ACADEMIA International Journal for Social Sciences
Volume 5, Issue 3(a), 2026 ISSN-L (Online): 3006-6638

Artificial Intelligence–Augmented Cognitive Behavioral Therapy as a Treatment for Depression and Anxiety: A Comparative Study with Other Non-Pharmacological Therapies in Pakistani Adult

Aneela Bibi
aneela.bibi@abasynisb.edu.pk
Abasyn University, Islamabad Campus

Ramish Moosa
Ramishmoosa640@gmail.com
Clinical psychologist, Sir ganga ram hospital

Dr Mussarat Hayat Sheikh
Komalsheikh500@gmail.com
Khyber Medical University kmu

Nimra Shehzadi
nimrashehzadi6@gmail.com
Lecturer, Higher Education Department, University of the Punjab

Kinza Shahzad
kinza.shahzad79@gmail.com
Lecturer, Government Associate College, (W), Chak 98/NB, Sargodha

Sardar Abdullah Hameed
sardarabdullahjee12@gmail.com
Henan Medical University, (Xinxiang China)

Corresponding Author: **Dr Mussarat Hayat Sheikh** Komalsheikh500@gmail.com

Received: 06-02-2026 **Revised:** 21-02-2026 **Accepted:** 08-03-2026 **Published:** 22-03-2026

ABSTRACT

***Background**: Depression and anxiety impose a substantial burden on Pakistan's adult population, yet access to evidence-based psychological care remains constrained by workforce shortages, cost, and stigma. We evaluated whether culturally adapted, AI-augmented cognitive behavioral therapy (AI-CBT) is non-inferior to therapist-delivered CBT and superior to psychoeducation/mindfulness for treating mild-to-moderate depression and anxiety in primary care settings. **Methods:** In this three-arm, assessor-blinded, randomized controlled trial, 321 adults (18–65 years; PHQ-9 ≥10 and/or GAD-7 ≥8) from urban and peri-urban clinics across Pakistan were randomized to: (1) Urdu-adapted AI-CBT (NLP-driven conversational agent + asynchronous clinician oversight), (2) therapist-delivered CBT, or (3) structured psychoeducation/mindfulness. Primary outcomes were changes in PHQ-9 and GAD-7 scores at 8 weeks. Analyses followed intention-to-treat using linear mixed-effects models with a pre-specified non-inferiority margin (Δ=1.5). **Results:** At 8 weeks, AI-CBT demonstrated non-inferior reductions in depressive (mean difference vs. therapist CBT: −0.4, 95% CI −1.0 to 0.2; p<0.01) and anxiety symptoms (−0.3, 95% CI −0.9 to 0.3; p<0.01), and was superior to psychoeducation/mindfulness (PHQ-9: −3.8, 95% CI −4.5 to −3.1; GAD-7: −3.2, 95% CI −3.9 to −2.5; both p<0.001). AI-CBT achieved higher intervention completion (78% vs. 64%; p<0.001), equivalent acceptability, and a 62% lower cost per QALY. Benefits were sustained at 12 weeks, with no serious adverse events reported. **Conclusion:** Culturally adapted AI-augmented CBT is a clinically non-inferior, cost-effective, and scalable non-pharmacological treatment for depression and anxiety in Pakistani adults. Integration of AI-delivered mental health interventions*

into primary care offers a pragmatic strategy to expand access and reduce the treatment gap in resource-constrained health systems.

Keywords: *Artificial intelligence; Cognitive behavioral therapy; Depression; Anxiety; Digital mental health; Pakistan; Comparative effectiveness; Global mental health; Non-Pharmacological intervention; Scalability*

INTRODUCTION

Mental health disorders, particularly depression and anxiety, represent a growing global public health crisis, with the World Health Organization (2023) estimating that over 280 million people worldwide suffer from depression and 301 million from anxiety disorders. These conditions contribute significantly to disability-adjusted life years (DALYs) and impose substantial economic burdens on healthcare systems and societies (Vos et al., 2020). In low- and middle-income countries (LMICs), including Pakistan, the treatment gap for mental health conditions remains critically high, with fewer than 10% of individuals receiving evidence-based care due to systemic barriers such as workforce shortages, stigma, and limited infrastructure (Kakuma et al., 2021). Non-pharmacological interventions have gained prominence as viable, accessible, and culturally adaptable alternatives or complements to pharmacotherapy in managing depression and anxiety. Among these, Cognitive Behavioral Therapy (CBT) is widely recognized as a first-line psychological treatment, supported by extensive meta-analytic evidence demonstrating its efficacy across diverse populations and settings (Hofmann et al., 2012). CBT's structured, skills-based approach empowers individuals to identify and modify maladaptive thought patterns and behaviors, fostering long-term resilience and symptom reduction (Beck, 2020). Despite its empirical support, the scalability of traditional CBT faces significant challenges, particularly in resource-constrained environments. Barriers include a shortage of trained therapists, high costs, geographical inaccessibility, and cultural mismatches in therapeutic content (Patel et al., 2018). These limitations have catalyzed interest in digital mental health innovations that can extend the reach of evidence-based therapies while maintaining fidelity and effectiveness (Torous et al., 2021).

Artificial Intelligence (AI) has emerged as a transformative force in digital mental health, offering novel pathways to augment psychological interventions. AI-augmented CBT (AI-CBT) integrates machine learning algorithms, natural language processing, and adaptive feedback systems to personalize therapeutic content, monitor progress in real time, and provide just-in-time support (Fitzpatrick et al., 2017). Preliminary studies indicate that AI-driven platforms, such as chatbot-delivered CBT, can produce clinically significant reductions in depressive and anxiety symptoms comparable to human-delivered therapy (Abd-Alrazaq et al., 2021; Inkster et al., 2022). The Pakistani context presents both urgent need and unique opportunity for AI-augmented mental health solutions. Pakistan faces a severe mental health treatment gap, with an estimated prevalence of depression and anxiety exceeding 30% among adults, yet fewer than 500 psychiatrists serve a population of over 240 million (Mirza & Jenkins, 2022). Cultural stigma, gender-based access barriers, and limited mental health literacy further impede help-seeking behaviors (Naeem et al., 2020). Digital interventions, particularly those delivered via mobile technology, which enjoys high penetration even in rural areas, offer a promising avenue to bridge this gap (Naslund et al., 2022). However, the evidence base for AI-CBT in South Asian contexts remains sparse. Most existing trials of digital CBT have been conducted in high-income Western settings, raising questions about cultural validity, linguistic appropriateness, and contextual relevance for Pakistani adults (Ali et al., 2023). Factors such as collectivist values, religious coping mechanisms, and distinct expressions of psychological distress necessitate culturally grounded adaptation of AI-CBT content and delivery mechanisms (Khan & Kausar, 2021). Without such adaptation, even technologically sophisticated interventions risk low engagement and limited clinical impact.

Furthermore, comparative effectiveness research is needed to position AI-CBT within Pakistan's evolving mental health ecosystem. While other non-pharmacological approaches—such as mindfulness-based stress reduction (MBSR), problem-solving therapy (PST), and peer support interventions, have shown promise in LMICs (Singla et al., 2017), their relative efficacy, cost-effectiveness, and acceptability compared to AI-augmented modalities remain unexamined in the Pakistani adult population. Understanding these comparative dynamics is essential for informing policy, resource allocation, and scalable implementation strategies. Therefore, this study aims to evaluate the efficacy, acceptability, and feasibility of AI-augmented CBT as a treatment for depression and anxiety among Pakistani adults, in comparison to other established non-pharmacological therapies. Specifically, the research will: (1) assess symptom reduction outcomes across intervention arms; (2) examine user engagement and cultural acceptability; and (3) explore moderators of treatment response, including digital literacy, gender, and socioeconomic status. By generating contextually relevant evidence, this work seeks to advance equitable, innovative, and scalable mental health care solutions aligned with Pakistan's Sustainable Development Goals and digital health priorities.

Objective:

- To compare clinically significant symptom reduction and remission rates across AI-CBT and alternative non-pharmacological intervention groups over a 12-week period.
- To assess participant engagement, cultural relevance, linguistic appropriateness, and perceived acceptability of AI-delivered therapeutic content within the Pakistani socio cultural context.
- To identify demographic, clinical, and technological moderators (e.g., age, gender, socioeconomic status, digital literacy, baseline severity) that influence treatment response, adherence, and long-term outcomes.
- To examine the cost-effectiveness and scalability potential of AI-CBT relative to traditional therapist-led and low-intensity psychological interventions in resource-constrained settings.

LITERATURE REVIEW

Depression and anxiety disorders represent a substantial public health crisis worldwide, with low- and middle-income countries experiencing disproportionate treatment gaps due to systemic barriers, workforce shortages, and socioeconomic constraints (World Health Organization [WHO], 2023). In Pakistan, epidemiological surveys estimate that approximately 30% to 35% of adults experience clinically significant symptoms of depression or anxiety, yet fewer than 10% receive adequate mental health care (Husain et al., 2022). The scarcity of trained mental health professionals—estimated at fewer than 0.5 psychiatrists per 100,000 individuals—exacerbates the crisis, particularly in rural and peri-urban regions (Rahman et al., 2021). Consequently, there is an urgent need for scalable, cost-effective, and culturally responsive non-pharmacological interventions that can bridge this treatment gap. Digital mental health solutions, particularly those leveraging artificial intelligence (AI), have emerged as promising alternatives to traditional service delivery models.

Cognitive behavioral therapy (CBT) remains the most extensively researched and empirically supported non-pharmacological treatment for depression and anxiety across diverse populations (Hofmann et al., 2012). By targeting maladaptive thought patterns, behavioral avoidance, and cognitive distortions, CBT has demonstrated robust effect sizes in both acute symptom reduction and long-term relapse prevention (Carpenter et al., 2018). In LMIC contexts, task-shifted and simplified CBT protocols have shown significant efficacy when delivered by non-specialist providers (Rahman et al., 2016). However, the

reliance on trained facilitators, session scheduling constraints, and high attrition rates in traditional CBT delivery limit its scalability. These limitations have catalyzed the development of technology-mediated CBT platforms that preserve therapeutic mechanisms while expanding accessibility.

Artificial intelligence–augmented CBT (AI-CBT) integrates machine learning algorithms, natural language processing, and adaptive feedback systems to personalize therapeutic content, monitor symptom trajectories, and deliver real-time interventions (Fitzpatrick et al., 2017; Torous et al., 2021). Unlike static digital CBT applications, AI-CBT platforms dynamically adjust cognitive restructuring exercises, behavioral activation prompts, and psychoeducational materials based on user engagement patterns and self-reported mood data. Meta-analytic evidence indicates that AI-driven therapeutic chatbots and adaptive CBT programs yield moderate to large reductions in depressive and anxious symptomatology, with effect sizes comparable to unguided digital CBT (Abd-Alrazaq et al., 2020; Vaidyam et al., 2019). Furthermore, AI-CBT demonstrates high user retention when designed with conversational interfaces and ecological momentary assessment features (Miner et al., 2022).

Comparative studies consistently reveal that AI-CBT achieves non-inferior outcomes to therapist-delivered CBT for mild to moderate depression and anxiety, particularly in structured, short-term interventions (Carl et al., 2021; Luo et al., 2023). While human-delivered CBT offers nuanced therapeutic alliance and complex case formulation, AI-CBT compensates through scalability, 24/7 availability, and reduced stigma associated with in-person visits. When compared to other digital modalities such as internet-based CBT or mobile wellness apps, AI-CBT demonstrates superior personalization and engagement metrics, largely due to its capacity for real-time symptom tracking and adaptive content delivery (Kazantzis et al., 2022). Nevertheless, concerns regarding algorithmic transparency, data privacy, and the potential dehumanization of care remain active areas of ethical and clinical debate (Luxton, 2016).

Beyond CBT, several non-pharmacological interventions—including mindfulness-based cognitive therapy, physical exercise programs, interpersonal psychotherapy, and expressive arts therapy—have demonstrated efficacy in managing depression and anxiety (Hofmann & Gómez, 2017; Schuch et al., 2018). Comparative trials suggest that while mindfulness and exercise yield moderate benefits primarily through physiological regulation and stress reduction, CBT-based approaches, including AI-augmented variants, produce more targeted cognitive restructuring and sustained behavioral change (Goldin et al., 2021). AI-CBT further distinguishes itself by integrating psychoeducation, cognitive journaling, and behavioral scheduling into automated workflows, whereas other modalities often require intensive facilitator involvement or structured group settings (Karyotaki et al., 2021). Head-to-head evaluations in diverse cohorts indicate that AI-CBT may offer superior cost-effectiveness and accessibility for population-level mental health promotion.

The successful deployment of any psychological intervention in Pakistan necessitates rigorous cultural adaptation to align with local idioms of distress, familial decision-making structures, and religious-spiritual worldviews (Chaudhry et al., 2020). Mental health stigma remains deeply entrenched, with psychological distress frequently somaticized or attributed to supernatural causes, thereby delaying help-seeking behavior (Javed & Kastrup, 2016). Culturally adapted CBT programs that incorporate Islamic coping strategies, family psychoeducation, and colloquial Urdu terminology have demonstrated improved engagement and clinical outcomes among Pakistani adults (Sikander et al., 2019). For AI-CBT to be effective in this context, algorithmic training data, conversational design, and therapeutic metaphors must reflect local cultural narratives, literacy levels, and socioeconomic realities, rather than relying solely on Western-centric mental health frameworks.

Pakistan's digital mental health ecosystem is rapidly evolving, supported by increasing smartphone penetration, expanding 4G coverage, and growing youth demographic engagement with online platforms (Pakistan Telecommunication Authority [PTA], 2024). Recent pilot initiatives have introduced telepsychiatry services, WhatsApp-based counseling, and locally developed mental health applications targeting university students and young professionals (Nasir et al., 2023). However, significant challenges persist, including intermittent internet reliability in rural districts, low digital literacy among older adults, and limited regulatory oversight for AI-driven health technologies (Ali et al., 2022). Furthermore, data governance frameworks specific to mental health AI remain underdeveloped, raising concerns about user privacy, algorithmic bias, and cross-border data storage (Khan & Hussain, 2024). Despite the global proliferation of AI-CBT, empirical research specifically evaluating its efficacy, acceptability, and cultural safety among Pakistani adults remains critically sparse. Existing studies predominantly rely on convenience samples from urban academic or clinical settings, limiting generalizability to diverse socioeconomic, linguistic, and regional populations (Rizvi et al., 2021). Methodological shortcomings include short follow-up periods, absence of active control groups, and overreliance on self-report measures without clinical validation (Ahmed et al., 2023). Additionally, few trials have directly compared AI-CBT with other non-pharmacological interventions within the Pakistani healthcare context, leaving unanswered questions regarding differential effectiveness, implementation feasibility, and long-term sustainability. Rigorous, culturally grounded randomized controlled trials are urgently needed to establish evidence-based guidelines for AI-CBT deployment in LMIC settings.

In summary, AI-augmented CBT represents a transformative opportunity to address Pakistan's substantial mental health treatment gap by combining the empirical rigor of cognitive behavioral principles with the scalability of artificial intelligence. While comparative evidence globally supports its non-inferiority to traditional therapies and its advantages over less adaptive digital interventions, successful implementation in Pakistan requires deliberate cultural adaptation, robust ethical safeguards, and context-sensitive delivery models. Future research should prioritize longitudinal, multi-site trials that evaluate AI-CBT against established non-pharmacological alternatives, incorporate mixed-methods designs to capture user experiences, and engage community stakeholders in co-design processes. With strategic investment in digital infrastructure, clinician-AI collaboration frameworks, and culturally validated algorithms, AI-CBT holds significant potential to democratize access to evidence-based mental health care for Pakistani adults.

METHODOLOGY

Study Design and Participants

This three-arm, parallel-group, assessor-blinded, randomized controlled trial was conducted across eight primary care clinics in Punjab and Sindh provinces, Pakistan between 10 October 2022 and 15 September 2023. Ethical approval was granted by the Shifa International Hospital Institutional Review Board, Islamabad (Ref: SIH-IRB-2022-094) and the Lahore General Hospital Ethics Committee (Ref: LGH/ERC/2022/117). The study was registered with the Pakistan Clinical Trials Registry (PCTR/2022/10/045) and ClinicalTrials.gov (NCT05638219). All participants provided written informed consent after study procedures were explained in their preferred language (Urdu, Punjabi, or English). Eligible participants were adults aged 18–65 years who screened positive for mild-to-moderate depression (Patient Health Questionnaire-9 [PHQ-9] score ≥10) and/or anxiety (Generalized Anxiety Disorder-7 [GAD-7] score ≥8). Exclusion criteria included: (1) severe psychiatric symptoms requiring immediate intervention (PHQ-9/GAD-7 ≥20), (2) active suicidal ideation, (3) psychosis or bipolar disorder, (4) current engagement in structured psychotherapy, or (5) inability to use a smartphone application.

Randomization and Masking

Participants were randomly assigned (1:1:1) to one of three intervention arms using computer-generated block randomization (block sizes 6 and 9), stratified by site and baseline symptom severity (mild vs. moderate). Allocation was concealed via a secure web-based system. Outcome assessors and statisticians were blinded to group assignment; participants and intervention providers could not be blinded due to intervention nature.

Interventions

AI-Augmented CBT (AI-CBT): Participants accessed a secure mobile application delivering an 8-week, Urdu-adapted CBT program via a natural language processing (NLP)-driven conversational agent. Core modules included psychoeducation, cognitive restructuring, behavioral activation, and relapse prevention, with culturally contextualized examples. The system incorporated asynchronous clinician oversight for risk monitoring and complex case escalation.

Therapist-Delivered CBT (T-CBT): Participants received eight weekly 45-minute individual CBT sessions from licensed clinical psychologists trained in a standardized manual, following identical content structure to the AI-CBT arm.

Psychoeducation/Mindfulness (PE/M): Participants received eight weekly structured group sessions (60 minutes) covering mental health literacy, stress management, and mindfulness-based stress reduction techniques, delivered by trained facilitators.

Outcomes

Primary Outcome: Change in symptom severity from baseline to week 8, measured by PHQ-9 (depression) and GAD-7 (anxiety).

Secondary Outcomes:

Durability of effect at week 12 follow-up

Functional impairment (WHO Disability Assessment Schedule 2.0 [WHODAS 2.0])

Treatment adherence (% modules/sessions completed)

Cost per quality-adjusted life year (QALY), calculated using EQ-5D-5L and healthcare utilization data

Cultural acceptability (adapted Client Satisfaction Questionnaire-8 [CSQ-8] + qualitative feedback)

Safety: Adverse events monitored throughout via automated alerts (AI-CBT) and session check-ins (T-CBT/PE/M).

Statistical Analysis

Sample size was calculated to test non-inferiority of AI-CBT versus T-CBT for the primary outcome. Assuming a standard deviation of 4.5, 80% power, $\alpha=0.025$ (one-sided), and a non-inferiority margin (Δ) of 1.5 points on PHQ-9/GAD-7, 90 participants per arm were required, inflated to 107 per arm (321 total) to account for 20% attrition.

Analyses followed the intention-to-treat principle. Primary outcomes were analyzed using linear mixed-effects models with fixed effects for group, time, group×time interaction, baseline score, and stratification factors; random intercepts accounted for repeated measures. Non-inferiority was concluded if the upper bound of the two-sided 95% confidence interval (CI) for the mean difference (AI-CBT minus T-CBT) was below $\Delta=1.5$. Superiority versus PE/M was tested at $\alpha=0.05$ (two-sided). Secondary continuous outcomes used similar models; binary outcomes used logistic regression. Cost-effectiveness was evaluated via incremental cost-effectiveness ratios (ICERs). All analyses were conducted in R v4.3.1.

ANALYSIS

Descriptive Statistic:

Table 01: Baseline Characteristics of Randomized Participant

Characteristic	AI-CBT (n=107)	Therapist CBT (n=107)	Psychoeducation /Mindfulness (n=107)	Total (N=321)
Age, mean (SD), years	33.2 (9.8)	32.8 (10.1)	34.1 (9.5)	33.4 (9.8)
Female, n (%)	62 (58%)	60 (56%)	64 (60%)	186 (58%)
Education, n (%)				
Primary	34 (32%)	31 (29%)	36 (34%)	101 (31%)
Secondary	41 (38%)	44 (41%)	40 (37%)	125 (39%)
College	32 (30%)	32 (30%)	31 (29%)	95 (30%)
PHQ-9, mean (SD)	14.6 (2.9)	14.3 (3.1)	14.8 (2.8)	14.6 (2.9)
GAD-7, mean (SD)	13.9 (3.0)	13.7 (3.2)	14.1 (2.9)	13.9 (3.0)
WHODAS 2.0, mean (SD)	27.4 (7.8)	26.9 (8.1)	28.1 (7.6)	27.5 (7.8)
Prior mental health treatment, n (%)	31 (29%)	28 (26%)	35 (33%)	94 (29%)

Note: SD = standard deviation; PHQ-9 = Patient Health Questionnaire-9; GAD-7 = Generalized Anxiety Disorder-7; WHODAS = WHO Disability Assessment Schedule. Baseline characteristics were balanced across arms (all $p>0.10$).

A total of 321 adults meeting eligibility criteria were randomized equally across the three study arms (AI-CBT: n=107; Therapist CBT: n=107; Psychoeducation/Mindfulness: n=107). The overall sample had a mean age of 33.4 years (SD=9.8), with 58% female participants, reflecting a balanced gender distribution consistent with primary care attendance patterns in the study regions. Educational attainment was heterogeneous: 31% had completed primary education or less, 39% secondary education, and 30% college or higher, with no meaningful between-group differences. At baseline, participants exhibited moderate symptom severity, with mean PHQ-9 scores of 14.6 (SD=2.9) and GAD-7 scores of 13.9

(SD=3.0), indicating clinically significant depression and anxiety. Functional impairment, measured by WHODAS 2.0, averaged 27.5 (SD=7.8), consistent with moderate disability. Approximately 29% of participants reported prior mental health treatment, with comparable proportions across arms. All baseline demographic and clinical characteristics were well-balanced between intervention groups (all p>0.10), confirming successful randomization and supporting the validity of subsequent comparative effectiveness analyses.

Intention-to-Treat Analysis:

Table 2: Primary and Secondary Outcomes at 8 Weeks

Outcome	AI-CBT (n=98)	Therapist CBT (n=95)	Psychoeducation (n=89)	AI-CBT vs. T-CBT Mean Diff (95% CI)	AI-CBT vs. PE/M Mean Diff (95% CI)	*p*-value (Non-inferiority)	*p*-value (Superiority)
PHQ-9 change, mean (SD)	−5.4 (3.2)	−5.0 (3.4)	−1.6 (3.8)	−0.4 (−1.0 to 0.2)	−3.8 (−4.5 to −3.1)	<0.01	<0.001
GAD-7 change, mean (SD)	−4.9 (3.0)	−4.6 (3.2)	−1.7 (3.5)	−0.3 (−0.9 to 0.3)	−3.2 (−3.9 to −2.5)	<0.01	<0.001
WHODAS 2.0 change, mean (SD)	−8.2 (6.1)	−7.8 (6.3)	−3.5 (7.0)	−0.4 (−2.1 to 1.3)	−4.7 (−6.5 to −2.9)	0.68	<0.001
Module/Session Completion, % (SD)	78% (12)	64% (18)	58% (20)	—	—	—	<0.001 †
CSQ-8 Acceptability Score, mean (SD)	26.8 (3.1)	27.2 (2.9)	26.1 (3.4)	−0.4 (−1.3 to 0.5)	0.7 (−0.3 to 1.7)	0.38	0.16
Cost per QALY, USD (95% CI)	$245 ($198–$312)	$645 ($520–$798)	$380 ($310–$465)	−62%	—	—	—

Note: Mean Diff = Mean Difference (AI-CBT minus comparator); CI = Confidence Interval; QALY = Quality-Adjusted Life Year; CSQ-8 = Client Satisfaction Questionnaire-8 (range 8–32, higher = better). Non-inferiority margin Δ=1.5 for PHQ-9/GAD-7. †Comparison of completion rates: AI-CBT vs. T-CBT (χ^2 test). Sample sizes reflect 8-week assessment completion.

At the 8-week primary endpoint, 282 of 321 randomized participants (88%) completed outcome assessments (AI-CBT: n=98; Therapist CBT: n=95; Psychoeducation/Mindfulness: n=89). AI-CBT

demonstrated non-inferior reductions in depressive symptoms compared to therapist-delivered CBT (mean difference −0.4, 95% CI −1.0 to 0.2; p<0.01 for non-inferiority) and was significantly superior to psychoeducation/mindfulness (mean difference −3.8, 95% CI −4.5 to −3.1; p<0.001). Parallel findings were observed for anxiety symptoms: AI-CBT was non-inferior to therapist CBT (−0.3, 95% CI −0.9 to 0.3; p<0.01) and superior to psychoeducation/mindfulness (−3.2, 95% CI −3.9 to −2.5; p<0.001). Functional impairment (WHODAS 2.0) improved significantly more with AI-CBT versus psychoeducation/mindfulness (−4.7, 95% CI −6.5 to −2.9; p<0.001), while differences versus therapist CBT were not significant. AI-CBT achieved higher intervention completion (78% vs. 64% for therapist CBT; p<0.001) and equivalent cultural acceptability (CSQ-8 scores: 26.8 vs. 27.2; p=0.38). Economically, AI-CBT yielded a 62% lower cost per QALY ($245; 95% CI $198–$312) compared to therapist-delivered CBT ($645; 95% CI $520–$798), supporting its scalability in resource-constrained settings

Table 3: Durability of Treatment Effects at 12-Week Follow-Up

Outcome	AI-CBT (n=92)	Therapist CBT (n=89)	Psychoeducation (n=84)	Between-Group *p*-value (AI-CBT vs. T-CBT)	Between-Group *p*-value (AI-CBT vs. PE/M)
PHQ-9, mean (SD)	8.2 (4.1)	8.5 (4.3)	12.1 (4.8)	0.62	<0.001
GAD-7, mean (SD)	7.8 (3.9)	8.0 (4.1)	11.2 (4.5)	0.71	<0.001
*Relapse Rate (PHQ-9/GAD-7 ≥10), n (%)**	17 (18%)	18 (20%)	32 (38%)	0.74	<0.01

Note: Relapse defined as return to moderate symptom threshold (PHQ-9 or GAD-7 ≥10) after initial response at week 8. Sample sizes reflect 12-week assessment completion.

At the 12-week follow-up assessment, 265 participants (83% of the randomized sample) provided outcome data (AI-CBT: n=92; Therapist CBT: n=89; Psychoeducation/Mindfulness: n=84). Treatment gains observed at 8 weeks were largely maintained in both active CBT arms: mean PHQ-9 scores remained low and comparable for AI-CBT (8.2, SD=4.1) and therapist-delivered CBT (8.5, SD=4.3), with no significant between-group difference (p=0.62), while the psychoeducation/mindfulness arm showed significantly higher residual depressive symptoms (12.1, SD=4.8; p<0.001 vs. AI-CBT). Similarly, anxiety symptoms (GAD-7) remained stable and equivalent between AI-CBT (7.8, SD=3.9) and therapist CBT (8.0, SD=4.1; p=0.71), but were significantly elevated in the psychoeducation/mindfulness group (11.2, SD=4.5; p<0.001). Relapse rates—defined as return to moderate symptom severity (PHQ-9 or GAD-7 ≥10)—were low and statistically indistinguishable between AI-CBT (18%) and therapist CBT (20%; p=0.74), yet significantly higher in the psychoeducation/mindfulness arm (38%; p<0.01 vs. AI-CBT). These findings indicate that the clinical benefits of AI-augmented CBT are durable over the short term and comparable to standard therapist-delivered CBT, while both CBT modalities confer significantly greater protection against symptom recurrence than psychoeducation/mindfulness alone.

Table 4: Safety and Adverse Events

Event Type	AI-CBT (n=107)	Therapist CBT (n=107)	Psychoeducation/Mindfulness (n=107)
Serious Adverse Events, n (%)	0 (0%)	0 (0%)	0 (0%)
Mild/Moderate Adverse Events, n (%)			
Technical difficulties	12 (11%)	—	—
Temporary symptom increase	5 (5%)	6 (6%)	7 (7%)
Dropout due to dissatisfaction	3 (3%)	4 (4%)	15 (14%)
Total Adverse Events	20	10	22

Note: All adverse events were monitored and managed per protocol. No events were deemed intervention-related serious harms. Technical difficulties in AI-CBT arm primarily involved app connectivity issues in low-bandwidth areas.

Across all three intervention arms, no serious adverse events were reported, confirming the overall safety of AI-augmented CBT, therapist-delivered CBT, and psychoeducation/mindfulness for treating mild-to-moderate depression and anxiety in Pakistani adults. Mild-to-moderate adverse events were infrequent and largely intervention-specific: technical difficulties (e.g., app connectivity issues in low-bandwidth settings) occurred exclusively in the AI-CBT arm (11%), while temporary symptom increases, reflecting expected emotional processing during therapy, were comparably low across all groups (AI-CBT: 5%; Therapist CBT: 6%; Psychoeducation/Mindfulness: 7%). Notably, dropout due to dissatisfaction was substantially higher in the psychoeducation/mindfulness arm (14%) compared to both CBT modalities (AI-CBT: 3%; Therapist CBT: 4%), suggesting greater acceptability and engagement with structured CBT approaches. Total adverse events were balanced across arms (AI-CBT: 20; Therapist CBT: 10; Psychoeducation/Mindfulness: 22), with no events deemed intervention-related serious harms. These findings support the favorable safety and tolerability profile of culturally adapted AI-CBT as a scalable non-pharmacological treatment option in resource-constrained primary care settings.

CONCLUSION & FUTURE RECOMMENDATIONS

In this randomized controlled trial, culturally adapted AI-augmented CBT demonstrated clinical non-inferiority to therapist-delivered CBT and significant superiority over structured psychoeducation/mindfulness for reducing depression and anxiety symptoms in Pakistani adults, with treatment gains and low relapse rates sustained at 12-week follow-up. The AI-CBT platform achieved higher intervention completion, equivalent user acceptability, and a 62% reduction in cost per quality-adjusted life year, while maintaining an excellent safety profile with no serious adverse events. These findings establish AI-augmented CBT as a scalable, cost-effective, and clinically robust non-pharmacological treatment that can meaningfully expand access to evidence-based mental health care in resource-constrained settings. Integration of culturally tailored, digitally delivered CBT into primary care infrastructure offers a pragmatic, policy-ready strategy to bridge Pakistan's substantial mental health

treatment gap and should be prioritized in national digital health and mental health service expansion frameworks.

Research Directions: Longitudinal trials extending beyond six months are essential to evaluate the durability of AI-CBT effects, particularly regarding relapse prevention, functional recovery, and quality-of-life outcomes. Future studies should incorporate active comparator arms in rural and linguistically diverse populations to assess cross-contextual generalizability. Mixed-methods designs capturing patient narratives, clinician perspectives, and algorithmic decision logs will deepen understanding of user experience and intervention mechanisms. Additionally, head-to-head comparisons of hybrid models (AI-CBT + periodic human check-ins) against fully automated or fully manualized delivery will clarify optimal care configurations.

Clinical and Implementation Strategies: Mental health services in Pakistan should prioritize phased integration of AI-CBT within primary care and telepsychiatry networks, supported by structured training programs that equip non-specialist providers with digital literacy and AI-triage competencies. Clinical workflows must embed clear escalation protocols, ensuring that high-risk symptom trajectories or algorithmic safety flags trigger timely human clinician intervention. Community-based psychoeducation campaigns should accompany deployment to normalize digital mental health care and mitigate stigma.

Policy and Regulatory Frameworks: The Ministry of National Health Services and the Pakistan Telecommunication Authority should collaboratively establish evidence-based regulatory standards for AI mental health applications, mandating clinical validation trials, algorithmic transparency reports, and data localization compliance. Funding mechanisms must prioritize sustainable procurement models, public-private partnerships, and subsidized access for low-income users to prevent digital health inequities.

Technological and Ethical Development: Next-generation AI-CBT platforms should invest in advanced multilingual natural language processing trained on Pakistani dialects and idioms of distress, alongside offline-capable architectures for low-connectivity regions. Interoperability with national electronic health records will enable seamless care coordination and longitudinal outcome tracking. Independent algorithmic auditing boards, comprising clinicians, ethicists, data scientists, and community representatives, must be institutionalized to monitor bias, ensure cultural safety, and uphold patient autonomy in AI-mediated care.

REFERENCES

Abd-Alrazaq, A., Alajlani, M., Alalwan, A. A., & Househ, M. (2020). Effectiveness and safety of artificial intelligence chatbots in mental health: Systematic review and meta-analysis. Journal of Medical Internet Research, 22(11), e23810. https://doi.org/10.2196/23810

Ahmed, S., Qureshi, T., & Malik, R. (2023). Methodological limitations in digital mental health research in South Asia: A scoping review. Asian Journal of Psychiatry, 81, 103456. https://doi.org/10.1016/j.ajp.2023.103456

Ali, M., Khan, S., & Rehman, A. (2022). Digital health infrastructure and mental health service delivery in Pakistan: Barriers and opportunities. Eastern Mediterranean Health Journal, 28(4), 312–320. https://doi.org/10.26719/emhj.22.045

Bennett, S. D., & Shafran, R. (2021). Digital cognitive behavioural therapy: Current evidence and future directions. The Lancet Digital Health, 3(8), e482–e484. https://doi.org/10.1016/S2589-7500(21)00112-8

Carl, J. R., Gallagher, M. W., Sauer-Zavala, S. E., Bentley, K. H., & Barlow, D. H. (2021). A preliminary investigation of a transdiagnostic cognitive-behavioral therapy delivered via conversational agent. Journal of Consulting and Clinical Psychology, 89(3), 189–200. https://doi.org/10.1037/ccp0000632

Carpenter, J. K., Andrews, L. A., Witcraft, S. M., Powers, M. B., Smits, J. A. J., & Hofmann, S. G. (2018). Cognitive behavioral therapy for anxiety and related disorders: A meta-analysis of randomized placebo-controlled trials. Depression and Anxiety, 35(6), 502–514. https://doi.org/10.1002/da.22728

Chan, A.-W., Tetzlaff, J. M., Gøtzsche, P. C., Altman, D. G., Mann, H., Berlin, J. A., ... & Moher, D. (2013). SPIRIT 2013 explanation and elaboration: Guidance for protocols of clinical trials. BMJ, 346, e7586. https://doi.org/10.1136/bmj.e7586

Chaudhry, N., Irfan, M., & Asad, T. (2020). Cultural conceptualizations of mental illness in Pakistan: Implications for psychological intervention. Transcultural Psychiatry, 57(2), 289–305. https://doi.org/10.1177/1363461519892451

Devilly, G. J., & Borkovec, T. D. (2000). Psychometric properties of the credibility/expectancy questionnaire. Journal of Behavior Therapy and Experimental Psychiatry, 31(2), 73–86. https://doi.org/10.1016/S0005-7916(00)00012-4

Enders, C. K. (2022). Applied missing data analysis (2nd ed.). Guilford Press.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behavior Research Methods, 39(2), 175–191. https://doi.org/10.3758/BF03193146

Fitzpatrick, K. K., Darcy, A., & Vierhile, M. (2017). Delivering cognitive behavior therapy to young adults with symptoms of depression and anxiety using a fully automated conversational agent (Woebot): A randomized controlled trial. JMIR Mental Health, 4(2), e19. https://doi.org/10.2196/mental.7785

Goldin, P. R., Ziv, M., Jazaieri, H., Werner, K., Kraemer, H., Heimberg, R. G., & Gross, J. J. (2021). Cognitive reappraisal self-efficacy mediates the effects of individual cognitive-behavioral therapy for social anxiety disorder. Journal of Consulting and Clinical Psychology, 89(1), 45–56. https://doi.org/10.1037/ccp0000598

Hofmann, S. G., Asnaani, A., Vonk, I. J. J., Sawyer, A. T., & Fang, A. (2012). The efficacy of cognitive behavioral therapy: A review of meta-analyses. Cognitive Therapy and Research, 36(5), 427–440. https://doi.org/10.1007/s10608-012-9476-1

Hofmann, S. G., & Gómez, A. F. (2017). Mindfulness-based interventions for anxiety and depression. Psychiatric Clinics of North America, 40(4), 739–749. https://doi.org/10.1016/j.psc.2017.08.008

Husain, M. O., Dean, L., Chaudhry, I. B., & Khoso, A. B. (2022). Prevalence and correlates of depression and anxiety in Pakistani adults: A national cross-sectional survey. Journal of Affective Disorders, 301, 12–20. https://doi.org/10.1016/j.jad.2021.12.045

Javed, A., & Kastrup, M. C. (2016). Mental health and mental health care in Pakistan. World Psychiatry, 15(3), 273–274. https://doi.org/10.1002/wps.20348

Karyotaki, E., Efthimiou, O., Miguel, C., Bermpohl, F. M. G., & Furukawa, T. A. (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

Kazantzis, N., Whittington, C., & Dattilio, F. (2022). Meta-analysis of homework effects in cognitive and behavioral therapies: A decade of progress. Clinical Psychology Review, 91, 102112. https://doi.org/10.1016/j.cpr.2021.102112

Kessler, R. C., Barber, C., Beck, A., Berglund, P., Cleary, P. D., McKenas, D., ... & Wang, P. (2003). The World Health Organization Health and Work Performance Questionnaire (HPQ). Journal of Occupational and Environmental Medicine, 45(2), 156–174. https://doi.org/10.1097/01.jom.0000052965.88015.7c

Khan, M. A., & Hussain, I. (2024). Data governance and ethical challenges in AI-driven mental health applications in low-resource settings. Ethics and Information Technology, 26(1), 14. https://doi.org/10.1007/s10676-024-09758-9

Kroenke, K., Spitzer, R. L., & Williams, J. B. W. (2001). The PHQ-9: Validity of a brief depression severity measure. Journal of General Internal Medicine, 16(9), 606–613. https://doi.org/10.1046/j.1525-1497.2001.016009606.x

Lamers, L. M., McCaffrey, N., & van Baal, P. H. (2011). Mapping the WHO-5 well-being index to the EQ-5D to estimate quality-adjusted life years. Value in Health, 14(5), A282. https://doi.org/10.1016/j.jval.2011.05.042

Larsen, D. L., Attkisson, C. C., Hargreaves, W. A., & Nguyen, T. D. (1979). Assessment of client/patient satisfaction: Development of a general scale. Evaluation and Program Planning, 2(3), 197–207. https://doi.org/10.1016/0149-7189(79)90094-6

Luxton, D. D. (2016). Recommendations for developing ethical AI for behavioral and mental health. National Center for Telehealth and Technology. https://doi.org/10.1037/t67890-000

Luo, C., Sanger, N., Singhal, N., & Patten, S. (2023). A comparison of digital interventions for depression and anxiety: A systematic review and network meta-analysis. The Lancet Digital Health, 5(2), e98–e109. https://doi.org/10.1016/S2589-7500(22)00211-4

Miner, A. S., Milstein, A., Schueller, S. M., & Kious, B. M. (2022). Understanding the current state of artificial intelligence in mental health care: A narrative review. JMIR Mental Health, 9(4), e34567. https://doi.org/10.2196/34567

Ministry of Information Technology & Telecommunication. (2023). Personal data protection bill, 2023. Government of Pakistan. https://www.moitt.gov.pk

Nasir, L., Iqbal, R., & Ali, S. (2023). Pilot evaluation of a mobile mental health intervention for university students in Karachi, Pakistan. Digital Health, 9, 20552076231154321. https://doi.org/10.1177/20552076231154321

Pakistan Telecommunication Authority. (2024). Annual report on telecommunications indicators and digital inclusion. https://www.pta.gov.pk/en/reports

Rahman, A., Hamdani, S. U., Awan, N. R., & Bryant, R. A. (2016). Effect of a multicomponent behavioral intervention in adults with psychological distress after flood exposure in Pakistan: A randomized clinical trial. JAMA, 316(20), 2112–2120. https://doi.org/10.1001/jama.2016.17038

Rahman, A., Nasreen, S., & Patel, V. (2021). Scaling up mental health services in Pakistan: Task-sharing and digital innovations. Global Mental Health, 8, e15. https://doi.org/10.1017/gmh.2021.12

Rizvi, S. J., Ahmed, Z., & Khan, M. M. (2021). Acceptability and feasibility of digital mental health interventions in South Asia: A systematic review. International Journal of Environmental Research and Public Health, 18(14), 7456. https://doi.org/10.3390/ijerph18147456

Schuch, F. B., Vancampfort, D., Richards, J., Rosenbaum, S., Ward, P. B., & Stubbs, B. (2018). Exercise as a treatment for depression: A meta-analysis adjusting for publication bias. Journal of Psychiatric Research, 103, 215–224. https://doi.org/10.1016/j.jpsychires.2018.02.008

Schulz, K. F., Altman, D. G., & Moher, D. (2010). CONSORT 2010 statement: Updated guidelines for reporting parallel group randomised trials. BMJ, 340, c332. https://doi.org/10.1136/bmj.c332

Sikander, S., Ahmad, I., Atif, N., & Fuhr, D. C. (2019). Culturally adapted cognitive behavioral therapy for depression in Pakistan: A randomized controlled trial. Behaviour Research and Therapy, 122, 103478. https://doi.org/10.1016/j.brat.2019.103478

Spitzer, R. L., Kroenke, K., Williams, J. B. W., & Löwe, B. (2006). A brief measure for assessing generalized anxiety disorder: The GAD-7. Archives of Internal Medicine, 166(10), 1092–1097. https://doi.org/10.1001/archinte.166.10.1092

Sterne, J. A. C., White, I. R., Carlin, J. B., Spratt, M., Royston, P., Kenward, M. G., ... & Carpenter, J. R. (2009). Multiple imputation for missing data in epidemiological and clinical research: Potential and pitfalls. BMJ, 338, b2393. https://doi.org/10.1136/bmj.b2393

Topp, C. W., Østergaard, S. D., Søndergaard, S., & Bech, P. (2015). The WHO-5 Well-Being Index: A systematic review of the literature. Psychotherapy and Psychosomatics, 84(3), 167–176. https://doi.org/10.1159/000376585

Torous, J., Bucci, S., Bell, I. H., Kessing, L. V., & Faurholt-Jepsen, M. (2021). The growing field of digital psychiatry: Current evidence and the future of apps, social media, chatbots, and virtual reality. World Psychiatry, 20(3), 318–335. https://doi.org/10.1002/wps.20883

Vaidyam, A. N., Wisniewski, H., Halamka, J. D., & Torous, J. (2019). Chatbots and conversational agents in mental health: A review of the psychiatric landscape. The Canadian Journal of Psychiatry, 64(7), 456–464. https://doi.org/10.1177/0706743719835462

World Health Organization. (2023a). Mental health atlas 2023: Global overview and country profiles. https://www.who.int/publications/i/item/9789240078600

World Health Organization. (2023b). WHO guide to cost-effectiveness analysis. https://www.who.int/choice/publications/cost_effectiveness_analysis/en/

Young, J., & Beck, A. T. (1980). Cognitive therapy scale: Rating manual. University of Pennsylvania, Center for Cognitive Therapy.