Journal of Affective Disorders 383 (2025) 228–239

Contents lists available at ScienceDirect

Journal of Affective Disorders

journal homepage: www.elsevier.com/locate/jad

Research paper

Effectiveness of internet-based cognitive behavioral therapy with virtual reality exposure therapy for social anxiety disorder: A randomized controlled trial in Hong Kong

Jia-Yan Pan [a,*], Graham R. Thew [b], David M. Clark [b]

[a] Department of Social Work, Hong Kong Baptist University, Hong Kong, China
[b] Department of Experimental Psychology, University of Oxford, UK

ARTICLE INFO

Keywords:
Internet-based cognitive behavioral therapy
Virtual reality exposure therapy
Social anxiety disorder
Chinese

ABSTRACT

Background: Social anxiety disorder (SAD) is a common but under-treated mental health condition. Internet-based cognitive behavioral therapy (iCBT) and virtual reality exposure therapy (VRET) are effective treatment approaches for SAD. However, few studies have integrated both, particularly in Chinese communities. This study examines the effectiveness of a 14-week iCBT program that includes VRET, called "Ease Anxiety in Social Event Online" (Ease Online), among Hong Kong adults with SAD.

Method: 329 Hong Kong Chinese adults with SAD were randomized into web-based iCBT with VRET ($n = 117$), app-based iCBT with VRET ($n = 111$), or waitlist control (WLC) ($n = 101$) groups. The mean age was 30.49 years old (SD = 9.34), with 36 % male and 64 % female. Assessments were administered at pre-test, post-test, and 3- and 6-month follow-ups. The primary outcome measure was the Social Phobia Inventory (SPIN). Data were analysed by using linear regression and mixed effects models.

Results: Both treatment groups were superior to WLC group on both the primary and secondary outcome measures. The effects were comparable between the two iCBT formats. Improvements were maintained at 3-month and 6-month follow-ups. The rate of reliable improvement based on the SPIN was 34 % and 40 % in the web-based and app-based iCBT groups, respectively, compared to 11 % in the WLC group; and 15 % and 23 % who meet the criteria for remission of social anxiety, compared to 3 % in the WLC group.

Conclusions: Both web- and app-based iCBT with VRET are effective for Hong Kong Chinese adults with SAD. The EASE Online iCBT programme is an effective treatment approach for Hong Kong Chinese with SAD.

1. Introduction

Social anxiety disorder (SAD), or social phobia, is one of the most common mental health problems, yet often neglected with a low treatment rate (Stein et al., 2017). SAD is characterised by fear of negative evaluation or rejection in social situations which leads to embarrassed or humiliation (Emmelkamp and Meyerbröker, 2021). Lee et al. (2005) reported that the 12-month prevalence of SAD in Hong Kong is 3.2 % which translates into an estimated 230,000 sufferers, but only 8.7 % have sought treatment. SAD has far-reaching impacts not only on individuals, such as under-performance and under-achievement, impaired social life, increased risk for other mental health issues, and poor quality of life, but also on society, such as low work productivity, increased healthcare costs, and reduced social cohesion (National Collaborating Centre for Mental Health (UK), 2013). People with SAD usually avoid social situations, so they might feel overwhelmed if they were to meet a stranger for traditional face-to-face treatment. As such, internet-based interventions may be a better way to meet their treatment needs (Erwin et al., 2004).

1.1. Internet-based cognitive behavioral therapy for SAD

Internet-based cognitive behavioral therapy (iCBT) is an online intervention that can be delivered through either web platforms (web-based iCBT) or mobile phone applications (apps) (app-based iCBT) with both being equally effective in reducing SAD symptoms and increasing well-being (Stolz et al., 2018). Compared to face-to-face CBT, there are several potential advantages of iCBT, such as shorter therapist time

* Corresponding author at: Department of Social Work, Hong Kong Baptist University, Kowloon Tong, Hong Kong, China.
E-mail address: jiayan@hkbu.edu.hk (J.-Y. Pan).

https://doi.org/10.1016/j.jad.2025.04.100
Received 30 September 2024; Received in revised form 5 April 2025; Accepted 19 April 2025
Available online 22 April 2025

required, easy and increased access to treatment, affordability, anonymity, flexibility and convenience, well-documented efficacy, reduced stigma associated with mental health problems, and overcoming obstacles to treatment, such as when social anxiety prevents a client from leaving home (Aboujaoude et al., 2015; Andrews et al., 2018; Ashford et al., 2016). ICBT is also cost-effective (You et al., 2022). For example, the therapist time in iCBT can be more than halved for the same amount of reduction in social anxiety (Clark et al., 2023).

A recent meta-analysis shows that iCBT has a significant positive treatment effect for SAD compared to control groups (g = −0.55) and an equivalent effect with face-to-face CBT on treating SAD (g = −0.18) (Guo et al., 2021). Randomized controlled trials (RCTs) have shown that guided iCBT, where therapists provide regular support and feedback, is more effective than unguided iCBT (Karyotaki et al., 2021) in reducing general and social anxiety, avoidance, depression, and dysfunctional thinking, as well as improving quality of life and functioning for people with SAD (e.g. Andersson et al., 2006; Carlbring et al., 2007; Gershkovich et al., 2017; Tulbure et al., 2015). In addition, guided iCBT programs for SAD show loss of diagnosis rates (Stolz et al., 2018). Benefits have been maintained at 6-month (e.g. Tulbure et al., 2015), 1-year (e.g. Andersson et al., 2006; Clark et al., 2023), 2-year (e.g. Hullu et al., 2017), and 4-year (Hedman et al., 2016) follow-ups.

As a newer development in internet interventions, iCBT delivered by smartphone application (app-based iCBT) has shown comparable outcomes to iCBT delivered through web platforms (web-based iCBT) in the treatment of SAD, with both conditions being effective in reducing SAD symptoms and increasing psychological well-being (Stolz et al., 2018). Treatment gains were maintained at the 3-month follow-up (Stolz et al., 2018). The recovery rate ranged from 15 % (Stolz et al., 2018) to 55.6 % (Dagöö et al., 2014) for the treatment of SAD. Compared to conventional computer-delivered iCBT programs, the time use of smartphone applications is more evenly spread throughout the day, thus indicating the integration of the iCBT for smartphone as part of daily life routine (Stolz et al., 2018). Users have found the apps both acceptable and easy to use (Pramana et al., 2014). However, majority of the available mental health apps lack scientific evidence about their efficacy (Donker et al., 2013). Thus, further rigorous research is required to develop and test evidence-based mental health apps (Donker et al., 2013).

1.2. ICBT for Chinese people with SAD

A few studies on iCBT for those with SAD in Chinese communities have emerged in recent years due to the increasing needs with promising evidence of the effectiveness of both therapist-guided and self-help iCBT compared to waitlist controls (Kishimoto et al., 2016; Lin et al., 2020; Thew et al., 2022; Wang et al., 2020). ICBT reduces shame proneness which mediates engagement in exposure therapy and changes in SAD symptoms (Wang et al., 2020). ICBT with a shame intervention component can significantly reduce both shame and social anxiety symptoms at posttreatment compared to normal iCBT and waitlist control groups in China (Wen et al., 2024). The current iCBT programs for SAD in the Chinese population were developed based on programs from the West which were translated into Chinese with some cultural adaptations (Kishimoto et al., 2016; Lin et al., 2020; Wang et al., 2020). When implementing iCBT in Chinese population, cultural adaptations may further enhance its effectiveness as showed by a meta-analysis study which demonstrated short-term effects (Ng and Wong, 2018). Li et al. (2023) also showed in their meta-analysis that culturally adapted interventions for Chinese people have medium effect sizes in reducing both self-reported and clinician-rated symptom severity across mental disorders at post-intervention. However, they also concluded that their findings are limited by the insufficient reporting of cultural adaptation of interventions for Chinese population, particularly for iCBT. In addition, current studies on iCBT for Chinese with SAD are limited by small sample sizes (Lin et al., 2020; Thew et al., 2022; Wang et al., 2020), non-RCT designs (Kishimoto et al., 2016), untranslated and unadapted treatments (Thew et al., 2022), or lack of follow-up (Kishimoto et al., 2016; Lin et al., 2020; Wang et al., 2020; Wen et al., 2024). Finally, there are currently no Chinese language iCBT studies on Hong Kong Chinese with SAD.

1.3. Virtual reality exposure therapy

Virtual reality exposure therapy (VRET) is an innovative approach that bridges traditional exposure therapy and digital intervention by using computer-generated virtual social environments to expose clients to feared stimuli (Morina et al., 2023). VRET is often used with CBT to challenge and modify anxious thoughts and behaviours (Clemmensen et al., 2020). Meta-analysis studies show the efficacy of VRET which can sustain up to 6 years (Anderson et al., 2017; Arif et al., 2023; Horigome et al., 2020). Compared to in vivo exposure, VRET shows similar efficacy at post-intervention, but declines at later follow-up points (Horigome et al., 2020). Specifically, VRET was found to be effective in reducing social fear and avoidance, fear of negative evaluation, self-reported public speaking anxiety, catastrophic belief expectancy, probability and cost biases, distress, perceived stress and depressive symptoms, and increasing length of speech time, perceived performance quality and confidence (e.g. Anderson et al., 2013; Bouchard et al., 2017; Lindner et al., 2021; Kim et al., 2017). However, only one study was conducted in Chinese community, which found that VRET reduced symptoms caused by fear of COVID-19 infection (Zhang et al., 2020). While VRET is promising and innovative for treating SAD, no work has been done to integrate iCBT with VRET to treat SAD in the Chinese population.

1.4. The present study

The absence of VRET in Chinese-speaking communities, such as Hong Kong, led to the development of an iCBT program that incorporates VRET, which is called “Ease Anxiety in Social Event Online” (Ease Online), for Hong Kong adults with SAD. The primary aim of the present randomized controlled trial was to evaluate whether the EASE Online iCBT program was superior to a waitlist control group in reducing SAD symptoms and on a range of secondary outcome measures in the Hong Kong context. It also examined whether the program showed sustained clinical effects on these measures at 3- and 6-month follow-up. This study also delivered EASE Online iCBT in two formats – one using a web platform (web-based iCBT) and one via an app (app-based iCBT). It also aimed to examine whether web-based iCBT and app-based iCBT showed comparable treatment effects. It was hypothesized that both the web-based and app-based iCBT groups would be superior to waitlist at post-treatment on the primary outcome (SAD symptoms) and on the secondary outcomes of generalised anxiety and depression symptoms, psychological distress, automatic thoughts, internalised stigma, and quality of life. These effects were expected to be comparable between the two treatment formats, with sustained improvements at the 3- and 6-month follow-ups.

2. Methods

2.1. Participants and procedure

A total of 1807 participants were recruited on an ongoing basis between January 2020 and January 2023 via social media (Facebook and Instagram) and Google, a press conference, posters, and referrals from local non-governmental organisations. The selection criteria are: fluency in Cantonese; between the ages of 18 and 70; a score of 24 or more on the Chinese version of the Social Phobia Inventory (SPIN) (Tsai et al., 2009) (representing a clinically validated threshold for identifying likely cases of social anxiety disorder in the Chinese population); having a social anxiety disorder assessed by the Structured Clinical Interview for DSM–IV Disorders (SCID–5-CV) (First et al., 2016); having no psychological treatment at the time of registration or willingness to suspend

treatment during the study; having access to a computer or smartphone with internet connection; and having a valid email address. The exclusion criteria are: having severe depressive symptoms with a score over 30 on the Beck Depression Inventory-II (BDI-II) (Beck et al., 1996); having suicidal risk in the past three months (score of Item 9 in BDI-II is "2" or "3" and assessed to have suicidal risk during an intake interview); and having a self-reported severe psychiatric condition (e.g. bipolar disorder, schizophrenia, or borderline personality disorder) diagnosed by a psychiatrist or clinical psychologist. All of the participants provided informed consent and completed an online screening questionnaire that included the BAI, BDI-II, and SPIN on the program website. A total of 439 potential participants attended a 1.5-hour intake interview with the Structured Clinical Interview for SAD and assessment of suicidal risk. Marginal cases were discussed in a case meeting (including the first author, an intake worker and a program therapist). A project assistant contacted the eligible participants to reconfirm their participation. In the end, 329 participants were recruited and randomized (see Fig. 1). Those with severe depressive symptoms and/or suicidal risk identified during screening were referred to local mental health services with consent.

2.2. Research design

A 3-arm RCT was conducted in which the participants were randomly assigned to three groups by computer-generated random numbers in 12 cohorts with an average of 27 participants in each cohort. The two experimental groups received either the web-based iCBT (n = 117) or app-based iCBT (n = 111). A waitlist control (WLC) group (n = 101) received no intervention for 14 weeks and were then given access to the app-based iCBT. All completed the same online questionnaires at pre-test, post-test, and 3- and 6-month follow-up assessments. The WLC group completed the questionnaire one more time as a post-test after the two experimental groups completed the program. This study was granted ethics approval by the Human Research Ethics Committee of the university where the first author is employed and was pre-registered at https://clinicaltrials.gov/.

2.3. Intervention: Ease Online program

Ease Online is a 14-week therapist-guided iCBT program that was tailor-made for Hong Kong people with SAD (Pan, 2023). It consisted of 9 online modules, 3 counselling sessions and 2 VRET sessions. The online modules were premised on the CBT framework in Beck (2011) and CBT work for Chinese clients in Wong (2005) and Pan and Zhuang (2022). Participants learnt various CBT skills to cope with social anxiety through animated videos and 4 case demonstration videos developed from local cases. At the end of each module, participants were asked to complete an assignment to apply the CBT skills to deal with their own social anxiety. The program functions also included internal messaging, session review, a moderated online discussion forum, online questionnaires, reminders, and an online booking system. In the 3 counselling sessions, the therapist supported participants in reviewing and consolidating the module contents and planning ways to apply CBT skills in their daily life. Therapist also provided feedback on assignments. Each counselling session was 60 minutes conducted in person, on Zoom or through a WhatsApp call. The VRET sessions used five virtual scenarios developed for this study: (1) job interview; (2) delivering a presentation; (3) participating in a work performance appraisal; (4) expressing disagreement; and (5) drinking in public. Participants chose one and spent up to 15 minutes in the virtual environment. The VRET session was conducted in person with a duration of up to 60 minutes (including setup and debriefing) for each session. For a detailed description of the EASE Online program, please refer to Pan (2023).

As Li et al. (2023) suggested, cultural adaptation that either has appropriate modifications or is rooted in the sociocultural context, can enhance intervention effects for Chinese people. Thus, the case demonstration videos were developed based on local SAD cases, which would resonate with the real-life situation of the participants and served as good role models for them to learn and apply CBT skills to cope with SAD symptoms. Chinese peoples social anxiety may be influenced by culturally relevant beliefs. For example, the pressure to be a "good offspring" reflects the emphasis on filial piety and maintaining face in Chinese culture, which is central to Chinese family relationship and social interaction. Also, being a "good student" is highly valued in Chinese culture, which may be related to an over-emphasis on academic achievement and career prospects. Fear of not living up to the familial and societal expectations may contribute to social anxiety as Chinese people may worry about negative evaluations from others, such as being perceived as incompetent or impolite. Thus, the EASE Online program also focuses on working with culturally relevant beliefs related to social anxiety, such as redefining a "good offspring" and "good student", and making unhelpful comparisons with others. For example, the "pie chart" technique is used to relax the cognitive rule of "To be a good offspring, I can't make mistakes" to "Besides not making mistakes, there are many other ways to be a good offspring".

The online modules were released to participants weekly, with the first counselling session occurring between Modules 3 and 4, second counselling and two VRET sessions between Modules 6 and 7, and the final counselling session after Module 9. The Cantonese dialect was used for program development and service delivery. Data security and privacy were ensured by data encryption, two-factor authentication for system login, user acceptance test and security test by a third party before the program launch. Technical support was provided by two consecutive programmers to facilitate service delivery and participant engagement.

2.4. Therapist and treatment fidelity

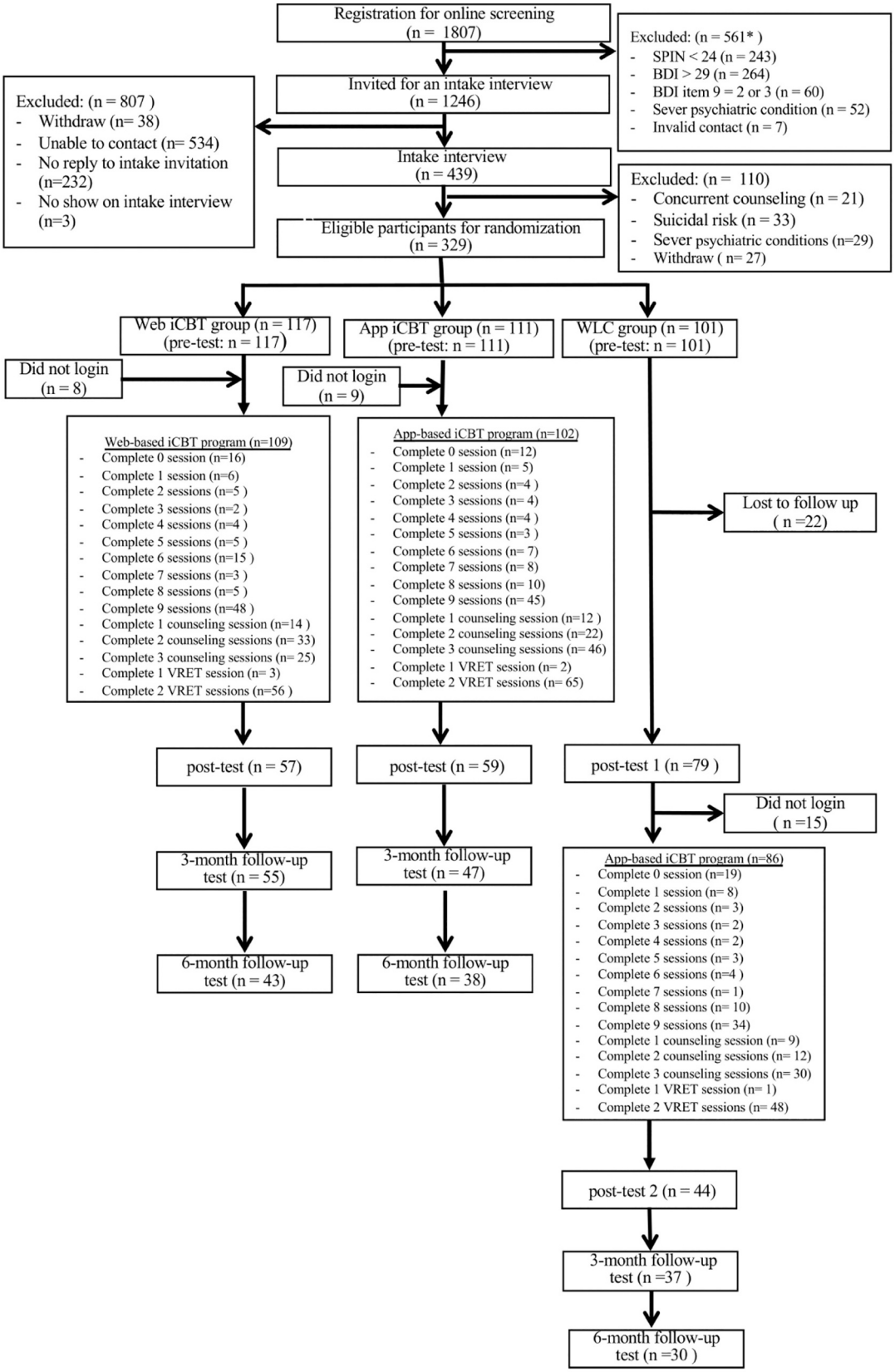
One therapist, having a masters degree in counselling (Clinical Mental Health), delivered the EASE Online program. She is a certified counsellor in both the U.S.A. and Canada with 9 years of counselling experience in Hong Kong, including experience of working with clients with SAD. She received CBT training, including CBT for SAD in both the U.S.A. and Hong Kong. The intake interviews were conducted by both the therapist and an experienced social worker who was registered in Hong Kong with bachelors and masters degrees in social work, has >30 years of counselling experience in Hong Kong and received CBT training. Both are native Cantonese speakers.

To ensure treatment fidelity, the following strategies were adopted: (1) progress reports were completed and submitted by the therapist after each individual counselling session to record participants understanding of the content of each online modules and their challenges in self-learning as well as application of CBT skills to cope with their own social anxiety, and client feedback; (2) progress reports were also submitted by the therapist for each VRET session to record the session contents, including the skills that the client used to cope with social anxiety in the VRET environment, reflections from their experience in VRET, and client feedback. The VRET process was recorded for each client for debriefing by the end of each VRET session; and (3) all the tasks, including assignments, completed by the clients were recorded in the system. The first author reviewed a randomly selected sample of progress reports from the counselling and VRET sessions across both the web-based and app-based iCBT conditions to examine session content and fidelity to the treatment protocols. No substantive protocol deviations were observed in either condition.

2.5. Outcome measures

2.5.1. Primary outcome measure

The Chinese version of the SPIN (Connor et al., 2000) was used to assess the severity of social anxiety symptoms. It consists of 17 items with 3 subscales: fear, avoidance and physiological response.



* The sum of the following number is bigger than excluded number as some participants have fulfilled more than two exclusion criteria.

Fig. 1. Participant flow chart of the study.

Participants are asked to rate their distress for each item during the past week on a 5-point Likert scale that ranges from "0" (not at all) to "4" (very much so). All of the item scores are summed up into a total score that ranges from 0 to 68, with a higher score indicating a higher level of social anxiety. Sample items are "fear of others watching", "avoid talking to others" and "bothered by blushing". The alpha coefficient is 0.89 for the Chinese SPIN (Tsai et al., 2009) and 0.89 in the current sample.

2.5.2. Secondary outcome measures

Chinese version of the Beck Anxiety Inventory (BAI) (Beck and Steer, 1993) was used to measure anxiety symptom. Participants are asked to rate 21 items on a 4-point Likert scale. Item scores are summed up, with a higher total score indicating a higher level of anxiety. The alpha coefficient is 0.95 in a Chinese sample (Cheng et al., 2002) and 0.92 in the current sample.

BDI-II (Beck et al., 1996) was used to measure depressive symptom. Participants are asked to rate 21 items on a 4-point Likert scale. The item scores are summed up, with a higher total score indicating a higher level of depressive symptoms. The alpha coefficient is 0.86 for the Chinese BDI-II (Shek, 1990) and 0.91 in the current sample.

General Health Questionnaire-12 (GHQ-12) (Goldberg and Williams, 1988) was used to measure psychological distress. The 0–0–1-1 scoring method was used to calculate the scale score (which ranges from 0 to 12). All item scores are summed up, with higher scores indicating higher levels of psychological distress. The Cronbach's alpha is 0.87 in a Hong Kong Chinese sample (Li et al., 2009) and 0.88 in the current sample.

Chinese Automatic Thoughts Questionnaire (CATQ) (Pan et al., 2016) was used to measure positive and negative automatic thoughts (AT). It contains 14-items for assessing positive and negative automatic thoughts. Participants are asked to rate the frequency of 14 items in the past week on a 5-point Likert scale (which ranges from "1" = "Not at all" to "5" = "All the time"). Item scores are average for the two subscales, with higher total scores indicating more positive and negative automatic thoughts, respectively. The Cronbach's alpha is 0.83 in a Hong Kong Chinese sample (Pan et al., 2016) and 0.80 and 0.89 for the positive and negative AT sbuscales, respectively, in the current sample.

WHO Quality of life Scale-BREF (WHOQOL-BREF) (Leung et al., 2005) was used to measure quality of life. It consists of 28 items, including 2 items that measure the overall quality of life and 26 items that measure physical and psychological health, social relationships and the environment. Each item is rated on a 5-point Likert scale that ranges from 1 (very dissatisfied) to 5 (very satisfied), with a higher score indicating better quality of life. The Cronbachs alpha ranges from 0.59 to 0.78 and test-retest reliability ranges from 0.72 to 0.83 for the Chinese WHOQOL-BREF (Leung et al., 2005) and 0.88 in the current sample.

Internalised Stigma of Mental Illness (ISMI) (Ritsher et al., 2003) was used to measure subjective experiences of self-stigma on mental illness. It consists of 24 items and 4 subscales: shame/alienation, stereotype endorsement, perceived discrimination and social withdrawal. Participants are asked to rate on a 4-point Likert scale that ranges from "1" ("strongly disagree") to "4" ("strongly agree"). All items were averaged as a scale score, with a higher score indicating a higher level of self-stigma. The Cronbach's alpha is 0.93 in a Hong Kong Chinese sample (Young et al., 2017) and 0.95 in the current sample.

2.6. Statistical analysis

Each treatment was compared against waitlist by using linear regression models to predict the posttreatment/postwait score. The waitlist was specified as the reference category for the condition variable. These models included the baseline score, gender and status of psychiatric medication (Yes/No) as covariates. Analyses of secondary outcome measures additionally included the baseline primary outcome (SPIN) score as a covariate.

To compare the two active treatments over the posttreatment, 3-month, and 6-month timepoints, linear mixed effects models were used to allow random effects of the participants to be specified to account for the between-subject variation across the three timepoints. These models included categorical fixed factors of timepoint, condition, and their interaction, which allow group differences to be estimated at each timepoint. The covariates were the same as described above. Q-Q plots indicated that the normality of residuals assumption was met for all of the models. Standardised between-group effect sizes were calculated by dividing the adjusted group difference by the baseline standard deviation. Standardised within-group effect sizes were computed from separate models that included the baseline score as a timepoint in the model, rather than a covariate, to allow estimation of within-group changes from the baseline. Based on Cohen (1988), small, medium and large effect sizes are 0.2, 0.5 and 0.8, respectively.

Reliable change and remission were defined based on changes on the primary measure (SPIN) between the baseline and postwait/posttreatment. Reliable improvement or deterioration was defined as a change of 10 or more points on SPIN. Remission was defined as starting in clinical caseness (19 or more points), showing reliable improvement, and finishing below caseness (<19 points) (see National Collaborating Centre for Mental Health (2024)). The commonly used SPIN cutoff of 19 was used for these analyses to permit comparability with existing literature.

Mann-Whitney U and chi-square tests were used to examine differences in baseline clinical or demographic variables between treatment completers (defined as completing all nine modules and providing posttreatment data) and non-completers. Measures of treatment adherence (modules completed, counselling and VRET sessions attended) were explored as candidate predictors of clinical outcomes by using a linear or logistic regression. Analyses were conducted in R version 4.3.1 (The R Foundation, 2023) by using the packages 'tidyverse' (Wickham et al., 2019), 'jmv' (Selker et al., 2018) and 'nlme' (Pinheiro et al., 2018).

3. Results

3.1. Demographic characteristics

A total of 329 eligible participants were randomized into three groups: (1) web-based iCBT (n = 117); (2) app-based iCBT (n = 111); and (3) WLC (n = 101). The mean age was 30.49 years old (SD = 9.34), with 36 % male and 64 % female. Most were single (75 %), had a university or higher degree (81 %), and atheist (69 %). The majority had a monthly family income of HK$10,001–30,000 (USD1,287–3861, 42 %), followed by HK$30,001–50,000 (USD3,861–6435, 28 %) and HK $50,001 or higher (USD6,435 +, 22 %). The majority did not have a mental disorder diagnosis (74 %), were not receiving counselling service (84 %) and had not reported suicide attempt/ideation in past 3 months (89 %) at the time of registration, and were not taking psychiatric medication (88 %). Their demographics are presented in Table 1.

3.2. Participant flow and adherence

The flow of the participants through the trial is shown in Fig. 1. Data completeness at the post, 3-month, and 6-month timepoints were 49 %, 47 %, and 37 % for the web-based iCBT group, and 53 %, 42 %, and 34 % for the app-based iCBT group, respectively. Data completeness at postwait was 78 % for the WLC group. Following the wait period, the WLC participants then received app-based iCBT (see outcomes in supplementary material Table S1).

Among the web-based iCBT group, 109/117 participants (93 %) logged into the program. On average, 5.52 out of 9 (61 %) modules (SD = 3.67) were completed, 34 %, 13 %, 30 % and 23 % of the logged-in participants completed zero, one, two and three counselling sessions, and 46 %, 3 % and 51 % completed zero, one and two VRET sessions, respectively. Among the app-based iCBT group, 102/111 participants (92 %) logged into the programme. On average, they completed 5.76 out of 9 (64 %) modules (SD = 3.63), 21 %, 12 %, 22 % and 45 % of the

Table 1
Participant demographics.

Variable		Web (n = 117)	App (n = 111)	WLC (n = 101)	Total (*n* = 329)
Age		30.63 (9.99)	30.16 (9.62)	30.69 (8.26)	30.49 (9.34)
Gender	Male	32 (27 %)	49 (44 %)	39 (39 %)	120 (36 %)
	Female	85 (73 %)	62 (56 %)	62 (61 %)	209 (64 %)
Marital status	Single	85 (73 %)	86 (77 %)	76 (75 %)	247 (75 %)
	Married	23 (20 %)	17 (15 %)	15 (15 %)	55 (17 %)
	Widowed	1 (0.9 %)	1 (0.9 %)	1 (1.0 %)	3 (0.9 %)
	Cohabiting	7 (6.0 %)	4 (3.6 %)	6 (5.9 %)	17 (5.2 %)
	Other	1 (0.9 %)	3 (2.7 %)	3 (3.0 %)	7 (2.1 %)
Family monthly income	HK $0–10,000	9 (7.7 %)	6 (5.5 %)	11 (11 %)	26 (7.9 %)
	HK$10,001-30,000	45 (38 %)	50 (45 %)	44 (44 %)	139 (42 %)
	HK$30,001-50,000	31 (26 %)	30 (27 %)	30 (30 %)	91 (28 %)
	HK $50,001+	32 (27 %)	24 (22 %)	16 (16 %)	72 (22 %)
Education	Secondary school	23 (20 %)	18 (16 %)	20 (20 %)	61 (19 %)
	University or higher	94 (80 %)	93 (84 %)	80 (80 %)	267 (81 %)
Religion	None	82 (70 %)	77 (69 %)	67 (66 %)	226 (69 %)
	Christian	26 (22 %)	29 (26 %)	23 (23 %)	78 (24 %)
	Catholic	6 (5.1 %)	3 (2.7 %)	8 (7.9 %)	17 (5.2 %)
	Buddhist	1 (0.9 %)	1 (0.9 %)	1 (1.0 %)	3 (0.9 %)
	Other	2 (1.7 %)	1 (0.9 %)	2 (2.0 %)	5 (1.5 %)
Any diagnosed mental health condition	No	83 (71 %)	87 (78 %)	75 (74 %)	245 (74 %)
	Yes	34 (29 %)	24 (22 %)	26 (26 %)	84 (26 %)
Receiving counselling at the time of registration	No	101 (86 %)	94 (85 %)	83 (82 %)	278 (84 %)
	Yes	16 (14 %)	17 (15 %)	18 (18 %)	51 (16 %)
Self-reported suicide attempt/ ideation in past 3 months at the time of registration	No	105 (90 %)	99 (89 %)	90 (89 %)	294 (89 %)
	Yes	12 (10 %)	12 (11 %)	11 (11 %)	35 (11 %)
Psychiatric medication	No	100 (85 %)	100 (90 %)	89 (88 %)	289 (88 %)
	Yes	17 (15 %)	11 (9.9 %)	12 (12 %)	40 (12 %)

participants who logged in completed zero, one, two and three counselling sessions, and 34 %, 2 % and 64 % completed zero, one and two VRET sessions, respectively.

3.3. Comparison of each treatment to waitlist

The results of the regression models to compare each treatment to the WLC are shown in Table 2. Both treatments were superior to the WLC at post-test on the primary outcome measure (SPIN), as shown in Fig. 2. Both treatments were also superior to the WLC on the secondary outcome outcomes at post-test, with significantly reduced general anxiety symptoms (BAI), depression symptoms (BDI), psychological distress (GHQ-12), and internalised stigma (ISMI), as well as improved quality of life (QoLS) and automatic thoughts (CATQ). The between-group effect size on the SPIN was 1.02 and 1.15 in the web- and app-based iCBT groups, respectively while those on the secondary outcome measures ranged from 0.28–0.85 and 0.43–1.12 for the web- and app-based iCBT groups, respectively.

Eight web-based and nine app-based iCBT participants did not log into the program. A sensitivity analysis that removed these cases showed no effect on the model results (see supplementary material Table S2). Additionally, we found two baseline variables that in logistic regressions were significant predictors of missingness on the SPIN at the post timepoint: age (estimate = 0.05, $p < .001$, OR = 1.05), where being older was associated with the greater likelihood of presenting data, and baseline BDI score (estimate = −0.03, $p = .016$, OR = 0.97), where more baseline depression symptoms were associated with a greater likelihood of missingness. A sensitivity analysis which included age and baseline BDI score as additional covariates in the model showed that they did not substantially affect the model results (see supplementary material Table S2). Among the WLC group, no significant predictors of postwait SPIN scores were found.

A secondary analysis was then performed to determine the impact of replacing missing values. Given the extent of missing data at the post timepoints, we assumed that the missing values reflect lack of change (i.e., no improvement or deterioration from the previous timepoint). We replaced missing values using a "last observation carried forward" approach and ran the same models (see supplementary material Table S3). The results were consistent with the primary analyses and showed that both treatments were superior to the WLC on the primary and secondary outcome measures, except the social relationship subscale in the WHOQOL-BREF for the web-based iCBT group, and the physical health subscale in the WHOQOL-BREF for the app-based iCBT group. As expected, the effect size estimates were smaller. The effect size of the SPIN was in the medium range with 0.44 and 0.56 in the web- and app-based iCBT groups, compared to 1.02 and 1.15 with the original model, respectively. The effect sizes of the secondary outcome measures ranged from small to medium, or between 0.13 and 0.38 and 0.19 and 0.43 in the web- and app-based iCBT groups, respectively. This suggested that under a relatively strict assumption for replacing missing data, both treatments showed effect sizes in the medium range for the SPIN, and the small to medium range for most secondary outcomes.

3.4. Comparison of two active treatments

The results of the linear mixed effects models that compared the two active treatments against each other are shown in Table 3. No significant differences were observed for the primary or secondary outcome measures across the post, 3-month, or 6-month timepoints, apart from the GHQ-12 at 6-month follow-up. The means and within-group effect sizes showed that the clinical effects of both interventions were well-sustained over the 3-month and 6-month timepoints.

In line with previous regression models, we conducted a sensitivity analysis that included age and baseline BDI score as additional covariates in the model, which did not substantially affect the model results (see supplementary material Table S4). We also conducted secondary analyses that replaced the missing data by using "last observation carried forward" approach (see supplementary material Table S5). The findings were consistent with the primary analyses in that no significant differences between the treatments were observed across the post, 3-month, or 6-month timepoints, apart from the GHQ-12 at 6-month follow-up. The within-group effect size estimates compared to the baseline were smaller. The effect size of the SPIN was 0.80 and 0.89 in the web- and app-based iCBT groups at posttreatment, compared to 1.63 and 1.69 in the original model, respectively. The posttreatment effect sizes for the secondary outcome measures were small to medium, which ranged between 0.08 and 0.45, and 0.12 and 0.50, in the web- and app-based iCBT groups, respectively.

Table 2
Comparison of web-based and app-based iCBT groups with WLC group on primary and secondary outcome measures at initial allocation.

Measure	Time	Unadjusted mean (SD) [N]			Adjusted difference [95%CI], *p* value		Standardised between-group effect size [95%CI]	
		Web	App	Wait	Web vs Wait	App vs Wait	Web vs Wait	App vs Wait
SPIN	Pre	39.76 (9.45) [117]	37.77 (9.86) [111]	37.42 (10.58) [101]				
	Post	23.82 (10.61) [57]	20.83 (11.41) [59]	36.05 (11.65) [79]	−13.36 [−16.79, −9.93], <0.001	−15.16 [−18.53, −11.80], <0.001	1.02 [0.75, 1.28]	1.15 [0.90, 1.41]
BAI	Pre	19.79 (10.58) [117]	19.02 (9.55) [111]	20.11 (10.14) [101]				
	Post	11.75 (7.39) [57]	10.44 (8.23) [59]	19.47 (10.86) [79]	−7.30 [−10.11, −4.49], <0.001	−8.64 [−11.38, −5.89], <0.001	0.73 [0.45, 1.01]	0.86 [0.59, 1.13]
BDI	Pre	18.10 (8.59) [117]	15.56 (8.89) [111]	17.07 (8.06) [101]				
	Post	9.53 (8.67) [57]	6.98 (6.21) [59]	16.89 (8.12) [79]	−7.59 [−10.08, −5.10], <0.001	−8.73 [−11.22, −6.25], <0.001	0.85 [0.57, 1.13]	0.98 [0.70, 1.26]
GHQ	Pre	5.18 (3.55) [117]	4.95 (3.80) [111]	6.09 (3.56) [101]				
	Post	1.93 (2.81) [57]	0.86 (1.54) [59]	4.82 (3.44) [79]	−2.75 [−3.71, −1.80], <0.001	−3.66 [−4.61, −2.71], <0.001	0.84 [0.55, 1.13]	1.12 [0.83, 1.41]
AT positive	Pre	1.92 (0.50) [117]	2.06 (0.54) [111]	1.98 (0.43) [101]				
	Post	2.26 (0.75) [57]	2.46 (0.68) [59]	1.98 (0.47) [79]	0.29 [0.10, 0.48],0 .003	0.42 [0.23, 0.61], <0.001	0.44 [0.15, 0.73]	0.64 [0.35, 0.92]
AT negative	Pre	2.49 (0.80) [117]	2.37 (0.73) [111]	2.43 (0.71) [101]				
	Post	1.84 (0.64) [57]	1.69 (0.52) [59]	2.45 (0.74) [79]	−0.60 [−0.81, −0.40], <0.001	−0.70 [−0.90, −0.50], <0.001	0.83 [0.55, 1.11]	0.95 [0.68, 1.23]
QoLS Physical health	Pre	54.59 (13.08) [117]	57.06 (13.58) [111]	55.73 (11.19) [101]				
	Post	63.72 (15.33) [57]	65.83 (12.96) [59]	56.35 (10.47) [79]	7.57 [3.74, 11.40], <0.001	6.93 [3.13, 10.73], <0.001	0.56 [0.28, 0.85]	0.52 [0.23, 0.80]
QoLS Mental health	Pre	38.00 (13.59) [117]	42.35 (14.45) [111]	39.95 (12.58) [101]				
	Post	47.07 (15.90) [57]	52.97 (16.06) [59]	39.81 (11.36) [79]	7.23 [3.35, 11.11], <0.001	9.89 [6.04, 13.74], <0.001	0.47 [0.22, 0.73]	0.65 [0.40, 0.90]
QoLS Social relationship	Pre	40.74 (14.27) [117]	39.12 (15.13) [111]	37.18 (13.51) [101]				
	Post	47.39 (13.88) [57]	49.92 (15.3) [59]	38.56 (14.87) [79]	6.26 [1.71, 10.81],0 .007	9.49 [5.06, 13.92], <0.001	0.40 [0.11, 0.70]	0.61 [0.33, 0.90]
QoLS Environment	Pre	53.08 (15.46) [117]	55.06 (13.33) [111]	54.89 (12.53) [101]				
	Post	57.68 (17.12) [57]	60.49 (14.04) [59]	52.82 (13.43) [79]	4.21 [0.39, 8.02],0 .031	6.45 [2.69, 10.20],0 .001	0.28 [0.03, 0.53]	0.43 [0.18, 0.68]
ISMI	Pre	2.22 (0.49) [117]	2.13 (0.58) [111]	2.22 (0.52) [101]				
	Post	1.99 (0.50) [57]	1.86 (0.60) [58]	2.29 (0.43) [79]	−0.25 [−0.38, −0.12], <0.001	−0.31 [−0.44, −0.18], <0.001	0.47 [0.22, 0.72]	0.57 [0.33, 0.82]

Notes: Linear regression models to predict post score from condition, controlling for baseline score, gender, and medical treatment status. SPIN = Social Phobia Inventory; BAI = Beck Anxiety Inventory; BDI = Beck Depression Inventory; GHQ = General Health Questionnaire; AT = Automatic Thoughts questionnaire; QoLS = Quality of Life Scale; and ISMI = Internalised Stigma of Mental Illness scale.

3.5. Reliable change and remission

Based on the criteria described in the Method section, the number of participants in each condition who showed reliable improvement, reliable deterioration, or remission between baseline and postwait/post-treatment are shown in Table 4. The results were calculated based on the available SPIN data at posttest/postwait. In the web- and app-based iCBT conditions, 34 % and 40 % showed reliable improvement based on the SPIN score, compared to 11 % in the WLC group; 0 % and 1 % showed reliable deterioration, compared to 8 % in the WLC group; and 15 % and 23 % met the criteria for remission of social anxiety, compared to 3 % in the WLC group, respectively.

3.6. Exploration of treatment completion

In each treatment condition, 38 % of participants completed all nine modules and provided posttreatment data, and were therefore classified as treatment completers. The baseline demographic and clinical characteristics compared to the non-completers are provided in the supplementary material section (Table S6). Compared to the completers, the

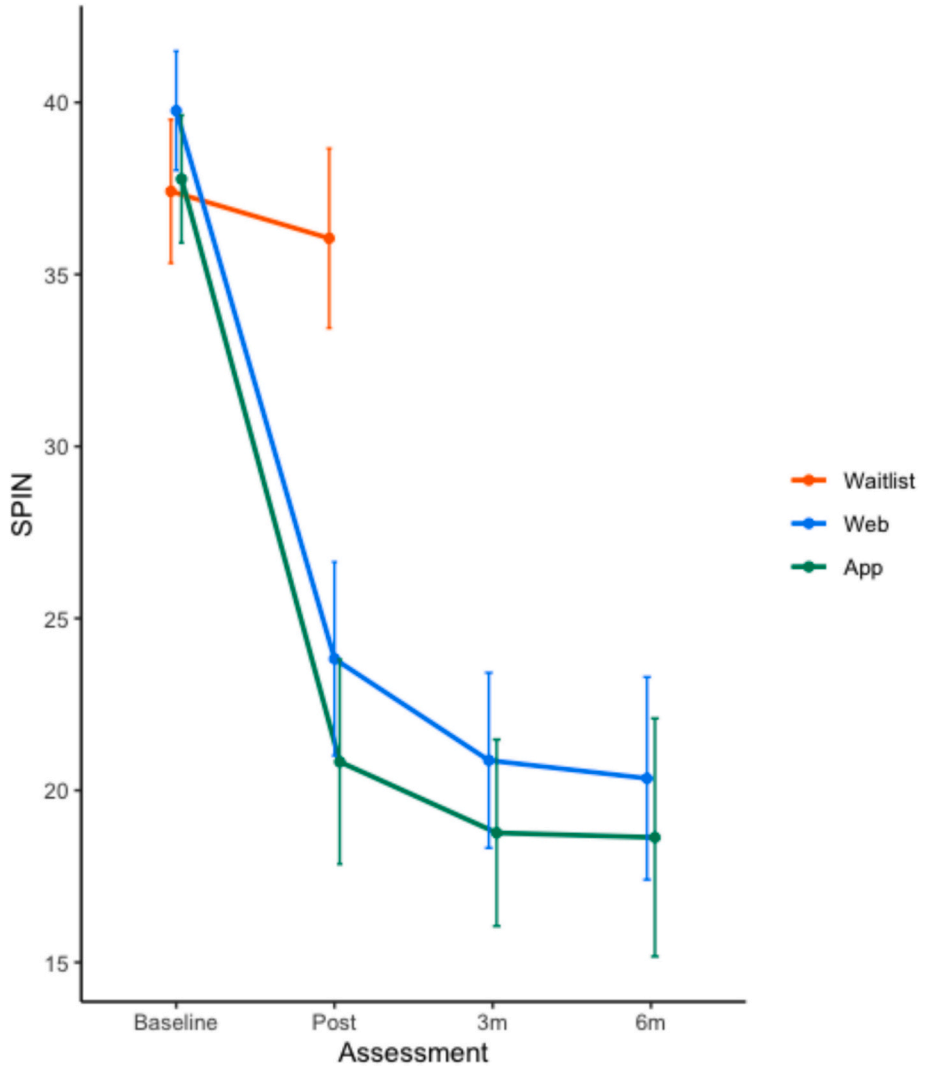


Fig. 2. Mean scores on SPIN at baseline, postwait/posttreatment, 3-month and 6-month follow-ups. Error bars = 95%CI.

non-completers were younger, single, and had more severe depression symptoms on the BDI at baseline.

We examined whether the extent of treatment completion was associated with the posttreatment SPIN scores. Completing more modules was associated with a greater likelihood of providing posttreatment SPIN data (estimate = 0.72, SE = 0.09, $p < .001$). Although data visualisations indicated trends that completing more modules and attending more counselling sessions were associated with lower SPIN scores at posttreatment, these variables were not significant predictors of outcome (modules completed estimate = −0.55, $p = .353$; counselling sessions attended estimate = −1.25, $p = .294$). Those who completed at least one VR session finished treatment with a slightly lower SPIN score (M = 21.97, SD = 11.10), compared to those who did not (M = 24.92, SD = 10.99), but overall, completing the VR sessions does not significantly predict outcome (estimate = −3.49, $p = .263$).

4. Discussion

4.1. Effectiveness of iCBT with VRET for Hong Kong Chinese with SAD

To the best of our knowledge, this is the first study to test the effectiveness of iCBT in combination with VRET for Chinese participants with SAD in Hong Kong. Although attrition rate was high, the results indicated that both web-based and app-based Chinese language iCBT with VRET were superior to the WLC in reducing social and general anxiety and depression symptom, psychological distress and internalised stigma, and improving automatic thoughts and quality of life. No significant differences between the two treatment formats were observed on almost all secondary outcome measure, and the positive effects were maintained at the 3-month and 6-month follow-up assessments (except psychological distress at 6-month follow-up for app-based iCBT group). The findings are promising and consistent with those reported in Western contexts (e.g. Andersson et al., 2006), China (e.g. Lin et al., 2020) and Hong Kong (Thew et al., 2022). In addition, 34 % and 40 % of the participants allocated to the web-based and app-based iCBT groups showed reliable improvement on the SPIN, respectively, and 15 % and 23 % met the criteria for remission of social anxiety disorder. These are conservative estimates based on the shown changes. Those who did not provide SPIN data at the post timepoints may also have improved but this cannot be confirmed.

The positive effects may be related to the use of Cantonese language (the first language of Hong Kong people) to facilitate participants' understanding of the program content, use of real human beings in VR videos to enhance sense of reality and presence, therapist support delivered in counselling and VRET sessions to facilitate participants' skills application, and video-based iCBT which fits preferred ways of receiving information by Hong Kong people. Although similar intervention effects were found for web-based and app-based iCBT for the

Table 3
Comparisons of web-based and app-based iCBT on the primary and secondary outcome measures.

Measure	Time	Unadjusted mean (SD) [N]		Adjusted difference [95% CI], p value	Standardised Between-Group Effect size [95%CI]	Standardised Within-Group Effect size [95%CI]	
		Web	App			Web	App
SPIN	Pre	39.76 (9.45) [117]	37.77 (9.86) [111]				
	Post	23.82 (10.61) [57]	20.83 (11.41) [59]	1.97 [−1.70, 5.65], 0.290	0.20 [−0.18, 0.58]	1.63 [1.37, 1.89]	1.69 [1.44, 1.95]
	3 m	20.87 (9.42) [55]	18.77 (9.24) [47]	0.31 [−3.50, 4.11], 0.873	0.03 [−0.36, 0.42]	1.92 [1.65, 2.18]	1.82 [1.54, 2.11]
	6 m	20.35 (9.57) [43]	18.63 (10.53) [38]	1.08 [−2.94, 5.11], 0.596	0.11 [−0.30, 0.53]	1.93 [1.64, 2.22]	1.87 [1.56, 2.17]
BAI	Pre	19.79 (10.58) [117]	19.02 (9.55) [111]				
	Post	11.75 (7.39) [57]	10.44 (8.23) [59]	0.83 [−1.81, 3.48], 0.535	0.08 [−0.18, 0.35]	0.72 [0.52, 0.93]	0.77 [0.57, 0.98]
	3 m	10.22 (7.65) [55]	9.55 (8.43) [47]	−0.39 [−3.14, 2.36], 0.780	0.04 [−0.23, 0.31]	0.88 [0.67, 1.09]	0.79 [0.56, 1.01]
	6 m	9.14 (7.09) [43]	9.39 (6.84) [38]	−1.22 [−4.14, 1.69], 0.408	0.12 [−0.17, 0.41]	1.03 [0.80, 1.26]	0.84 [0.60, 1.08]
BDI	Pre	18.10 (8.59) [117]	15.56 (8.89) [111]				
	Post	9.53 (8.67) [57]	6.98 (6.21) [59]	1.04 [−1.63, 3.72], 0.442	0.12 [−0.19, 0.42]	0.93 [0.70, 1.16]	0.83 [0.60, 1.06]
	3 m	9.16 (7.92) [55]	6.06 (6.18) [47]	1.44 [−1.36, 4.25], 0.310	0.16 [−0.15, 0.48]	0.96 [0.72, 1.19]	0.92 [0.67, 1.18]
	6 m	7.93 (7.08) [43]	8.74 (9.45) [38]	−2.37 [−5.41, 0.67], 0.125	0.27 [−0.08, 0.61]	1.11 [0.85, 1.37]	0.62 [0.34, 0.89]
GHQ	Pre	5.18 (3.55) [117]	4.95 (3.80) [111]				
	Post	1.93 (2.81) [57]	0.86 (1.54) [59]	0.65 [−0.26, 1.55], 0.161	0.18 [−0.07, 0.42]	0.90 [0.67, 1.13]	1.04 [0.80, 1.27]
	3 m	1.60 (2.12) [55]	1.34 (2.46) [47]	−0.12 [−1.08, 0.84], 0.804	0.03 [−0.23, 0.29]	1.00 [0.77, 1.24]	0.91 [0.65, 1.16]
	6 m	1.63 (2.73) [43]	2.61 (3.51) [38]	−1.31 [−2.37, −0.25], 0.015	0.36 [0.07, 0.65]	1.00 [0.74, 1.26]	0.57 [0.30, 0.85]
AT positive	Pre	1.92 (0.50) [117]	2.06 (0.54) [111]				
	Post	2.26 (0.75) [57]	2.46 (0.68) [59]	−0.13 [−0.37, 0.11], 0.296	0.25 [−0.21, 0.70]	0.60 [0.32, 0.90]	0.69 [0.40, 0.97]
	3 m	2.36 (0.76) [55]	2.49 (0.83) [47]	−0.02 [−0.28, 0.23], 0.848	0.05 [−0.44, 0.53]	0.78 [0.48, 1.07]	0.70 [0.38, 1.01]
	6 m	2.29 (0.92) [43]	2.54 (0.74) [38]	−0.12 [−0.39, 0.15], 0.385	0.23 [−0.29, 0.74]	0.66 [0.34, 0.99]	0.76 [0.42, 1.10]
AT negative	Pre	2.49 (0.80) [117]	2.37 (0.73) [111]				
	Post	1.84 (0.64) [57]	1.69 (0.52) [59]	0.08 [−0.12, 0.28], 0.433	0.10 [−0.16, 0.36]	0.81 [0.60, 1.03]	0.81 [0.58, 1.03]
	3 m	1.79 (0.53) [55]	1.65 (0.49) [47]	0.07 [−0.14, 0.29], 0.496	0.10 [−0.18, 0.38]	0.85 [0.64, 1.08]	0.85 [0.61, 1.09]
	6 m	1.76 (0.66) [43]	1.82 (0.76) [38]	−0.16 [−0.39, 0.07], 0.179	0.21 [−0.09, 0.51]	0.95 [0.70, 1.19]	0.63 [0.38, 0.90]
QoLS Physical health	Pre	54.59 (13.08) [117]	57.06 (13.58) [111]				
	Post	63.72 (15.33) [57]	65.83 (12.96) [59]	1.58 [−3.13, 6.28], 0.508	0.12 [−0.23, 0.47]	0.66 [0.42, 0.90]	0.48 [0.24, 0.72]
	3 m	62.11 (13.37) [55]	69.02 (13.24) [47]	−4.16 [−9.09, 0.77], 0.097	0.31 [−0.06, 0.68]	0.48 [0.23, 0.72]	0.73 [0.47, 0.99]
	6 m	63.05 (15.42) [43]	64.29 (18.09) [38]	1.88 [−3.45, 7.21], 0.486	0.14 [−0.26, 0.54]	0.60 [0.34, 0.87]	0.39 [0.11, 0.67]
QoLS Mental health	Pre	38.00 (13.59) [117]	42.35 (14.45) [111]				
	Post	47.07 (15.90) [57]	52.97 (16.06) [59]	−2.53 [−7.43, 2.37], 0.309	0.18 [−0.17, 0.53]	0.54 [0.31, 0.77]	0.61 [0.38, 0.84]
	3 m	45.96 (15.28) [55]	55.09 (16.04) [47]	−4.50 [−9.64, 0.64], 0.086	0.32 [−0.05, 0.68]	0.46 [0.23, 0.69]	0.68 [0.43, 0.93]
	6 m	51.33 (17.55) [43]	53.84 (17.78) [38]	3.45 [−2.11, 9.00], 0.221	0.24 [−0.15, 0.64]	0.86 [0.60, 1.11]	0.51 [0.24, 0.78]
QoLS Social relationship	Pre	40.74 (14.27) [117]	39.12 (15.13) [111]				
	Post	47.39 (13.88) [57]	49.92 (15.30) [59]	−2.71 [−7.82, 2.39], 0.294	0.18 [−0.16, 0.53]	0.40 [0.17, 0.63]	0.66 [0.43, 0.89]
	3 m	48.31 (14.67) [55]	52.57 (15.99) [47]	−4.07 [−9.37, 1.22], 0.130	0.28 [−0.08, 0.64]	0.44 [0.20, 0.67]	0.77 [0.52, 1.02]
	6 m	48.72 (17.65) [43]	49.84 (18.82) [38]	−1.39 [−7.03, 4.25], 0.628	0.09 [−0.29, 0.48]	0.46 [0.20, 0.72]	0.62 [0.34, 0.89]

(*continued on next page*)

Table 3 (*continued*)

Measure	Time	Unadjusted mean (SD) [N]		Adjusted difference [95% CI], p value	Standardised Between-Group Effect size [95%CI]	Standardised Within-Group Effect size [95%CI]	
		Web	App			Web	App
QoLS Environ-ment	Pre	53.08 (15.46) [117]	55.06 (13.33) [111]				
	Post	57.68 (17.12) [57]	60.49 (14.04) [59]	−1.78 [−6.34, 2.79], 0.443	0.12 [−0.19, 0.44]	0.19 [−0.02, 0.40]	0.26 [0.05, 0.46]
	3 m	57.78 (17.36) [55]	62.68 (14.99) [47]	−4.58 [−9.35, 0.19], 0.060	0.32 [−0.01, 0.65]	0.11 [−0.10, 0.32]	0.39 [0.16, 0.62]
	6 m	60.70 (19.19) [43]	66.39 (15.98) [38]	−4.16 [−9.28, 0.95], 0.110	0.29 [−0.07, 0.64]	0.32 [0.09, 0.55]	0.56 [0.31, 0.80]
ISMI	Pre	2.22 (0.49) [117]	2.13 (0.58) [111]				
	Post	1.99 (0.50) [57]	1.86 (0.60) [58]	0.03 [−0.12, 0.19], 0.677	0.06 [−0.22, 0.35]	0.33 [0.15, 0.52]	0.39 [0.19, 0.58]
	3 m	1.85 (0.50) [55]	1.77 (0.61) [47]	0.05 [−0.11, 0.21], 0.545	0.09 [−0.20, 0.39]	0.51 [0.32, 0.71]	0.59 [0.37, 0.80]
	6 m	1.84 (0.59) [43]	1.66 (0.53) [38]	0.08 [−0.09, 0.25], 0.350	0.15 [−0.17, 0.46]	0.61 [0.39, 0.82]	0.76 [0.54, 0.98]

Notes: Linear mixed effects models include post/3-month/6-month timepoints, and controlling for baseline score, gender and medical treatment status. Within-group effect sizes indicate change from baseline, calculated from separate models including pre/post/3-month/6-month timepoints, and controlling for baseline score, gender and medical treatment status. SPIN = Social Phobia Inventory; BAI = Beck Anxiety Inventory; BDI = Beck Depression Inventory; GHQ = General Health Questionnaire; AT = Automatic Thoughts questionnaire; QoLS = Quality of Life Scale; and ISMI = Internalised Stigma of Mental Illness scale.

Table 4
Rates of Reliable Improvement, Reliable Deterioration, and Remission based on SPIN scores between baseline and postwait/posttreatment.

	Web (n = 117) (57 provided post data)	App (n = 111) (59 provided post data)	Wait (n = 101) (79 provided post data)
Reliable Improvement	40/117 (34 %)	44/111 (40 %)	11/101 (11 %)
Reliable Deterioration	0/117 (0 %)	1/111 (1 %)	8/101 (8 %)
Remission	18/117 (15 %)	25/111 (23 %)	3/101 (3 %)

Notes: Reliable improvement/deterioration = pre-post change of 10 or more SPIN points. Remission defined as starting in caseness (19 or more points), showing reliable improvement, and finishing below caseness (<19 points). Note that % values include all randomized participants; if only those who provided data at post are included, the rates of Reliable Improvement, Reliable Deterioration, and Remission are 70 %, 0 %, and 32 % respectively in the Web-based iCBT condition, 75 %, 2 %, and 42 % in the App-based iCBT condition, and 14 %, 10 %, and 4 % in the waitlist condition.

treatment of SAD for Hong Kong people, the rates of reliable improvement (40 % vs 34 %) and remission (23 % vs 15 %) in app-based iCBT were slightly higher than those in web-based iCBT. The slightly higher rates may be attributed to the enhanced accessibility and convenience of mobile applications and seamless integration with daily life to fit Hong Kong's fast-paced lifestyle, improved engagement features within the app, such as automated reminder notifications, and a possible 'mobile-first' preference by young people (Mean age of 30.49 in the sample).

4.2. Program engagement

The initial uptake of both treatment conditions was good, with nearly all of the participants logging into the program. The average completion rates of the online modules (61 % and 64 % for the web-based and app-based groups, respectively) are comparable to the 59 % in Nordgreen et al. (2018) and 63 % in Kishimoto et al. (2016), but lower than the 81 % in Clark et al. (2023). Counselling and VRET session attendances were moderate (67 % and 79 % for counselling session, and 54 % and 66 % for VRET session for the web-based and app-based iCBT groups, respectively) probably because most of the appointment time slots were provided on weekdays which may have conflicted with the working time of participants, but they may have helped to support continued engagement with the intervention.

4.3. Attrition during study

The attrition rates in this study (51 % and 47 % at post-test, 53 % and 58 % at 3-month, 63 % and 66 % at 6-month follow-up for web- and app-based groups, respectively) are comparable to those reported in iCBT studies in China (33 % - 62 %) (Kishimoto et al., 2016; Wang et al., 2020; Wen et al., 2024), but higher than those reported by Thew et al. (2022) in Hong Kong (5 % and 9 % at post-test and 3-month follow-up test, respectively), and lower than those reported in Mak et al. (2017) in Hong Kong (83 % and 90 % at post-test and 3-month follow-up test, respectively). Although various means were used to minimise withdrawal, including automatic and staff reminders, attrition and missing data were relatively high. This may reflect the different levels of commitment or motivation for treatment among the sample, perhaps linked to busy lifestyles that are common in Hong Kong, or possible difficulties related to clinical comorbidity or technical challenges. Further examination of the reasons for withdrawal would be helpful for future studies. The attrition rate at post-test was lower in the WLC group (22 %), likely because they were required to complete the post-test questionnaire before participating in the app-based iCBT program.

4.4. Implications

This study is the first to provide empirical evidence of the effectiveness of iCBT combined with VRET for Hong Kong people with SAD, and contributes to the broader development and evaluation of internet interventions in Chinese communities. Given the extremely low treatment rate of SAD in Hong Kong, iCBT is a promising treatment option due to its flexibility and convenience. This treatment approach can address the gap between high service demands and the limited number of mental health professionals in Hong Kong. More investment to develop, evaluate, and implement iCBT programs for SAD and support therapist training may be therefore beneficial.

4.5. Strengths and limitations

The current study culturally adapted the treatment contents to accommodate the service needs of Chinese people, used a randomized design with a large sample size, included follow-up assessments, and used sensitivity and secondary analyses to verify the robustness of the findings. Although the EASE Online Program was developed for the Hong Kong context, it may be relevant and applicable to Chinese people

worldwide. Therefore, it has potential to support wider access to evidence-based mental healthcare. Furthermore, there would also be scope to undertake linguistic translation and/or alternative cultural adaptations to make the program suitable for use in other settings.

The limitations of this study are the relatively high attrition rate and missing data at later timepoints. Nevertheless, the sensitivity analysis suggests that these do not substantively impact the results. However, further improvements may be needed to engage and retain participants in the intervention. For example, the time slots of the VR sessions could be provided at night or on Saturday and Sunday to avoid scheduling difficulties of the working participants. Therapist time was not recorded during the study, which would have been helpful for supporting the work of cost-effective analysis. The remission rate was calculated based on the SPIN score, instead of diagnostic clinical interviews at post-intervention, which may have affected the accuracy. No booster sessions were offered, which could have been helpful for consolidating treatment gains. Finally, to avoid the wait period being too long, the control group received treatment immediately after the two iCBT groups completed the intervention. Thus, no assessment data were collected at 3-month and 6-month follow-ups from the control group for comparison.

5. Conclusions

Overall, the results suggest that iCBT with VRET is promising to effectively treat Hong Kong Chinese adults with SAD, and that the effects do not significantly differ between the web-based and app-based delivery formats. Further work to promote engagement and reduce attrition is warranted, but the programme represents a viable and effective treatment option for mental healthcare professionals in Hong Kong.

CRediT authorship contribution statement

Jia-Yan Pan: Writing – original draft, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Graham R. Thew:** Writing – original draft, Formal analysis. **David M. Clark:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Jiayan Pan reports financial support was provided by Hong Kong Research Grants Council. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This study is financially supported by the Research Impact Fund in Research Grants Council in Hong Kong (Project No.: R2018-18). The authors would like to thank Professor Per Carlbring for his advice during the grant application phase of this project. Thanks also go to Mr. Chun Man Leung and AESIR Limited for the development of the EASE Online platform and VRET system of this study, respectively, as well as to Mr. Chun Man Leung and Mr. Ng Chi Keun for providing technical support. The authors would also like to thank Ms. Selina Sou and Ms. Tina Kun for conducting the intake interviews, Ms. Selina Sou for the service delivery and Ms. Mei Yu Ho for providing administrative support to this project.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jad.2025.04.100.

References

Aboujaoude, E., Salame, W., Naim, L., 2015. Tele-mental health: a status update. World Psychiatry 14, 223–230.
Anderson, P.L., Price, M., Edwards, S.M., Obasaju, M.A., Schmertz, S.K., Zimand, E., Calamaras, M.R., 2013. Virtual reality exposure therapy for social anxiety disorder: a randomized controlled trial. J. Consult. Clin. Psychol. 81 (5), 751–760.
Anderson, P.L., Edwards, S.M., Goodnight, J.R., 2017. Virtual reality and exposure group therapy for social anxiety disorder: results from a 4–6 year follow-up. Cogn. Ther. Res. 41, 230–236.
Andersson, G., Carlbring, P., Holmstrom, A., Sparthan, E., Furmark, T., Nilsson-Ihrfelt, E., Buhrman, M., Ekselius, L., 2006. Internet-based self-help with therapist feedback and in vivo group exposure for social phobia: a randomized controlled trial. J. Consult. Clin. Psychol. 74 (4), 677–686.
Andrews, G., Basub, A., Cuijpersc, P., Craskee, M.G., McEvoyf, P., Englishh, C.L., Newbyi, J.M., 2018. Computer therapy for the anxiety and depression disorders is effective, acceptable and practical health care: an updated meta-analysis. J. Anxiety Disord. 55, 70–78.
Arif, R., Ashraf, S., Bhatt, K., Shah, K., 2023. A literature review examining virtual reality exposure therapy for individuals diagnosed with social anxiety disorder. J. Nerv. Ment. Dis. 211 (10). https://journals.lww.com/jonmd/fulltext/2023/10000/a_literature_review_examining_virtual_reality.1.aspx.
Ashford, M.T., Olander, E.K., Ayers, S., 2016. Finding web-based anxiety interventions on the world wide web: a scoping review. JMIR mental health 3 (2), e14.
Beck, J.S., 2011. Cognitive Behavior Therapy: Basics and beyond, 2nd ed. The Guilford Publications.
Beck, A.T., Steer, R.A., 1993. Beck Anxiety Inventory (BAI) Manual. Psychological Corporation, San Antonio, TX.
Beck, A.T., Steer, R.A., Brown, G.K., 1996. Manual for BDI-II. Psychological Corporation, San Antonio, TX.
Bouchard, S., Dumoulin, S., Robillard, G., Guitard, T., Klinger, E., Forget, H., et al., 2017. Virtual reality compared with in vivo exposure in the treatment of social anxiety disorder: a three-arm randomized controlled trial. Br. J. Psychiatry 210, 276–283.
Carlbring, P., Gunnarsdottir, M., Hedensjo, L., Andersson, G., Ekselius, L., Furmark, T., 2007. Treatment of social phobia: randomised trial of internet-delivered cognitive behavioural therapy with telephone support. Br. J. Psychiatry 190, 123–128.
Cheng, S.K.W., Wong, C.S., Wong, K.C., Chong, G.H.C., Wong, M.T.P., Chang, S.S.Y., 2002. A study of psychometric properties, normative scores, and factor structure of the Beck Anxiety Inventory - the Chinese version. Chin. J. Clin. Psych. 10 (1), 4–6.
Clark, D., Wild, J., Warnock-Parkes, E., Stott, R., Grey, N., Thew, G., Ehlers, A., 2023. More than doubling the clinical benefit of each hour of therapist time: a randomized controlled trial of internet cognitive therapy for social anxiety disorder. Psychol. Med. 53 (11), 5022–5032. https://doi.org/10.1017/S0033291722002008.
Clemmensen, L., Bouchard, S., Rasmussen, J., Holmberg, T.T., Nielsen, J.H., Jepsen, J.R. M., Lichtenstein, M.B., 2020. Study protocol: exposure in virtual reality for social anxiety disorder - a randomized controlled superiority trial comparing cognitive behavioral therapy with virtual reality-based exposure to cognitive behavioral therapy with in vivo exposure. BMC Psychiatry 20 (1), 32. https://doi.org/10.1186/s12888-020-2453-4.
Cohen, J., 1988. Statistical Power Analysis for the Behavioral Sciences, 2nd ed. Lawrence Erlbaum Associates.
Connor, K.M., Davidson, J.R.T., Sherwood, A., Foa, E., Weisler, R.H., 2000. Psychometric properties of the social phobia inventory (SPIN): new self-rating scale. Br. J. Psychiatry 179, 379–386.
Dagöö, J., Asplund, R.P., Bsenko, H.A., Hjerling, S., Holmberg, A., Westh, S., Öberg, L., Ljótsson, B., Carlbring, P., Furmark, T., Andersson, G., 2014. Cognitive behavior therapy versus interpersonal psychotherapy for social anxiety disorder delivered via smartphone and computer: a randomized controlled trial. J. Anxiety Disord. 28 (4), 410–417. https://doi.org/10.1016/j.janxdis.2014.02.003.
Donker, T., Petrie, K., Proudfoot, J., Clarke, J., Birch, M.R., Christensen, H., 2013. Smartphones for smarter delivery of mental health programs: a systematic review. J. Med. Internet Res. 15 (11), e247.
Emmelkamp, P.M.G., Meyerbröker, K., 2021. Virtual reality therapy in mental health. Annu. Rev. Clin. Psychol. 17, 495–519.
Erwin, B.A., Turk, C.L., Heimberg, R.G., Fresco, D.M., Hantula, D.A., 2004. The internet: home to a severe population of individuals with social anxiety disorder? J. Anxiety Disord. 18 (5), 629–646.
First, M.B., Williams, J.B.W., Karg, R.S., Spitzer, R.L., 2016. Structured Clinical Interview for DSM-5 Disorders (SCID-5-CV) (Clinician Version). American Psychiatric Association Publishing.
Gershkovich, M., Herbert, J.D., Forman, E.M., Schumacher, L.M., Fischer, L.E., 2017. Internet-delivered acceptance-based cognitive-behavioral intervention for social anxiety disorder with and without therapist support: a randomized trial. Behav. Modif. 41 (5), 583–608.
Goldberg, D.P., Williams, P., 1988. A User's Guide to the General Health Questionnaire. NFER-Nelson, Basingstoke.
Guo, S., Deng, W., Wang, H., Liu, J., Liu, X., Yang, X., He, C., Zhang, Q., Liu, B., Dong, X., Yang, Z., Li, Z., Li, X., 2021. The efficacy of internet-based cognitive behavioural therapy for social anxiety disorder: a systematic review and meta-analysis. Clinical Psychology and Psychotherapy 28 (3), 656–668. https://doi.org/10.1002/cpp.2528.
Hedman, E., Botella, C., Berger, T., 2016. Internet-based cognitive behavior therapy for social anxiety disorder. In: Lindefors, N., Andersson, G. (Eds.), Guided Internet-based Treatments in Psychiatry. Springer International Publishing, pp. 53–78. https://doi.org/10.1007/978-3-319-06083-5_4.
Horigome, T., Kurokawa, S., Sawada, K., Kudo, S., Shiga, K., Mimura, M., Kishimoto, T., 2020. Virtual reality exposure therapy for social anxiety disorder: a systematic

review and meta-analysis. Psychol. Med. 50 (15), 2487–2497. https://doi.org/10.1017/S0033291720003785.
Hullu, E., Sportel, B.E., Nauta, M.H., Jong, P.J., 2017. Cognitive bias modification and CBT as early interventions for adolescent social and test anxiety: two-year follow-up of a randomized controlled trial. J. Behav. Ther. Exp. Psychiatry 55, 81–89.
Karyotaki, E., Efthimiou, O., Miguel, C., Maas Genannt Bermpohl, F., Furukawa, T.A., Cuijpers, P., Collaboration, I. P. D. M.-A. f. D, 2021. Internet-based cognitive behavioral therapy for depression: a systematic review and individual patient data network meta-analysis. JAMA Psychiatry 78 (4), 361–371. https://doi.org/10.1001/jamapsychiatry.2020.4364.
Kim, H.E., Hong, Y.J., Kim, M.K., Jung, Y.H., Kyeong, S., Kim, J.J., 2017. Effectiveness of self-training using the mobile-based virtual reality program in patients with social anxiety disorder. Comput. Hum. Behav. 73, 614–619.
Kishimoto, T., Krieger, T., Berger, T., Qian, M., Chen, H., Yang, Y., 2016. Internet-based cognitive behavioral therapy for social anxiety with and without guidance compared to a wait list in China: a propensity score study. Psychother. Psychosom. 85 (5), 317–319. https://doi.org/10.1159/000446584.
Lee, S., Tsang, A., Kwok, K., 2005. A community-based telephone survey of panic disorder in Hong Kong. Depress. Anxiety 22, 77–83.
Leung, K.K., Tay, S.M., Chu, M.L., Ng, S.W., 2005. Development and validation of the interview version of the Hong Kong Chinese WHOQOL-BREF. Qual. Life Res. 14, 1413–1419.
Li, W.H.C., Chung, J.O.K., Chui, M.M.L., Chan, P.S.L., 2009. Factorial structure of the Chinese version of the 12-item General Health Questionnaire in adolescents. Child and Adolescent Health 18, 3253–3261.
Li, S.Y., Xi, Z.Y., Barnett, P., Saunders, R., Shafran, R., Pilling, S., 2023. Efficacy of culturally adapted interventions for common mental disorders in people of Chinese descent: a systematic review and meta-analysis. Lancet Psychiatry 10, 426–440. https://doi.org/10.1016/S2215-0366(23)00118-9.
Lin, L.Y., Wang, K., Kishimoto, T., Rodriguez, M., Qian, M., Yang, Y., Zhao, Q., Berger, T., Tian, C., 2020. An internet-based intervention for individuals with social anxiety and different levels of Taijin Kyofusho in China. J. Cross-Cult. Psychol. 51 (5), 387–402. https://doi.org/10.1177/0022022120920720.
Lindner, P., Dagöö, J., Hamilton, W., Miloff, A., Andersson, G., Schill, A., al., e., 2021. Virtual reality exposure therapy for public speaking anxiety in routine care: a single-subject effectiveness trial. Cogn. Behav. Ther. 50 (1), 67–87.
Mak, W.W.S., Chio, F.H.N., Chan, A.T.Y., Liui, W.W.S., Wu, E.K.Y., 2017. The efficacy of internet-based mindfulness training and cognitive-behavioral training with telephone support in the enhancement of mental health among college students and young working adults: randomized controlled trial. J. Med. Internet Res. 19 (3), e84.
Morina, N., Kampmann, I., Emmelkamp, P., Barbui, C., Hoppen, T.H., 2023. Meta-analysis of virtual reality exposure therapy for social anxiety disorder. Psychol. Med. 53, 2176–2178. https://doi.org/10.1017/S0033291721001690.
National Collaborating Centre for Mental Health, 2024. NHS Talking Therapies for Anxiety and Depression Manual. Retrieved from. https://www.england.nhs.uk/publication/the-improving-access-to-psychological-therapies-manual/.
National Collaborating Centre for Mental Health (UK), 2013. Social Anxiety Disorder: Recognition, Assessment and Treatment (Vol. (NICE Clinical Guidelines, No. 159.)). British Psychological Society (UK), Leicester (UK). https://www.ncbi.nlm.nih.gov/books/NBK327674/.
Ng, T.K., Wong, D.F.K., 2018. The efficacy of cognitive behavioral therapy for Chinese people: a meta-analysis. Aust. N. Z. J. Psychiatry 52 (7), 620–637.
Nordgreen, T., Gjestad, R., Andersson, G., Carlbring, P., Havik, O.E., 2018. The effectiveness of guided internet-based cognitive behavioral therapy for social anxiety disorder in a routine care setting. Internet Interv. 13, 24–29. https://doi.org/10.1016/j.invent.2018.05.003.
Pan, J.Y., 2023. Internet-based cognitive behavioral therapy and virtual reality exposure therapy for social anxiety disorder: a randomized controlled trial in Hong Kong. JMIR Research Protocols 12, e48437. https://doi.org/10.2196/48437.
Pan, J.Y., Zhuang, X.Y., 2022. Effectiveness of an adventure-based cognitive behavioral program for Hong Kong university student. Res. Soc. Work. Pract. 32 (3), 227–237. https://doi.org/10.1177/10497315211042096.
Pan, J.Y., Ye, S., Ng, P., 2016. Validation of the automatic thoughts questionnaire in a Chinese student sample in Hong Kong. J. Clin. Psychol. 72 (1), 38–48. https://doi.org/10.1002/jclp.22193.
Pinheiro, J., Bates, D., DebRoy, S., Sarkar, D., R Core Team, 2018. Nlme: Linear and Nonlinear Mixed Effects Models. [R package version 3.1–131.1.] [Computer software].
Pramana, G., Parmanto, B., Kendall, P.C., Silk, J.S., 2014. The SmartCAT: an m-health platform for ecological momentary intervention in child anxiety treatment. TeleMedicine and e-Health 20 (5), 419–427.
Ritsher, J.B., Otilingam, P.G., Grajiales, M., 2003. Internalized stigma of mental illness: psychometric properties of a new measure. Psychiatry Res. 121, 31–49.
Selker, R., Love, J., Dropmann, D., 2018. Jmv: The 'Jamovi' Analyses. [R package version 0.8.6.2] [Computer software].
Shek, D.T.L., 1990. Reliability and factorial structure of the Chinese version of the Beck Depression Inventory. J. Clin. Psychol. 46 (1), 35–43.
Stein, D.J., Lim, C.C.W., Roest, A.M., de Jonge, P., Aguilar-Gaxiola, S., Al-Hamzawi, A., Alonso, J., Benjet, C., Bromet, E.J., Bruffaerts, R., de Girolamo, G., Florescu, S., Gureje, O., Haro, J.M., Harris, M.G., He, Y., Hinkov, H., Horiguchi, I., Hu, C., Collaborators, W. H. O. W. M. H. S, 2017. The cross-national epidemiology of social anxiety disorder: data from the World Mental Health Survey Initiative. BMC Med. 15 (1), 143. https://doi.org/10.1186/s12916-017-0889-2.
Stolz, T., Schulz, A., Krieger, T., Vincent, A., Urech, A., Moser, C., Westermann, S., Berger, T., 2018. A mobile app for social anxiety disorder: a three-arm randomized controlled trial comparing mobile and PC-based guided self-help interventions. J. Consult. Clin. Psychol. 86 (6), 493–504.
The R Foundation, 2023. R: A Language and Environment for Statistical Computing. [Computer Software]. Retrieved from. https://www.R-project.org/.
Thew, G.R., Kwok, A.P.L., Lissillour Chan, M.H., Powell, C.L.Y.M., Wild, J., Leung, P.W. L., Clark, D.M., 2022. Internet-delivered cognitive therapy for social anxiety disorder in Hong Kong: a randomized controlled trial. Internet Interv. 28, 100539. https://doi.org/10.1016/j.invent.2022.100539.
Tsai, C.F., Wang, S.J., Juang, K.D., Fuh, J.L., 2009. Use of the Chinese (Taiwan) version of the social phobia inventory (spin) among early adolescents in rural areas: reliability and validity study. Journal of Chinese Medical Association 72 (8), 422–429.
Tulbure, B.T., Szentagotai, A., David, O., Ştefan, S., Månsson, K.N.T., David, D., Andersson, G., 2015. Internet-delivered cognitive-behavioral therapy for social anxiety disorder in Romania: a randomized controlled trial. PlosOne 10 (5), e0123997.
Wang, H., Zhao, Q., Mu, W., Rodriguez, M., Qian, M., Berger, T., 2020. The effect of shame on patients with social anxiety disorder in internet-based cognitive behavioral therapy: randomized controlled trial. JMIR mental health 7 (7), 1. https://doi.org/10.2196/15797.
Wen, X., Gou, M., Chen, H., Kishimoto, T., Qian, M., Margraf, J., Berger, T., 2024. The efficacy of web-based cognitive behavioral therapy with a shame-specific intervention for social anxiety disorder: randomized controlled trial. JMIR Mental Health 11, e50535. https://doi.org/10.2196/50535.
Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L.D., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersen, T.L., Miller, E., Bache, S.M., Müller, K., Ooms, J., Robinson, D., Seidel, D.P., Spinu, V., Yutani, H., 2019. Welcome to the Tidyverse. Journal of Open Source Software 4 (43), 1686. https://doi.org/10.21105/joss.01686.
Wong, D.F.K., 2005. Coming out of the Valley of Depression: Cognitive Therapy Self-help Manual. Natural Health Press (in Chinese).
You, J.H.S., Luk, S.W.C., Chow, D.Y.W., Jiang, X.C., Mak, A.D.P., Mak, W.W.S., 2022. Cost-effectiveness of internet-supported cognitive behavioral therapy for university students with anxiety symptoms: a Markov-model analysis. PLoS One 17 (5), e0268061. https://doi.org/10.1371/journal.pone.0268061.
Young, K.W., Ng, P., JY, P., Cheng, D., 2017. Validity and reliability of internalized stigma of mental illness (Cantonese). Res. Soc. Work. Pract. 27 (1), 103–110.
Zhang, W., Paudel, D., Shi, R., Liang, J., Liu, J., Zeng, X., Zhou, Y., Zhang, B., 2020. Virtual reality exposure therapy (VRET) for anxiety due to fear of COVID-19 infection: a case series. Neuropsychiatr. Dis. Treat. 16 (null), 2669–2675. https://doi.org/10.2147/NDT.S276203.