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Review

Toward Participatory Precision Health With Co-Designed Recommendations: Systematic Review of Just-in-Time Adaptive Interventions in Adolescents and Young Adults

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Abstract

Background: The transition from adolescence to young adulthood (age 10-25 years) constitutes a sensitive developmental period marked by rapid biological, psychological, and social change, during which preventive health interventions can shape long-term outcomes. Mobile health tools offer accessible opportunities for tailored support for this population, but often adapt poorly to dynamic contexts, resulting in inconsistent engagement and effects. Just-in-time adaptive interventions (JITAIs), which tailor support in real time using ongoing data, are increasingly explored as precision health strategies. However, how these mechanisms are designed, implemented, and evaluated for adolescents and young adults (AYAs) has not been systematically reviewed.

Objective: This review aimed to synthesize the evidence on JITAIs developed for AYAs, examine how their adaptive mechanisms have been designed to support specific health goals and changing AYA contexts, and assess methodological reporting quality to inform future precision health intervention development.

Methods: We conducted a systematic review in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and SWiM (Synthesis Without Meta-Analysis) reporting guidelines. Twelve databases were searched for peer-reviewed studies published from 2013 to 2025. Eligible studies focused on participants aged 10 to 25 years and reported real-time adaptive mobile health interventions consistent with JITAI design principles. Two reviewers independently conducted screening, data extraction, and methodological quality appraisal using the Joanna Briggs Institute checklists. AYA coauthors contributed to all phases. Due to substantial heterogeneity in study populations, intervention content, adaptive

mechanisms, comparators, and outcome measurements, findings were synthesized narratively, and no meta-analysis was conducted.

Results: A total of 61 unique interventions were included. JITAIs for AYAs addressed substance use (n=24, 39.3%), mental health (n=23, 37.7%), and physical health or chronic conditions (n=14, 23%). JITAI tailoring mechanisms relied predominantly on self-reported behavioral data. Decision rules were typically symptom threshold–based, and decision points were commonly daily or event-triggered. Methodological concerns with reporting on intervention administration, participant selection, and outcome measurement reliability were pervasive across all studies, limiting the interpretability of observed effects and cross-study comparisons. Ethical considerations, including researcher positioning and reflexivity, alongside the depth of reporting around participatory AYA engagement in design and implementation, were also inconsistent.

Conclusions: This review contributes a novel perspective to AYA digital health by moving beyond intervention outcomes to examine how core adaptive mechanisms are operationalized for AYAs across multiple health domains, while also integrating AYA perspectives into the interpretation of findings and recommendations. Unlike prior reviews focused primarily on adults or specific conditions, it identifies broader contextual, methodological, and ethical considerations relevant to AYA precision health. These findings highlight the need for more transparent, contextually responsive, and youth-centered adaptive interventions, alongside more rigorous designs for evaluating adaptive intervention components in daily life contexts.

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Keywords: adolescents; young adults; just-in-time adaptive interventions; mobile health; health behaviors; precision health

Introduction

Adolescence is a formative period for preventive health interventions. As they transition into young adulthood, adolescents experience continued brain and physical development, alongside heightened vulnerability to risk factors for poor health [1,2]. For example, partaking in behaviors that compromise health, such as substance use, poor diet, and insufficient physical activity, in early life can increase the risk of chronic diseases such as cancer [3], and disrupt key neurodevelopmental processes related to stress regulation and executive functioning [4]. Further, the transition to adulthood is a complex developmental stage, shaped by rapidly shifting and interrelated biological, psychological, and social changes that are unique to each individual [5]. Behavioral patterns during this period emerge dynamically in response to fluctuating contexts and interactions, with significant implications for long-term health. For example, food insecurity may predispose adolescents to poor dietary habits, which in turn can affect their physical health, cognitive development, and emotional resilience over time [6]. In light of these vulnerabilities, early and precisely targeted interventions during this period are critical for mitigating both immediate and long-term health risks to promote healthier developmental pathways. Given the record number of adolescents and young adults (AYAs; aged 10-25 years) globally [7], investing in tailored health interventions during adolescence can significantly improve population health outcomes while alleviating pressures on health care systems [8].

Precision health represents a significant paradigm shift from generalized medical approaches, prioritizing adaptive strategies that tailor health support to optimize diverse outcomes unique to each individual [9]. Although much of the initial application of precision health has occurred within adult medical contexts [8], there is growing recognition that such approaches may be particularly suited to addressing the multifaceted challenges during the transition to adulthood [10]. Importantly, precision health approaches during this unique period can enhance both the relevance and effectiveness of AYA health interventions. In particular, addressing behaviors and states calls for interventions that precisely tailor support to individual risk factors and contextual influences shaping AYAs' lives.

Mobile health (mHealth) technologies are a key avenue for delivering tailored health support to AYAs, whose pervasive use of digital platforms throughout their daily lives and affinity for mobile communication provide opportunities for accessible intervention delivery. Such tools have demonstrated some potential to support and promote positive health behaviors, such as increasing physical activity, improving nutrition, and reducing substance use among adolescents [11]. However, mHealth interventions often produce inconsistent effects due to challenges in delivering engaging content that is precisely relevant to AYAs' evolving health contexts over time [12,13]. Extant literature has suggested that the use of digital tools to support health behaviors may decline when interventions fail to resonate with or adapt to changing circumstances [14,15]. Demographics (eg, age and gender), psychosocial characteristics (eg, mood), and contextual factors (eg, setting of delivery) play a significant role in individual engagement with mHealth interventions [13]. Thus, it is necessary to identify key considerations for designing mobile interventions that are not only tailored but also dynamically and temporally responsive to AYAs' shifting needs.

One particularly promising precision health approach that has emerged is the just-in-time adaptive intervention (JITAI). JITAIs use ongoing data from mobile sensing technology with the aim of delivering tailored, contextually relevant

support precisely when it is most needed for each individual [16]. JITAIs can provide a flexible strategy for promoting positive health behaviors across individually salient moments and contexts by dynamically adjusting content in response to individual changes. The temporal adaptability of JITAIs is particularly important given the variability in AYA development, as their health risks and support needs can rapidly shift based on environmental and intrapersonal factors such as mood, stress levels, and social interactions from moment to moment [17,18]. JITAIs can crucially enhance the responsiveness of precision health strategies by delivering support attuned to ongoing changes in AYA contexts, particularly when individuals can be receptive to this support, which can help ensure tailored intervention content remains relevant and effective in addressing evolving needs.

Despite their potential, most prior analyses of JITAIs have focused on older adults or specific health conditions [19-24]. As such, there is a limited understanding of how JITAIs can support the dynamic health needs of AYAs as they transition into early adulthood. Given the rapidly changing and diverse contexts that characterize this formative developmental stage, understanding how JITAIs adapt to this period (10-25 years) is critical.

This review thus had 3 specific objectives. First, it aimed to map and synthesize the evidence based on JITAIs developed for AYA health contexts. Second, it aimed to characterize how key adaptive components—namely, tailoring variables, intervention options, decision rules, and decision points [16]—were designed and applied in relation to targeted AYA health outcomes. Third, it aimed to critically appraise the quality of the included studies to identify methodological and evidence gaps. Overall, the findings are intended to inform the design of more effective, personalized, and contextually responsive mHealth interventions to support healthier trajectories from adolescence into adulthood and beyond.

Methods

Overview of Search Strategy

This systematic review followed reporting guidelines from PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and SWiM (Synthesis Without Meta-Analysis), respectively [25,26]. The review was preregistered in the International Prospective Register of Systematic Reviews (PROSPERO) database under registration number CRD42023473117. The review protocol was also published after peer review [27]. No ethical approval was required as this review uses only publicly available literature.

The search strategy for the review was developed in consultation with an information specialist, and the rationale for the search strategy, including scope of dates and search terms, is reported in the additional material according to PRISMA–Search extenion (PRISMA-S) [28]. The search strategy used a combination of keywords and database-specific subject headings (eg, Medical Subject Headings terms) to capture peer-reviewed literature related to JITAIs, AYAs, digital health technologies, and health outcomes and was peer-reviewed [27]. The literature search took place across multiple electronic databases to identify relevant literature from 2013 to 2025; these databases included PubMed, Scopus, Web of Science, PsycINFO, Embase, Cumulative Index to Nursing and Allied Health Literature, Institute of Electrical and Electronics Engineers Xplore, Association for Computing Machinery Digital Library, Cochrane Central, Dimensions, World Health Organization Global Index Medicus, and Google Scholar.

The individual database searches were conducted in July 2025, with additional keyword-based searching in Google Scholar until December 2025. Reference list screening of extracted studies was used to identify further eligible studies. Further, studies included in prior systematic reviews of JITAIs were consulted [19-24], which enabled inclusion of all relevant studies published before (as the literature search strategy only started in 2013, the first explicit mention of JITAI and AYAs in the literature [29,30]). These steps helped ensure comprehensive coverage of past and emerging studies. It was not deemed necessary to contact any study authors.

Screening and Data Extraction

All literature search records were imported into Covidence, a systematic review management platform developed by Veritas Health Innovation, with duplicates automatically removed. Each title and its accompanying abstract were screened by 2 reviewers (either KWG, CA, CI, IK, and/or RA, each independently), following a pilot screening phase to ensure consistency in eligibility decisions. Full texts were also screened by 2 reviewers each. All discrepancies during screening or assessment of full texts were resolved through discussion.

Study inclusion was primarily determined by whether studies provided sufficient detail on JITAI components to inform the review's focus on how these interventions adapt to AYA contexts and health needs. Studies were eligible for inclusion if they were peer-reviewed, focused on AYAs aged 10-25 years, reported mHealth interventions that adapted in real time to user data, and were consistent with the defining features of JITAIs. Other mHealth studies were out of scope, including JITAI studies that involved participants beyond the AYA age range (determined by reported sample age range and mean age, where available) and did not report these findings separately [31]. We selected the age range of 10 to 25 years, given its increasing recognition as its own heterogeneous yet distinct developmental period among scholars [10,32-34]. We did not restrict by study type or design, such as control conditions. We also excluded just-in-time simulation studies that did not involve evaluating an intervention [35].

Data from each study were also extracted by 2 reviewers (either KWG, SG, VC, and/or RA, each independently) using a piloted, standardized data extraction form to ensure consistency. The data extraction form followed standardized conceptualizations of JITAI in the literature [16,27], which outline key components guiding interventions to be adapted to individual needs: intervention options or the different forms of support or methods for delivering that health support,

which may be considered based on tailoring variables; tailoring variables, referring to the data collected about an individual, which inform how and when an intervention should be adapted; and decision rules or the guidelines that use these tailoring variables to determine the selection, timing, and delivery of intervention options at specific decision points or specific moments, such as particular times of the day or contextual triggers when these decisions are made [16,27]. These components together shape how JITAIs dynamically adjust to ensure interventions remain relevant across shifting adolescent contexts [16]. By structuring the form around these components, the method was aligned with the review's focus on mechanisms of adaptability in JITAIs.

Further, distal and proximal outcomes were also extracted, as they indicate the health objectives toward which tailoring mechanisms are directed. Specifically, distal outcomes represent the overarching, long-term goals of a JITAI, while proximal outcomes are short-term health objectives that often serve as mediators that lead toward these distal targets [16]. Thus, data extracted from each study included participant characteristics, intervention details, tailoring mechanisms, study design, and outcomes reflecting the goals of tailoring mechanisms (both proximal and distal). Refer to Multimedia Appendices 1-3 for the full extraction data for each study.

No formal amendments were made to the registered or published protocol [27]. Several additional outcomes of interest, including user engagement and ethical considerations, were identified in the protocol as potentially informative for interpreting effectiveness; however, inconsistent measurement and incomplete reporting meant they could not be systematically synthesized or graded. While information on AYA engagement and ethical considerations was documented during data extraction for each study where reported, reporting was sparse and also lacked sufficient detail for structured synthesis.

Risk of Bias and Synthesis

Two reviewers (KWG and MA) independently assessed methodological quality, including risk of bias, using the Joanna Briggs Institute checklists for distinct study designs, with discrepancies resolved through discussion [36]. The Joanna Briggs Institute checklists for each study included critical appraisal according to temporal precedence, selection and allocation, confounding factors, intervention administration, outcome measurement (time points, method, and reliability), participant retention, and statistical conclusion validity, which we report in the Results section.

These appraisals informed consideration of the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) framework [37], which was prespecified in the protocol to assess certainty of evidence across studies. However, application of GRADE across studies requires sufficient comparability in outcome definitions, measures, and reporting [38], and this was not present within any outcome domain in this review. We therefore did not undertake a formal assessment of evidence certainty or reporting bias. Further, although studies could be grouped broadly by outcome domain, substantial heterogeneity remained in participant populations and settings, intervention content and delivery, tailoring mechanisms, comparator conditions, and outcome assessment. We therefore also did not conduct a meta-analysis because we did not deem the included studies sufficiently similar to support a meaningful pooled estimate. Findings were instead synthesized narratively and organized according to key JITAI tailoring components and outcome domains, including intervention aims, tailoring variables, decision rules, and decision points. All included studies were considered in the narrative synthesis.

Engagement of AYAs

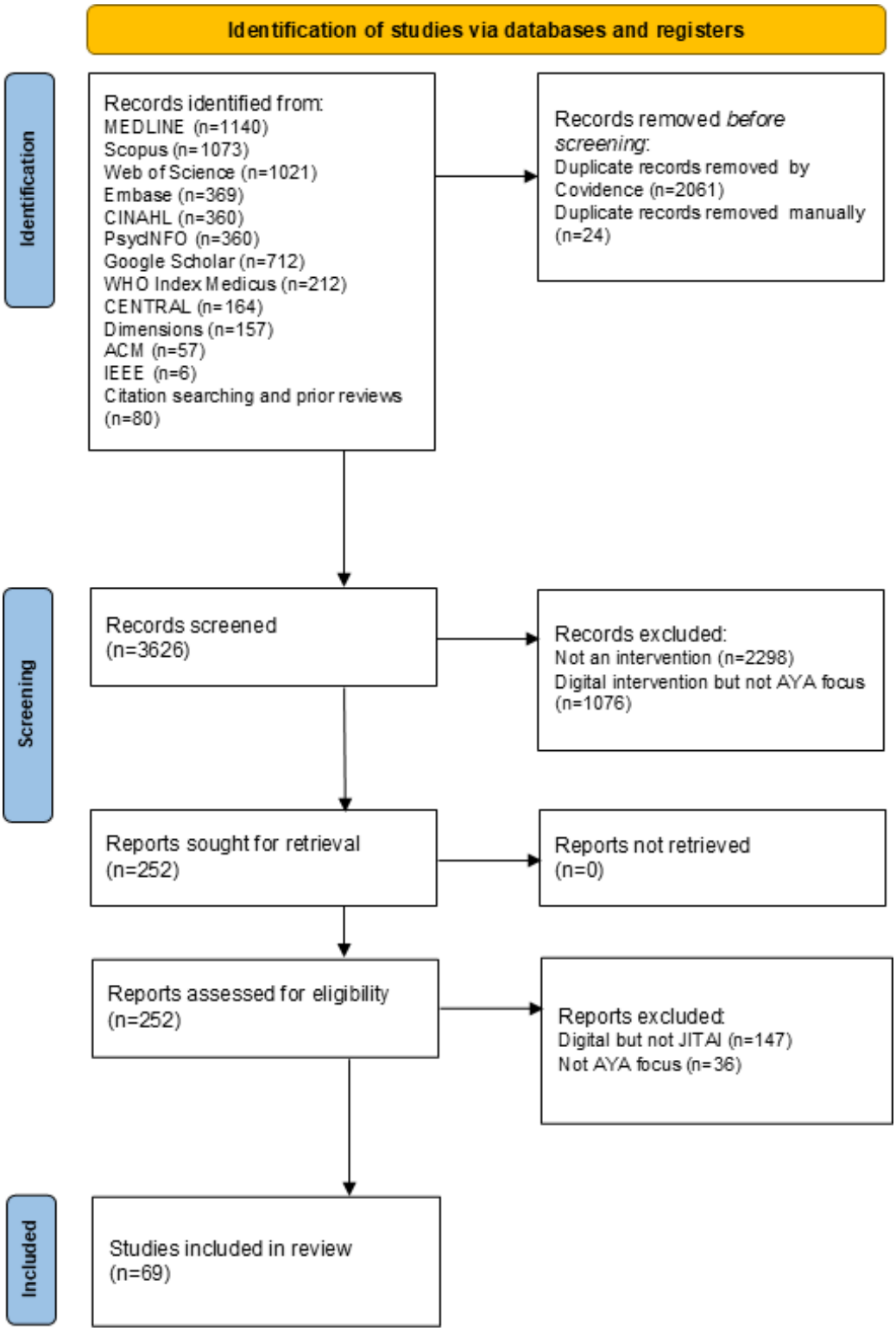
To ground implications of this review in lived experience, we directly engaged 12 AYAs, including health activists from the World Health Organization European Region's Youth4Health network, a platform for AYA participation in health policymaking. These AYAs, including young entrepreneurs, medical students, and policy advocates, provided critical perspectives that informed study interpretations and implications. Seven AYAs were directly involved as coauthors in screening studies, extracting data, and conducting critical appraisals, including the lead author. AYA perspectives were further elicited through a dedicated virtual consultative session with AYAs who were not part of the coauthorship team. During this session, 5 AYAs reviewed the data extraction tables from the review and engaged in semistructured critical dialogue regarding intervention acceptability, design relevance, and the alignment of findings with lived adolescent experiences. These discussions were documented via meeting minutes and synthesized by KWG and MA to identify recurring interpretive themes. Given several of the AYA participants' roles as coauthors in the review alongside the limited sample, these AYA contributions are reported in the Discussion section as explicitly interpretive observations to contextualize preliminary recommendations for future work, rather than as additional empirical data derived from the included studies.

Results

Overview

A total of 3626 unique records were identified via the literature search and screened in the title and abstract phase (Figure 1). Of these, 3374 records were excluded as they were clearly focused on adult populations or not intervention studies, such as studies collecting ecological momentary assessments only. Following this exclusion, a total of 252 full-text papers were assessed for relevance. Papers that were excluded at the full-text stage did not develop mobile interventions that were tailored to dynamic adolescent contexts, for example, those offering only prescheduled digital health support without ongoing adaptation, and therefore did not meet the definition of a JITAI [16]. This resulted in a total of 69 studies (representing 61 unique interventions) developing JITAIs for AYAs included in the findings synthesis that follows.

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram for adolescents and young adults (AYAs) just-in-time adaptive intervention (JITAI) study selection.



Risk of Bias and Quality of Evidence

The risk of bias and critical appraisal matrix (Figure 2) shows that every study had at least one methodological concern, indicating a moderate to high risk of bias present across the evidence base. We organize these by study design (randomized controlled trial [RCT], noncontrolled experimental studies, and qualitative studies), as critical appraisal is conducted based on the specific design of a study [36]. Importantly, many "unclear" ratings are likely attributable to incomplete reporting rather than the absence of methodological safeguards, reflecting variability in reporting practices and the lack of standardized conventions in this field. These issues significantly reduce confidence in reports of effectiveness and complicate comparisons across studies.

Figure 2. Risk of bias and methodological quality appraisal of randomized controlled trials, noncontrolled experimental studies, and qualitative studies of just-in-time adaptive interventions (JITAIs) for adolescents and young adults (AYAs). RCT: randomized controlled trial [39-104].

Authors and Year	Temporal precedence	Selection and allocation	Confounding factors	Intervention administration	Outcome measurement (timepoints)	Outcome measurement (method)	Outcome measurement (reliability)	Participant retention	Statistical conclusion validity
Rodgers et al. 2005	RCT	Yes	Yes	Unclear	Yes	Yes	Yes	Unclear	Yes
Weitzel et al. 2007	RCT	Unclear	Unclear	No	Yes	Yes	Unclear	Yes	Unclear
Suffoletto et al. 2012	RCT	Yes	Yes	No	Yes	Yes	Yes	Yes	Unclear
Nollen et al. 2014	RCT	Unclear	Yes	No	Yes	Yes	Yes	Yes	Unclear
Witkiewitz et al. 2014	RCT	Unclear	Unclear	No	Yes	Yes	Yes	Yes	Yes
Suffoletto et al. 2015	RCT	Yes	Yes	Unclear	Yes	Yes	Yes	Unclear	Yes
Perry et al. 2017	RCT	Unclear	Yes	No	Yes	Yes	Yes	Unclear	Unclear
Pyky et al. 2017	RCT	Yes	Yes	Unclear	Yes	Yes	Yes	Unclear	Yes
Shrier et al. 2018	RCT	Unclear	Yes	No	Yes	Yes	Yes	Unclear	Yes
Simons et al. 2018	RCT	Unclear	Yes	No	Yes	Yes	Yes	Yes	Yes
Wright et al. 2018	RCT	Unclear	Yes	No	Yes	Yes	Unclear	No	Yes
Kennard et al. 2018	RCT	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
O'Donnell et al. 2019	RCT	Yes	Yes	Unclear	Yes	Yes	Unclear	Yes	Yes
Suffoletto et al. 2019	RCT	Yes	Unclear	Unclear	Yes	Yes	Unclear	Unclear	Yes
Hunter et al. 2020	RCT	Unclear	Yes	No	Yes	Yes	Yes	Yes	Unclear
van Aubel et al. 2020	RCT	Unclear	Yes	Unclear	Yes	Yes	Unclear	Yes	Yes
Fedele et al. 2021	RCT	Yes	Yes	No	Yes	Yes	Yes	Yes	Unclear
King-Dowling et al. 2021	RCT	Unclear	Yes	No	Yes	Yes	Unclear	Yes	Unclear
Santa Maria et al. 2021	RCT	Unclear	Yes	No	Yes	Yes	Unclear	Unclear	Yes
Suffoletto et al. 2021	RCT	Unclear	Unclear	Unclear	Yes	Yes	Yes	Yes	Unclear
Paetzold et al. 2022	RCT	Unclear	Unclear	Unclear	Yes	Yes	Unclear	Yes	Unclear
Schenkel et al. 2022	RCT	Unclear	Unclear	No	Yes	Yes	Unclear	Unclear	Yes
Bell et al. 2023	RCT	Yes	Yes	No	Yes	Yes	Yes	Yes	Unclear
Lucas-Thompson et al. 2023	RCT	Unclear	Unclear	No	Yes	Yes	Yes	Unclear	Unclear
Marciniak et al. 2023	RCT	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes
Reininghaus et al. 2023	RCT	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes
Reininghaus et al. 2024	RCT	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes
Orzikulova et al. 2024	MRT	Unclear	Yes	Unclear	Yes	Yes	Yes	Unclear	Yes
Engelskirchen et al. 2025	RCT	Unclear	Yes	No	Yes	Yes	Yes	Unclear	Yes
Lee et al. 2025	RCT	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Riley et al. 2008	Yes	Unclear	Unclear	Yes	No	Yes	Unclear	Unclear	Unclear
Shrier et al. 2014a	Yes	No	No	Yes	Yes	Yes	Unclear	No	Unclear
Spruijt-Metz et al. 2015	Yes	No	No	Yes	Yes	Yes	Unclear	Yes	Unclear
Ding et al. 2016	Yes	Yes	Unclear	Yes	Yes	Yes	Unclear	Unclear	Unclear
Fortier et al. 2016	Yes	No	No	Yes	Yes	Yes	Yes	Unclear	Unclear
Leonard et al. 2017	Yes	No	No	Yes	Yes	Yes	Unclear	Yes	Unclear
Bracisjewski et al. 2018	Yes	No	No	Yes	Yes	Yes	Unclear	No	Unclear
Leonard et al. 2018	Yes	Unclear	No	Yes	Yes	Yes	Unclear	Unclear	Unclear
Suffoletto et al. 2018	Yes	No	No	Yes	Yes	Yes	Unclear	Unclear	Unclear
Neal-Barnett et al. 2019	Yes	No	No	Yes	Yes	Yes	Yes	Unclear	Unclear
Kazemi et al. 2020	Yes	Yes	Unclear	Yes	No	Yes	Yes	No	Unclear
Shrier et al. 2020	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Unclear
Silk et al. 2020	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Unclear
Stevenson et al. 2020	Yes	No	No	Yes	Yes	Yes	Unclear	No	Unclear
Blevins et al. 2021	Yes	No	No	Yes	Yes	Yes	Yes	Unclear	Unclear
Coughlin et al. 2021	Yes	No	Unclear	Unclear	Yes	Yes	Yes	Unclear	Yes
Cushing et al. 2021	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes	Yes
Rauschenberg et al. 2021	Yes	No	No	Yes	Yes	Yes	Unclear	Yes	Unclear
Caon et al. 2022	Yes	Yes	Unclear	Yes	Yes	Yes	Unclear	Unclear	Unclear
Domin et al. 2022	Yes	No	No	Yes	Yes	Yes	Unclear	Unclear	Unclear
Wu et al. 2024	Yes	No	Yes	Yes	Yes	Yes	Unclear	Yes	No
Cushing et al. 2025	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Unclear	Yes
van Asselt et al. 2025	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Unclear	Yes

	Philosophical–methodological congruity	Researcher positioning and reflexivity	Participant representation	Ethics and approval	Data–conclusion consistency
Chand et al. 2006	Yes	No	Yes	Unclear	Yes
Shrier et al. 2014b	Unclear	No	Yes	Yes	Yes
Wright et al. 2016	Yes	Unclear	Yes	Yes	Yes
Cerrada et al. 2017	Unclear	No	Yes	Yes	Yes
Leonard et al. 2017	Yes	No	Yes	Yes	Yes
Shrier et al. 2017	Unclear	No	Yes	Yes	Yes
Kazemi et al. 2018	Unclear	No	No	Unclear	Yes
Lucas-Thompson et al. 2020	Unclear	No	No	Yes	Yes
Martin et al. 2020	Yes	Unclear	Yes	Yes	Yes
Acorda et al. 2021	Yes	Unclear	Yes	Yes	Yes
Ranney et al. 2021	Yes	No	Yes	Yes	Yes
Van Keulen et al. 2022	Yes	No	No	Yes	Yes
Postma et al. 2024	Yes	Yes	Yes	Yes	Yes
Hiller et al. 2025	Yes	Yes	Yes	Yes	Yes
van Asselt and Roke 2025	Yes	Yes	Unclear	Yes	Yes

Figure Legend	
Yes	Authors describe in detail
Unclear	Authors describe but not ifully
No	Authors do not describe

Intervention administration was the most prominent limitation unique to RCTs. Across studies, reporting was limited on whether treatment groups were treated identically apart from the intervention of interest. Importantly, intervention administration is inherently difficult to deliver in a blinded and standardized manner in JITAIs because these interventions are designed to deliver tailored and timely support based on momentary context, vulnerability, and receptivity, rather than static content delivered uniformly across participants [16]. As a result, intervention groups often received more personalized prompts, summaries, feedback, adaptive logic, or supportive features than comparator groups, making performance bias difficult to avoid.

Meanwhile, noncontrolled studies frequently showed weaknesses in selection procedures, as comparison groups were often absent and allocation methods lacked detailed justification. This limits confidence that observed effects can be attributed to the JITAIs being evaluated rather than to pre-existing participant differences or co-occurring influences. Again, this limitation may be especially important for JITAIs, because their effects are hypothesized to depend on timing, context, and adaptive delivery, making it necessary to isolate the contribution of specific intervention components [16]. Further, both randomized and noncontrolled studies in this study demonstrated consistent weaknesses in outcome measurement reliability, participant retention, and statistical conclusion validity. Few studies provided

sufficient study-specific evidence on measurement reliability, and loss to follow-up was often incompletely reported. Further, comprehensive details on statistical power and power assumptions were frequently absent or reported with caveats, consistent with the predominance of pilot samples across the included studies.

Within qualitative studies, the most consistent limitation was researcher positioning and reflexivity, which was rarely reported or addressed. This was reflected in the limited reporting of whether the researcher's cultural or theoretical orientation was declared. Further, the potential influence of the researcher on study participants, or vice versa, was rarely acknowledged.

Health Outcomes Addressed by JITAIs for AYAs

Overview

Among JITAIs for AYAs, distal outcomes and their related proximal outcomes demonstrate some consistent priorities as well as emerging trends, with diverse conditions as the target of tailored support. We organize key outcomes targeted in JITAIs for AYAs into 3 domains: substance use, mental health, and physical health (Table 1). While substance use typically spans both mental and physical health, we present it separately here as it has been the most frequent and distinct focus of JITAIs for AYAs. Further, while we highlight some notable observed effects as well as inconsistencies, all results we report below should be interpreted with caution given the aforementioned methodological limitations and risks of bias detected across the evidence base.

Table 1. Contexts of just-in-time adaptive interventions (JITAIs) for adolescents and young adults (AYAs) in substance use, mental health, and physical health.

Domain	Contexts for just-in-time adaptive intervention
Substance use (n=24)	University students with alcohol-related risk or use (n=6, 25%), emergency department patients with hazardous drinking (n=4, 16.7%), general AYA[a] population with alcohol-related risk or use (n=3, 12.5%), homeless AYAs with alcohol-related risk or use (n=2, 8.3%), primary care clinic patients with cannabis use (n=2, 8.3%), general adolescent and young adult population who smoke (n=1, 4.2%), college or university students who smoke (n=1, 4.2%), university students with alcohol and smoking co-use (n=1, 4.2%), patients receiving psychiatric partial hospitalization services who drink to cope with anxiety or depression (n=1, 4.2%), foster care transition youth with alcohol-related risk or use (n=1, 4.2%), Korean American daily smokers (n=1, 4.2%), and apprenticeship or vocational students with alcohol-related risk or use (n=1, 4.2%).
Mental health (n=23)	Clinical mental health care patients with depression, anxiety, and/or psychosis-related problems (n=5, 21.7%), university students with nonclinical mental health or stress-related problems (n=3, 13%), AYAs with mixed or nonspecific mental health care problems (n=2, 8.7%), adolescents with mental health or well-being-related needs (n=2, 8.7%), autistic AYAs in outpatient mental health services (n=2, 8.7%), AYA female patients at community clinics with sexual behavior risks (n=2, 8.7%), general population with digital behavior risks (n=1, 4.3%), homeless adolescent mothers in transitional living with psychosocial vulnerability (n=1, 4.3%), psychiatric inpatient adolescents with suicidality (n=1, 4.3%), AYAs with generalized anxiety (n=1, 4.3%), AYAs with low self-esteem and childhood adversity (n=1, 4.3%), apprenticeship or vocational students (unspecified mental health context; n=1, 4.3%), and general healthy AYAs (n=1, 4.3%).
Physical health (n=14)	Asthma patients and their parents (n=2, 14.3%), healthy adolescents (n=2, 14.3%), healthy university students (n=2, 14.3%), secondary school students (n=1, 7.1%), patients with asthma (n=1, 7.1%), AYA cancer survivors (n=1, 7.1%), adolescents undergoing cancer treatment (n=1, 7.1%), low-income racial or ethnic minority females (n=1, 7.1%), lower-educated working young adults (n=1, 7.1%), overweight Hispanic adolescents (n=1, 7.1%), and young men preparing for military conscription (n=1, 7.1%).

[a]AYA: adolescent and young adult.

JITAIs Addressing AYA Substance Use

Substance use reduction has been a consistently central focus of JITAIs for AYAs, with interventions (39.3%, n=24/61) targeting reduction in areas such as smoking cessation, alcohol moderation, and marijuana use [39-61,105]. The most common intervention contexts were for college or university students with alcohol-related risk or use (n=6, 25%) and emergency department patients with hazardous drinking (n=4, 16.7%). Novel population-specific pilot studies included interventions with homeless young adults and AYAs in foster care, respectively, with alcohol-related risks, as well as clinic patients with cannabis use [45,53,60].

JITAIs addressing substance use among AYAs typically emphasize regulating urges and reinforcing commitment to abstinence, often using momentary tailoring based on triggers and urge states [39,45,49,50,54,60]. AYA JITAIs targeting smoking cessation demonstrated positive outcomes in several studies, including higher engagement linked to reduced smoking and a lower likelihood of smoking reported in one study [44]. Evidence includes higher abstinence at 6 weeks in an RCT (relative risk 2.20, 95% CI 1.79-2.70) [39]. Similarly, marijuana use reduction interventions also yielded encouraging results. Another pilot randomized trial found reduced odds of marijuana use after contextual or behavioral triggers (odds ratio 0.54, 95% CI 0.31-0.95), alongside a greater decline in momentary marijuana desire [45]. Additionally, interventions aimed at reducing drug use

showed some promise, including in an RCT with AYAs experiencing homelessness with lower odds of reported drug use over time [49,60].

Alcohol-related outcomes were more mixed. Some studies reported reductions, including reduced heavy drinking days and drinks per drinking day. One emergency department sample found longer-term benefits, where interactive text messages reduced binge drinking and alcohol-related injury, with one third fewer binge drinking days at 9 months compared with controls (interrater reliability 0.69, 95% CI 0.60-0.79) [47,62,63]. In contrast, a small but nonsignificant increases in consumption during heavy drinking occasions were reported elsewhere [46]. Other studies found mostly limited or nonsignificant between-group differences in alcohol outcomes [46,105]. Another intervention increased protective behavioral strategies even when drinking outcomes did not differ [48].

JITAIs Addressing AYA Mental Health

JITAIs with a specific focus on AYA mental health and well-being emerged in 2017 and have been steadily growing since (37.7%, n=23/61). These include interventions that target anxiety, depression, psychological distress, and suicide prevention among AYAs [64-79,106]. Further, JITAIs that address AYAs' well-being more generally (as opposed to clinical symptoms) focus on enhancing emotional resilience and coping strategies [80-85], including after experiencing cyber-victimization [86]. A development since 2024 includes 2 studies focused on promoting healthy digital behaviors, specifically to address the overuse of digital devices [87,88]. Intervention contexts were highly heterogeneous, with some JITAIs designed for clinical depression, anxiety, or psychosis-related problems (n=5, 21.7%). Pilot studies included interventions conducted with autistic AYAs in outpatient services, female community clinic patients with sexual risk behaviors, and homeless adolescent mothers in transitional living programs [76,82,85]. Further, JITAIs for AYA mental health were supplements to in-person counseling or support group programs in several studies (n=9, 39.1%), although the structure of these programs (eg, individual vs group sessions and therapeutic framework) differed greatly.

Several AYA JITAIs targeting anxiety and depression symptoms demonstrated promising improvements across follow-up assessments, indicating potential effectiveness in alleviating specific clinical symptoms. Two RCTs reported promising mental health effects, with one trial observing significant reductions in depressive symptoms (β=–0.34; P=.004), anxiety symptoms (β=–0.10; P=.01), and perceived stress (β=–0.18; P=.04), while another found greater reductions in anxiety than in the control group (General Anxiety Disorder 7-item [GAD-7] scale: $F_{1,51}$=9.06; P=.004; d=0.61), with a nonsignificant trend for depression (Patient Health Questionnaire 8-item [PHQ-8] scale: $F_{1,51}$=3.21; P=.08; d=0.50) [70,79]. However, less definitive results were observed in other studies. In one suicide prevention trial, no significant differences were found between intervention and control groups in suicide attempts or suicidal ideation, although effects were in the hypothesized direction [65,67]. Meanwhile, findings for general mental well-being outcomes were mixed: some interventions reported reduced perceived stress or improved self-esteem and confidence, whereas others found no significant effects on stress outcomes [72,79,80,82].

JITAIs Addressing AYA Physical Health

AYA physical health JITAIs (22.9%, n=14/61) often addressed obesity risk through the promotion of physical activity and healthy diets in distinct populations (eg, racial minority groups) [89-98], although some studies have also focused on the management of chronic conditions, such as pain in cancer management and asthma [99-102]. Physical health strategies in these JITAIs often focused on incremental shifts, such as reducing sedentary behavior and promoting daily walking [90,92,93,96,97]. AYA JITAIs focused on nutrition encouraged immediate healthy choices to mitigate obesity risks [89,94,95,98]. Meanwhile, AYA JITAIs for chronic condition management promoted adherence behaviors (eg, medication adherence) as well as pain management support, incorporating hybrid "clinical escalation" logic, such as nurse practitioner alerts triggered by diary thresholds and symptom ratings in pediatric oncology pain support, as well as caregiver and clinical staff alerts triggered by safety rules in an asthma action-plan app [99-101].

Physical activity promotion outcomes were variable. Modest increases in daily physical activity levels were observed, although these changes did not always extend to reductions in sedentary time [96,97]. For example, one study showed an initial decrease in sedentary minutes following intervention (t_{17}=–1.79; P=.04), though this effect attenuated over time and became nonsignificant by the second and third weeks [97]. Interventions targeting obesity-related risks also demonstrated limited effectiveness, with no significant changes in key indicators such as screen time and BMI. However, some evidence indicated improvements in diet such as increased fruit and vegetable consumption and decreased sugar-sweetened beverage intake [89]. Finally, in a study specifically targeting cancer pain management, the intervention group reported fewer instances of moderate to severe pain compared to control (t_{2145}=2.67; 95% CI 0.0036-0.0235; P=.01), although there were no significant differences in average daily pain reduction [100].

Theoretical Frameworks Informing Intervention Options

Table 2 presents a domain-level synthesis of the theoretical frameworks that informed (distinct) intervention designs, alongside the primary intervention options, tailoring variables, and decision points. Note that counts overlap as studies applied multiple components simultaneously. Across all JITAIs targeting AYA health, researchers commonly used tailored digital messages, which were delivered via text or app-based messaging tools, while leveraging diverse theoretical frameworks to inform intervention content.

Table 2. Summary of theoretical frameworks, intervention options, tailoring variables, and decision points in just-in-time adaptive interventions (JITAIs) for adolescents and young adults (AYAs) in substance use, mental health, and physical health.

Domain	Substance use (n=24)	Mental health (n=23)	Physical health (n=14)
Theoretical frameworks	Motivational interviewing and related approaches (n=8, 33.3%), cognitive behavioral and related approaches (n=6, 25%), transtheoretical model (n=4, 16.7%), self-regulation (n=3, 12.5%), information-motivation-behavioral skills model (n=2, 8.3%), harm reduction (n=2, 8.3%), and not reported (n=3, 12.5%).	Cognitive behavioral and related approaches (n=8, 34.8%), emotion regulation approaches (n=3, 13%), motivational interviewing (n=3, 13%), mindfulness-based approaches (n=3, 13%), transdiagnostic approaches (n=3, 13%), and compassion-focused approaches (n=2, 8.7%).	Self-regulation and control-based approaches (n=6, 42.9%), Behavior Change Wheel (n=3, 21.4%), positive psychology (n=2, 14.3%), self-determination theory (n=2, 14.3%), and not reported (n=2, 14.3%).
Intervention options	Psychoeducation modules (n=16, 66.7%), supportive messages (n=15, 62.5%), self-monitoring assessment (n=14, 58.3%), goal-setting or planning support (n=8, 33.3%), interactive activities (n=8, 33.3%), protective strategies or coping support (n=8, 33.3%), and reminders (n=5, 20.8%).	Coping and emotional support messages (n=15, 65.2%), psychoeducation modules (n=15, 65.2%), therapeutic skills practice (n=11, 47.8%), self-monitoring check-ins (n=9, 39.1%), interactive activities (n=7, 30.4%), feedback/progress summaries (n=6, 26.1%), and reminders (n=5, 21.7%).	Interactive activities (n=10, 71.4%), psychoeducation modules (n=10, 71.4%), suggestions/feedback (n=10, 71.4%), goal setting (n=8, 57.1%), reminders (n=8, 57.1%), and self-monitoring/tracking (n=7, 50%).
Tailoring variables	Self-reports of behavior (n=16, 66.7%), motivation or readiness (n=15, 62.5%), triggers or high-risk situations (n=11, 45.8%), emotion or affect (n=8, 33.3%), goal attainment (n=8, 33.3%), urges (n=7, 29.2%), and self-efficacy level (n=5, 20.8%). One study collected electrodermal activity [52].	Self-reports of emotion or affect (n=15, 65.2%), behavior/recent activity (n=8, 34.8%), self-efficacy (n=5, 21.7%), cognitive state (n=5, 21.7%), goals progress (n=4, 17.4%). Passive collection included geolocation (n=4, 17.4%), device usage (n=2, 8.7%), and electrodermal activity [52].	Self-reported behavior (n=10, 71.4%), goals progress (n=7, 50%), clinical symptoms (n=5, 35.7%), triggers or high-risk situations (n=4, 28.6%). Passive collection included sedentary time (n=4, 28.6%), step count (n=4, 28.6%), geolocation (n=3, 21.4%), and food purchase history (n=1) [98].
Decision points	Daily (n=14, 58.3%), event-triggered (n=12, 50%), fixed scheduled time (n=9, 37.5%), weekly (n=8, 33.3%), and on-demand/user-initiated (n=6, 25%).	Daily (n=19, 82.6%), fixed scheduled time (n=15, 65.2%), event-triggered (n=11, 47.8%), on-demand/user-initiated (n=9, 39.1%), and weekly (n=7, 30.4%).	Daily (n=10, 71.4%), fixed scheduled time (n=7, 50%), weekly (n=6, 42.9%), event-triggered (n=5, 35.7%), and on-demand/user-initiated (n=2, 14.3%).

In AYA JITAIs targeting substance use, motivational approaches were most frequently applied (n=8, 33.3%), informing intervention components on self-reflection and dynamic goal-setting [43,45,47,50,52,53,57,59,61]. Cognitive-behavioral approaches were also frequently applied (n=6, 25%), such as informing coping prompts for managing substance cravings and related emotional distress that may trigger use [44,52,54,55,105]. Several JITAIs for AYA substance use also adopted the transtheoretical model (n=4, 16.7%), which guided the tailoring of feedback specific to an individual's stage of behavior change [40,53,56,59]. Among JITAIs focused on AYA mental health, most (n=8, 34.8%) also leveraged cognitive behavioral approaches to inform intervention content around cognitive restructuring and stress-related coping strategies [65,70,75,76,78,85,86]. JITAIs for AYA mental health also consisted of supportive messages based on emotion regulation [67,84,85], motivational interviewing [67,76,86], mindfulness-based strategies [71,77,85], and transdiagnostic approaches [69,70,72] during heightened stress events (n=3, 13% for each respective approach). Similarly, during individually challenging moments, compassion-focused JITAIs (n=2, 8.7% within this domain) delivered content aimed at promoting emotional resilience and self-kindness [64,66,69].

For JITAIs promoting AYA physical health, self-regulation and control-based approaches were most frequently adopted (n=6, 42.9%) to tailor motivational prompts that emphasize autonomy and self-efficacy to encourage sustained health behaviors [89,91,95-97]. Around 21.4% (n=3) of JITAIs for AYA physical health also adopted the Behavior Change Wheel to guide structured prompts and reinforcement strategies, such as reminders to reduce sedentary behavior and promote physical activity, including supplementation with gamified reward systems [94,95,97]. Among JITAIs focused specifically on managing physical symptoms of chronic health conditions, frameworks such as self-regulation theory were used to structure feedback mechanisms to address adherence barriers, such as for asthma management [102].

There is an overall trend of basing adaptive content on theories related to promoting AYAs' levels of motivation and self-efficacy, cognitive and behavioral change states, although the specific application of these principles varies by context. For example, cognitive-behavioral approaches can be broadly applied to aid in managing cravings in substance use in addition to cognitive restructuring in mental health, while also supporting adherence behaviors in chronic pain management. Behavioral intent and goal-setting also inform intervention content, with JITAIs commonly adapting their support based on AYA-defined goals and progress [63,89,91,96,97,103]. This significant variability underscores the need to understand how the adaptive selection of these dynamic interventions, such as timing, content, and delivery, align with ongoing AYA contexts, which is the focus of the next section.

Tailoring Variables, Decision Rules, and Decision Points

Tailoring mechanisms within AYA JITAIs are primarily informed by behavioral, psychological, and other contextual

data (Table 2). Further, the tailoring variables were aligned with the proximal and distal outcomes of the interventions. For example, behavioral data, such as self-reported nutritional consumption and physical activity levels, were used to prompt personalized feedback and inform the content of messages [91,95,96]. Meanwhile, psychological variables, such as fluctuations in mood and self-efficacy, informed JITAIs aimed at improving AYAs' emotional regulation and reducing negative affect [65,67,69,70,76]. Across these approaches, contextual awareness is emphasized, with JITAIs tailoring content based on individual and environmental factors.

Among AYA JITAIs addressing substance use and mental health, most tailoring variables rely on self-reported data, such as mood, stress, and alcohol consumption. Substance use interventions predominantly tailored content to self-reports of substance use (eg, frequency, quantity, cravings, and triggers; n=16, 66.7%); additional tailoring drew upon motivational states (n=15, 62.5%) as well as high-risk social or situational contexts (eg, location, time of week, and social setting; n=11, 45.8%). One study collected electrodermal activity to determine high-risk stress states requiring intervention to prevent drinking [52]. Mental health–focused JITAIs are tailored primarily to self-reported affective states (n=15, 65.2%), such as mood, stress, and negative thinking. Some studies also tailored support based on self-reported self-efficacy and coping needs (n=5, 21.7%, respectively). Passive collection included geolocation (n=4, 17.4%), device usage (n=2, 8.7%), and electrodermal activity in one study to determine states of stress [52].

In contrast to JITAIs for AYA substance use or mental health, over half of JITAIs for AYA physical health tailored intervention delivery based on passive activity data. These include tailoring based on step counts (n=4, 28.6%) and sedentary time (n=4, 28.6%), including via sensing data using Bluetooth geofencing (n=3, 21.4%). This reflects a trend toward real-time, event-triggered decision points in JITAIs, characterized by interventions that are activated based on immediate sensor data, such as detecting physical inactivity [92,93,97]. Notwithstanding, self-reported data were also frequently leveraged in JITAIs for AYA physical health, including for monitoring behavior (n=10, 71.4%), chronic disease symptoms (n=5, 35.7%), and goal progress (n=7, 50%).

In terms of decision points, JITAI delivery is characterized by the use of daily or multiple times daily surveys to collect these tailoring variables [89,96,99-102]. These decision points enabled AYAs to prompt immediate interventions adapted based on the self-reported data. Across all AYA JITAIs, these mechanisms can also be broadly characterized as following threshold-based triggers, where responses are activated if predefined conditions are met, such as reaching a specific stress level or failing to meet activity goals [43,52,54,55,64,65,67,69,71,79,97,99,101]. This approach allowed for adaptive interventions to be activated after consistent patterns of inactivity, poor mental health, or unmet goals. Such mechanisms were further enabled through the incorporation of high-frequency, scheduled prompts, including multiple daily check-ins or morning and evening notifications [48,50,68,71,79,96,99,102,105].

Some studies also allowed for AYA-initiated check-ins to promote flexibility in need-based and real-time support [40,52,58,68,69,74,86]. Meanwhile, in studies that used behavioral monitoring, interventions were characterized by fixed-schedule decision points, which were based on predefined intervals [53,65,79,81,89,96,100,102,105]. Studies also tailored intervention schedules based on participant-defined or behaviorally relevant times, such as following peak drinking days [43,47,105]. Time of day and spatial cues have also been leveraged to refine the timing and delivery of interventions, with methods including geofencing used to automatically identify high-risk locations and detect sedentary behavior to prompt tailored notifications [46,74,97,105,106].

Since 2024, JITAIs for AYAs have leveraged artificial intelligence to enhance the adaptability of interventions. One study developed a JITAI to prevent smartphone overuse, introducing a friction-based intervention to disrupt access to blacklisted apps when overuse was detected. The authors used a machine learning model, which was updated daily with passive sensing data such as app usage, activity, social context, location, and temporal patterns to predict overuse, triggering interventions upon app launches and task-switching moments [87]. Another recent study leveraged large language models (LLMs) for dynamic adaptability, also with the goal of reducing problematic smartphone use [88]. Similarly, when AYA users opened blacklisted apps, the LLM generated persuasive messages using 4 communication strategies of understanding, comforting, evoking, and scaffolding. LLM messages were also aligned with tailoring variables, which included real-time usage, context, mental states, and user-defined goals related to app use.

Ethical Considerations in JITAIs for AYAs

A critical gap emerges in the lack of detailed reporting on AYA engagement across studies, limiting formal analysis with the tailoring mechanisms identified in prior sections. AYA's engagement in the development of JITAI components demonstrates considerable variation in both depth and rigor. Certain studies integrated the participants directly into the design process [57,59,95,102], while others consulted AYAs with demographic profiles similar to the intended intervention audience [39,77,83]. Such engagement is frequently framed as a strategy to enhance intervention relevance and acceptability by involving adolescents in consulting on the relevance of content. However, the extent of AYA participation in these studies is also inconsistently reported, particularly within RCTs, which often prioritize the evaluation of predeveloped interventions over documentation of co-design processes. In contrast, qualitative studies focused on describing processes of adolescent engagement in JITAI component development explicitly.

While unreported involvement in these interventions is also possible, the absence of such documentation limits our ability to assess their impact on JITAI tailoring mechanisms. Moreover, among studies claiming AYA involvement,

the depth of engagement was frequently superficial. It was unclear whether AYAs had substantive influence over core design decisions regarding decision rules, except for among the small sample of qualitative studies. For example, one study engaged AYAs exiting foster care in co-designing a JITAI for substance use reduction [53]. Through focus groups with these AYAs, participants provided iterative feedback on intervention structure, language, message frequency, and content relevance, which led to key modifications in JITAI content, including adjustments to message tone, content specificity, and delivery timing. Similarly, one study involved Dutch lower-educated AYAs in the iterative development of JITAI content, including informing modifications to text clarity, visual elements, navigation, and notification settings [61]. Another study involved ethnic minority adolescent females in developing a Build Your Own Theme Song app [75]. Adolescent females contributed to JITAI design by creating personal theme songs through rewriting and recording lyrics based on their experiences. Subsequently, the app would prompt adolescents to engage with their theme song during moments of negative thinking, providing a personalized coping mechanism based on their own input.

Ethical considerations were rarely addressed in detail for specific intervention components or data collection mechanisms. A minority described explicit strategies that were primarily limited to study design, such as providing devices or data plans [44,52,85], using data encryption [99], or advising participants on secure message deletion [65]. However, reporting on the ethical implications of tailoring mechanisms was notably absent. No studies discussed mechanisms for data sovereignty or the granularity of consent regarding how distinct personal data might inform algorithmic and intervention decision-making. Despite the increasing use of passive sensing and machine learning [87], there was a lack of transparency regarding how these automated decisions were explained to adolescent users. This obscures potential risks related to privacy and autonomy, highlighting an urgent need for standardized ethical reporting guidelines in AYA digital health.

Discussion

Overview of Findings

This systematic review identified key patterns in how JITAIs for AYAs use dynamic tailoring mechanisms, decision rules, and adaptive data sources to personalize health interventions for improving substance use, mental health, and physical health (including chronic disease) outcomes. Most JITAIs relied on self-reported data, with growing trends toward integrating passive and sensor-based data, such as geofencing, app usage, and physiological monitoring [65,74,85,87,89]. Decision rules were frequently based on threshold triggers or scheduled intervals, though emerging studies have begun to explore LLMs and machine learning models for real-time, adaptive interventions [87,88].

The dominance of self-report behavioral data in JITAIs also suggests limited consideration of broader contextual and social determinants of health in their tailoring mechanisms, even when studies were piloted specifically with underserved communities [49,60,61,75,85,89]. Moreover, while our risk of bias appraisal assessed participant retention across studies, JITAI-specific data missingness also includes ecological momentary assessment nonresponse, sensor data loss, or selective absence of data at clinically important moments [107,108], which likely affects outcome measurement quality as well as intervention delivery. It is crucial for future work to investigate the incorporation of both social and missingness factors in JITAI tailoring to enhance contextual relevance and better address barriers to equitable health support among diverse individuals [27,109,110].

Further, JITAI mechanisms were highly heterogeneous, and confidence in the evidence base was constrained by inconsistent reporting and heterogeneous study designs. Further, while specific outcomes have yielded positive effects, most outcomes exhibit variable or limited findings [44,46,80,90,91,105]. Taken together, these patterns suggest the need for further investigation into the methodological determinants of intervention success, particularly regarding how JITAI and study design influence observed effectiveness.

Limitations of Existing JITAI Study Designs

It is crucial to interpret current observations of effectiveness in this review, including limited effects, with significant caution. The majority of current evidence for AYA JITAIs comes from small, pilot studies. Comparison groups were often absent or weak, and attrition or response burden was common. Several authors also explicitly noted that observed improvements could not be disentangled from self-monitoring effects, baseline reporting, treatment as usual, in-person counseling, or other concurrent influences [50,55,64]. Meanwhile, while a substantial number of studies were randomized, the risk of bias assessment highlighted recurrent challenges such as limited blinding, unclear allocation concealment, and nonidentical intervention administration. Heterogeneity in comparators also reduces confidence that the current observed effects can be attributed solely to the JITAIs being tested [111].

Given these limitations, the literature may benefit less from further RCTs but more from optimization-oriented trials, particularly microrandomized trials (MRTs), which can evaluate which intervention components work, at what moments, and for what specific AYAs' daily life contexts. MRTs, in contrast to conventional RCTs, randomize intervention options at multiple and repeated decision points to help precisely determine the effectiveness of individual adaptive components across diverse individual contexts [112]. Such an approach can enable "a holistic comprehension of intervention dynamics over various timescales" [109]. We posit that even randomized JITAI study designs may be unable to sufficiently detect within-person variability or isolate momentary effects over time and may therefore underestimate or misrepresent the effectiveness of JITAI. To deliver precise JITAIs to AYAs, it may be important to assess diverse contextual factors that may influence the effectiveness

of different adaptive components, as this can help understand "when and in what contexts a particular intervention option should be delivered"—a key differentiator of JITAIs from other digital health interventions [112]. In summary, MRTs can more precisely enable the measurement of the specific tailoring variables, decision points, and intervention options that are optimal for different individuals and health outcomes [109]. MRTs can also help to estimate proximal effects even under variable engagement and contextual missingness.

Further, for qualitative studies, the risk of bias assessment highlighted that many authors did not sufficiently consider researcher positioning and reflexivity [113]. AYA's participation in JITAI development was often limited to feedback on usability or content refinement rather than shared involvement in intervention design. We also observed inconsistent considerations of privacy, consent, and ethical safeguards in AYA JITAI studies. These findings highlight critical gaps in ensuring that JITAIs align meaningfully with AYA contexts and needs alongside critical ethical standards [114].

JITAIs for AYAs: Preliminary Recommendations for Future Directions

Overview

To address limitations of existing JITAI study designs, we sought interpretive feedback from AYAs regarding our current evidence base (refer to Methods section for details of the process). Their contributions provide a complementary perspective on the evidence, highlighting gaps and priorities for future JITAI research from their perspectives as target users.

Despite current JITAIs incorporating frequent rule-based adaptations, AYAs we consulted showed a preference for simplicity and user-controlled customization of intervention options. They highlighted how current JITAI tailoring mechanisms are overly complex or opaque. They also mentioned the lack of modular designs, whereby users can select which features they wish to engage with to enhance contextual relevance. Ongoing notifications, which characterize many of the JITAIs in this review [39,53,68,79,89,96,97], were criticized for potentially contributing to notification fatigue, which may limit engagement over time. For example, our AYA consultants discussed how excessive prompts can lead to desensitization, frustration, and eventual disregard of JITAIs. Subtle, passive engagement strategies, such as visual cues or widgets that update in the background of devices and can be checked flexibly, were highlighted as a potential alternative [115]. This raises the possibility that high-frequency prompting may undermine engagement or perceived usefulness, particularly among AYAs already experiencing digital overload and other digital determinants of poor health [116,117]. Our AYA consultants also raised concerns about data privacy and lack of control over what information is collected, advocating for opt-in tailoring mechanisms that allow users to choose which data they are comfortable sharing [118].

This feedback from our AYA consultants regarding our current evidence base highlights a potential tension within current JITAI development and trends toward passive sensing and multimodal integration with artificial intelligence [119]. In an effort to enhance engagement and precision, these mechanisms may also risk reducing engagement or acceptability for some AYAs [120]. Our AYA co-authors described this phenomenon as an "engagement paradox"—a concept emerging from the divergence between the high-frequency adaptability reported in the literature and the desire for autonomy expressed by our AYA consultants. This may indicate that the success of adaptive interventions depends not only on the incorporation of multiple levels of tailoring but also on how well tailoring mechanisms align overall with AYAs' ongoing preferences and needs for autonomy [121,122]. Despite automation's role in enhancing adaptation, our AYA consultants suggested that excessive automation may reduce AYAs' engagement if the tailoring mechanisms lack transparency and explainability. As such, adaptive systems in which AYAs can define their preferred tailoring mechanisms may be a worthwhile direction for future precision health interventions. Transparent data practices, which can promote participant control over tailoring mechanisms, may also be essential to privacy considerations as well as intervention relevance [123,124].

Notwithstanding, both the AYAs we consulted and engaged in this review as co-authors were limited in number and may not represent other AYAs' perspectives. Substantial further participatory research is necessary to improve the precision and relevance of JITAIs for diverse AYA lived experiences [109]. To provide a foundation for such work, we present preliminary recommendations for future directions in investigations of AYA JITAIs.

Investigate Mechanisms of Meaningful Engagement in Real-World Contexts

Understanding the mechanisms by which JITAIs influence behavioral outcomes is critical for advancing the field [16,109]. The review highlighted uncertainties regarding how adaptive mechanisms operate and influence engagement and outcomes, alongside key limitations of existing JITAI study designs. To address these challenges, future research can use optimization trial designs [112], such as microrandomized or sequential multiple assignment trials, to systematically test how specific tailoring variables, such as timing, content format, and data type, as well as theoretical frameworks, may impact engagement and behavioral outcomes. This can enable a more precise understanding of how different intervention components and decision rules perform and help clarify the tailoring mechanisms that are most effective for specific AYA contexts [109].

Further, more meaningful co-design in creating relevant, effective interventions is a crucial next step [125]. The review revealed limited AYA involvement in the design of many JITAIs, resulting in interventions that may not fully align with users' lived experiences or preferences [110]. Insights from our consultation with AYAs reinforced this, highlighting the value of relevance and understandability in design. There

is a need to embed precision health designs within real-life contexts to ensure interventions are adaptable and impactful for ongoing AYA health needs [109,110,126]. Participatory workshops can facilitate meaningful input, enabling AYAs to contribute ideas about preferred tailoring mechanisms. For example, studies can engage adolescent participants in informing the proximal outcomes, intervention options, tailoring variables, decision points, as well as the overall user experience of JITAIs [53]. Integration of participatory design components to additionally inform, as well as interpret, individual outcomes in ongoing MRTs would enable a more comprehensive understanding of what works, for whom, and why [127]. Such approaches would help acknowledge AYAs as experts by experience, resulting in interventions that are more grounded in real-life contexts [128]. In this manner, AYAs can directly participate in shaping mechanisms in precision health interventions.

Continuous Adaptation Directed by Adolescents and Young Adults

Adaptation is a cornerstone of effective JITAI design [16], yet the review findings identified notable gaps and inconsistencies in how such adaptation is actually implemented. Further, our AYA consultants, in reviewing our evidence base, expressed alternative preferences for systems that allowed for greater control and customization rather than opaque, automated adaptations. To address these concerns, future JITAIs can incorporate modular, user-directed adaptation features that empower adolescents to adjust the level and type of adaptation as their preferences and needs evolve [123,129]. For instance, intervention component dashboards could be developed, allowing AYAs to select their preferred notification frequencies, data sources for tailoring, and engagement formats, such as text, video, or visual cues [53,61,130,131]. Such affordances for ongoing participatory adaptation may help promote AYA agency while fostering enhanced trust and relevance, ensuring that JITAI mechanisms are both transparent and AYA-centered. However, we acknowledge that such open customization introduces heterogeneity in intervention exposure, potentially complicating the assessment of internal validity [132]. To address this, we again recommend that future research use optimization trial designs, such as MRTs, which are uniquely capable of handling within-person variability [133]. By treating user-defined preferences as dynamic tailoring variables within the statistical model, researchers may be able to better understand the mechanism of such autonomy, separate from the effects of the content itself.

Minimizing Engagement Fatigue While Promoting More Meaningful Engagement

The systematic review identified inconsistent outcomes and effects among current JITAIs for AYAs, which may be in part attributable to the methodological heterogeneity or lack of consistent theoretical grounding across studies. Further, based on the interpretive feedback from AYAs we consulted, we posit that low user engagement may also be driven by "notification fatigue" [134]—a phenomenon they identified as a critical barrier to sustained use. While the empirical studies in our review rarely measured fatigue explicitly, AYAs we consulted criticized frequent and intrusive notifications for contributing to disengagement. To address these challenges, future intervention development might explore alternative, less intrusive engagement strategies [135]. For example, AYA JITAIs might explore replacing frequent text notifications with visual nudges or contextual prompts [61]. Interventions could also explore integrating prompts into commonly used platforms, such as social media feeds, to ensure engagement occurs within familiar and comfortable digital spaces to enhance relevance to AYAs [136,137].

Strengthening Ethical Standards for Transparent Personalization and Digital Self-Determination

The review identified significant gaps in ethical reporting, with most studies neglecting to mention ethical considerations in JITAI design mechanisms. Such considerations are particularly critical given JITAIs, which rely on sensitive data collection and passive monitoring [138]. Such an approach also aligns with principles of digital self-determination, which emphasize the reduction of information asymmetries by ensuring adolescents have control over their data and tailoring mechanisms [130]. Our AYA consultants also expressed discomfort with unclear or opaque data practices of current JITAIs and emphasized a strong preference for opt-in mechanisms that allowed them to control the type and extent of data they shared. In this context, a key consideration in future JITAI development may include the need to promote AYAs' individual agency over their digital data and enable participatory tailoring mechanisms [123,139].

To address these concerns, dynamic consent processes within ongoing JITAI tailoring mechanisms may be one promising approach. Dynamic consent refers to when individuals are continuously informed and able to manage their data-sharing preferences over time [104]. Such a practice can enhance data sovereignty, defined as the need for individuals to have control over the use of their shared data, without which JITAI usage may be significantly hindered [104]. These processes can provide clear, accessible information about what data are collected, how the data are used, and the purpose of each data point in tailoring mechanisms. AYAs can be further empowered to opt in or opt out of specific data types and be given the opportunity to modify data points over time. This can be operationalized through user-friendly privacy dashboards which enable real-time adjustment of intervention-tailoring settings [104,140].

Dynamic consent in AYA digital health remains very limited. Recent studies highlight the approach's alignment with technology users' desire for transparency and control [104]. Studies have also shown how dynamic consent preferences are highly individual based on demographic and social contexts [131], making the approach particularly salient for application in precision adolescent and digital health contexts. Based on our AYA consultation, we posit that increased emphasis on self-determination and sovereignty in

JITAI design may help improve their alignment and relevance with adolescent health needs and expectations.

Strengths and Limitations

This review is the first to focus on JITAIs across a wide range of health conditions within a specific developmental period, highlighting the unique needs and intervention contexts for adolescents, who face distinct physical, mental, and social health challenges that differ from those of children or adults. A key strength of this review is the meaningful involvement of AYAs in screening, data extraction, and critical interpretation, which enhances the relevance and actionability of the findings and future recommendations. The current synthesis of common theoretical frameworks and tailoring mechanisms also represents an important first step toward a more coherent body of evidence for the application of JITAIs in AYA health. However, due to substantial heterogeneity in intervention designs, high risk of bias (particularly with outcome reliability and statistical validity), and inconsistent outcome effects observed, meta-analysis was not feasible. Additionally, despite a broad search strategy, some relevant studies may have been inadvertently missed, as most included interventions did not explicitly describe their mechanisms as just-in-time or adaptive.

Conclusion

This review provides the first comprehensive synthesis of how JITAI mechanisms are being designed and studied for AYAs across multiple health domains, while also integrating AYA perspectives into the interpretation of findings and future directions. Beyond showing where JITAIs are being applied, it highlights important limitations in the current evidence base, including heavy reliance on self-reported behavioral data and limited attention to broader social determinants in tailoring mechanisms. The review also highlights substantial methodological heterogeneity among studies evaluating similar outcomes, as well as insufficient ethical transparency, including limited participatory engagement to ensure intervention designs are grounded in real-life AYA contexts. Our findings suggest that progress in AYA precision health may depend not only on developing more adaptive interventions but on measuring and designing them in ways that are more transparent and participatory. Limitations of traditional study designs, including measurement of JITAI administration in RCTs, point to the need for more robust designs such as MRTs as a key methodological next step for identifying which adaptive components work, at what moments, and in which daily life contexts. Based on AYA coauthor and consultant input, we further outline preliminary recommendations for future research to help ensure JITAIs better align precision with AYA agencies, including through co-designed tailoring mechanisms, reduced notification burden, and clearer control over personal data and automated decision-making.

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Data Availability

All data extracted and reported during this review are included in this published paper and its additional information files.

Authors' Contributions

KWG is the review guarantor and contributed to conceptualization, project administration, methodology, investigation, formal analysis, writing—original draft, and writing—review and editing. MA contributed to investigation, formal analysis, writing—original draft, and writing—review and editing. VC, IK, SG, CI, RA, CA, and ET each contributed equally to investigation and writing—review and editing. CRS, AV, and EvR contributed to methodology and writing—review and editing. LK contributed to funding acquisition, methodology, and writing—review and editing. MdR contributed to funding acquisition, supervision,

methodology, and writing—review and editing. CAF contributed to funding acquisition, supervision, project administration, methodology, and writing—review and editing.

Conflicts of Interest

KWG, MA, SG, VC, and CI are members of the World Health Organization Regional Office for Europe's Youth4Health network. However, their views do not represent the World Health Organization or other network members. ET is employed by Gro-up, a nonprofit organization in the Netherlands promoting the well-being of children and youth and their families. Gro-up has no involvement in the development of this review or interpretation of its findings.

Multimedia Appendix 1

Data extraction for just-in-time adaptive interventions (JITAIs) for adolescent and young adult (AYA) substance use.
[PDF File (Adobe File), 278 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Data extraction for just-in-time adaptive interventions (JITAIs) for adolescent and young adult (AYA) mental health.
[PDF File (Adobe File), 280 KB-Multimedia Appendix 2]

Multimedia Appendix 3

Data extraction for just-in-time adaptive interventions (JITAIs) for adolescent and young adult (AYA) physical health.
[PDF File (Adobe File), 224 KB-Multimedia Appendix 3]

Checklist 1

PRISMA-S checklist.
[PDF File (Adobe File), 100 KB-Checklist 1]

Checklist 2

SWiM checklist.
[PDF File (Adobe File), 170 KB-Checklist 2]

References

1. Chahal R, Gotlib IH, Guyer AE. Research review: brain network connectivity and the heterogeneity of depression in adolescence - a precision mental health perspective. J Child Psychol Psychiatry. Dec 2020;61(12):1282-1298. [doi: 10.1111/jcpp.13250] [Medline: 32458453]
2. Ryder JR, Kaizer AM, Jenkins TM, Kelly AS, Inge TH, Shaibi GQ. Heterogeneity in response to treatment of adolescents with severe obesity: the need for precision obesity medicine. Obesity (Silver Spring). Feb 2019;27(2):288-294. [doi: 10.1002/oby.22369] [Medline: 30677258]
3. Kerr J, Anderson C, Lippman SM. Physical activity, sedentary behaviour, diet, and cancer: an update and emerging new evidence. Lancet Oncol. Aug 2017;18(8):e457-e471. [doi: 10.1016/S1470-2045(17)30411-4] [Medline: 28759385]
4. Fleary SA, Joseph P, Pappagianopoulos JE. Adolescent health literacy and health behaviors: a systematic review. J Adolesc. Jan 2018;62:116-127. [doi: 10.1016/j.adolescence.2017.11.010] [Medline: 29179126]
5. Cicchetti D, Rogosch FA. A developmental psychopathology perspective on adolescence. J Consult Clin Psychol. 2002;70(1):6-20. [doi: 10.1037/0022-006X.70.1.6]
6. Paquin V, Muckle G, Bolanis D, et al. Longitudinal trajectories of food insecurity in childhood and their associations with mental health and functioning in adolescence. JAMA Netw Open. Dec 1, 2021;4(12):e2140085. [doi: 10.1001/jamanetworkopen.2021.40085] [Medline: 34928352]
7. Adolescents. UNICEF. URL: https://data.unicef.org/topic/adolescents/overview/ [Accessed 2025-03-25]
8. Johnson MH, Fearon P, Pickles A, Jones EJH. Editorial perspective: the paradox of precision health in early development – building large samples to yield individual-level measures. Child Psychology Psychiatry. Jul 2024;65(7):991-994. [doi: 10.1111/jcpp.13974]
9. Shen M di, Chen SB, Ding XD. The effectiveness of digital twins in promoting precision health across the entire population: a systematic review. NPJ Digit Med. Jun 3, 2024;7(1):145. [doi: 10.1038/s41746-024-01146-0] [Medline: 38831093]
10. Sawyer SM, Azzopardi PS, Wickremarathne D, Patton GC. The age of adolescence. Lancet Child Adolesc Health. Mar 2018;2(3):223-228. [doi: 10.1016/S2352-4642(18)30022-1]
11. Wyatt TH, Bayless AK, Krauskopf P, Gaylord N. Using mHealth applications to promote self-managed health behaviors among teens. J Pediatr Nurs. 2021;59:164-172. [doi: 10.1016/j.pedn.2021.04.025] [Medline: 33932646]
12. Hightow-Weidman LB, Horvath KJ, Scott H, Hill-Rorie J, Bauermeister JA. Engaging youth in mHealth: what works and how can we be sure? Mhealth. 2021;7:23-23. [doi: 10.21037/mhealth-20-48]

13. Psihogios AM, King-Dowling S, O'Hagan B, et al. Contextual predictors of engagement in a tailored mHealth intervention for adolescent and young adult cancer survivors. Ann Behav Med. Nov 18, 2021;55(12):1220-1230. [doi: 10.1093/abm/kaab008] [Medline: 33674863]
14. Kozelka EE, Acquilano SC, Al-Abdulmunem M, et al. Digital mental health and its discontents: assumptions about technology that create barriers to equitable access. Psych Serv. Mar 1, 2024;75(3):299-302. [doi: 10.1176/appi.ps.20230238]
15. Villegas Mejía C, Remmerswaal D, Engels RCME, Ludden GDS, Boffo M. Macro-engagement in mHealth: exploring user engagement beyond the screen. Digit Health. 2024;10:20552076231225591. [doi: 10.1177/20552076231225591] [Medline: 38269371]
16. Nahum-Shani I, Smith SN, Spring BJ, et al. Just-in-time adaptive interventions (JITAIs) in mobile health: key components and design principles for ongoing health behavior support. Ann Behav Med. May 18, 2018;52(6):446-462. [doi: 10.1007/s12160-016-9830-8] [Medline: 27663578]
17. Crone EA, Dahl RE. Understanding adolescence as a period of social–affective engagement and goal flexibility. Nat Rev Neurosci. Sep 2012;13(9):636-650. [doi: 10.1038/nrn3313]
18. Hurrelmann K, Richter M. Risk behaviour in adolescence: the relationship between developmental and health problems. J Public Health. Feb 2006;14(1):20-28. [doi: 10.1007/s10389-005-0005-5]
19. Hardeman W, Houghton J, Lane K, Jones A, Naughton F. A systematic review of just-in-time adaptive interventions (JITAIs) to promote physical activity. Int J Behav Nutr Phys Act. Apr 3, 2019;16(1):31. [doi: 10.1186/s12966-019-0792-7] [Medline: 30943983]
20. Oikonomidi T, Ravaud P, LeBeau J, Tran VT. A systematic scoping review of just-in-time, adaptive interventions finds limited automation and incomplete reporting. J Clin Epidemiol. Feb 2023;154:108-116. [doi: 10.1016/j.jclinepi.2022.12.006] [Medline: 36521653]
21. Perski O, Hébert ET, Naughton F, Hekler EB, Brown J, Businelle MS. Technology-mediated just-in-time adaptive interventions (JITAIs) to reduce harmful substance use: a systematic review. Addiction. May 2022;117(5):1220-1241. [doi: 10.1111/add.15687] [Medline: 34514668]
22. Teepe GW, Da Fonseca A, Kleim B, et al. Just-in-time adaptive mechanisms of popular mobile applications for individuals with depression: systematic app search and literature review. J Med Internet Res. Sep 28, 2021;23(9):e29412. [doi: 10.2196/29412] [Medline: 34309569]
23. Wang L, Miller LC. Just-in-the-moment adaptive interventions (JITAI): a meta-analytical review. Health Commun. Nov 2020;35(12):1531-1544. [doi: 10.1080/10410236.2019.1652388] [Medline: 31488002]
24. Koike C, Nestor BA, Gelmez PS, Fladger A, Shrier LA, Kossowsky J. Just-in-time adaptive interventions for adolescent and young adult substance use: a systematic review. J Adolesc Health. Dec 2025;77(6):1038-1049. [doi: 10.1016/j.jadohealth.2025.07.027] [Medline: 41065631]
25. Campbell M, McKenzie JE, Sowden A, et al. Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline. BMJ. Jan 16, 2020;368:l6890. [doi: 10.1136/bmj.l6890] [Medline: 31948937]
26. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. n71. [doi: 10.1136/bmj.n71]
27. Guan KW, Adlung C, Keijsers L, et al. Just-in-time adaptive interventions for adolescent and young adult health and well-being: protocol for a systematic review. BMJ Open. Jul 2024;14(7):e083870. [doi: 10.1136/bmjopen-2024-083870]
28. Rethlefsen ML, Kirtley S, Waffenschmidt S, et al. PRISMA-S: an extension to the PRISMA Statement for Reporting Literature Searches in Systematic Reviews. Syst Rev. 2021;10(1). [doi: 10.1186/s13643-020-01542-z]
29. Timms KP, Rivera DE, Collins LM, Piper ME. Control systems engineering for understanding and optimizing smoking cessation interventions. Proc Am Control Conf. 2013:1964-1969. [doi: 10.1109/acc.2013.6580123] [Medline: 24362946]
30. Kumar S, Nilsen W, Pavel M, Srivastava M. Mobile health: revolutionizing healthcare through transdisciplinary research. Computer (Long Beach Calif). Jan 2013;46(1):28-35. [doi: 10.1109/MC.2012.392]
31. Chow PI, Smith J, Saini R, et al. A novel just-in-time intervention for promoting safer drinking among college students: app testing across 2 independent pre-post trials. JMIR Hum Factors. Apr 10, 2025;12:e69873. [doi: 10.2196/69873] [Medline: 40209208]
32. Blum RW, Bastos F, Kabiru CW, Le LC. Adolescent health in the 21st century. Lancet. Apr 28, 2012;379(9826):1567-1568. [doi: 10.1016/S0140-6736(12)60407-3] [Medline: 22538177]
33. Jaworska N, MacQueen G. Adolescence as a unique developmental period. J Psychiatry Neurosci. Sep 2015;40(5):291-293. [doi: 10.1503/jpn.150268] [Medline: 26290063]
34. Arnone JM. Adolescents may be older than we think: today 25 is the new 18, or is it? Int J Celiac Dis. Jan 5, 2014;2(2):47-48. [doi: 10.12691/ijcd-2-2-4]

35. Majmundar A, Cerrada C, Fang W, Huh J. In lieu of smoking: are smokers more likely to enact certain types of implementation intention plans during a jit smoking cessation? IntJ Behav Med. Oct 2020;27(5):556-564. [doi: 10.1007/s12529-020-09893-6]
36. Barker TH, Stone JC, Sears K, et al. Revising the JBI quantitative critical appraisal tools to improve their applicability: an overview of methods and the development process. JBI Evid Synth. Mar 1, 2023;21(3):478-493. [doi: 10.11124/JBIES-22-00125] [Medline: 36121230]
37. Prasad M. Introduction to the GRADE tool for rating certainty in evidence and recommendations. Clin Epidemiol Glob Health. Jan 2024;25:101484. [doi: 10.1016/j.cegh.2023.101484]
38. Murad MH, Mustafa RA, Schünemann HJ, Sultan S, Santesso N. Rating the certainty in evidence in the absence of a single estimate of effect. Evid Based Med. Jun 2017;22(3):85-87. [doi: 10.1136/ebmed-2017-110668]
39. Rodgers A, Corbett T, Bramley D, et al. Do u smoke after txt? Results of a randomised trial of smoking cessation using mobile phone text messaging. Tob Control. Aug 2005;14(4):255-261. [doi: 10.1136/tc.2005.011577] [Medline: 16046689]
40. Riley W, Obermayer J, Jean-Mary J. Internet and mobile phone text messaging intervention for college smokers. J Am Coll Health. 2008;57(2):245-248. [doi: 10.3200/JACH.57.2.245-248] [Medline: 18809542]
41. Coughlin LN, Nahum-Shani I, Philyaw-Kotov ML, et al. Developing an adaptive mobile intervention to address risky substance use among adolescents and emerging adults: usability study. JMIR Mhealth Uhealth. Jan 15, 2021;9(1):e24424. [doi: 10.2196/24424] [Medline: 33448931]
42. Weitzel JA, Bernhardt JM, Usdan S, Mays D, Glanz K. Using wireless handheld computers and tailored text messaging to reduce negative consequences of drinking alcohol. J Stud Alcohol Drugs. Jul 2007;68(4):534-537. [doi: 10.15288/jsad.2007.68.534] [Medline: 17568957]
43. Suffoletto B, Callaway C, Kristan J, Kraemer K, Clark DB. Text-message-based drinking assessments and brief interventions for young adults discharged from the emergency department. Alcoholism Clin Exp Res. Mar 2012;36(3):552-560. [doi: 10.1111/j.1530-0277.2011.01646.x]
44. Witkiewitz K, Desai SA, Bowen S, Leigh BC, Kirouac M, Larimer ME. Development and evaluation of a mobile intervention for heavy drinking and smoking among college students. Psychol Addict Behav. Sep 2014;28(3):639-650. [doi: 10.1037/a0034747] [Medline: 25000269]
45. Shrier LA, Burke PJ, Kells M, et al. Pilot randomized trial of MOMENT, a motivational counseling-plus-ecological momentary intervention to reduce marijuana use in youth. Mhealth. 2018;4(7):29. [doi: 10.21037/mhealth.2018.07.04] [Medline: 30148142]
46. Wright C, Dietze PM, Agius PA, et al. Mobile phone-based ecological momentary intervention to reduce young adults' alcohol use in the event: a three-armed randomized controlled trial. JMIR Mhealth Uhealth. Jul 20, 2018;6(7):e149. [doi: 10.2196/mhealth.9324] [Medline: 30030211]
47. Suffoletto B, Kirisci L, Clark DB, Chung T. Which behavior change techniques help young adults reduce binge drinking? A pilot randomized clinical trial of 5 text message interventions. Addict Behav. May 2019;92:161-167. [doi: 10.1016/j.addbeh.2019.01.006]
48. O'Donnell R, Richardson B, Fuller-Tyszkiewicz M, et al. Ecological momentary assessment of drinking in young adults: an investigation into social context, affect and motives. Addict Behav. Nov 2019;98:106019. [doi: 10.1016/j.addbeh.2019.06.008] [Medline: 31247534]
49. Santa Maria D, Padhye N, Businelle M, et al. Efficacy of a just-in-time adaptive intervention to promote HIV risk reduction behaviors among young adults experiencing homelessness: pilot randomized controlled trial. J Med Internet Res. Jul 6, 2021;23(7):e26704. [doi: 10.2196/26704] [Medline: 34255679]
50. Shrier LA, Rhoads A, Burke P, Walls C, Blood EA. Real-time, contextual intervention using mobile technology to reduce marijuana use among youth: a pilot study. Addict Behav. Jan 2014;39(1):173-180. [doi: 10.1016/j.addbeh.2013.09.028] [Medline: 24139665]
51. Shrier LA, Rhoads AM, Fredette ME, Burke PJ. "Counselor in Your Pocket": youth and provider perspectives on a mobile motivational intervention for marijuana use. Subst Use Misuse. Jan 1, 2014;49(1-2):134-144. [doi: 10.3109/10826084.2013.824470] [Medline: 24000892]
52. Leonard NR, Silverman M, Sherpa DP, et al. Mobile health technology using a wearable sensorband for female college students with problem drinking: an acceptability and feasibility study. JMIR Mhealth Uhealth. Jul 7, 2017;5(7):e90. [doi: 10.2196/mhealth.7399] [Medline: 28687533]
53. Braciszewski JM, Tzilos Wernette GK, Moore RS, et al. Developing a tailored substance use intervention for youth exiting foster care. Child Abuse Neglect. Mar 2018;77:211-221. [doi: 10.1016/j.chiabu.2018.01.013]
54. Stevenson BL, Blevins CE, Marsh E, Feltus S, Stein M, Abrantes AM. An ecological momentary assessment of mood, coping and alcohol use among emerging adults in psychiatric treatment. Am J Drug Alcohol Abuse. Sep 2, 2020;46(5):651-658. [doi: 10.1080/00952990.2020.1783672]

55. Blevins CE, Marsh EL, Stein MD, Schatten HT, Abrantes AM. Project CHOICE: choosing healthy options in coping with emotions, an EMA/EMI plus in-person intervention for alcohol use. Subst Abuse. Oct 2021;42(4):569-576. [doi: 10.1080/08897077.2020.1806182]
56. Kazemi DM, Borsari B, Levine MJ, et al. Effectiveness of a theory-based mHealth intervention for high-risk drinking in college students. Subst Use Misuse. May 2020;55(10):1667-1676. [doi: 10.1080/10826084.2020.1756851] [Medline: 32394772]
57. Wright CJC, Dietze PM, Crockett B, Lim MSC. Participatory development of MIDY (Mobile Intervention for Drinking in Young people). BMC Public Health. Feb 24, 2016;16(1):184. [doi: 10.1186/s12889-016-2876-5] [Medline: 26911299]
58. Cerrada CJ, Dzubur E, Blackman KCA, Mays V, Shoptaw S, Huh J. Development of a just-in-time adaptive intervention for smoking cessation among Korean American emerging adults. Int J Behav Med. Oct 2017;24(5):665-672. [doi: 10.1007/s12529-016-9628-x] [Medline: 28070868]
59. Kazemi DM, Borsari B, Levine MJ, Lamberson KA, Dooley B. REMIT: development of a mHealth theory-based intervention to decrease heavy episodic drinking among college students. Addict Res Theory. 2018;26(5):377-385. [doi: 10.1080/16066359.2017.1420783] [Medline: 32694964]
60. Acorda DE, Jones JT, Maria DS. Acceptability of a just-in-time adaptive intervention for HIV prevention among youth experiencing homelessness: a qualitative analysis. J Health Care Poor Underserved. May 2021;32(2S):25-42. [doi: 10.1353/hpu.2021.0049]
61. van Keulen H, Voogt C, Kleinjan M, Kramer J, Andree R, van Empelen P. Development of a dynamically tailored mHealth intervention (What Do You Drink) to reduce excessive drinking among Dutch lower-educated students: user-centered design approach. JMIR Form Res. Aug 11, 2022;6(8):e36969. [doi: 10.2196/36969] [Medline: 35969428]
62. Suffoletto B, Kristan J, Chung T, et al. An interactive text message intervention to reduce binge drinking in young adults: a randomized controlled trial with 9-month outcomes. PLoS One. 2015;10(11):e0142877. [doi: 10.1371/journal.pone.0142877] [Medline: 26580802]
63. Suffoletto B, Chung T, Muench F, Monti P, Clark DB. A text message intervention with adaptive goal support to reduce alcohol consumption among non-treatment-seeking young adults: non-randomized clinical trial with voluntary length of enrollment. JMIR Mhealth Uhealth. Feb 16, 2018;6(2):e35. [doi: 10.2196/mhealth.8530] [Medline: 29453191]
64. Rauschenberg C, Boecking B, Paetzold I, et al. A compassion-focused ecological momentary intervention for enhancing resilience in help-seeking youth: uncontrolled pilot study. JMIR Ment Health. Aug 5, 2021;8(8):e25650. [doi: 10.2196/25650] [Medline: 34383687]
65. Suffoletto B, Goldstein T, Gotkiewicz D, Gotkiewicz E, George B, Brent D. Acceptability, engagement, and effects of a mobile digital intervention to support mental health for young adults transitioning to college: pilot randomized controlled trial. JMIR Form Res. Oct 14, 2021;5(10):e32271. [doi: 10.2196/32271] [Medline: 34647893]
66. Reininghaus U, Paetzold I, Rauschenberg C, et al. Effects of a novel, transdiagnostic ecological momentary intervention for prevention, and early intervention of severe mental disorder in youth (EMIcompass): findings from an exploratory randomized controlled trial. Schizophr Bull. May 3, 2023;49(3):592-604. [doi: 10.1093/schbul/sbac212] [Medline: 36738168]
67. Kennard BD, Goldstein T, Foxwell AA, et al. As Safe as Possible (ASAP): a brief app-supported inpatient intervention to prevent postdischarge suicidal behavior in hospitalized, suicidal adolescents. AJP. Sep 1, 2018;175(9):864-872. [doi: 10.1176/appi.ajp.2018.17101151]
68. van Aubel E, Bakker JM, Batink T, et al. Blended care in the treatment of subthreshold symptoms of depression and psychosis in emerging adults: a randomised controlled trial of Acceptance and Commitment Therapy in Daily-Life (ACT-DL). Behav Res Ther. May 2020;128:103592. [doi: 10.1016/j.brat.2020.103592] [Medline: 32146218]
69. Paetzold I, Schick A, Rauschenberg C, et al. A hybrid ecological momentary compassion–focused intervention for enhancing resilience in help-seeking young people: prospective study of baseline characteristics in the EMIcompass trial. JMIR Form Res. Nov 4, 2022;6(11):e39511. [doi: 10.2196/39511] [Medline: 36331526]
70. Bell I, Arnold C, Gilbertson T, et al. A personalized, transdiagnostic smartphone intervention (Mello) targeting repetitive negative thinking in young people with depression and anxiety: pilot randomized controlled trial. J Med Internet Res. Dec 13, 2023;25:e47860. [doi: 10.2196/47860] [Medline: 38090786]
71. Lucas-Thompson RG, Prince MA, Rigsby BA, et al. Preliminary evaluation of learning to BREATHE PLUS for university students: does a multi-modal adaptive supplement strengthen effects of a mindfulness-based intervention? Mindfulness. Nov 2023;14(11):2699-2715. [doi: 10.1007/s12671-023-02229-x]
72. Reininghaus U, Daemen M, Postma MR, et al. Transdiagnostic ecological momentary intervention for improving self-esteem in youth exposed to childhood adversity. JAMA Psychiatry. Mar 1, 2024;81(3):227-239. [doi: 10.1001/jamapsychiatry.2023.4590] [Medline: 38019495]

73. Postma MR, Vrancken S, Daemen M, et al. Working mechanisms of the use and acceptability of ecological momentary interventions: a realist evaluation of a guided self-help ecological momentary intervention targeting self-esteem. BMC Public Health. Jun 19, 2024;24(1):1633. [doi: 10.1186/s12889-024-19143-z] [Medline: 38898412]
74. Silk JS, Pramana G, Sequeira SL, et al. Using a smartphone app and clinician portal to enhance brief cognitive behavioral therapy for childhood anxiety disorders. Behav Ther. Jan 2020;51(1):69-84. [doi: 10.1016/j.beth.2019.05.002] [Medline: 32005341]
75. Neal-Barnett A, Stadulis R, Ellzey D, et al. Evaluation of the effectiveness of a musical cognitive restructuring app for black inner-city girls: survey, usage, and focus group evaluation. JMIR Mhealth Uhealth. Jun 27, 2019;7(6):e11310. [doi: 10.2196/11310] [Medline: 31188130]
76. Shrier LA, Burke PJ, Parker S, et al. Development and pilot testing of a counseling-plus-mHealth intervention to reduce risk for pregnancy and sexually transmitted infection in young women with depression. Mhealth. 2020;6:17. [doi: 10.21037/mhealth.2019.11.05] [Medline: 32270009]
77. Lucas-Thompson RG, Rayburn S, Seiter NS, et al. Learning to BREATHE "Plus": a multi-modal adaptive supplement to an evidence-based mindfulness intervention for adolescents. Front Public Health. 2020;8:579556. [doi: 10.3389/fpubh.2020.579556] [Medline: 33282814]
78. Shrier LA, Spalding A. "Just Take a Moment and Breathe and Think": young women with depression talk about the development of an ecological momentary intervention to reduce their sexual risk. J Pediatr Adolesc Gynecol. Feb 2017;30(1):116-122. [doi: 10.1016/j.jpag.2016.08.009] [Medline: 27575408]
79. Marciniak MA, Shanahan L, Myin-Germeys I, et al. Imager-a mobile health mental imagery-based ecological momentary intervention targeting reward sensitivity: a randomized controlled trial. Applied Psych Health Well. May 2024;16(2):576-596. [doi: 10.1111/aphw.12505] [Medline: 37942875]
80. Schenkel K, Haug S, Castro RP, et al. One SMS a day keeps the stress away? A just-in-time planning intervention to reduce occupational stress among apprentices. Applied Psych Health Well. Nov 2022;14(4):1389-1407. [doi: 10.1111/aphw.12340]
81. van Asselt A, Roke Y. Co-creating the Stress Autism Mate (SAM): development of an mHealth application for autistic adults using a design thinking approach. Health Psychol Behav Med. 2025;13(1):2597607. [doi: 10.1080/21642850.2025.2597607] [Medline: 41378280]
82. van Asselt A, Hoeberichts K, Demirel S, Scheeren A, Roke Y. Effectiveness of the mobile Stress Autism Mate Junior application in reducing stress and improving quality of life in adolescents with autism: a pilot study. Front Psychiatry. 2024;15:1469257. [doi: 10.3389/fpsyt.2024.1469257] [Medline: 39845363]
83. Hiller S, Götzl C, Rauschenberg C, et al. Health-promoting effects and everyday experiences with a mental health app using ecological momentary assessments and AI-based ecological momentary interventions among young people: qualitative interview and focus group study. JMIR Mhealth Uhealth. Apr 29, 2025;13:e65106. [doi: 10.2196/65106] [Medline: 40300160]
84. Engelskirchen L, Asbrand J, Tuschen-Caffier B. Feasibility and potential efficacy of an ecological momentary intervention for training acceptance and problem solving in young people. Cogn Ther Res. Sep 9, 2025. [doi: 10.1007/s10608-025-10643-9]
85. Leonard NR, Casarjian B, Fletcher RR, et al. Theoretically-based emotion regulation strategies using a mobile app and wearable sensor among homeless adolescent mothers: acceptability and feasibility study. JMIR Pediatr Parent. 2018;1(1):e1. [doi: 10.2196/pediatrics.9037] [Medline: 30637376]
86. Ranney ML, Pittman SK, Moseley I, et al. Cyberbullying prevention for adolescents: iterative qualitative methods for mobile intervention design. JMIR Form Res. Aug 27, 2021;5(8):e25900. [doi: 10.2196/25900] [Medline: 34448702]
87. Orzikulova A, Xiao H, Li Z, et al. Time2Stop: adaptive and explainable human-AI loop for smartphone overuse intervention. Presented at: CHI '24: CHI Conference on Human Factors in Computing Systems; May 11-16, 2024:1-20; Honolulu, HI. [doi: 10.1145/3613904.3642747]
88. Wu R, Yu C, Pan X, et al. MindShift: leveraging large language models for mental-states-based problematic smartphone use intervention. Presented at: CHI '24: Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems; May 11-16, 2024; Honolulu, HI. 2024.[doi: 10.1145/3613904.3642790]
89. Nollen NL, Mayo MS, Carlson SE, Rapoff MA, Goggin KJ, Ellerbeck EF. Mobile technology for obesity prevention. Am J Prev Med. Apr 2014;46(4):404-408. [doi: 10.1016/j.amepre.2013.12.011]
90. Pyky R, Koivumaa-Honkanen H, Leinonen AM, et al. Effect of tailored, gamified, mobile physical activity intervention on life satisfaction and self-rated health in young adolescent men: a population-based, randomized controlled trial (MOPO study). Comput Human Behav. Jul 2017;72:13-22. [doi: 10.1016/j.chb.2017.02.032]
91. Simons D, De Bourdeaudhuij I, Clarys P, De Cocker K, Vandelanotte C, Deforche B. A smartphone app to promote an active lifestyle in lower-educated working young adults: development, usability, acceptability, and feasibility study. JMIR Mhealth Uhealth. Feb 20, 2018;6(2):e44. [doi: 10.2196/mhealth.8287] [Medline: 29463491]

92. Spruijt-Metz D, Wen CKF, O'Reilly G, et al. Innovations in the use of interactive technology to support weight management. Curr Obes Rep. Dec 2015;4(4):510-519. [doi: 10.1007/s13679-015-0183-6] [Medline: 26364308]
93. Ding X, Xu J, Wang H, Chen G, Thind H, Zhang Y. WalkMore: promoting walking with just-in-time context-aware prompts. Presented at: 2016 IEEE Wireless Health; Oct 25-27, 2016:1-8; Bethesda, MD. [doi: 10.1109/WH.2016.7764558]
94. Caon M, Prinelli F, Angelini L, et al. PEGASO e-Diary: user engagement and dietary behavior change of a mobile food record for adolescents. Front Nutr. 2022;9:727480. [doi: 10.3389/fnut.2022.727480] [Medline: 35369096]
95. Martin A, Caon M, Adorni F, et al. A mobile phone intervention to improve obesity-related health behaviors of adolescents across Europe: iterative co-design and feasibility study. JMIR Mhealth Uhealth. Mar 2, 2020;8(3):e14118. [doi: 10.2196/14118] [Medline: 32130179]
96. Cushing CC, Bejarano CM, Ortega A, Sayre N, Fedele DA, Smyth JM. Adaptive mHealth intervention for adolescent physical activity promotion. J Pediatr Psychol. Jun 3, 2021;46(5):536-546. [doi: 10.1093/jpepsy/jsaa125] [Medline: 33484137]
97. Domin A, Uslu A, Schulz A, Ouzzahra Y, Vögele C. A theory-informed, personalized mHealth intervention for adolescents (mobile app for physical activity): development and pilot study. JMIR Form Res. Jun 10, 2022;6(6):e35118. [doi: 10.2196/35118] [Medline: 35687409]
98. Chand A, Gonzalez M, Missig J, Phanichphant P, Sun PF. Balance pass: service design for a healthy college lifestyle. Presented at: CHI06: CHI 2006 Conference on Human Factors in Computing Systems; Apr 22-27, 2006:1813-1818; Montréal, Canada. [doi: 10.1145/1125451.1125795]
99. Fortier MA, Chung WW, Martinez A, Gago-Masague S, Sender L. Pain buddy: a novel use of m-health in the management of children's cancer pain. Comput Biol Med. Sep 1, 2016;76:202-214. [doi: 10.1016/j.compbiomed.2016.07.012] [Medline: 27479493]
100. Hunter JF, Acevedo AM, Gago-Masague S, et al. A pilot study of the preliminary efficacy of Pain Buddy: a novel intervention for the management of children's cancer-related pain. Pediatr Blood Cancer. Oct 2020;67(10):e28278. [doi: 10.1002/pbc.28278] [Medline: 32743950]
101. Perry TT, Marshall A, Berlinski A, et al. Smartphone-based vs paper-based asthma action plans for adolescents. Ann Allergy Asthma Immunol. Mar 2017;118(3):298-303. [doi: 10.1016/j.anai.2016.11.028]
102. Fedele DA, Cushing CC, Koskela-Staples N, et al. Adaptive mobile health intervention for adolescents with asthma: iterative user-centered development. JMIR Mhealth Uhealth. May 6, 2020;8(5):e18400. [doi: 10.2196/18400] [Medline: 32374273]
103. King-Dowling S, Psihogios AM, Hill-Kayser C, et al. Acceptability and feasibility of survivorship care plans and an accompanying mobile health intervention for adolescent and young adult survivors of childhood cancer. Pediatric Blood Cancer. Mar 2021;68(3):e28884. [doi: 10.1002/pbc.28884]
104. Lee AR, Koo D, Kim IK, Lee E, Yoo S, Lee HY. Opportunities and challenges of a dynamic consent-based application: personalized options for personal health data sharing and utilization. BMC Med Ethics. Aug 31, 2024;25(1):92. [doi: 10.1186/s12910-024-01091-3] [Medline: 39217356]
105. Lee CM, Cadigan JM, Calhoun BH, et al. A just-in-time adaptive personalized mobile app intervention produces limited short-term reductions in heavy episodic drinking frequency in college students: a randomized control trial during the COVID-19 pandemic. Alcohol Clin Exp Res. Jun 2025;49(6):1321-1336. [doi: 10.1111/acer.70056]
106. Pramana G, Parmanto B, Lomas J, Lindhiem O, Kendall PC, Silk J. Using mobile health gamification to facilitate cognitive behavioral therapy skills practice in child anxiety treatment: open clinical trial. JMIR Serious Games. May 10, 2018;6(2):e9. [doi: 10.2196/games.8902] [Medline: 29748165]
107. Cho YW, Chow SM, Li J, et al. Within- and between-individual compliance in mobile health: joint modeling approach to nonrandom missingness in an intensive longitudinal observational study. JMIR Mhealth Uhealth. Oct 30, 2025;13:e65350. [doi: 10.2196/65350] [Medline: 41167252]
108. Seewald NJ, Smith SN, Lee AJ, Klasnja P, Murphy SA. Practical considerations for data collection and management in mobile health micro-randomized trials. Stat Biosci. Jul 2019;11(2):355-370. [doi: 10.1007/s12561-018-09228-w] [Medline: 31462937]
109. Zainal NH, Liu X, Leong U, Yan X, Chakraborty B. Bridging innovation and equity: advancing public health through just-in-time adaptive interventions. Annu Rev Public Health. Apr 2025;46(1):43-68. [doi: 10.1146/annurev-publhealth-071723-103909] [Medline: 39656954]
110. Ramanadhan S, Alemán R, Bradley CD, et al. Using participatory implementation science to advance health equity. Annu Rev Public Health. May 2024;45(1):47-67. [doi: 10.1146/annurev-publhealth-060722-024251] [Medline: 38109515]
111. Barker TH, Stone JC, Sears K, et al. The revised JBI critical appraisal tool for the assessment of risk of bias for randomized controlled trials. JBI Evidence Synthesis. Mar 2023;21(3):494-506. [doi: 10.11124/JBIES-22-00430]
112. Klasnja P, Hekler EB, Shiffman S, et al. Microrandomized trials: an experimental design for developing just-in-time adaptive interventions. Health Psychol. Dec 2015;34S:1220-1228. [doi: 10.1037/hea0000305] [Medline: 26651463]

113. Lockwood C, Munn Z, Porritt K. Qualitative research synthesis: methodological guidance for systematic reviewers utilizing meta-aggregation. Int J Evid Based Healthc. Sep 2015;13(3):179-187. [doi: 10.1097/XEB.0000000000000062] [Medline: 26262565]
114. Wies B, Landers C, Ienca M. Digital mental health for young people: a scoping review of ethical promises and challenges. Front Digit Health. 2021;3:697072. [doi: 10.3389/fdgth.2021.697072] [Medline: 34713173]
115. Murnane EL, Jiang X, Kong A, et al. Designing ambient narrative-based interfaces to reflect and motivate physical activity. Presented at: CHI '20: Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems; Apr 25-30, 2020:1-14; Honolulu, HI. Apr 21, 2020.[doi: 10.1145/3313831.3376478]
116. Steele RG, Hall JA, Christofferson JL. Conceptualizing digital stress in adolescents and young adults: toward the development of an empirically based model. Clin Child Fam Psychol Rev. Mar 2020;23(1):15-26. [doi: 10.1007/s10567-019-00300-5] [Medline: 31392451]
117. Holly L, Demaio S, Kickbusch I. Public health interventions to address digital determinants of children's health and wellbeing. Lancet Public Health. Sep 2024;9(9):e700-e704. [doi: 10.1016/S2468-2667(24)00180-4]
118. Biasiotto R, Viberg Johansson J, Alemu MB, et al. Public preferences for digital health data sharing: discrete choice experiment study in 12 European countries. J Med Internet Res. Nov 23, 2023;25:e47066. [doi: 10.2196/47066] [Medline: 37995125]
119. Timmons AC, Tutul AA, Avramidis K, et al. Developing personalized algorithms for sensing mental health symptoms in daily life. npj Mental Health Res. Aug 6, 2025;4(1):34. [doi: 10.1038/s44184-025-00147-5]
120. Huckvale K, Venkatesh S, Christensen H. Toward clinical digital phenotyping: a timely opportunity to consider purpose, quality, and safety. NPJ Digit Med. 2019;2(1):88. [doi: 10.1038/s41746-019-0166-1] [Medline: 31508498]
121. Zhu S, Wang Y, Hu Y. Facilitators and barriers to digital mental health interventions for depression, anxiety, and stress in adolescents and young adults: scoping review. J Med Internet Res. Mar 24, 2025;27:e62870. [doi: 10.2196/62870] [Medline: 40127430]
122. Wilson KL, Flores S, Apata BO, Tasnim S, Garney WR, Ajayi KV. Understanding healthcare autonomy among adolescents and young adults in the United States: a scoping review. Front Health Serv. Jan 12, 2026;5:1720972. [doi: 10.3389/frhs.2025.1720972]
123. Wanniarachchi VU, Greenhalgh C, Choi A, Warren JR. Personalization variables in digital mental health interventions for depression and anxiety in adolescents and youth: a scoping review. Front Digit Health. May 15, 2025;7:1500220. [doi: 10.3389/fdgth.2025.1500220]
124. Baines R, Stevens S, Austin D, et al. Patient and public willingness to share personal health data for third-party or secondary uses: systematic review. J Med Internet Res. Mar 5, 2024;26:e50421. [doi: 10.2196/50421] [Medline: 38441944]
125. McGovern Ó, Glennon S, Walsh I, Gallagher P, McCashin D. The use of co-design with young people for digital mental health support development: a systematic review. Internet Interv. Sep 2025;41:100835. [doi: 10.1016/j.invent.2025.100835] [Medline: 40521225]
126. Hekler E, Tiro JA, Hunter CM, Nebeker C. Precision health: the role of the social and behavioral sciences in advancing the vision. Ann Behav Med. Nov 1, 2020;54(11):805-826. [doi: 10.1093/abm/kaaa018] [Medline: 32338719]
127. Leong U, Chakraborty B. Participant engagement in microrandomized trials of mHealth interventions: scoping review. JMIR Mhealth Uhealth. May 22, 2023;11:e44685. [doi: 10.2196/44685] [Medline: 37213178]
128. Fusar-Poli P, Estradé A, Esposito CM, et al. The lived experience of mental disorders in adolescents: a bottom-up review co-designed, co-conducted and co-written by experts by experience and academics. World Psychiatry. Jun 2024;23(2):191-208. [doi: 10.1002/wps.21189] [Medline: 38727047]
129. Vogel C, Kraft R, Antunes Lima R, Idrees AR, Steiger P, Pryss R. Extending a highly configurable EMA and JITAI mobile app framework with passive sensing, gamification, and AI features for a large-scale physical activity and nutrition study. In: Arabnia HR, Deligiannidis L, Shenavarmasouleh F, Amirian S, Ghareh Mohammadi F, editors. Computational Science and Computational Intelligence. Springer Nature; 2025:26-41. [doi: 10.1007/978-3-031-94950-0_3] ISBN: 978-3-031-94949-4
130. Verhulst SG. Operationalizing digital self-determination. Data & Policy. 2023;5:e14. [doi: 10.1017/dap.2023.11]
131. Kassam I, Ilkina D, Kemp J, Roble H, Carter-Langford A, Shen N. Patient perspectives and preferences for consent in the digital health context: state-of-the-art literature review. J Med Internet Res. Feb 10, 2023;25(1):e42507. [doi: 10.2196/42507] [Medline: 36763409]
132. Bolinger E, Tyl B. Key considerations for designing clinical studies to evaluate digital health solutions. J Med Internet Res. Jun 17, 2024;26:e54518. [doi: 10.2196/54518] [Medline: 38885020]
133. Liu X, Deliu N, Chakraborty B. Microrandomized trials: developing just-in-time adaptive interventions for better public health. Am J Public Health. Jan 2023;113(1):60-69. [doi: 10.2105/AJPH.2022.307150] [Medline: 36413704]
134. Kim J, Park S. Empowering individual preferences in mobile notifications: a balanced approach to cognitive load and information needs. IEEE Access. 2025;13:44936-44950. [doi: 10.1109/ACCESS.2025.3549033]

135. Wang S, Zhang C, Kröse B, van Hoof H. Optimizing adaptive notifications in mobile health interventions systems: reinforcement learning from a data-driven behavioral simulator. J Med Syst. Oct 18, 2021;45(12):102. [doi: 10.1007/s10916-021-01773-0] [Medline: 34664120]
136. Roberts C, Sage A, Geryk L, Sleath B, Carpenter D. Adolescent preferences and design recommendations for an asthma self-management app: mixed-methods study. JMIR Formativ Res. Sep 13, 2018;2(2):e10055. [doi: 10.2196/10055]
137. Zimmermann E, Tomczyk S. The ways of using social media for health promotion among adolescents: qualitative interview and focus group study. J Med Internet Res. Jun 9, 2025;27:e71510. [doi: 10.2196/71510] [Medline: 40489771]
138. Martinez-Martin N, Insel TR, Dagum P, Greely HT, Cho MK. Data mining for health: staking out the ethical territory of digital phenotyping. npj Digital Med. Dec 19, 2018;1(1):68. [doi: 10.1038/s41746-018-0075-8]
139. Poulsen A, Hickie IB, Chong MK, LaMonica HM, Turner A, Iorfino F. Personalised care, youth mental health, and digital technology: a value sensitive design perspective and framework. Ethics Inf Technol. 2025;27(4):61. [doi: 10.1007/s10676-025-09866-x] [Medline: 41142874]
140. Brückner S, Dridi A, Deshmukh A, et al. A user-driven consent platform for health data sharing in digital health applications. npj Digit Med. 2025;8(1):699. [doi: 10.1038/s41746-025-02147-3]

Abbreviations

AYA: adolescent and young adult
GAD-7: General Anxiety Disorder 7-item
GRADE: Grading of Recommendations, Assessment, Development, and Evaluation
JITAI: just-in-time-adaptive intervention
LLM: large language model
mHealth: mobile health
MRT: microrandomized trial
PHQ-8: Patient Health Questionnaire 8-item
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PRISMA-S: Preferred Reporting Items for Systematic Reviews and Meta-Analyses–Search extenion
PROSPERO: International Prospective Register of Systematic Reviews
RCT: randomized controlled trial
SWiM: Synthesis Without Meta-Analysis

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