# Epidemiology and treatment of mental disorders in a rapidly developing urban region in China

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# CHAPTER 6

# The Use and Characteristics of Mobile Mental Health Apps in China: A systematic review

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# ABSTRACT

**Background:** smartphones have become ubiquitous in China, offering a promising way to deliver mental health interventions. However, little is known about current use and characteristics of smartphone Apps for mental health. The purpose of this study was to gain insight into available Mobile Mental Health apps in China as of December 2018.

**Method:** A systematic review was conducted to search, screen and evaluate the most downloaded apps from the iOS and Android platforms. Selected apps were categorized according to their main purpose and downloaded to further evaluate their content. Each app's affiliation, cost, target users, information security and evidence-based nature were evaluated.

**Results:** 172 unique apps were identifies. There were 37 apps (35.2%) for psychological counseling, 50 apps (47.6%) for assessment, 12 apps (11.4%) for stress relieve, 24 apps (22.9%) for psychoeducation, and 49 multipurpose apps (e.g., combination of counseling and assessment; 46.7%). Most apps were developed for adults (96.5%) in the general population, rather than psychiatric patients. App-based counseling was mostly provided by psychologists and of assessment apps, only 40% used evidence-based scales to assess mental problems such as anxiety and/or depressed mood. Guided meditation was used as the main method to reduce stress in the stress relieving apps.

**Conclusion:** Many apps contain useful and evidence-based elements, such as good quality information, validated measurements and useful meditation methods. However, for mobile apps to contribute significantly to mental healthcare in China, considerable challenges remain, including the need for more patient-focused apps that can actually take on the role of a healthcare provider. In addition, efficacy studies are needed.

## KEYWORDS:

# INTRODUCTION

Mental health problems cause significant distress and negatively impact social relationships, school performance, occupational attainment, and physical health[1]. Mental disorders have been found to affect 12% to 47.4% of populations worldwide[2]. In China, the lifetime prevalence of mental disorders has been found to be 16.6%[3] to 23.6%[4]. Unfortunately, mental health services are currently limited within the existing Chinese healthcare systems and many patients cannot obtain appropriate treatment or help for their mental problems[5,6]. In addition to the lack of available facilities and trained professionals, low perceived need, poor knowledge of mental disorders, and mental illness stigma have also been identified as potential barriers to help-seeking for mental illness[5].

Digital technologies could help to partly overcome the above-mentioned obstacles to help-seeking as they could further the reach of mental healthcare beyond available healthcare providers and/or clinics. The smartphone is one of the most rapidly adopted innovations in history[7] and provides ubiquitous Internet connectivity and the possibilities to access, download and run externally created software applications ("apps"). As such, smartphone technology provides a unique opportunity to deliver cost-effective and evidence-based mental healthcare services to large groups of people[8]. Indeed, studies have shown that smartphone mental healthcare apps can play an important role in the assessment, prediction, and monitoring of mental health, as well as in delivery of psycho-education, self-management strategies, recovery support, prevention, promotion and training of mental health providers[9–13].

The great number of smartphone users in China, which is estimated to reach 748.3 million in 2019[14] and the mobile Health market in China, which grew by 74.5% from 2016 to 2017[15], shows that there is a large potential for mental healthcare apps in China. However, very few studies have been done to gain insight into the number and types of available apps and their possible effectiveness in China.

On the one hand, available literature seems to suggest limited availability and use of mental health-related apps in China. For instance, a review study on health apps in China found that there were many apps targeting both non-professional and professional users, but described only one app related to mental health[16]. Another review on digital technology for treating and preventing mental disorders in low-and

middle-income countries found six studies about digital technology in China, in which only one study was about a mental health application. On the other hand, an examination of the Chinese iOS and Android app stores shows that despite the scarcity of research, there is an abundance of publicly available mental health apps. This is unfortunate as consumers cannot access to any information about the quality of available apps beyond the 'star' rating system and user reviews on the app stores. It is unlikely that these indicators of popularity also reflect the quality, effectiveness or evidence base of an app. Previous studies outside of China have found that most mental health apps in commercial market places do not provide evidence-based therapies, do not follow clinical guidelines, and do not respect privacy regulations with regard to personal information[17–20]. Consequently, it is a challenge for both patients and clinicians to find useful apps when needed. A recent review of 44 mental health apps (available as of October 2017) in China showed some common features, such as commercial purpose, services including counseling, education and assessment[21]. However, the current market for mental health apps is considerably larger (e.g., 100+ available apps were found based on the search term 'mental' in the Baidu app store)[22]. In addition, important characteristics of available apps have remained unclear, such as the apps' target user populations, the evidence-base for their content, and their consideration of data safety issues. To determine if and how apps could play a role in Chinese mental healthcare delivery, these should be more thoroughly explored. Therefore the present systematic review was undertaken.

The purpose of this study was to (1) characterize the purpose and content of the most downloaded mental health smartphone apps available for use by the general Chinese public, (2) to evaluate whether the content in the offered apps is evidence-based and (3) to gain insight into the application costs and the quality and comprehensiveness of reporting on data safety in the apps.

## METHODS

### Mobile application market search

On December 26, 2018, we conducted a search from both the Android (google, Mountain view, CA, USA) and iOS (Apple Inc., Cupertino, CA, USA) smartphone app stores in China. The three largest Android app stores in China are Tencent (Tencent Holding Limited, Shenzhen, China), 360 (Qihoo 360 Technology CO. Ltd, Beijing

China) and Baidu (Baidu, Inc, Beijing, China) and were chosen to sample apps because they make up more than 50% of Chinese Android market share. In addition, we used the Chinese iOS App store to gather a list of apps for the Chinese iOS market.

We restricted our search to the apps that had the Chinese characters for 'mental health', 'mental', 'psychology', 'psychiatry' or 'psychological intervention' or 'psychological prevention' in the title or store description of the app. The top 100 apps were collected in each app store. Apps from Android are free to download and iOS apps are either free or paid. We listed free and paid apps together, mainly because very few paid apps were found. The eventual selection of apps (see **Figure 1**) was done according to the following inclusion criteria. (1) The app should in fact be related to mental health, (2) the app should be available for download, (3) the app should make use of simplified Chinese language so that any literate Chinese individual could understand the content of the app easily, and (4) the app should be useable in Mainland China.

## App assessment

The apps that met the inclusion criteria were downloaded onto either a Huawei mate 9 (Android version 8.0.0), Xiaomi 8 (Android version 8.0.0) or an iPhone 5s (iOS version 7.1) smartphone device for a complete assessment. The reason for downloading each app for inspection was that the app description may not be enough to make a full judgment of the nature and quality of its content. For instance, in a previous review, authors downloaded apps and found that some could provide patients with very poor or potentially harmful advice (e.g., recommend people with a manic episode to drink alcohol before bedtime to assist with sleeping[20]). Therefore, for each app it was evaluated if the information in the apps is evidence-based or not. For apps that were present in multiple app stores, the consistency of the descriptions across stores was evaluated and complete duplicates were eliminated. Some apps had a patient version and a clinician version. We assessed these versions separately because they might provide different services.

For each app, the following general information was extracted (see **Table 1**): (1) the main purpose of the app, (2) the app's affiliation (i.e. commercial, medical center, or university), (3) the cost, (4) the intended target user, (5) whether or not information security was emphasized, and (6) whether the contents of the app were based on a

evidence-based psychological theory or based on advice by professional certified staff including psychologists, psychotherapists or psychiatrists. The apps were first categorized based on their main purpose into 5 categories by one of the authors (YHW) through reading the description of each app: psychological counseling apps, assessment apps, stress relieving apps, psychoeducation apps, and multipurpose apps (incorporating components of assessment, education, psychological counseling and stress relieve). Each category of apps was then further investigated by one of the co-authors (HFY, YHW, NW, YZH and WJC; randomly assigned to a category). If anyone found that the initial category was not suitable for an app, the 4 authors discussed it to reach consensus. For each category, specific additional information was extracted, which is detailed in **Table 1**. For mental health education apps, 8 core aspects of mental health information (see **Table 2**) were investigated. These aspects have previously been proposed by the National Health Commission of China[23] and are used to guide mental health education work in the whole country.

**Table 1.** The information collected for each of the selected apps

| Content | | Values |
|---|---|---|
| **General information collected for each app** | Affiliation | commercial, university, or medical center. |
| | Cost | pay for download, fully free, or partly free. |
| | Target user | children or adolescents, general public adults, special for women, special for patients with mental problems, or special for professional staff. |
| | Data safety information | Whether each app self-reported relevant information security measures or not? (yes or no). |
| | Professional background | Whether the contents of the app were based on a psychological theory or were based on advice by professional certified staff including psychologists, psychotherapists or psychiatrists? (yes or no). |
| **Specific information for psychological counseling apps** | Counseling pattern | Online (text typing or audio) or offline (help to make an appointment). |
| | Counseling provider | Professionals (including psychologists, psychotherapists or psychiatrists) or trained lay health supporter. |
| | Target users | Individuals with diagnoses of a mental disorder or general public. |
| **Specific information for assessment apps** | Assessment aspect | Personality, symptoms, intelligence, cognitive function, assessment just for entertainment (e.g., Constellations, fortune or other). |
| | Evidence | Are evidence-based measurements or scales used? (yes or no). |
| **Specific Information for stress relieving apps** | Methods | Music, mindfulness, relaxation therapy, etc. |
| | Evidence | Is there reference in the app that shows the therapy is effective? (yes or no). |
| **Specific Information for education apps** | Apps for training mental health providers | Books, lectures, audios or other method. |
| | Apps for mental health knowledge to public | According to the 8 core information in Circular of the General Office of the Ministry of Health on the Issuance of the Key Information and Knowledge Points of Mental Health Education. |

**Table 2.** Eight aspects of mental health information

| items | content |
|---|---|
| 1 | Mental health is an integral part of health. No mental illness does not necessarily mean mental health. Everyone needs not only physical health but mental health as well. |
| 2 | Mental health and mental illness, like physical health and physical illness, are determined by multiple interacting biological, psychological, and social factors. |
| 3 | Given everyone could encounter a kind of mental health problems in his/ her life. It is necessary to pay attention to and maintain their mental health. |
| 4 | Schizophrenia, depression, behavioral disorders in children and adolescents, and senile dementia are China's current priority mental illnesses for prevention and treatment. |
| 5 | Someone who is suspected of psychological behavior problems or mental illness should go to the medical institutions as soon as possible to receive advice and formal diagnosis and treatment. |
| 6 | Mental illness can be prevented and treated. |
| 7 | Care for and discriminate against mentally ill patients, and help them return to their families, communities and society. |
| 8 | Mental health is related to social harmony and development. Promotion of mental health and prevention and treatment of mental illness is the responsibility of society as a whole. |

## RESULTS

Of the 400 screened apps, 172 unique apps met the inclusion criteria (see **Figure 1**). Of these, 105 (61.0%) were available in Android App stores, 28 (16.3%) in the iOS app store and 39 (37.1%) in both iOS and Android app stores. Based on the descriptions of the main purpose of the apps, there were 37 apps (35.2%) for psychological consulting, 50 apps (47.6%) for assessment, 12 apps (11.4%) for stress relieve, 24 apps (22.9%) for psychoeducation, and 49 multipurpose apps (46.7%). The number of downloads ranged from 16 to 107 million in the Android stored (download number cannot be obtained in the iOS app store). Detailed information about the different groups of apps is shown in **Table 3**.
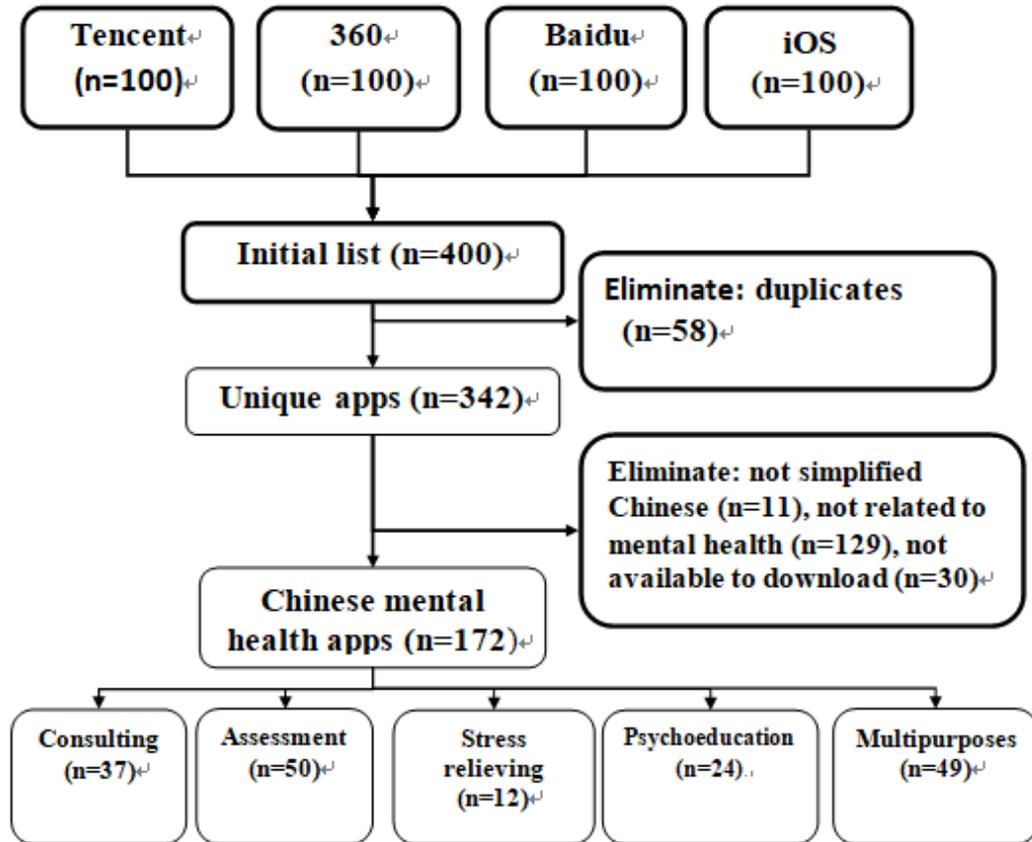
**Figure 1.** Flowchart of the in- and exclusion of apps in the current review of Chinese mental health apps

**Table 3.** The characteristics of apps in different categories n (%)

| Contents | Counseling | Assessment | Stress | Psychoeducation | Multipurpose |
|---|---|---|---|---|---|
| **Affiliation** | | | | | |
| Commercial company | 33(89) | 30(60) | 11(92) | 14(58) | 43(88) |
| University | 0 | 0 | 0 | 0 | 1(2) |
| No information | 4 (11) | 20(40) | 1(8) | 10(42) | 5(10) |
| **Cost** | | | | | |
| Pay for download | 1(3) | 0 | 0 | 0 | 0 |
| Fully free | 7(19) | 44(88) | 3(25) | 20(83) | 10(20) |
| Partly free | 29(78) | 16(12) | 9(75) | 4(17) | 39(80) |
| **Target user** | | | | | |
| Only children or Adolescents | 1(3) | 0 | 0 | 1(4) | 4(8) |
| Only adults | 28(76) | 50(100) | 10(83) | 23(96) | 38(78) |
|     General adults | 24(65) | 47(94) | 10(83) | 19(79) | 37(76) |
|     Special for women | 1(3) | 3(6) | 0 | 0 | 0 |
|     Special for patients with | 0 | 0 | 0 | 0 | 0 |
|     Special for professional | 3(8) | 0 | 0 | 4(17) | 1(2) |
| Adults and children | 8(22) | 0 | 2(17) | 0 | 7(14) |
| **Data safety information** | | | | | |
| Yes | 20(54) | 5(10) | 1(8) | 0 | 20(41) |
| **Professional background or evidence-based** | | | | | |
| Yes | 36(97) | 17(34) | 9(75) | 24(100) | 45(92) |
| **Counseling pattern** | | - | - | - | |
| Online | 37(100) | | | | 39(100) |
| Offline | 24(65) | | | | 15(38) |
| **Counseling provider** | | - | - | - | |
| Professionals | 36(97) | | | | 37(97) |
| Trained lay health supporter | 1(3) | | | | 2(3) |
| **Assessment aspect** | - | | - | - | |
| Personality | | 12(24) | | | 21(51) |
| Symptoms | | 10(20) | | | 33(80) |
| Intelligence | | 0 | | | 0 |
| Cognitive function | | 1(2) | | | 0 |
| Entertainment | | 36(72) | | | 22(54) |
| **Stress relieving methods** | - | - | | - | |
| Music | | | 2(17) | | 4(28) |
| Meditation | | | 7(58) | | 6(43) |
| Course | | | 1(8) | | 1(7) |
| Audio books | | | 1(8) | | 1(7) |
| Community for stress relieving | | | 1(8) | | 2(7) |
| **Psychoeducation of the knowledge of mental health** | - | - | - | | |
| Item1:Mental health is an integral part of health | | | | 10(42) | 35(100) |
| Item2: multiple interacting factors determinants | | | | 9(38) | 26(74) |
| Item3: everyone could encounter a mental health problems | | | | 10(42) | 32(91) |
| Item4: China's current priority mental illnesses | | | | 10(42) | 26(74) |
| Item5: go to the medical institutions for treatment | | | | 10(42) | 33(94) |
| Item6: Mental illness can be prevented and treated | | | | 10(42) | 32(91) |
| Item7: Care for and discriminate against mentally ill patients | | | | 10(42) | 30(86) |
| Item8: Promotion of mental health is the responsibility of society | | | | 10(42) | 30(86) |

## Counseling apps

There were 37 counseling apps and they were all developed by commercial companies. Of the counseling apps, 7 apps were free to use, 29 apps could be downloaded for free but charged counseling fees to consumers wishing to use the app. One app charged a download fee. In terms of the target population, 8 apps were aimed at adults and adolescents, one was aimed specifically at children and adolescents, 24 were only aimed at adults. Of the latter, one app was only aimed at women and 3 apps were aimed specifically at professionals. Twenty apps made explicit claims about information security measures. All of the apps provided some kind of online consultation, which means that staff is online to give users feedback and consultation. Counseling by typed messages was used in 34 apps. Users could voice-chat with staff in 26 apps. Twenty apps provided an appointment making service and 4 apps provided services to register appointments at hospitals. Of 37 apps, 36 apps had professionals acting as consultation providers (e.g., psychologists, psychotherapists or psychiatrists). In 10 apps, the consultation was provided by psychiatrists. Only 1 app provided consultation by a trained lay health supporter.

## Assessment apps

Of the 50 assessment apps, 30 apps had information about the affiliations of their developers. All of them were developed by companies. Of the apps, 44 were free to use and the other 6 were free to download but charged a fee for some of the offered assessments. All apps were aimed at adults and 3 apps were aimed specifically for women. Only 5 apps made a claim about information security. Evidence-based scales were used in 17 apps, of which 12 apps used a personality assessment, 8 assessed emotional problems and one assessed cognitive ability. The most popular validated questionnaires were the Eysenck Personality Questionnaire (EPQ)[24,25] that was used in 8 apps and the Cattell sixteen personality factor questionnaire (16PF)[26,27] that was used in 4 apps. The Self-Rating Anxiety Scale (SAS)[28,29] and Self-Rating Depression Scale (SDS)[30,31] were used to assess anxious and depressive symptoms in 8 apps. The other 33 apps were mainly aimed to provide some form of entertainment; they assessed fortunes, mental age, marriage and love, and occupation abilities, and using items from unknown sources.

## Stress relieving apps

The 12 stress relieving apps were all developed by companies; three apps were free and 9 apps were free to download but charged a fee for some of the content. Only one app had a claim of information security. Nine apps provided references to evidence showing that meditation is an effective method to relieve stress. Audio was the main medium for stress relieving apps. One app played audio recordings of methods to maintain mental stability from the Huangdi Neijing (this is an ancient Chinese medical text that has been treated as the fundamental doctrinal source for Chinese medicine for more than two millennia). One app provided audio of mood control courses, 2 apps provided nature sound recordings, and 7 apps provided audio recordings to guide meditation. Two apps specifically aimed at children and adolescents and focused on improving their concentration and memory and relieving examination anxiety. One app provided social community functionality, allowing users to communicate with each other to relieve stress. The meditation apps provided different methods, such as respiration exercises in 5 apps, gradual relaxation exercises in 7 apps, and biofeedback therapy in one app.

## Psychoeducation apps

All psychoeducation apps (n=24) were developed by commercial companies. Of the apps, 4 apps were targeted to mental health professionals and provided training courses and e-books about mental health to improve the skills of psychologists. Of these apps, 3 charged a fee for some of the courses in the apps. The other 19 apps were aimed at the general population and their main purpose was to provide education and/or knowledge about psychology and mental health. All of these apps were free for download. None of the apps had a claim about data security. Of the 19 apps, 2 were e-books about behavioral psychology and general psychology, one provided a list of psychological website links to users, one provided audio recordings about mental health, one provided case descriptions to let users know the manifestation of mental disorders, and one provided information about the diagnostic process of mental disorders. The other 14 apps included psychological popular science articles in which the common mental problems in parenting, workplace, marriage and love and development and the coping methods were described. We scanned the articles in the 14 apps and checked whether they referred to any of the

eight aspects of mental health information and found that 10 apps referred at least one aspect and 9 apps covered all of the 8 aspects.

**Multipurpose apps**

Forty-nine multipurpose apps were evaluated in this study in which 44 apps provided the affiliation information. One app was developed by institute of psychology of Chinese academy of sciences and the other 43 apps were developed by companies. Of the 49 apps, 38 were mainly aimed for adults, 7 apps aimed for individuals without age limitation, and 4 apps aimed at children and adolescents. In the apps for adults, there was one app (Guan Ai ++) for people in the workplace; one (Guan Ai Ji Ceng Gan Bu) was for the cadres at grass-roots level; one app (Hao Xin Qing) had a version for clients and a version for clinicians. Data safety claims were found for 20 apps. All the apps could be downloaded for free, but users were charged an additional fee for some content in 39 apps. Most apps (45 apps) involved professional staff, evidence-based therapies and/or references to evidence-based materials.

Five of the multipurpose apps combined the four functions of consulting, assessment, psychoeducation and stress relieve. To apps combined consulting, assessment and stress relieve, 19 apps combined consulting, assessment and psychoeducation, none combined counseling and assessment; five combined counseling and psychoeducation, and nine apps combined assessment, psychoeducation and/or stress relieve (two combined assessment and stress relieve, two combined assessment and stress relieve, and three combined stress relieve and psychoeducation functions).

In total, 39 multipurpose apps provided some kind of online counseling. Except for two apps, counseling services were provided by mental health professionals (33 apps involved a psychologists/psychological therapists; 6 apps involved a psychiatrists). In several apps, users could choose one professional to have a psychological counseling with, after looking through the profiles of listed professionals. Depending on the app, users could contact the professional by telephone, online video/voice chat, text typing, or they could make an appointment with the professional. Here, users had to pay a fee, depending on the price of the listed professional. Two apps integrated the appointment registration system for hospital outpatient in the apps. In these apps, patients could not only consult a

professional online but also could register an appointment with a professional at a hospital. One app (Hao Xin Qin doctor version) aimed to help professionals to manage their clients online.

In total, 41 of the multipurpose apps had some sort of assessment functionality. Of these, 33 apps used evidence-based self-report questionnaires to evaluate personality (2 apps use the EPQ and 1 app uses the 16PF), anxious (14 apps use the SAS) and depressive mood (26 apps use the SDS, 1 app uses the Hamilton Depression Scale [HAMD][32] and one app uses the symptom checklist-90 [SCL-90][33]), or social phobia (items from the Liebowitz Social Anxiety Scale; LSAS)[34]. Some entertainment assessments such as fortune, love and marriage were also included in 23 apps. None of the apps aimed to assess intelligence or cognitive abilities.

Fourteen of the multipurpose apps had stress relieving sections and provided audio recordings of relaxing music or meditation guidance. Thirty-six apps provided either psychoeducation articles or audio recordings related to the eight key aspects of mental health knowledge.

There were 4 multipurpose apps specifically for children and adolescents. One (jie you nuan xin mao) focused on assessing everyday mood, providing counseling services and possibilities for discussion with fellow users. One app (xin li mei) is developed specifically for students in primary and secondary schools in a certain area, providing multiple services including assessment, stress relieve, counseling and making appointments with a teacher-counselor. The third app (Q xin li) provided counseling, questions and answers, micro-lectures and psychoeducational articles for users. The fourth app (Gao kao jian ya bao) was developed to help students to reduce stress induced by college entrance examinations by providing counseling, stress reducing music and assessment.

## DISCUSSION

To our knowledge, this is the first study to review the full range of available and most widely used mental health smartphone apps in China. Evaluation of each of the apps showed that available apps have different primary aims, with most focusing on assessment, counseling and/or a combination of multiple purposes (i.e. assessment, counseling, stress relieve and/or psychoeducation). Most apps were developed for profit and focused on the adult population. Only 6 apps were specifically aimed at children and/or adolescents. A majority of the apps provided counseling and/or

assessment, often enlisting online psychological counselling services from professional such as psychologists, psychotherapists or psychiatrist. However, even though psychometrically valid assessments of personality, anxiety and depressive mood were included in some assessment apps, assessments in most apps were more focused on entertainment than on assessment of psychiatric symptoms. Audio-recordings to guide or accompany meditation were the main materials provided by the apps that focused on stress reduction. Most psychoeducation apps provided information that aligned with national guidelines on mental health information.

Evaluation of the target populations for the reviewed apps provided clear insights into the perceived market opportunities by app developers. This study shows that developers of mental health apps prefer targeting the general population rather than patients with mental disorders: no reviewed app focused specifically on patients with mental disorders. In addition, although there was small number of mental health apps for specific adult populations (e.g., women, workplace staff) or for mental health professionals, most apps were aimed at a broad audience. This is understandable given that most developers will want to acquire as many users as possible, but this seems to leave room for apps that would focus on assistance to patients with mental disorders. Interestingly, only few apps were developed for children and adolescents. This does not reflect the current situation where the prevalence of mental disorder in children and adolescents in China lies close to the high worldwide prevalence of 20%[35]. In fact, mental health of children and adolescents clearly is a point of attention for both policy maker and researchers. The fact that app developers have largely ignored this population could be due to various reasons. For instance, there are worries about negative effects induced by mobile phone use[36] and many parents/schools impose time restrictions on mobile phone use by children and adolescents.

Few of the reviewed apps provided special intervention for actual patients with mental disorders. This may partly be motivated by market considerations (i.e. smaller target user population), but could also reflect the current lack of consensus about and evidence-based guidelines for mobile device-based therapy for mental health patients. There is a large body of international literature about the use of mobile interventions for people with mental disorders[11,37–39] and similar work has been carried out in China[40]. However, the development of smartphone-based therapy is still in quite an early phase and it may indeed be too early to offer it outside an

experimental/academic mental healthcare setting. At this point, there is still a long way to go both in terms of app development and efficacy evaluation, before evidence-based mobile technology-based therapy can be routinely offered to patients in China.

With the exception of one app, all apps could be downloaded for free. However, the actual cost of the offered services depended strongly on what was provided in the apps. In this study, more than 70% of the counseling apps, stress relieving apps and multipurpose apps charged a fee for some services, whereas a large part of the assessment apps and psychoeducation apps were free to use. This might be because counseling apps, stress relieving apps and multipurpose apps involved more user-specific services, offered either by paid professionals or as part of evidence-based stress relieving methods that require a larger initial investment of the developer than, for instance, the inclusion of articles about mental health or the use of questionnaires that were previously developed by others. The cost on apps might present a burden for users, but in this study we do not have the data to investigate on this.

Assessment was the most popular function across all apps: there were 49 assessment apps and 41 multipurpose apps that had an assessment section. However, most assessment apps/sections focused on assessment as a form of entertainment rather than on assessments of real psychological problems and/or characteristics. Most multipurpose apps that also included counseling and/or stress relieving sections, used assessments with actual psychological scales, whereas entertainment assessments were included in most single purpose assessment apps. Assessments of personality, anxiety and depression were the most common across the apps that used actual psychological assessment scales, which makes sense given the high prevalence of anxiety and depressive disorders in China[3,4] and aligns with previous observations that people with anxiety and/or depression symptoms often do not seek help from professional institutes or physicians[41]. It could be that this group is relatively likely to use a freely available mobile app for self-assessment.

Psychological counseling was the second most popular service across the reviewed apps and was provided in 37 counseling apps and in 39 multipurpose apps with a counseling section. Psychologists were the main counseling providers and only 16 apps involved psychiatrists as counseling providers. This indicates that psychologists in China are playing an important role to provide mental health care to

the general population. This could be due to their larger number, which makes it easier for users to find a psychologist for mental health services. Indeed, in 2017 it was estimated that about 40,000 people held a national second- or third-level certificate in psychological counseling and provided psychological counseling on either a full- or part-time basis in China[42]. In contrast, the number of certified psychiatrists in China (in 2015) was 27,733. Another explanation for the relatively larger number of psychologists involved in the reviewed apps could be that regulation in China leads psychologists and psychiatrists to work in different settings. Psychologists work in a broad range of settings, whereas all psychiatrists in China need to be registered to a mental hospital or psychiatric ward in a general hospital that provides inpatient service[5]. According to the Mental Health Law of the People's Republic of China[43] psychologists should only perform counseling and are not authorized to neither perform psychotherapy nor engage in the diagnosis or treatment of mental disorders. If psychologists detect that a person receiving counseling may suffer from mental disorders, he or she should recommend the consulter to seek services in a medical institute. As such, online counseling is a good way for psychologists to perform initial counseling in population-dwelling persons. However, it is currently hard to estimate the effectiveness of online psychological counseling by psychologists in China, because of serious problems with the level of professionalism of psychological counseling in, with low overall performance levels, a lack of norms and uneven levels of training and expertise across consulting staff[44]. Unfortunately, we did not have any access to information about the kinds of problems users seek treatment for via the apps and the numbers of users that should be and that are referred to medical care by the consulting psychologists.

Another important finding in this study is that most mental health apps simply serve as a means to connect help seekers to healthcare providers, but do not use digital technologies (e.g., interactive computer-guided treatment algorithms) to deliver mobile-based interventions that could (partly) replace a healthcare provider. This is not a problem per se, but it means that such apps do not solve the current problem in China that there are not enough mental healthcare providers to meet the demand. For that, apps should actually be developed that can (partially) provide services that would otherwise be provided by healthcare professionals. More and more apps are being developed that actually offer a completely digital interactive therapy environment. For instance, cognitive behavioral therapy-based mobile apps have

been developed for a large range of mental problems and the effectiveness of those mobile-based interventions has been confirmed in several studies[45–49]. To the best of our knowledge, such apps have not yet been developed nor tested for the Chinese population.

This review showed that meditation was the main offered intervention by apps that aim to help users relieve stress. Previous studies have indeed shown that meditation supported by online tools can have a significant beneficial effect on depression, anxiety and well-being and a large effect on stress[50,51]. This seems to at least partially support the evidence-based nature of these apps. However, no research evaluation exists about the effectiveness of mobile app-assisted meditation specifically in China.

Most psychoeducation apps covered one or more of the 8 core aspects of mental health information that have been proposed as part of national policy. As a result, the apps usually were quite complete and accurate in their information coverage. The fact that some psychoeducation apps were downloaded more than one hundred thousand times (e.g., the app 'geilixinli' had been downloaded 780,000 times and the app xinlizixunyidianling had been downloaded 580,000 times), indicates that mobile psychoeducation can play an important role in disseminating mental health knowledge, which in turn could help reduce levels of depressive emotions and psychological distress[52,53].

**Limitations**

This review has some limitations. First, we could not obtain the number of downloads for all apps because the iOS App store does not provide this information. In addition, even for the apps for which the download numbers were known, we could not be sure about the number of persons that actually used the app. Second, We base the evaluation of the apps on quite a superficial screening of what the app looks like and the information delivered by the developers. We did not check and cannot be sure that all services (e.g., contact with certified professional) are really provided as claimed and/or that all apps function correctly. Third, we evaluated if apps made any statements and/or claims about data safety, but could not evaluate if they in fact handled data securely. Fourth, we chose a set of search terms to make sure that we included many top relevant apps. However, it is still possible that we missed potentially relevant apps.

## Conclusion

This review uncovered a large number of available mental health apps in China. The results show that there is a large variety in the selected apps' aims and evidence-base. A considerable part of the apps did contain useful and evidence-based elements, such as good quality information about mental health, validated questionnaires, useful meditation methods, and/or access to counselors, which makes it likely that they can contribute positively to mental health in China. However, for mental healthcare apps to substantially contribute to mental health in China, considerable challenges remain, which include the need for more patient-focused and children- and adolescent-focused apps, the development of apps that can actually take on the role of a healthcare provider, and effectiveness studies of such apps.

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## Authors' Contributions

HY, GX and RAS designed the study. HY, YW, NW, WCH and YZH download and collected data. HY analyzed data. HY and KJW wrote the initial draft of the paper. All authors read, contributed to, and approved the final manuscript.

## Conflicts of Interest

None declared

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