, incomplete responses and how these were statistically handled is given	3 individuals from the selected sample decided not to participate;  9 participants were lost at the post-treatment;  6 were not reached for the M.I.NI. interview and declared as unimproved in the analysis	-

Are the results of this study directly applicable to the target group of the paper?	Yes, patients with major depressive disorder	-
How well does the study help to answer key questions? (Summarize the main conclusion and how it relates to the relevant key question. Comment on any particular strengths and weaknesses of the study as a source of evidence)	This study compared two smartphone applications based on established psychotherapeutic techniques (behavioral activation vs. mindfulness) used for reducing symptoms of depression. The study found that both interventions were useful in reducing symptoms of depression.	-
		-
What is your overall assessment of the methodological quality of this study?	This RCT is well conducted and described in detail. Analysis and results are presented comprehensively. Limitations (e.g., statistical power, sample characteristics, active control condition) are provided including indications for the interpretation of the results.	-

**Table 2: Quality checklist used for the systematic literature review.**

Source: table adapted from the Scottish Intercollegiate Guidelines Network (SIGN) templates [115].

## 7 Appendix II. Survey questionnaire

The following questionnaire and introductory text was used in the online-survey on health care professionals' attitudes towards the use of therapeutic mobile applications for depression. It consisted of three parts: personal data and experience with computer technologies and apps; attitude, knowledge and personal experience related to therapeutic apps in clinical practice and finally a rating of barriers and facilitators related to therapeutic apps.

The questionnaire was administered with the online-survey tool "SurveyMonkey". The web-link to the survey was distributed via websites and emails (e.g., newsletters) of supporting organizations. The survey had an open-access character and data was collected and saved anonymously.

Dear health care professional,

Thank you for participating in our survey on mobile applications (apps) in the treatment of mental disorders in general and depression in particular. Your contribution provides important insights on experiences and opinions of practitioners on e-mental health interventions. The survey is conducted under the lead of Prof. Dr. Wolfgang Gaebel, LVR-Klinikum Düsseldorf.

The completion of the survey will only take 5-10 minutes.

This survey is completely anonymous. The research team cannot trace back given information to the respondent. Please be assured that all data will be protected according to the data protection policy of our survey tool. No data is given to third parties. The procedure in this study has been approved by the ethics committee of the medical faculty of the Heinrich-Heine-University Düsseldorf.

If you have any questions about the study, please do not hesitate to send an email to: [ariane.kerst@lvr.de](mailto:ariane.kerst@lvr.de).

Your participation is highly appreciated. Thank you for your time and effort.

Sincerely,

Prof. Dr. Wolfgang Gaebel  
Project leader

Ariane Kerst  
Scientific survey coordinator

## Personal data and personal smartphone use

The following questions refer to your personal data and your personal smartphone use. The second part of the survey deals with your experience and opinion about smartphone-use in clinical practice.

### What is your gender?

Male

Female

### What is your year of birth?

\_\_\_\_\_

### In which country do you live?

\_\_\_\_\_ (country)

### What is your profession?

Psychiatrist  General Practitioner (GP)

Psychologist  Nurse

Mental health nurse  Social worker

Mental health worker  Occupational therapist

Other \_\_\_\_\_

### How many years of professional experience do you have?

\_\_\_\_\_ years

**Do you own a smartphone\*?**

Yes

No

\*A smartphone is a mobile phone that performs many of the functions of a computer, typically having a touchscreen interface, Internet access, and an operating system capable of running downloaded apps.

**In your opinion, how much experience do you have with computer technologies (for example PC, smartphone, Tablet)?**

A lot

Quite a lot

A little

Very little

None

**If you own a smartphone, how often do you use the apps on your smartphone approximately?**

Daily

4-5 times per week

2-3 times a week

Once a week or less

Never

\*An application or „app“ typically is a small specialized program downloaded by a user to a mobile device (e.g., smartphone or tablet)



### **Knowledge, personal experience and attitudes towards apps in clinical practice**

In the treatment of mental disorders, apps may serve different purposes (e.g., pure information provision to patients or prompting patients to enhance medication adherence).

In the scope of this survey, we focus on „treatment apps“. These apps contain active psychotherapeutic treatment components (e.g., based on cognitive behavioral therapy, behavioral activation) with the aim of symptom reduction. The following questions all refer to these treatment apps. In addition, we are specifically interested in your opinion on app use in the treatment of depression.

**In general, do you know existing apps that are used for psychotherapy of mental disorders?**

Yes

No

If yes, which one(s):

**In general, have you ever used treatment apps in clinical practice for mental disorders before?**

Yes

No

If yes, which one(s):

**Specifically, do you know existing apps that are used for psychotherapy of depression?**

Yes

No

If yes, which one(s):

**Specifically, have you ever used treatment apps for depression in clinical practice before?**

Yes

No

If yes, which one(s):

**If you have never used treatment apps in clinical practice before, can you name reasons for this (in keywords)?**

\_\_\_\_\_

**If you have not used treatment apps in clinical practice before, how much would you consider using them with your patients?**

A lot

Quite a lot

A little

Very little

Not at all

**Can you give reasons for your choice?**

\_\_\_\_\_

**In your opinion, how much could treatment apps help different target groups to reduce symptoms of depression? Please give a rating for each group.**

	A lot	Quite a lot	A little	Very little	Not at all
Individuals with sub-clinical depressive symptoms					
Individuals with mild/moderate depression					
Individuals with severe depression					

**In your opinion, should treatment apps for depression be freely available to anyone?**

Yes

no

Comment:

**In your opinion, should treatment apps for depression only be used with support of a mental health professional?**

yes

no

Comment:

**With respect to patient outcomes (e.g., the reduction of depressive symptoms), how would treatment apps as a stand-alone intervention compare to face-to-face psychotherapy alone?**

- Much better
- Better
- The same
- Worse
- Much worse

**With respect to patient outcomes (e.g., the reduction of depressive symptoms), how would the additional use of treatment apps in face-to-face psychotherapy compare to face-to-face psychotherapy alone?**

- Much better
- Better
- The same
- Worse
- Much worse

**How much concern do you have about the use of apps for the treatment of depression (either as a stand-alone intervention or as additional intervention)? Please rate according to your opinion:**

- A lot
- Quite a lot
- A little
- Very little
- No concern

**If you have concerns, could you briefly describe them (in keywords)?**

---

**The following items have been identified as potential barriers in the use of treatment apps for mental diseases. In how far do you agree that each of these aspects could be a problem?**

	strongly agree	agree	disagree	strongly disagree
Negative attitudes of patients towards digital treatment				
Negative attitudes of therapists towards digital treatment				
Patients' limited adherence to app use				
Patients' limited experience with technologies and app-use				
Technical problems (e.g., failed internet connection)				
Lack of therapist contact				
App are not tailored to patients' individual needs				
Limited security of patients' personal data & privacy protection				
Apps are difficult to implement in clinical practice				
Apps are not suitable for all patient groups (e.g., older patients)				

**The following items have been identified as potential facilitators in the use of treatment apps for mental diseases. In how far do you agree that each of these aspects could be an advantage?**

	strongly agree	agree	disagree	strongly disagree
Easy access to treatment				
Increased availability of therapy in general				
Increased availability of therapy in rural areas				
Apps help to handle limited resources in health care (e.g., lack of therapists)				
Reduced waiting times until begin of treatment				
Digital treatments via apps reduce stigma				
Apps are available 24/7 and can be used anytime				
Apps can be used anywhere (e.g., at home)				
Patients are less dependent on the therapist				
Outcome measures can be collected				
Reduced cost of treatment				
Apps help to reach certain patient groups (e.g., young individuals)				

**Thank you for completing the survey. Please feel free to leave any additional comment to this questionnaire if you like. Otherwise, please press the "Finished" button below.**



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