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Mapping the Evidence on Just-in-Time Adaptive Interventions for Depression: A Scoping Review

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Abstract:

Background: Just-in-Time Adaptive Interventions (JITAIs) use real-time data from mobile and digital technologies to give personalized help when someone is most likely to need it or when an opportunity arises. Because symptoms of depression can change over time, JITAIs are a possible but still new way to stop and treat depression.

Objective: This scoping review aimed to clarify and synthesize the current evidence regarding JITAIs targeting depression, including preventive and transdiagnostic interventions with depressive outcomes. The review sought to clarify intervention concepts, target demographics, implementation attributes, and the current evidence regarding feasibility, engagement, and effectiveness.

Methods: A scoping review methodology was employed to analyze peer-reviewed empirical studies and research protocols that either self-identified as JITAIs or incorporated fundamental JITAI components, such as decision points, tailoring variables, decision rules, and adaptive intervention options. Qualified investigations focused on depression, depressive symptoms, or closely related transdiagnostic pathways. Fifty studies met the inclusion criteria and were carefully recorded. The data that was removed included details about the conceptual foundations, the level of automation, the options for customization, the use of sensors and analytical methods, the quality of reporting, and the clinical and engagement outcomes.

Results: The papers reviewed indicated a modest yet rapidly evolving body of JITAI research pertaining to depression and other mental health concerns. Most of the interventions were in the early stages (feasibility or proof-of-concept), were mostly app-based, and used self-reported mood or stress as the main way to change them. There were not many chances to use passive sensing and advanced analytic techniques. There was frequently only partial conceptual alignment with JITAI design principles, and decision rules and adaptive logic were often insufficiently elucidated. Usability and acceptability were generally outstanding, and preliminary results indicated slight improvements in depressive symptoms or psychological distress.

Conclusions: JITAIs for depression are still in their early stages, but they show promise. Future research should prioritize theory- and data-driven adaptability, enhanced automation, rigorous randomized evaluations, and an emphasis on scalability and equity in practical applications.

1. Introduction

Just-in-time adaptive interventions (JITAIs) are a type of digital intervention that uses information from sensors, self-reports, or the situation to figure out what kind of help to give and when. The goal is to help people in their daily lives by giving them "the right help at the right time" (Qian et al., 2021; Kraus et al., 2019). In theory, JITAIs originated from ecological momentary assessment (EMA) and ecological momentary interventions (EMIs), which utilize mobile devices to integrate

assessment and treatment into individuals' daily routines (Schueller et al., 2017; Russell & Gajos, 2020; Beames et al., 2021; Smith & Juarascio, 2019; Heron & Smyth, 2010). EMA enables ongoing, real-time assessment of symptoms, behaviors, and environmental factors, while EMIs deliver immediate interventions based on these assessments. Initial research on electronic mental health interventions for depression and anxiety showed that short-term, mobile-based therapies can help with symptoms, lower stress, and improve positive functioning (Schueller et al., 2017; Schröder et al., 2016). These findings indicate that utilizing drugs in everyday contexts is feasible and potentially beneficial, rather than being confined to hospital settings.

Recent advancements in research methodologies have enhanced the understanding of the essential components of Just-in-Time Adaptive Interventions (JITAIs), encompassing decision points, tailoring variables, decision rules, and intervention options. They have also developed novel methodologies for testing, such as microrandomized trials (MRTs) and Sequential Multiple Assignment Randomized Trials (SMART), to enhance intervention delivery (Qian et al., 2021; Liu et al., 2022; Lei et al., 2012; Nahum-Shani et al., 2018). These frameworks help you plan interventions that can change depending on how someone feels, how they act, or what is going on around them. Mobile health (mHealth) programs have also made it easier for people to get mental health care, especially through apps on their phones. These apps offer a scalable and personalized method to monitor and assist individuals (Klasnja & Pratt, 2012).

Despite these advancements, there are still not many fully developed JITAIs that are specifically designed for depression and have been thoroughly tested. A broader array of studies, including EMA/EMI research, internet-based interventions, smartphone-delivered mental health resources, and mobile interventions for both youth and adults, demonstrate that JITAIs possess significant potential to enhance the accessibility, personalization, and timeliness of depression care (Schueller et al., 2017; Russell & Gajos, 2020; Schröder et al., 2016; Torous et al., 2021; Grossman et al., 2020; Drozd et al., 2016; Bernstein et al., 2023; Heron & Smyth, 2010; Klasnja & Pratt, 2012). Additionally, mHealth interventions enable ongoing monitoring and feedback, facilitating prompt adjustments to interventions based on users' evolving requirements and situations.

Reviews from digital psychiatry and implementation science show that it is still hard to move interventions from research settings to regular clinical practice. Some of these problems are getting people to use the interventions, making sure they are fair, making sure organizations are ready, and thinking about ethics (Torous et al., 2021; Grossman et al., 2020; Drozd et al., 2016; Zainal et al., 2024). We need to address issues including as intervention fatigue, inequitable access to technology, and privacy concerns to ensure that JITAIs function effectively and are used equitably.

Because the research is moving quickly and it is hard to keep up with, it is important to map out the current data, explain the conceptual and methodological frameworks, and find out what we do not know about JITAIs for depression. As a result, this study provides a comprehensive overview of the literature. The review aims to clarify existing interventions and study designs, identify critical components and methodological frameworks, summarize outcomes and implementation considerations, and highlight gaps and unresolved questions to guide future research. This review seeks to furnish a comprehensive overview for researchers and practitioners engaged in the design, optimization, and implementation of Just-in-Time Adaptive Interventions (JITAIs) in depression care, while simultaneously fostering the development of more effective, scalable, and user-centric digital interventions.

2. Methods

A comprehensive Deep Search was conducted across >170 million papers indexed in Semantic Scholar, PubMed, and other

sources focusing on JITAIs, EMIs, and closely related mobile/digital interventions for depression and mood. The multi-step process initially **identified 1006** potentially relevant papers, of which **659** were screened after de-duplication. From these, **287** met broad eligibility criteria related to adaptive or momentary digital mental health interventions and depression or closely related outcomes; the **50 most relevant** and methodologically informative papers were included in this review. No formal risk-of-bias rating was applied, but priority was given to recent systematic reviews, meta-analyses, and key methodological or conceptual papers.

TABLE 1: Flow of study identification, screening, eligibility, and inclusion

Identification	**Screening**	Eligibility	Included
1006	659	287	50

Across 21 distinct but related database queries, the search strategy combined terms for depression and mood with JITAIs, EMIs, EMA, mobile health, youth/older adults, and adaptive digital interventions.

3. Results

3.1 Conceptual Foundations: From EMA/EMI to JITAIs

Many reviews look at JITAIs in light of how ambulatory assessment and intervention have changed over time.

Ecological momentary interventions (EMIs) have been rigorously studied across various mental health fields, with preliminary research highlighting their capacity to integrate evaluation and intervention into daily life through mobile devices. Schueller et al. (2017) EMIs for anxiety and depression are real-life treatments that help with both the symptoms and the stress they cause. They also make people feel better mentally. They believe that just-in-time adaptive therapies (JITAIs) are a "special class" of EMIs because they use algorithms to change over time based on short-term results and take into account things like

mood, context, and behavior. Russell and Gajos (2020) investigate the utilization of ecological momentary assessment (EMA) in children and adolescents, suggesting that the integration of EMA with mobile interventions and sensor data represents a crucial pathway toward Just-In-Time Adaptive Interventions (JITAIs) that can effectively engage high-risk youth "when and where" support is most critical. The emphasis on prompt and tailored assistance aligns with comprehensive frameworks for individualized intervention, exemplified by the "science of personalized intervention" proposed by Ng and Weisz (2016). This model stresses the importance of feedback systems in modular, sequential, and adaptive frameworks. Similar deficiencies and opportunities have been identified across multiple clinical domains; for instance, in their analysis of electronic mobile interventions (EMIs) for eating disorders, Smith and Juarascio (2019) observe that most current mobile interventions lack adequate adaptability to immediate contexts and explicitly advocate for the creation of adaptive EMIs or Just-In-Time Adaptive Interventions (JITAIs) as a rational subsequent measure. This body of literature shows how EMA, EMI, and customized intervention methods are all moving closer together toward JITAIs as a possible treatment for many mental health problems.

These findings collectively delineate a conceptual shift from static, session-based therapy to continuous, context-responsive interventions that adapt to individual variability (Schueller et al., 2017; Russell & Gajos, 2020; Ng & Weisz, 2016; Smith & Juarascio, 2019).

3.2 Methodological Advances: Designs for Developing JITAIs

Microrandomized trials (MRTs) and sequential multiple assignment randomized trials (SMARTs) are very important for making, testing, and improving just-in-time adaptive treatments (JITAIs). MRTs were made just for the fact that JITAIs are hard and always changing. This strategy randomly picks people a few times—sometimes hundreds or thousands of times—at set decision points to

decide whether or not to get a certain part of the intervention (Qian et al., 2021; Liu et al., 2022). This randomization that happens over and over again lets us figure out causal "excursion effects," which are the small, immediate effects of giving a certain intervention component at a certain time, based on how the person is doing right now. MRTs are great at figuring out the best times, types, and frequencies for sending notifications and micro-interventions several times a day in JITAIs. Liu et al. (2022) build on this idea by making a distinction between traditional MRTs and outcome-adaptive MRTs. In outcome-adaptive MRTs, the chances of randomization can change over time as more data is collected. Outcome-adaptive MRTs try to bring learning and optimization together by constantly generating evidence and giving more weight to the most promising intervention options. This is very much in line with the goal of providing personalized and effective help in real-life situations.

SMART designs, along with MRTs, provide a more complete experimental framework for creating multi-stage adaptive treatment methods. These methods change the treatment options based on how the person responds over time (Lei et al., 2012). People often use SMARTs to evaluate step-up or step-down intervention sequences and to help make rules for how to move between treatment components. SMARTs do not always work on "just-in-time" schedules, and they usually work on coarser time scales than MRTs. However, they do provide a useful framework for adaptive intervention research in terms of ideas and methods. In the field of digital mental health, JITAIs can be used as small, temporary parts of larger adaptive care frameworks that are based on SMART principles. MRTs and SMARTs are two different ways of doing things that work well together to make sure that JITAIs are developed and tested in a strict way. They also show how many different kinds of experiments are being done in this new field, which shows how important it is to plan them out in a logical way.

Digital behavioral medicine is using these methods more and more, and they are being pushed more and more for mental health JITAIs, especially those that deal with depression, anxiety, and negative thinking that will not go away (Liu et al., 2022; Lei et al., 2012; Qian et al., 2021; Cross et al., 2025).

3.3 Evidence That Adaptive/JIT-like Digital Interventions Can Improve Mood

Direct, large-scale JITAIs specifically for major depressive disorder remain limited, but several lines of evidence are relevant:

1. **Meta-analytic evidence that JITAIs outperform non-adaptive interventions**

Recent secondary syntheses suggest that adaptive digital therapies, like JITAIs, might offer advantages over non-adaptive approaches in various mental health and behavioral outcomes.Arigo et al. (2024) examine a meta-analysis conducted by Wang and Miller, which demonstrates that JITAIs are generally more effective than non-adaptive digital interventions. This study shows that adapting to changing, temporary situations, like changes in stress, location, or current activities, has stronger effects than personalization based only on stable individual traits or baseline characteristics. This distinction is particularly relevant to depression, a disorder characterized by substantial intra-individual variations in mood, motivation, and context over time. A related systematic review of JITAIs that focus on physical activity, also summarized by Arigo et al. (2024), shows that treatments that change over time have more consistent effects on behavior change than treatments that do not change. These reviews cover a wide range of health and behavioral areas, not just depression. They all say that it is usually helpful to be able to change with the times. This indirectly supports the idea of using JITAIs to help people with depression, which is important from a theoretical point of view. These findings place depression-focused JITAIs within a wider body of evidence,

highlighting the need for strong adaptive trial methods for evaluations in specific areas.

2. Internet interventions for depression (precursors to JITAIs)

A substantial body of evidence regarding internet-based cognitive behavioral therapy (iCBT) for depression provides an essential contextual basis for the progression of JITAIs. Comprehensive meta-analyses of iCBT interventions reveal small to medium effect sizes for unguided programs and medium to large effects for therapist-guided interventions compared to standard care, indicating that digitally administered CBT can produce clinically significant improvements in depressive symptoms (Schröder et al., 2016). These interventions are frequently delivered in a static or predetermined format and lack real-time, sensor-based adaptation; however, they demonstrate the feasibility and effectiveness of delivering structured psychotherapy content through digital platforms. From a scoping review perspective, iCBT is considered a crucial precursor to JITAIs, illustrating that core CBT components—such as cognitive restructuring, behavioral activation, and skills practice—can be successfully modified for digital platforms. The database suggests that further enhancements could be achieved through optimized timing, contextual adaptability, and customization, which are essential design principles of JITAIs. Consequently, data from iCBT research elucidate both the advantages and shortcomings of prior digital therapies, while emphasizing the necessity for the progression towards more adaptable, just-in-time methodologies in depression treatment.

3. EMIs and mechanism-targeted smartphone interventions

Research on ecological momentary interventions (EMIs) and mechanism-targeted smartphone therapies elucidates the impact of psychological support in quotidian contexts on depressive symptoms and associated processes. Schueller et al. (2017) provide a review of diverse ecological momentary interventions (EMIs) that incorporate therapeutic modalities, including cognitive behavioral therapy, behavioral activation, and mindfulness, into everyday life. Numerous studies indicate that these therapies can alleviate symptoms of depression and anxiety. Along with this research, Bernstein et al. (2023) present a summary of smartphone-based physical activity therapies designed to elevate activity levels, acknowledged as an antidepressant mechanism, employing strategies such as self-monitoring, cues, and feedback. Significantly, numerous trials demonstrate improvements in mood or psychological distress, even when affective outcomes are not the primary focus of the intervention. This indicates that transient behavior-focused therapies might yield broader emotional advantages. Evidence from younger cohorts further supports the potential effectiveness of integrating real-time assessment with intervention delivery. Beames et al. (2021) examine EMA-integrated CBT for young adults with subclinical depression, highlighting symptom reduction and improved emotional awareness through the incorporation of daily mood monitoring and feedback into the treatment protocol. This body of evidence shows that EMIs and mechanism-focused smartphone therapies use immediate assessment, quick feedback, and contextual delivery to change both behavioral and emotional processes. From a scoping review perspective, these studies represent significant precursors and partial applications of JITAI concepts, while simultaneously underscoring the variability in adaptiveness and real-time decision-making across treatments.

4. JITAIs in broader digital psychiatry

Torous et al. (2021) describe the first prototypes of Just-in-Time Adaptive Interventions (JITAIs). These are personalized interventions for each person based on data that smartphones collect, both actively and passively. You could, for example, look at things like sleep patterns and social isolation to start the interventions.. These closed-loop devices exhibit adaptive, context-sensitive support for depression and related mental health disorders. Cross et al. (2025),In their assessment of digital mental health therapies

for adolescents aged 12–25 years, they highlight JITAIs as a notable innovative approach, particularly for delivering real-time interventions aimed at alleviating persistent negative thought patterns. Scoping reviews and empirical research also show that JITAIs use frequent decision points, context-specific tailoring variables, and a range of intervention options to provide timely behavioral and psychological support (Nahum-Shani et al., 2018; Hardeman et al., 2019). Evidence suggests that adaptive therapies may yield moderate enhancements in depression and anxiety symptoms; however, variations in engagement strategies, data collection methodologies, and decision-making protocols impede uniform implementation (Klasnja & Pratt, 2012; Riley et al., 2019).

In conclusion, these findings indicate that digital therapy can reliably alleviate depressive symptoms across diverse populations. Interventions that adapt over time and according to context, such as JITAIs, generally exhibit superior efficacy in improving mental health and behavior compared to fixed frameworks (Arigo et al., 2024; Nahum-Shani et al., 2018; Riley et al., 2019). There is a scarcity of substantial research on depression employing micro-randomized trials (MRTs) or sequential, multiple assignment randomized trials (SMART). Consequently, assessments of effect magnitude, optimal decision-making frameworks, and customization strategies are still in their infancy, requiring additional comprehensive research to formulate evidence-based standards for the design and implementation of JITAI (Klasnja et al., 2015; Heron & Smyth, 2010).

3.3 Populations, Settings, and Equity Considerations
- Youth and young adults

Recent research using ecological momentary assessment (EMA) and ecological momentary interventions (EMI) with teenagers and young adults shows that high-frequency, real-time monitoring and immediate interventions are both effective and well-received for managing mood swings, improving emotional awareness, and dealing with major risk factors like sleep problems and stress (Russell & Gajos, 2020; Beames et al., 2021; Crouse et al., 2021). Digital mental health interventions for youth increasingly emphasize co-design with end-users, content personalization, integration with existing services, and transdiagnostic mechanisms such as repetitive negative thinking, reflecting principles that closely align with just-in-time adaptive interventions (JITAIs) (Cross et al., 2025; Ng & Weisz, 2016). New research shows that EMA/EMI-based JITAIs can help people with mood and anxiety disorders feel better and less severe by giving them help when they need it, which makes digital mental health tools more useful in real life and in the clinic (Heron et al., 2022).

- Older adults

Mobile health (mHealth) research regarding depression and anxiety in older adults demonstrates that smartphone- and sensor-based evaluations can aid individuals facing mobility challenges and navigation difficulties. It also shows that there are not many therapies that are specifically designed to help older people with mood problems. Most of the time, just-in-time adaptive interventions (JITAIs) are just ideas for this group of people (Grossman et al., 2020).Additional data from network-based models of late-life depression indicates that targeted, customized digital interventions may affect impaired brain and cognitive-affective networks, providing a mechanistic rationale for JITAIs in this population (Gunning et al., 2021). Preliminary studies highlight the importance of adaptive, context-sensitive approaches in enhancing engagement and clinical efficacy among older adults, laying the groundwork for the future creation and assessment of JITAIs specifically tailored for late-life mental health (Klaiber et al., 2022).

- Public health and underserved populations

Some believe that just-in-time adaptive interventions (JITAIs) could help close health gaps by lowering opportunity costs, like taking time off work or traveling, giving personalized support through mobile devices, and changing

interventions to fit the needs of marginalized groups (Zainal et al., 2024). Micro-randomized trials (MRTs) have also been used to show how JITAIs can make public health better by improving the timing, content, and delivery of mobile therapies in real life. This makes the interventions work better and easier to grow (Liu et al., 2022). Recent studies indicate that JITAIs must implement design principles centered on equity to ensure that digital mental health solutions are accessible, culturally relevant, and capable of addressing the needs of diverse communities (Torous & Keshavan, 2021).

- **Implementation in routine care**

Scoping reviews of internet-based interventions for depression in routine care reveal that implementation efforts have significantly fallen behind research on efficacy and effectiveness, with insufficient emphasis on organizational and leadership factors and inconsistent reporting of essential implementation components (Drozd et al., 2016). Reviews in digital psychiatry similarly emphasize that engagement, integration with clinical workflows, reimbursement, and data governance remain substantial barriers to the proliferation of advanced interventions such as JITAIs in practical settings (Torous et al., 2021; Grossman et al., 2020; Zainal et al., 2024). Recent frameworks underscore the necessity for organized implementation methodologies, encompassing stakeholder engagement, uniform reporting, and policy alignment, to convert digital mental health innovations into enduring clinical practice (Mohr et al., 2022).

3.4 Results Timeline

Timeline of key studies showing the evolution and trends in EMA, EMI, JITAI, and digital depression interventions over time.

1. Table: Temporal Distribution of Key Studies

Year	Number of Papers	Key Studies	Notes
2012	2	Lei et al., 2012; Reynolds et al., 2012	Early EMA/JITAI prototypes
2016	1	Schröder et al., 2016	Integration in clinical settings
2017	2	Schueller et al., 2017; Raue et al., 2017	Expansion of EMA/EMI applications
2019	1	Wilkinson et al., 2019	mHealth engagement and feasibility
2020	2	Russell & Gajos, 2020; Grossman et al., 2020	Late-life interventions explored
2021	2	Torous et al., 2021; Beames et al., 2021	Smartphone-based JITAIs validated
2022	4	Marwaha et al., 2022; Donoso et al., 2022; Liu et al., 2022; Bennett & Shafran, 2022	Mechanistic studies and MRT designs
2024	4	Arigo et al., 2024; Wei et al., 2024; Zainal et al., 2024; Ledesma-Corvi et al., 2024	Equity-focused and personalized JITAIs
2025	2	Cross et al., 2025; Jiao, 2025	Latest youth digital interventions

Table 1 presents the temporal distribution of key studies on ecological momentary assessment (EMA), ecological momentary interventions (EMI), just-in-time adaptive interventions (JITAIs), and digital depression interventions included in this scoping review. The table summarizes the number of studies published per year, highlights seminal contributions, and provides notes on the thematic focus or methodological advances of each publication. This presentation allows readers to quickly assess trends in research output over time, identify periods of increased activity, and contextualize the evolution of digital mental health interventions across different populations and modalities.

3.5 Top Contributors

Table 3 highlights the most frequently appearing authors and journals in the included studies, providing insight into key contributors and publication outlets that have shaped research on EMA, EMI, JITAIs, and digital mental health interventions.

Table 2: Authors & journals that appeared most frequently in the included papers.

Type	Name	Papers
Author	I. Nahum-Shani	(Lei et al., 2012; Qian et al., 2021)
Author	M. Russell	(Russell & Gajos, 2020; Qian et al., 2021)
Author	S. Murphy	(Lei et al., 2012; Qian et al., 2021)
Journal	*Current Psychiatry Reports*	(Raue et al., 2017; Smith & Juarascio, 2019)
Journal	*Annual review of public health*	(Zainal et al., 2024; Reynolds et al., 2012)
Journal	*Journal of child psychology and psychiatry, and allied disciplines*	(Russell & Gajos, 2020; Ng & Weisz, 2016)

3.6 Claims and Evidence Table

Table 3 synthesizes the principal claims identified across the included studies and evaluates the strength of evidence supporting each claim. It links key conclusions to their empirical rationale and representative sources, offering a structured overview of where the evidence base is strong, emerging, or currently limited in the literature on digital interventions, EMA/EMI, and JITAIs for depression.

Table 3 : Key claims and support evidence identified in these papers.

Claim	Evidence Strength	Reasoning	Papers
Digital, internet-based interventions (mostly CBT) **reduce depressive symptoms** compared with usual care, especially when guided.	Evidence strength: Strong (9/10)	Multiple meta-analyses and large RCTs show consistent small–large effects; replicated across settings and populations.	(Schröder et al., 2016; Drozd et al., 2016; Torous et al., 2021; Reynolds et al., 2012; Ormel et al., 2019)
JITAIs and other **adaptive digital interventions** are more effective than non-adaptive comparators for mental health–related outcomes, particularly when adapting to momentary context.	Evidence strength: Moderate (7/10)	Meta-analytic findings and reviews show superiority of adaptive over static interventions, but many studies are outside pure MDD samples.	(Arigo et al., 2024; Liu et al., 2022; Qian et al., 2021; Zainal et al., 2024; Bernstein et al., 2023)
EMA/EMI-based mobile interventions are **feasible, acceptable, and can reduce depressive or anxiety symptoms** in youth and adults.	Evidence strength: Moderate (7/10)	Multiple trials in depression/anxiety, youth and adult samples, show symptom reductions and improved affective awareness; heterogeneity remains.	(Schueller et al., 2017; Russell & Gajos, 2020; Schröder et al., 2016; Torous et al., 2021; Beames et al., 2021; Bernstein et al., 2023; Smith & Juarascio, 2019)
JITAIs can **help reduce health disparities** by lowering opportunity costs and enabling personalized outreach in underserved communities.	Evidence strength: Moderate (5/10)	Strong theoretical/public health rationale with some feasibility examples, but limited direct, long-term equity outcome data.	(Zainal et al., 2024; Liu et al., 2022; Torous et al., 2021; Grossman et al., 2020; Reynolds et al., 2012)
Full-scale, depression-specific JITAIs integrated into routine care will **substantially reduce population prevalence** of depression.	Evidence strength: Weak (3/10)	Conceptually plausible, but current epidemiology shows no prevalence drop despite more treatment; implementation evidence is sparse.	(Drozd et al., 2016; Ormel et al., 2019; Zainal et al., 2024; Torous et al., 2021)
Advanced sensor-driven, AI-optimized closed-loop JITAIs will **outperform current digital interventions** for depression in effectiveness and scalability.	Evidence strength: Weak (2/10)	Early prototypes and theory are promising, but robust comparative RCTs and long-term safety/engagement data are lacking.	(Torous et al., 2021; Cross et al., 2025; Zainal et al., 2024; Schueller et al., 2017; Qian et al., 2021)

3.7 Research Gaps

There are still major gaps in the evidence. A lack of large-scale microrandomized trials (MRTs) and sequential multiple assignment randomized trials (SMARTs) that identify depression as the primary clinical outcome exists. Secondly, current research predominantly focuses on younger, relatively privileged populations, leading to inadequate

representation of older adults and individuals from diverse or disadvantaged backgrounds, thereby constraining generalizability. Third, there is insufficient empirical research examining the integration of JITAIs into current clinical care pathways, especially regarding their interoperability with conventional mental health services and physician workflows. Ultimately, there is still not enough information about how well, safely, and cost-effectively something works over time, especially when compared to standard high-quality treatment.

Research Gaps Matrix

The Research Gaps Matrix, based on the information in this scoping review, shows that research efforts related to JITAI outcomes, demographics, and study environments are very unevenly distributed. The research primarily focuses on the viability of Ecological Momentary Assessment (EMA) and symptom monitoring, in conjunction with mobile interventions associated with Just-In-Time Adaptive Intervention (JITAI), predominantly involving youth and young adult populations. Conversely, older individuals are consistently underrepresented, and evaluations conducted in standard clinical care settings are rare.

This analysis notably identified a scarcity of formal JITAI trials utilizing microrandomized or sequential multiple assignment randomized designs, particularly in studies where depression or mood outcomes were primary and the samples comprised individuals diagnosed with major depressive disorder. In all domains, evidence regarding real-world application, especially its integration into contemporary treatment pathways, is scarce. These results highlight the imperative for forthcoming research to prioritize resilient adaptive trial designs, the incorporation of varied and clinically representative cohorts, and the methodical evaluation of JITAIs within conventional mental health care environments.

Figure 4: Distribution of JITAI-related research across populations and study attributes.

Topic \ Attribute	Youth & Young Adults	Older Adults	Subclinical/At-risk Samples	Implementation in Routine Care
EMA feasibility & symptom monitoring	7	2	5	1
EMI / JIT-like mobile interventions for mood	4	1	3	1
Formal JITAI trials (MRT/SMART-based) with mood outcomes	2	GAP	1	GAP
Mechanism-targeted JITAIs (e.g., RNT, sleep, activity)	3	1	2	GAP
Implementation / health-system integration studies	1	GAP	GAP	2

4. Discussion

The findings of this scoping review demonstrate that the current evidence base supports three interrelated claims regarding digital therapies for depression and the development of just-in-time adaptive interventions (JITAIs). First, digital cognitive behavioral therapy (CBT) and comparable online interventions for depression have

demonstrated consistent efficacy, providing researchers with a robust foundation to develop more adaptable and contextually relevant treatment frameworks (Schröder et al., 2016; Drozd et al., 2016; Torous et al., 2021). These therapies have shown consistent benefits across various demographics and delivery methods, supporting the view that digital mental health care is no longer experimental but a fundamental component of contemporary depression treatment. In this context, JITAIs should not be regarded as a substitute for existing digital CBT methodologies, but rather as an enhanced iteration designed to optimize timing, customization, and responsiveness to evolving symptomatology.

Second, studies in various behavioral and mental health fields indicate that JITAIs and other highly adaptive digital therapies typically outperform non-adaptive or less adaptive options. This advantage appears most pronounced when adaptation is governed by transient contextual data—such as mood, stress, activity, or environmental signals—rather than exclusively by static baseline characteristics (Arigo et al., 2024; Liu et al., 2022; Qian et al., 2021). These findings are theoretically consistent with dynamic systems and process-oriented theories of depression, which emphasize intra-individual heterogeneity and context-dependent risk mechanisms. Nonetheless, while short-term and proximal outcomes (e.g., immediate emotion, engagement, target behaviors) frequently exhibit improvement, evidence for sustained symptom reduction and remission in clinically diagnosed major depressive disorder remains exceedingly limited. This suggests that the clinical potential of JITAIs is substantial but has not yet been fully realized at the disease level.

Third, the tools and methods needed to make, improve, and test JITAIs have come a long way in the last ten years. This holds particularly for micro-randomized trials (MRTs), sequential multiple assignment randomized trials (SMARTs), and intensive ecological momentary assessment (EMA) coupled with passive sensing (Lei et al., 2012; Liu et al., 2022; Russell & Gajos, 2020). These

methods make it possible to accurately measure time-varying causal effects and help create choice criteria that identify the best intervention components, target populations, and contextual variables. Unlike traditional randomized controlled trials (RCTs), which typically evaluate interventions as fixed and indivisible entities, these methodologies represent a substantial advancement in methodological practice. Despite this readiness, large-scale, well-structured trials specifically targeting major depression remain exceedingly rare, and the majority of contemporary research focuses on feasibility, engagement, or mechanistic outcomes rather than long-term clinical endpoints.

Research utilizing MRT and EMA methodologies is progressively focusing on processes that are conceptually integral to depression, including recurrent negative thinking, avoidance, behavioral activation, sleep disruption, and stress reactivity (Smith & Juarascio, 2019; Bernstein et al., 2023). This shift toward mechanism-focused intervention aligns with transdiagnostic and process-oriented frameworks, suggesting that JITAIs may be particularly effective in addressing dynamic vulnerability and resilience processes as they manifest in daily life. However, most of the data linking temporary mechanistic changes to long-term symptom improvement is indirect, and there are very few studies that systematically look at how JITAI-delivered components lead to long-term depression outcomes.

The conversation makes it clear that there is a big difference between what can happen in theory and what really happens, especially when it comes to justice and making things happen. There are a lot of good things about JITAIs, like how they are always there, easy to get to, can grow, and maybe even are not too expensive. Nonetheless, evaluations of digital psychiatry and internet-based depression interventions consistently underscore their limited applicability in clinical contexts, particularly within public mental health systems and resource-constrained environments (Torous et al., 2021; Grossman et al., 2020; Zainal et al., 2024). It is always

hard to scale up because you have to keep people interested, deal with intervention fatigue, manage user load, improve digital literacy, protect data privacy, and make sure everything works with current clinical procedures.These limitations are especially important because research shows that the number of people with depression in the general population has not gone down much, even though therapy is easier to get. This shows that it is not enough to just have access; it needs to be done well, fairly, and for a long time (Ormel et al., 2019).

This scooping review shows that JITAIs are a theoretically strong and methodologically advanced way to treat depression online, but they are still in the early stages of being used.The results have shown that there are big gaps in the evidence for JITAI interventions. There is a notable deficiency of comprehensive adaptive trials, encompassing microarrays and multi-selective sequential trials, particularly those employing depression as the primary clinical outcome. Current research emphasizes younger, more affluent demographics, leading to the underrepresentation of older adults and socially vulnerable populations, thereby limiting the generalizability of the findings. Furthermore, there is still limited evidence regarding the integration of these therapies into existing clinical treatment pathways and their compatibility with clinical practices and traditional mental health services. The research gap matrix demonstrates that research is not uniformly allocated. Many people are interested in how young people can get real-time symptom assessments and portable therapies, but not enough studies have been done in real-world clinical settings. In general, there is still not enough data to figure out how well these treatments work, how safe they are, and how much they cost compared to standard treatments. This indicates that further research is necessary in the future, employing more robust adaptive designs, representative clinical samples, and a systematic assessment of the application of JITAIs in real-world psychiatric care.

5. Conclusion

Numerous studies show that Just-In-Time Adaptive Therapies (JITAIs) are better at treating depression than regular internet-based therapies and ecological momentary interventions (EMIs), both in theory and in practice. JITAIs can help people at the right time and place. This solves problems that happen a lot with digital mental health therapies that do not change at all or only change a little bit. They do this by using decision-making algorithms that can change and data sources that are always up to date. Basic methodological research has shown that JITAIs have four main parts: decision points, factors that can be changed, choices of interventions, and rules for making decisions. This has given them a solid base on which to build and test their work in a systematic way.

Evidence from related areas in digital mental health, including mobile cognitive behavioral therapy, ecological momentary assessment-informed interventions, and adaptive behavioral interventions, suggests that smartphone-based approaches for treating depression are viable, acceptable, and potentially advantageous in clinical settings. These results suggest that JITAIs may work better and be more interesting when given at times when people are more likely to be vulnerable or have a chance. There is considerable theoretical backing and some indirect evidence for the effectiveness of JITAIs; however, there is a scarcity of direct, high-quality research investigating fully implemented JITAIs specifically aimed at individuals with severe depression. For example, there are not many large randomized trials or practical studies that take place in real-life medical settings. This makes it hard to figure out how well something works, how long it lasts, and how much it costs.

There are also other big problems that need to be fixed so that it can be used by more people. Some of these are how to improve adaptive algorithms, how to protect and keep data private, how to add JITAIs to existing healthcare systems, and how to reduce the risk of digital exclusion and health inequities. If

people do not think about how accessible JITAIs are, how culturally relevant they are, and how different groups participate, they could make gaps in mental health care even bigger. To get the most out of JITAIs for treating depression, future research needs to focus on thorough clinical evaluation, accurate documentation of adaptive processes, and the creation and implementation of fair methods.

References

Andrews, G., Basu, A., Cuijpers, P., Craske, M. G., McEvoy, P., English, C. L., & Newby, J. M. (2018). Computer therapy for the anxiety and depression disorders is effective, acceptable and practical health care: An updated meta-analysis. *Journal of Anxiety Disorders, 55*, 70–78. https://doi.org/10.1016/j.janxdis.2018.01.001

Arigo, D., Bercovitz, I., Lapitan, E., & Gular, S. (2024). Social comparison and mental health. *Current Treatment Options in Psychiatry*. https://doi.org/10.1007/s40501-024-00313-0

Beames, J., Kikas, K., & Werner-Seidler, A. (2021). Prevention and early intervention of depression in young people: An integrated narrative review of affective awareness and ecological momentary assessment. *BMC Psychology, 9*. https://doi.org/10.1186/s40359-021-00614-6

Bennett, S., & Shafran, R. (2022). Adaptation, personalization and capacity in mental health treatments: A balancing act? *Current Opinion in Psychiatry, 36*, 28–33. https://doi.org/10.1097/YCO.0000000000000834

Bernstein, E., Wolfe, E., Huguenel, B., & Wilhelm, S. (2023). Lessons and untapped potential of smartphone-based physical activity interventions for mental health: Narrative review. *JMIR mHealth and uHealth, 12*. https://doi.org/10.2196/45860

Bernstein, E. E., Weingarden, H., & McHugh, R. K. (2023). Mechanisms of change in digital and mobile mental health interventions: A

review of intensive longitudinal approaches. *Behaviour Research and Therapy, 165*, 104264. https://doi.org/10.1016/j.brat.2023.104264

Cross, S., Mangelsdorf, S., Valentine, L., O'Sullivan, S., McEnery, C., Scott, I., Gilbertson, T., Louis, S., Myer, J., Liu, P., Mac Dhonnagáin, N., Wren, T., Carey, E., Cagliarini, D., Jacobs, R., Pot-Kolder, R., Bell, I., Nicholas, J., Valmaggia, L., Gleeson, J., & Alvarez-Jimenez, M. (2025). Insights from fifteen years of real-world development, testing and implementation of youth digital mental health interventions. *Internet Interventions, 41*. https://doi.org/10.1016/j.invent.2025.100849

Crouse, J., Carpenter, J., Song, Y., Hockey, S., Naismith, S., Grunstein, R., Scott, E., Merikangas, K., Scott, J., & Hickie, I. (2021). Circadian rhythm sleep–wake disturbances and depression in young people: Implications for prevention and early intervention. *The Lancet Psychiatry, 8*(9), 813–823. https://doi.org/10.1016/S2215-0366(21)00034-1

Domhardt, M., Engler, S., Nowak, H., Lutsch, A., Baumel, A., & Baumeister, H. (2021). Mechanisms of change in digital health interventions for mental disorders in youth: Systematic review. *Journal of Medical Internet Research, 23*(11), e29742. https://doi.org/10.2196/29742

Donoso, F., Cryan, J., Olavarría-Ramírez, L., Nolan, Y., & Clarke, G. (2022). Inflammation, lifestyle factors, and the microbiome–gut–brain axis: Relevance to depression and antidepressant action. *Clinical Pharmacology and Therapeutics, 113*, 246–259. https://doi.org/10.1002/cpt.2581

Drozd, F., Vaskinn, L., Bergsund, H., Haga, S., Slinning, K., & Bjørkli, C. (2016). The implementation of internet interventions for depression: A scoping review. *Journal of Medical Internet Research, 18*. https://doi.org/10.2196/jmir.5670

Grossman, J., Frumkin, M., Rodebaugh, T., & Lenze, E. (2020). mHealth assessment and intervention of depression and anxiety in older adults. *Harvard Review of Psychiatry*. https://doi.org/10.1097/HRP.0000000000000255

Gunning, F., Oberlin, L., Schier, M., & Victoria, L. (2021). Brain-based mechanisms of late-life depression: Implications for novel interventions. *Seminars in Cell & Developmental Biology*. https://doi.org/10.1016/j.semcdb.2021.05.002

Hardeman, W., Houghton, J., Lane, K., et al. (2019). A systematic review of just-in-time adaptive interventions (JITAIs) to promote physical activity. *International Journal of Behavioral Nutrition and Physical Activity, 16*(1), 31. https://doi.org/10.1186/s12966-019-0792-7

Heron, K. E., & Smyth, J. M. (2010). Ecological momentary interventions: Incorporating mobile technology into psychosocial and health behaviour treatments. *British Journal of Health Psychology, 15*(1), 1–39. https://doi.org/10.1348/135910709X466063

Heron, K. E., Smyth, J. M., & Wonderlich, S. A. (2022). Ecological momentary interventions: Advances and applications in youth mental health. *Journal of Clinical Child & Adolescent Psychology, 51*(1), 1–17. https://doi.org/10.1080/15374416.2020.1849565

Jiao, D. (2025). Advancing personalized digital therapeutics: Integrating music therapy, brainwave entrainment methods, and AI-driven biofeedback. *Frontiers in Digital Health, 7*. https://doi.org/10.3389/fdgth.2025.1552396

Klasnja, P., & Pratt, W. (2012). Healthcare in the pocket: Mapping the space of mobile phone health interventions. *Journal of Biomedical Informatics, 45*(1), 184–198. https://doi.org/10.1016/j.jbi.2011.08.017

Klasnja, P., Hekler, E. B., Shiffman, S., Boruvka, A., Almirall, D., Tewari, A., & Murphy, S. A. (2015). Microrandomized trials: An experimental design for developing just-in-time adaptive interventions. *Health Psychology, 34*(S), 1220–1228. https://doi.org/10.1037/hea0000305

Kraus, C., Kadriu, B., Lanzenberger, R., Zarate, C., & Kasper, S. (2019). Prognosis and improved outcomes in major depression: A review. *Translational Psychiatry, 9*. https://doi.org/10.1038/s41398-019-0460-3

Lei, H., Nahum-Shani, I., Lynch, K., Oslin, D., & Murphy, S. (2012). A SMART design for building individualized treatment sequences. *Annual Review of Clinical Psychology, 8*, 21–48. https://doi.org/10.1146/annurev-clinpsy-032511-143152

Liu, X., Deliu, N., & Chakraborty, B. (2022). Microrandomized trials: Developing just-in-time adaptive interventions for better public health. *American Journal of Public Health*. https://doi.org/10.2105/AJPH.2022.307150

Marwaha, S., Palmer, E., Suppes, T., Cons, E., Young, A., & Upthegrove, R. (2022). Novel and emerging treatments for major depression. *The Lancet, 401*, 141–153. https://doi.org/10.1016/S0140-6736(22)02080-3

Nahum-Shani, I., Smith, S. N., Spring, B. J., Collins, L. M., Witkiewitz, K., Tewari, A., & Murphy, S. A. (2018). Just-in-time adaptive interventions (JITAIs) in mobile health: Key components and design principles for ongoing health behavior support. *Annals of Behavioral Medicine, 52*(6), 446–462. https://doi.org/10.1007/s12160-016-9830-8

Ng, M., & Weisz, J. (2016). Building a science of personalized intervention for youth mental health. *Journal of Child Psychology and Psychiatry, 57*(3), 216–236. https://doi.org/10.1111/jcpp.12470

Ormel, J., Kessler, R., & Schoevers, R. (2019). Depression: More treatment but no drop in prevalence. *Current Opinion in Psychiatry*.

https://doi.org/10.1097/YCO.0000000000000505

Patel, V., Saxena, S., Lund, C., Thornicroft, G., Baingana, F., Bolton, P., … Unützer, J. (2018). The Lancet Commission on global mental health and sustainable development. *The Lancet, 392*(10157), 1553–1598. https://doi.org/10.1016/S0140-6736(18)31612-X

Qian, T., Walton, A., Collins, L., Klasnja, P., Lanza, S., Nahum-Shani, I., Rabbi, M., Russell, M., Walton, M., Yoo, H., & Murphy, S. (2021). The microrandomized trial for developing digital interventions. *Psychological Methods*. https://doi.org/10.1037/met0000283

Raue, P., McGovern, A., Kiosses, D., & Sirey, J. (2017). Advances in psychotherapy for depressed older adults. *Current Psychiatry Reports, 19*, 1–9. https://doi.org/10.1007/s11920-017-0812-8

Reynolds, C., Cuijpers, P., Patel, V., Cohen, A., Dias, A., Chowdhary, N., … Albert, S. (2012). Early intervention to reduce the global health and economic burden of major depression in older adults. *Annual Review of Public Health, 33*, 123–135. https://doi.org/10.1146/annurev-publhealth-031811-124544

Riley, W. T., Rivera, D. E., Atienza, A. A., Nilsen, W., Allison, S. M., & Mermelstein, R. (2019). Health behavior models in the age of mobile interventions. *Translational Behavioral Medicine, 9*(1), 1–10. https://doi.org/10.1093/tbm/ibx045

Russell, M., & Gajos, J. (2020). Ecological momentary assessment studies in child psychology and psychiatry. *Journal of Child Psychology and Psychiatry*. https://doi.org/10.1111/jcpp.13204

Schröder, J., Berger, T., Westermann, S., Klein, J., & Moritz, S. (2016). Internet interventions for depression: New developments. *Dialogues in Clinical Neuroscience, 18*, 203–212.

https://doi.org/10.31887/dcns.2016.18.2/jschroeder

Schueller, S., Aguilera, A., & Mohr, D. (2017). Ecological momentary interventions for depression and anxiety. *Depression and Anxiety, 34*, 540–545. https://doi.org/10.1002/da.22649

Smith, K., & Juarascio, A. (2019). From EMA to EMI in eating disorders. *Current Psychiatry Reports, 21*, 1–8. https://doi.org/10.1007/s11920-019-1046-8

Torous, J., & Keshavan, M. (2021). Using digital tools to advance mental health equity. *NPJ Digital Medicine, 4*(1), 1–8. https://doi.org/10.1038/s41746-021-00424-2

Torous, J., Bucci, S., Bell, I., Kessing, L., Faurholt-Jepsen, M., Whelan, P., Carvalho, A., Keshavan, M., Linardon, J., & Firth, J. (2021). The growing field of digital psychiatry. *World Psychiatry, 20*. https://doi.org/10.1002/wps.20883

Wei, Y., Zheng, W., Fan, Q., & Zhang, X. (2024). Singing interventions in depression: A scoping review. *Psychology of Music*. https://doi.org/10.1177/03057356241305921

Wilkinson, S., Holtzheimer, P., Gao, S., Kirwin, D., & Price, R. (2019). Leveraging neuroplasticity to enhance adaptive learning. *Biological Psychiatry, 85*, 454–465. https://doi.org/10.1016/j.biopsych.2018.09.004

Zainal, N., Liu, X., Leong, U., Yan, X., & Chakraborty, B. (2024). Bridging innovation and equity: Advancing public health through just-in-time adaptive interventions. *Annual Review of Public Health*. https://doi.org/10.1146/annurev-publhealth-071723-103909