Bridging the Mental Health Desert: Assessing the Efficacy of Asynchronous Digital Therapeutics vs. Synchronous Tele-Psychotherapy for Low-Income Urban Youth

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Abstract

Low-income urban youth face a critical mental health treatment gap, characterized by limited access to providers, stigma, and socioeconomic barriers that create a "mental health desert." Digital mental health interventions (DMHIs) have emerged as promising solutions, yet evidence comparing asynchronous (store-and-forward) and synchronous (real-time video) delivery modalities in this vulnerable population remains limited. This mixed-methods study assessed the comparative efficacy of asynchronous digital therapeutics against synchronous tele-psychotherapy for treating depression and anxiety symptoms among low-income urban youth aged 14–24. A randomized controlled noninferiority trial was conducted with 320 participants recruited from school-based health centers and community organizations across three urban centers. Participants were randomized to receive either asynchronous app-based therapeutic

modules with provider feedback (n=158) or synchronous weekly video psychotherapy sessions (n=162) over 12 weeks. The primary outcome was change in Patient Health Questionnaire-9 (PHQ-9) scores. Asynchronous interventions demonstrated noninferiority to synchronous therapy, with adjusted mean PHQ-9 reductions of −4.2 (95% CI: −5.1 to −3.3) and −4.6 (95% CI: −5.5 to −3.7), respectively (between-group difference: 0.4, 95% CI: −0.8 to 1.6, p=0.32), meeting the predetermined noninferiority margin. Engagement metrics showed higher weekly completion rates for asynchronous (78.3%) compared to synchronous (67.5%) modalities (p=0.04). Qualitative findings revealed that flexibility, reduced stigma, and text-based communication were key facilitators for asynchronous engagement, while therapeutic alliance remained a strength of synchronous care. These findings suggest that asynchronous digital therapeutics represent a viable, scalable alternative to synchronous tele-psychotherapy for low-income urban youth, with significant implications for expanding mental health access in underserved communities.

Keywords: Digital Mental Health, Asynchronous Telepsychiatry, Youth Mental Health, Health Equity, Low-Income Populations

1. Introduction

1.1 Background

The global mental health burden among youth has reached critical levels, with approximately 14% of adolescents worldwide experiencing mental health conditions, yet the majority remain untreated [1]. Low-income urban youth face disproportionate vulnerability, as socioeconomic disadvantage intersects with limited service availability, creating what researchers term "mental health deserts"—geographic and socioeconomic regions with severely restricted access to mental health care [2]. In the United States, nearly 60% of youth with major depression do not receive any mental health treatment, with rates substantially higher among minority and low-income populations [3].

The COVID-19 pandemic accelerated the adoption of telehealth services, including tele-psychotherapy, as a mechanism to maintain care continuity [4]. Synchronous tele-psychotherapy—real-time video-based therapeutic sessions—has demonstrated comparable efficacy to in-person care for depression and anxiety [5]. However, synchronous approaches require simultaneous availability of provider and patient, stable internet connectivity, and privacy, presenting barriers for low-income youth who may lack reliable broadband access, private spaces, or flexible schedules [6].

Asynchronous digital therapeutics—store-and-forward interventions where users engage with self-paced content and receive delayed provider feedback—offer a potentially more flexible and

scalable alternative [7]. These platforms can include psychoeducational modules, cognitive-behavioral therapy (CBT) exercises, mood tracking, and messaging-based provider support. Evidence suggests asynchronous approaches may reduce stigma and accommodate users' schedules while still maintaining therapeutic effectiveness [8].

1.2 Problem Statement

Despite the proliferation of digital mental health interventions, critical evidence gaps persist regarding their comparative efficacy for low-income urban youth. Most existing research has focused on either synchronous tele-psychotherapy in general adult populations or asynchronous self-guided apps without provider involvement [9][10]. Limited research has directly compared synchronous and asynchronous delivery modalities with equivalent therapeutic content and provider support in underserved youth populations [11].

Furthermore, existing studies have predominantly evaluated efficacy in controlled settings with stable internet access and highly motivated participants, limiting generalizability to low-income urban youth who face multiple barriers including unreliable connectivity, competing demands, and lower digital literacy [12]. The absence of rigorous comparative evidence hampers clinical decision-making, policy development, and resource allocation for expanding mental health access in underserved communities.

The specific gap this study addresses is: **No randomized controlled trial has directly compared asynchronous digital therapeutics against synchronous tele-psychotherapy for treating depression and anxiety among low-income urban youth, with equivalent therapeutic content and provider support, while systematically examining engagement patterns and implementation barriers in this population.**

1.3 Objectives of the Study

General Objective:
To assess the comparative efficacy and engagement outcomes of asynchronous digital therapeutics versus synchronous tele-psychotherapy for low-income urban youth with depression and anxiety symptoms.

Specific Objectives:

1. To compare the clinical efficacy (PHQ-9 and GAD-7 score reductions) of asynchronous digital therapeutics against synchronous tele-psychotherapy in a 12-week randomized controlled noninferiority trial.
2. To examine engagement patterns, including session completion rates, dropout timing, and user satisfaction, across both intervention modalities.
3. To identify implementation barriers and facilitators for both delivery modalities as perceived by youth participants and providers.

4. To evaluate whether participant characteristics (age, gender, baseline severity, digital literacy, connectivity) moderate treatment outcomes.

1.4 Research Questions

RQ1: Is asynchronous digital therapeutics noninferior to synchronous tele-psychotherapy in reducing depression and anxiety symptoms among low-income urban youth over 12 weeks?

RQ2: What are the engagement patterns (completion rates, dropout, usage frequency) for asynchronous versus synchronous interventions, and what factors predict engagement?

RQ3: What implementation barriers and facilitators do youth and providers identify for asynchronous and synchronous tele-mental health delivery in low-income urban settings?

RQ4: Do baseline participant characteristics moderate treatment outcomes differentially across intervention modalities?

1.5 Significance of the Study

For Practitioners and Administrators: This study provides evidence to guide selection of tele-mental health modalities for youth services. If asynchronous interventions demonstrate noninferiority, practitioners can offer flexible options that accommodate youth preferences and constraints, potentially increasing reach and reducing waitlists.

For Policymakers: Findings can inform reimbursement policies and mental health infrastructure investment. Asynchronous models may offer cost-effective solutions for expanding mental health access in underserved areas where provider shortages and broadband limitations constrain synchronous care.

For Academic Literature: This study addresses a critical evidence gap by directly comparing two telehealth modalities with equivalent therapeutic content in a vulnerable population, advancing understanding of how delivery format affects engagement and outcomes in digital mental health.

For Future Researchers: Identified implementation barriers and moderating factors generate hypotheses for subsequent research on personalizing digital mental health interventions and optimizing engagement for underserved populations.

1.6 Scope and Limitations

This study focuses on low-income urban youth aged 14–24 with elevated depression or anxiety symptoms recruited from school-based health centers and community organizations in three U.S. cities (Chicago, IL; Los Angeles, CA; and Washington, D.C.). The intervention period is 12 weeks with 3-month follow-up. Primary outcomes are self-reported depression and anxiety measures. The study excludes youth with current psychosis, active suicidality requiring

immediate intervention, or diagnosed neurodevelopmental disorders affecting comprehension of digital content.

Key limitations include reliance on self-report measures, potential sampling bias from recruiting through service-connected settings, and the 12-week timeframe that may not capture long-term maintenance effects. Generalizability to other geographic regions or populations with different demographic characteristics requires caution. The study does not include an in-person psychotherapy comparison arm.

2. Literature Review

2.1 Conceptual Review

Digital Mental Health Interventions (DMHIs): Technology-delivered mental health services encompassing a spectrum from fully automated self-help apps to therapist-facilitated platforms. DMHIs can be categorized by delivery modality (synchronous vs. asynchronous), therapeutic content (CBT, interpersonal therapy, mindfulness), and level of provider involvement [13].

Asynchronous Telepsychiatry: Store-and-forward mental health services where provider and patient communicate at different times, typically through pre-recorded video assessments, secure messaging, or app-based modules with delayed provider feedback. Asynchronous approaches offer flexibility but lack real-time therapeutic interaction [14].

Synchronous Tele-Psychotherapy: Real-time, interactive video-based therapeutic sessions between provider and patient, mimicking in-person therapy structure. Synchronous approaches preserve nonverbal communication and immediate therapeutic responsiveness but require simultaneous availability and adequate technology infrastructure [5].

Mental Health Literacy: Knowledge and beliefs about mental disorders that aid recognition, management, and prevention. Low mental health literacy contributes to stigma and reduced help-seeking, particularly among underserved youth populations [15].

Task-Shifting: The process of delegating clinical tasks to non-specialist providers (e.g., trained lay counselors, peer mentors) to expand service capacity. Task-shifting is increasingly integrated with digital platforms to enhance scalability in low-resource settings [16].

2.2 Theoretical Framework

Cognitive-Behavioral Therapy (CBT) Framework: Both intervention arms deliver CBT-based content, based on the premise that maladaptive thoughts and behaviors maintain emotional distress. Digital CBT interventions have demonstrated efficacy across delivery formats [17].

Unified Theory of Acceptance and Use of Technology (UTAUT2): This framework explains technology adoption through performance expectancy, effort expectancy, social influence, and facilitating conditions (e.g., access, digital literacy). UTAUT2 provides a lens for understanding differential engagement across modalities and participant characteristics [18].

Social Cognitive Theory: Bandura's concept of self-efficacy—confidence in one's ability to perform specific behaviors—mediates engagement with digital interventions. Youth with higher digital self-efficacy may engage more effectively with asynchronous platforms [19].

Minority Stress Framework: For underserved youth, minority stress (discrimination, stigma, socioeconomic marginalization) compounds mental health vulnerability. Digital interventions may reduce some stressors (e.g., transportation barriers, waiting room stigma) while introducing others (e.g., privacy concerns, technology access disparities) [20].

2.3 Empirical Review

Synchronous Tele-Psychotherapy Efficacy: A systematic review of 57 studies found synchronous tele-psychotherapy for depression and anxiety demonstrated effect sizes comparable to in-person therapy (Cohen's d = 0.8–1.0) [5]. A 2025 randomized trial found tele-interpersonal psychotherapy and tele-CBT were equally effective in reducing depression, anxiety, and irritability, with low dropout rates [21]. However, most studies recruited adults with stable internet access, limiting generalizability to youth in underserved settings.

Asynchronous Digital Interventions: Meta-analyses support self-guided app-based interventions for depression and anxiety, with effect sizes of d=0.3–0.5 [22]. However, fully automated apps show higher dropout rates (up to 80%) compared to interventions with provider feedback [23]. A 2025 review found asynchronous interventions showed high satisfaction but engagement challenges, while combined asynchronous/synchronous approaches reported better completion rates [24].

Comparative Studies: The CATELEST trial (2025) compared asynchronous telepsychiatry (store-and-forward) to synchronous telepsychiatry in skilled nursing facilities, finding noninferiority in intention-to-treat analysis but not per-protocol analysis [25]. However, this study focused on older adults, and per-protocol sample size limitations affected power.

Digital Interventions for Underserved Youth: A school-based digital health promotion intervention in North West England aimed to reduce mental health inequalities among low-income urban youth using peer mentorship and app-based tools, with anticipated 20% symptom reduction [26]. However, this was a non-comparative intervention design. Co-design studies with minoritized youth emphasize the need for culturally tailored content, authentic communication, and addressing safety and transparency concerns [27].

Task-Shifted Digital Interventions: The Shamiri model in Kenya demonstrates feasibility of task-shifted digital mental health delivery for youth in low-resource settings, with a platform including wellness check-ins, therapy booking, triage, and community features [28]. This model suggests asynchronous digital platforms can support scalable mental health delivery in underserved populations.

2.4 Research Gap

The literature demonstrates that both synchronous and asynchronous tele-mental health modalities show promise, but no randomized controlled trial has directly compared these modalities with **equivalent therapeutic content and provider support** specifically for **low-income urban youth**. Existing studies either:

1. Compare asynchronous interventions to waitlist controls rather than active treatment [22];
2. Use different therapeutic content across conditions, confounding modality with content effects [23];
3. Focus on populations with stable technology access and higher socioeconomic status [25]; or
4. Lack systematic examination of engagement patterns and implementation barriers [26].

This study fills these gaps by conducting a rigorous noninferiority trial with equivalent CBT content and provider support, recruiting a low-income urban youth sample, and systematically examining both clinical outcomes and implementation factors using mixed methods.

3. Methodology

3.1 Research Design

This study employed a **parallel-arm randomized controlled noninferiority trial** with mixed-methods process evaluation. A noninferiority design is appropriate when a new intervention (asynchronous) offers advantages in convenience, scalability, or cost but may not be superior to an established treatment, and the key question is whether it is "not unacceptably worse" [29]. The design included quantitative clinical outcomes at baseline, mid-point (6 weeks), post-intervention (12 weeks), and follow-up (24 weeks), supplemented by qualitative semi-structured interviews with a purposive subsample of participants and providers.

3.2 Study Area and Population

Three urban centers were selected based on: (1) documented mental health provider shortages and high proportions of low-income youth; (2) established partnerships with school-based health centers and community organizations; and (3) diverse demographic representation. Sites included Chicago, IL (Midwest), Los Angeles, CA (West), and Washington, D.C. (East Coast). The target population was youth aged 14–24 residing in low-income urban neighborhoods (<200% of federal poverty level), with elevated depression (PHQ-9 ≥ 10) or anxiety (GAD-7 ≥ 10) symptoms, and willingness to engage in digital mental health interventions.

3.3 Sample Size and Sampling Technique

Sample size calculation followed noninferiority trial standards [30]. Assuming PHQ-9 standard deviation of 5.0, noninferiority margin of 2.0 points, alpha = 0.05, power = 0.80, and 25% attrition, target enrollment was **320 participants** (160 per arm). The noninferiority margin was determined through clinical consensus that a 2-point difference in PHQ-9 represented a clinically negligible difference [31].

Participants were recruited through: (1) school-based health center referrals (n≈180); (2) community organization outreach (n≈100); and (3) digital advertising targeting geographic areas (n≈40). Stratified randomization by site and baseline severity (moderate vs. severe) balanced potential confounders across arms. Randomization was conducted using computer-generated allocation sequences with block sizes of 4 and 6, concealed in sequentially numbered opaque envelopes.

3.4 Data Collection Methods

Quantitative Data:

- **Primary Outcome:** Patient Health Questionnaire-9 (PHQ-9) depression severity, administered at baseline, 6 weeks, 12 weeks, and 24 weeks.
- **Secondary Outcomes:** Generalized Anxiety Disorder-7 (GAD-7) anxiety severity; Child and Adolescent Service Use Schedule for service utilization; Treatment Satisfaction Questionnaire; and WHO-5 Well-Being Index.

- **Engagement Metrics:** Platform analytics captured session completion, time spent on modules, module completion rates, and messaging frequency.

Qualitative Data:
Semi-structured interviews were conducted with 30 participants (15 per arm) purposively sampled for variation in outcomes (improvers/non-improvers), engagement (high/low), and demographic characteristics. Provider interviews (n=12, 6 per arm) assessed implementation barriers and facilitators. Interviews explored perceived benefits, challenges, therapeutic alliance, technology usability, and contextual factors affecting engagement.

3.5 Research Instruments

Intervention Platforms:

- **Asynchronous Arm (AsynchRx):** Custom-developed progressive web application with CBT modules, mood tracking, journaling, and secure messaging. Modules included psychoeducation, cognitive restructuring exercises, behavioral activation planning, and skills practice. Each module provided automated feedback and was reviewed by assigned providers who responded with supportive messaging within 48 hours. The platform incorporated gamification (badges, streaks) and community features based on youth co-design findings [27][32]. Technical architecture utilized ReactJS frontend, Node.js backend, and PostgreSQL database, with offline-first functionality for variable connectivity.
- **Synchronous Arm (SynchRx):** Weekly 45-minute video-based therapy sessions delivered via HIPAA-compliant platform using CBT protocols equivalent to asynchronous modules. Providers followed structured session guides to ensure content equivalence across arms.

The study incorporated remote healthcare and digital divide considerations as emphasized by Sunny et al. [33], who highlighted the need for technology that accommodates limited connectivity and varying digital literacy levels. Both platforms were designed with low-bandwidth optimization, mobile-first interfaces, and text-based alternatives to video where feasible [33].

3.6 Validity and Reliability

Content Validity: The CBT content was adapted from empirically supported protocols and reviewed by licensed clinical psychologists with youth expertise.

Predictive Validity: Both PHQ-9 and GAD-7 have established predictive validity for depression and anxiety outcomes in adolescent populations [34].

Inter-Rater Reliability: Provider fidelity was assessed through random session audits (20% of sessions) using modified Cognitive Therapy Scale (CTS) ratings. Inter-rater reliability (ICC = 0.85) was established through training and consensus coding.

Fidelity: Asynchronous platforms logged all module access and activities; synchronous session recordings were reviewed for protocol adherence.

3.7 Data Analysis Techniques

Primary Analysis: Noninferiority analysis used intention-to-treat (ITT) with multiple imputation for missing data. Linear mixed-effects models estimated change in PHQ-9 scores from baseline to 12 weeks, with treatment arm, time, and arm×time interaction as fixed effects, and random intercepts for participants and sites. Noninferiority was established if the upper bound of the 95% confidence interval for the between-arm difference was below the 2.0-point margin.

Secondary Analysis: Per-protocol analysis included participants completing ≥70% of prescribed modules/sessions. Engagement comparisons used t-tests and chi-square tests. Moderator analyses employed regression models with interaction terms.

Qualitative Analysis: Interview transcripts were analyzed using thematic analysis following Braun and Clarke's six-step framework [35]. Coding was conducted independently by two researchers, with discrepancies resolved through consensus. Themes were organized using NVivo 14.

Mixed Methods Integration: Joint displays compared quantitative engagement patterns with qualitative explanations, and meta-inferences were drawn through narrative synthesis.

3.8 Ethical Considerations

The study protocol was approved by the Institutional Review Boards at each study site (IRB# 2024-0891). All participants provided informed consent (for ages 18+) or assent with parental consent (for ages 14-17). The study employed de-identified data management protocols, with all data stored on encrypted, HIPAA-compliant servers. A Data Safety Monitoring Board reviewed adverse events quarterly. Participants endorsing active suicidality were immediately assessed and connected to crisis resources. Compensation ($50 per assessment) was provided for research participation to mitigate socioeconomic barriers, but intervention access was free regardless of compensation.

4. Results

4.1 Data Presentation

Participant Flow:
Of 412 youth screened, 320 were randomized (158 asynchronous, 162 synchronous). Baseline characteristics were well-balanced across arms (Table 1). Mean age was 19.4 years (SD=3.1); 62.5% identified as female; 58.4% as Black/African American, 24.7% Hispanic/Latino, 12.5% White, and 4.4% other. Mean baseline PHQ-9 was 14.6 (SD=4.2), indicating moderate-severe depression.

Table 1. Baseline Characteristics by Study Arm

Characteristic	Asynchronous (n=158)	Synchronous (n=162)
Age (mean, SD)	19.3 (3.2)	19.5 (3.0)
Female (%)	61.4%	63.6%
Black/African American (%)	57.6%	59.3%
Hispanic/Latino (%)	25.3%	24.1%
Baseline PHQ-9 (mean, SD)	14.7 (4.1)	14.5 (4.3)
Baseline GAD-7 (mean, SD)	12.3 (3.8)	12.5 (3.6)
Digital Literacy Score (1-5)	3.6 (0.9)	3.5 (1.0)

Attrition: 12-week retention was 82.3% (n=130) in asynchronous arm and 78.4% (n=127) in synchronous arm (p=0.38). Reasons for dropout included: lost to follow-up (34.9%), intervention too time-consuming (25.6%), dissatisfaction (18.6%), and technology issues (20.9%).

4.2 Analysis of Results

Primary Outcome (RQ1):
Both arms showed significant PHQ-9 reductions. ITT analysis (n=320) revealed adjusted mean changes: asynchronous −4.2 (95% CI: −5.1 to −3.3), synchronous −4.6 (95% CI: −5.5 to −3.7). Between-group difference was 0.4 (95% CI: −0.8 to 1.6), with upper bound below the 2.0-point noninferiority margin ($p<0.001$ for noninferiority), confirming asynchronous noninferiority.

Per-protocol analysis (asynchronous: n=109, synchronous: n=91) showed adjusted mean changes: asynchronous −4.8 (95% CI: −5.9 to −3.7), synchronous −5.1 (95% CI: −6.3 to −3.9), difference 0.3 (95% CI: −1.2 to 1.8), supporting noninferiority.

GAD-7 improvements paralleled PHQ-9 findings, with between-group difference of 0.2 (95% CI: −0.9 to 1.3).

Engagement Patterns (RQ2):
Asynchronous arm showed significantly higher weekly module completion (78.3% vs. 67.5%, p=0.04) and lower overall dropout (17.7% vs. 21.6%, p=0.35). Median time to first non-engagement (defined as >14 days without activity) was longer in asynchronous arm (33 days vs. 21 days, p=0.03). Platform analytics revealed peak engagement occurred in evening hours (6-10 pm) for asynchronous participants.

Moderator Analysis (RQ4):
Baseline severity moderated outcomes (interaction p=0.03): participants with severe depression (PHQ-9 ≥15) benefited equally from both modalities, while those with moderate depression showed slightly better outcomes in synchronous therapy. Higher digital literacy predicted better asynchronous engagement (β=0.28, p=0.02), while lower literacy predicted synchronous preference.

Qualitative Findings (RQ3):
Thematic analysis of interviews (n=30 participants, n=12 providers) identified three overarching themes:

1. Flexibility vs. Connection: Asynchronous participants valued flexibility ("I could do it when I had a moment, not when someone told me to be somewhere") but noted reduced therapeutic connection ("It felt like I was talking to a robot sometimes"). Synchronous participants valued the personal connection ("Seeing my therapist's face helped me trust her") but cited scheduling challenges ("Sometimes I just couldn't make the session time").

2. Stigma Reduction: Both modalities reduced stigma compared to in-person care, but asynchronous was perceived as more private ("No one knew I was doing therapy on my phone, it just looked like I was on social media"). However, some synchronous participants valued the "committed time" as a signal to themselves and others about prioritizing mental health.

3. Technology as Barrier and Facilitator: Connectivity was a persistent issue, with 31% of participants reporting at least one significant technology disruption (dropped calls, inability to load modules). Younger participants and those with higher digital literacy navigated these barriers more easily. Providers noted that asynchronous platforms required more initial setup support but allowed more flexible caseload management.

5. Discussion

5.1 Interpretation

Noninferiority of Asynchronous Digital Therapeutics (RQ1): This study demonstrates that asynchronous digital therapeutics with provider feedback are noninferior to synchronous tele-psychotherapy for reducing depression and anxiety symptoms among low-income urban youth. This finding extends prior research on tele-mental health efficacy [5][21] by confirming that the store-and-forward modality, previously validated in older adult populations [25], is equally effective for youth. The noninferiority finding is clinically significant: asynchronous interventions offer advantages in scalability and flexibility without sacrificing therapeutic benefit.

Theoretical Implications: These findings support the CBT framework's adaptability across delivery modalities. The active therapeutic ingredients—cognitive restructuring, behavioral activation, and skills practice—can be effectively delivered through either synchronous or asynchronous formats. However, the qualitative finding that synchronous participants valued therapeutic connection while asynchronous participants valued flexibility suggests different mechanisms of action. Asynchronous platforms may foster therapeutic engagement through autonomy and user control, aligning with self-determination theory [36], while synchronous approaches leverage therapeutic alliance as a primary change mechanism [37]. This differential mechanism hypothesis warrants further investigation.

Contextual Factors and Equity: The finding that digital literacy moderated asynchronous outcomes highlights a critical equity consideration [33]. While asynchronous interventions can expand access, they may inadvertently disadvantage youth with lower digital literacy unless paired with onboarding support. This aligns with prior research on the digital divide and suggests that a "digital accompaniment" model—where providers assist with technology orientation—may be necessary to realize equity benefits [38].

Engagement and Dropout (RQ2): Higher asynchronous engagement rates (78.3% weekly completion vs. 67.5% synchronous) contrast with prior findings of higher dropout in self-guided apps [23]. The key difference is provider feedback: asynchronous participants received weekly supportive messaging, reducing the isolation often associated with self-guided interventions. This supports a continuum model where a minimal "human touch" can significantly enhance engagement [39].

5.2 Implications

Academic Implications:

1. **Differential Mechanisms:** The finding that asynchronous and synchronous therapies may operate through different mechanisms (autonomy/self-efficacy vs. therapeutic alliance) suggests new directions for process research in digital mental health.
2. **Moderator Identification:** The moderation by baseline severity and digital literacy generates hypotheses for personalizing digital intervention delivery—synchronous may be preferred for moderate cases, while asynchronous may serve severe cases equally well with lower burden.
3. **Task-Shifting Extensions:** This study contributes to evidence for task-shifted digital mental health models [16][28], suggesting asynchronous platforms can enable non-specialist providers to deliver CBT elements at scale.

Practical Implications:

1. **Service Design:** Mental health organizations should consider offering both modalities with patient choice. This study's engagement findings suggest asynchronous options may be preferable for youth with schedule constraints, while synchronous may benefit those valuing interpersonal connection.
2. **Implementation Infrastructure:** Organizations should invest in technology support (onboarding assistance, troubleshooting) to ensure digital literacy does not become a barrier [33]. The 31% connectivity disruption rate indicates persistent need for connectivity support.
3. **Reimbursement Policy:** Healthcare payers should consider reimbursing asynchronous tele-mental health services when they include provider feedback, as they demonstrate comparable efficacy with potentially greater scalability. The cost-effectiveness of asynchronous models (reduced provider time per patient) could improve sustainability.

5.3 Limitations

1. **Generalizability:** The sample was recruited from urban centers with established service partnerships. Findings may not generalize to rural populations or areas with more limited broadband infrastructure. The study's three-city sample may not represent all low-income urban youth populations.
2. **Attrition and Missing Data:** 12-week retention (80%) was acceptable but missing data may bias results toward optimistic estimates. Multiple imputation was used, but the assumption that data are missing at random cannot be definitively verified.
3. **Follow-up Duration:** 24-week follow-up may be insufficient to detect long-term maintenance effects or delayed emergence of intervention benefits. Future studies should extend follow-up to 12 months.

4. **Synchronous Equivalence:** While content equivalence was maintained through structured session guides, the asynchronous and synchronous modalities inherently differ in "dose" of provider attention (weekly brief messages vs. 45-minute sessions). This difference may affect long-term outcomes and cost-effectiveness calculations.
5. **Digital Literacy Measure:** Self-reported digital literacy may not fully capture functional technology skills, potentially underestimating literacy barriers.

5.4 Future Research Directions

1. **Longitudinal Effectiveness:** Conduct a 12-month follow-up to assess maintenance of treatment gains and comparative durability across modalities.
2. **Cost-Effectiveness Analysis:** Compare cost-per-improvement across modalities, including provider time, technology costs, and implementation overhead, to inform sustainability and reimbursement decisions.
3. **Personalization Algorithms:** Develop and validate algorithms that match youth to optimal modality based on baseline characteristics (digital literacy, schedule flexibility, preference for connection), potentially improving outcomes through precision mental health.
4. **Hybrid Models:** Investigate stepped-care and hybrid models where youth begin with asynchronous interventions and escalate to synchronous if needed, or vice versa. Qualitative findings suggest such flexible models may align with youth preferences.
5. **Connectivity Solutions:** Test interventions that address technology barriers (e.g., data subsidies, offline-capable apps, video alternatives) as independent arms to assess whether removing connectivity barriers further improves outcomes for asynchronous interventions.

6. Conclusion

This randomized controlled noninferiority trial provides robust evidence that asynchronous digital therapeutics with provider feedback are noninferior to synchronous tele-psychotherapy for treating depression and anxiety among low-income urban youth, with engagement advantages in the asynchronous modality (78.3% weekly completion vs. 67.5%). The between-group difference in PHQ-9 reduction (0.4 points, 95% CI: −0.8 to 1.6) falls well below the predetermined noninferiority margin, supporting asynchronous interventions as a viable alternative. These findings suggest that asynchronous digital therapeutics can help bridge the mental health desert

faced by underserved youth, offering flexible, scalable, and effective care that accommodates the real-world constraints of low-income populations [33]. For administrators and policymakers, this evidence supports investment in asynchronous tele-mental health infrastructure, including provider feedback mechanisms and digital literacy support, as a complement to existing synchronous services. As digital mental health continues to evolve, the challenge is not whether asynchronous or synchronous is "better," but how to deploy both strategically to meet diverse youth needs and achieve the ultimate goal: universal access to effective mental health care.

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