mHealth for transgender and gender-expansive youth: harnessing gender-affirmative cross-disciplinary innovations to advance HIV prevention and care interventions

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Abstract: Transgender and gender-expansive (TGE) youth endure stark disparities in health and wellbeing compared to their cisgender peers. A key social determinant of health for TGE adolescents and emerging adults is gender affirmation, which encompasses multidimensional validations of an individual's lived gender. Lacking available resources for one's gender affirmation, TGE young people may engage in high-risk maladaptive coping behaviors, linked to their disproportionately high HIV-acquisition risk. A range of innovative mobile technologies are guided by the Gender-Affirmative Framework to promote the health of TGE communities, including through HIV prevention and care continuum outcomes. The aim of this review was to examine key features of existing mobile technologies that can be leveraged to advance the field of TGE-responsive mHealth. We systematically searched scientific records, gray literature, and the iOS and Android app distribution services. To be eligible, platforms and interventions needed to be tailored exclusively to a TGE user base, incorporate gender-affirming features, and be optimized for or adaptive to mobile technologies. Eligible interventions (N=24) were compared on evidence of utility, core functionalities, and dimensions of gender affirmation. Smartphone applications (apps) and webapps (n=16) were the most common delivery modality. Many interventions (n=9) aimed to address HIV-related outcomes and integrated gender-affirmative features. The most common gender-affirmative features originated in fields of human-computer interactions and informatics, or were crowdfunded by TGE developers. HIV-focused interventions incorporated evidence-based health behavior change strategies and utilized rigorous evaluation methods. Across modalities and disciplines, behavioral self-monitoring and access to HIV prevention services were the most frequent features. Over two-thirds of the interventions reviewed aimed to provide medical gender affirmation (e.g, provided guidance on obtaining medically sanctioned hormone therapies, or safely practicing non-medical options such as chest-binding) or psychological gender affirmation (e.g, provided linkage to mental health counseling). Our results show that mHealth and other technology-mediated interventions offer a diverse range of both evidence-based and innovative features; however, many have not been rigorously evaluated in a randomized controlled trial to support TGE users. A continuing commitment to evidence-based health behavior change strategies, exemplified by the HIV-focused interventions included in this review, is essential to advancing gender-affirmative mHealth. The unique and highly innovative features of platforms originating outside the fields of HIV prevention and care suggest new directions for TGE-responsive mHealth, and the need for more conscientious models of knowledge exchange with investigators across scientific disciplines, private-sector developers, and potential users.

Introduction

Despite some advances in public awareness and legal protections, transgender and gender-expansive (TGE) youth continue to face grave health inequities that stem from multiple sources, such as biased and exclusionary laws and policies, societal discrimination, and a lack of access to quality and affirming health care (1), increasing their risk for HIV acquisition (2): among transgender people living with HIV in the U.S, 36.3% were youth under the age of 24 (3). The field of HIV prevention is increasingly moving towards technology-mediated interventions for youth, as mobile health (mHealth) and electronic health (eHealth) are easily accessible and can be delivered in real time (4). However, despite the promise of technology-mediated interventions, there has been limited focus on how these interventions can be harnessed to address HIV prevention and care for TGE youth (5,6).

This review was specifically focused on youth who fall under the umbrella of TGE, including those who may be actively questioning their gender (7,8). To clarify our discussion, we begin by providing some key definitions; however, these brief descriptions may not capture all of the nuances in this rapidly evolving field. "Sex", or "natal gender", is a label, which is generally defined as "male" or "female", that is assigned at birth, while, "gender identity" is one's inherent sense of self, which results from a multifaceted interaction of biological traits, developmental factors, and societal context (9). "Gender expression" refers to the different ways people display their gender through clothing, hair styles, mannerisms, or social roles (10).

These labels may or may not be congruent. The term "cisgender" is used when someone identifies with and expresses a gender that is consistent with the culturally defined norms of the sex that was assigned to them at birth (11). "Transgender" is usually reserved for the subset of individuals whose internal gender identity is inconsistent with the sex assigned on their birth certificate (12). These terms are not diagnoses but are instead personal and often dynamic ways of describing one's gender experience. "Gender diverse" or "gender expansive" are umbrella terms that individuals may

apply when their gender identity, expression, or physical attributes do not conform to the norms and stereotypes others expect of their assigned sex (13). More recently, the terms "nonbinary" or "genderqueer" have been adopted within scientific discourse and among many TGE communities to refer to individuals who do not conform to binary conceptualizations of gender as either male or female (14). In this review, we intentionally use the terms *TGE* to describe all non-cisgender youth, as some people use multiple gender identities and, additionally, some gender identities change across one's life course. For example, some nonbinary people identify as transgender; however, others do not (8). Thus, the term gender-expansive provides a means to begin to accommodate different experiences, expressions, and self-identifications (8).

Although few probability studies assess gender identity, it's been estimated that 0.7% to 3.2% of youth identify as transgender (15,16). These adolescents and emerging adults can find social inclusion elusive, and may lack access to tailored health resources. A recent nationally representative survey of 5,765 TGE teens, ages 13–17, found that less than a quarter feel safe being themselves at home and in school; 72% have heard their families make denigrating remarks toward sexual and gender minorities; and 84% have been threatened at school, a setting in which only 10% reported receiving safer sex information responsive to their lives and identities (8). TGE youth, particularly youth of color, are also at substantial risk of a multitude of adverse outcomes, with 25–43% experiencing unstable housing/homelessness (17,18), 66% enduring unemployment (18,19), 67% engaging in survival sex (17), and 1 in 10 surviving physical assault (20). To date, the majority of research among TGE youth has focused on the role stigma and discrimination play in creating or exacerbating these adverse social and health conditions (21).

More recently, the field has moved towards embracing gender affirmation as a key social determinant of health for gender-expansive people (22,23). The "Gender Affirmation Framework" refers to a multifaceted and often long-term process through which TGE individuals align their internal senses of embodiment and external expressions of

culturally bound gender norms with their inherent gender identities (24). Not getting gender affirmation needs met across different dimensions such as medical (e.g, exogenous hormone therapy to develop a more gender-congruent sense of embodiment, including through physical features), social (i.e, use of correct name and pronouns), psychological (i.e, perceptions of respect), and legal (i.e, name change documentation) can place TGE youth at increased risk of emotional distress, suicidality, sexual risk behaviors, medical mistrust (23,25,26), and serve as a barrier to engaging in HIV prevention and care (27). According to the Gender Affirmation Framework (24), lacking accessible sources of gender affirmation, TGE individuals may seek validation of their emerging identities through high-risk behaviors such as condomless anal sex (CAS) and bodily modifications in non-medical settings. TGE youth have reported rates of CAS between 27–48% and non-medical injection of hormones or silicone between 24–27% (28). Widespread stigma, sexism, and other vectors of oppression place already marginalized subpopulations, such as TGE youth of color, at particularly high risk of HIV acquisition (24). Given the complex risk profiles of many TGE communities, innovative approaches that address both gender affirmation and HIV prevention and care are needed.

Technology engagement among TGE youth

Teenagers across the LGBTQ spectrum report spending an average of 5 hours online every day, 45 minutes longer than their non-LGBTQ peers, with 76% preferring online chat or text message options when seeking support in a crisis (29,30). Within the LGBTQ spectrum, 26% of transgender youth communicate online with LGBTQ friends daily or almost daily, while 20% or less of their cisgender peers exhibit similar frequency. Using the internet to acquire health information was near-universal among transgender youth: 95% report doing so, versus 80% or less of their LGB peers. In regards to accessing HIV/AIDS and STI information online, transgender youth were outpaced only by cisgender gay and bisexual young men (29). Given these patterns of technology use (4,5,31), technology-mediated modalities are ideal for delivering gender-affirming health interventions to TGE young people, including interventions focused on HIV prevention and care. Social media, and other online venues that enable peer-to-peer interaction, selective self-presentation, and the sharing of user-generated content (32,33), can be essential sources of gender affirmation for TGE youth (34-36).

The features of these platforms can subvert the isolation and routine invalidations endured by TGE youth who do not have access to affirming homes or schools. For example, TGE Tumblr users can obtain social connection by making meaning of their experiences, establishing peer-to-peer "care structures" navigable via an array of gender-specific hashtags (37,38). TGE youth and their caregivers can equip themselves with clarifying terminologies and discover both on- and offline support networks through listservs, social forums, and the websites of local nonprofits (39). But the unique features of online platforms also enable harms that disproportionately impact TGE communities. Cyberbullying, harassment, stalking, and other abusive online behaviors are directed toward TGE youth at disparate rates (40). Many, as a result, may feel anxious, depressed, or suicidal (29,41,42). Misinformation and non-evidence-based anecdotes on gender-affirming care discoverable online can jeopardize TGE young people's wellbeing (39).

For many TGE youth, technology-mediated interventions are situated within this rich, yet fractious, online milieu, in which TGE youth spend approximately 5 hours daily (29). Recent mHealth interventions, which aim to build upon evidence-based bio-behavioral HIV prevention strategies, intend to activate this online milieu to advance the health and wellbeing of these vulnerable communities (43). Notably, the field of HIV prevention is not alone in advancing gender-affirming mobile interventions for TGE communities. The importance of gender affirmation in promoting the health and wellbeing of TGE communities has driven the development of other, distinct lineages of technology-mediated interventions tailored toward the needs of TGE communities (44,45). Often, these platforms are aligned with human-computer interaction (HCI) disciplines, or rely on crowdfunding, open-source architectures, and robust community engagement for sustainment (46-48). The core functionalities of these platforms intend to aid TGE users in affirming their gender identities and navigating their lives safely as TGE individuals (45,49). Notably, the functionalities often do not explicitly engage with traditional HIV prevention and care strategies; however, their emphases on gender affirmation is aligned with contemporary understandings of HIV acquisition among high-risk TGE populations. Specifically, these functionalities frame HIV transmission risk behaviors as maladaptive attempts to attain gender affirmation in oppressive, invalidating settings, where safer sources of

Table 1 Conceptualization of key terms in research question

Key term	Definition	Source
Customized software	Software "designed, created, deployed, and maintained," for a defined set of users, or specified functions	Custom software development, IBM (59)
Mobile networked technologies	Portable communications and computing devices—"typified by internet-enabled devices like smartphones, tablets and (smart) watches"—and the networking technology that connects them	Mobile technology, IBM (60)
mHealth	Medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices	mHealth: New Horizons for Health Through Mobile Technologies, Global Observatory for eHealth of the WHO, 2011:6 (61)
Young TGE communities	Adolescents and emerging adults whose gender transcends the sex assigned to them at birth (i.e., transgender) including individuals who do not embrace the "transgender" label (i.e., gender-expansive)	Gender-Expansive Youth Report, HRC: Human Rights Campaign, 2018:5 (8)
Affirming their lived genders	Developmentally appropriate care that appreciates and supports a youth's evolving gender experience as a non-pathological aspect of human diversity	Ensuring Comprehensive Care and Support for Transgender and Gender-Divers Children and Adolescents, AAP: American Academy of Pediatrics, 2018:4 (62)

validation are unavailable (24).

As such, a cross-disciplinary scoping review of smartphone-based, SMS, telemedicine, and other TGE-focused mobile technology-mediated interventions has the potential to provide new directions in honing the next generation of mHealth designed to improve HIV prevention and care with and for TGE youth. The present review aims to identify and describe a diverse catalog of technological platforms guided by the tenets of the Gender Affirmation Framework. In doing so, we adopt the lens of Affordance Theory, which views technological features in terms of *imagined affordances*: the human-perceptible actions and possibilities inherent in new technologies, emphasizing the previously inconceivable expectations and socio-cultural meanings they may accrue over time. "Human-perceptible", in this context, refers to possibilities that the end-user is aware of and, therefore, may integrate into their daily lives (50). Thus, a focus on affordances foregrounds new potentials that rely on the unique interplays between human and technological agency (51).

Methods

We used the Arksey and O'Malley five-stage framework for scoping review studies (52,53). A scoping review was chosen over a systematic review so that we could include a broad range of technology-mediated interventions, use a multi-pronged search strategy to capture traditional clinical trials (in progress, where necessary), and community-derived innovations across disciplines. We did not place any restrictions on publication type. In this, our approach is consistent with recent scoping reviews in mHealth and eHealth (54-57).

Stage 1: identifying the research question

The rationale for the review arose from the discontinuity and lack of knowledge sharing in the areas of gender-affirmative technology-mediated interventions evident across disciplines—specifically, between HIV-focused mHealth and parallel developments in informatics, HCI, and outside of traditional research infrastructures entirely. Our objective was to analyze these rich but varied advances through a single lens, guided by the Gender Affirmation Framework, and the abovementioned concept of imagined affordances.

Thus, the research question guiding our scoping review was: "*How has customized software, optimized for or adaptive to mobile technologies (including mHealth), aimed to advance the health and wellbeing of young TGE communities by affirming their lived genders?*"

The conceptualization of our key terms, in emulation of the format presented by Adepoju *et al.* (58), are shown in *Table 1*.

Table 2 Inclusion and exclusion criteria applied

Aspect	Included	Excluded
Primary intended users	Platforms and mobile/telehealth interventions tailored for TGE individuals and communities exclusively, of adolescent, emerging adult, or unspecified age range—but not explicitly tailored for older adults	Platforms for undefined/universal user bases and clinicians exclusively (e.g., e-Consult); those tailored for broader sexually and gender-diverse communities, which may or may not include TGE individuals; and those tailored for cisgender users seeking sexual encounters with TGE individuals
Core features	Platforms that aim to advance aspects of medical/embodied, psychological, social, and/or legal gender affirmation, or to advance circumstances through which gender diversity can be safely and openly lived	Platforms that lack interactivity (e.g., static websites, net art), consist solely of games or passive media, or consist exclusively of geosocial/sexual networking or dating features
Modality	Platforms optimized for or adaptive to mobile networked technologies such as smartphones, tablets, and smartwatches	Platforms exclusive to desktop computers or other non-mobile technologies, or telehealth extensions of primarily brick-and-mortar providers

Telehealth interventions were compiled prior to the COVID-19 pandemic, which has led to an immense scaling up of telehealth deployments in response to widespread physical distancing measures (66,67).

Stage 2: identifying relevant studies

To capture empirical articles, formative research, and other traditional publication types in medical, behavioral, and socio-technical science, PubMed, PsycINFO, and the ACM (Association for Computing Machinery) Digital Library were queried. To capture gray literature such as project reports, funding prospectuses, blogs, and popular media reporting, Google and DuckDuckGo (a search engine on the open web that forgoes the algorithmically personalized rankings that can render Google's search results impossible to replicate) (63) were used. Recent reference lists were hand-searched by the first author (SJS). All records were compiled and screened using the Zotero reference manager (64).

Search terms were developed iteratively, based on pilot searches in Google Scholar. Our final terms comprised "trans*gender", "genderqueer", "non*binary", "gender expansive", "gender diverse", "agender", "youth", "adolescent", "online", "web app", "tech*", "counsel*", "HIV", "health", "mobile", and "text message" alone and in combination. Results were unrestricted by date.

Additionally, Google Play and the App Store, the mobile app distribution services for the Android and iOS smartphone operating systems, respectively, were searched directly for software relevant to our abovementioned objective. Each was queried with the term "transgender", and the full results were screened against our selection criteria.

Our search was limited to English-language reporting and platforms. All searches were undertaken initially by the first author (SJS) in August, 2019, with secondary title/abstract screening by a research intern (AP) in November,

2019. All databases were systematically re-queried, and our results updated, in April and May, 2020.

Finally, as the authors are involved in various roles within the UNC/Emory Center for Innovative Technology (iTech) (65), we were able to include the integrated TechStep platforms prior to any external reporting on that intervention.

Stage 3: study selection

The inclusion of mHealth and other platforms in this review was dependent on the selection criteria shown in *Table 2*. Out of our initial 565 candidate platforms identified via title/abstract screening, gray literature searches, app distribution services, and the iTech network, 24 were selected for inclusion. The complete process is illustrated in *Figure 1*.

Stage 4: charting the data

Consistent with Arksey & O'Malley (52), we developed a descriptive-analytical summary of our findings, delineating key aspects of each platform for comparison, with a focus on distinguishing novel gender-affirming functionality. The respective platforms' key features were categorized inductively by the first author with the aid of a consensus coder (AP).

The four recognized dimensions of gender affirmation were adapted from the typology of gender affirmation as a social determinant of health described by Reisner *et al.* (23),
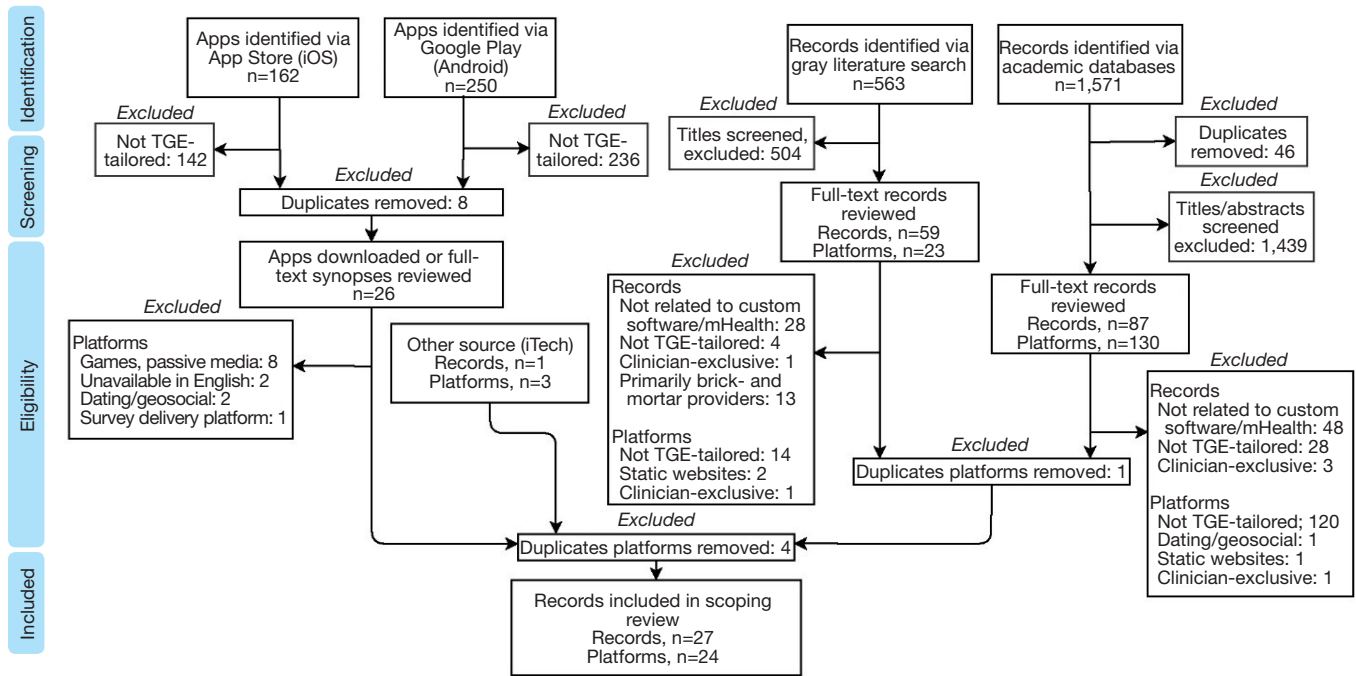
Figure 1 Flow diagram illustrating the search and selection of commercially available and in-development or mid-evaluation platforms and interventions.

and defined in the previous section. Because many approaches to bodily gender affirmation (e.g, chest binders, electrolysis) can be accessed outside of medical settings, we replace "medical" with *embodied* in the present typology. These dimensions were assigned by the first author with the aid of a second consensus coder (PG). In both coding procedures, discrepancies were resolved in conference until unanimity was reached.

Stage 5: collating, summarizing, and reporting the results

We then compiled and summarized the results of each of the platforms and report on comparisons between platforms in the use of evaluation methods, theoretical grounding, key/unique features, and dimensions of gender affirmation.

Results

The final sample included 24 platforms or interventions, in widely disparate phases of development. Their names and brief descriptions, modes of delivery, state of their evidence bases, theoretical groundings (if specified), key or noteworthy features, and the dimensions of gender affirmation they aim to engage, are presented in *Table 3*.

Outcomes and efficacy

Of the 24 platforms examined, nine included HIV prevention and treatment outcomes, with seven platforms HIV focused; three had undergone pilot studies that provided acceptability and feasibility outcomes, and only one used a fully powered randomized controlled trial (RCT) to evaluate intervention efficacy. One pilot study, *Project Moxie*, which is a remote video counseling intervention, found that approximately half of the total participants assigned to the intervention group took part in the counseling sessions; however, the TGE participants who did take part reported uniformly high rates of satisfaction with the counseling and software. Although sexual risk behaviors remained unchanged at 3 months, there was a significant increase in STI testing rates and PrEP acceptability among participants at 3 months (73). *Trans Women Connected*, a small acceptability and usability pilot study, showed increases in self-efficacy to access specialized and online support (102). Similarly, the unnamed Washington, DC– based telehealth intervention, which included HIV services among its referrals, showed increases in users' intentions to seek TGE-affirming and other specialized care (104). *Text Me, Girl!*, which provided trans women with supportive text

Table 3 Summary of technology-mediated (N=24) interventions tailored for or inclusive of TGE youth

Name, description	Modality	HIV prevention– and/or care-focused	Evidence summary	Explicit theoretical grounding	Key/unique features	Gender affirmation dimension
Binder Reminder is tailored toward trans-masculine, nonbinary, and other users who wear compressive chest binders to reduce the appearance of natal breasts. The app consists of a simple interface that permits users to set time- and location-based alerts to remove their binder or undertake brief stretching exercises. These features aim to stem the discomfort and shortness of breath that can accompany uninterrupted binding (68). The developer engages the community on Tumblr, where updates are shared and user feedback is solicited (46).	Smartphone app: Android exclusive	No	No *Binder Reminder* formal outcomes evaluations have been reported.	n/a	Behavioral self-monitoring	Embodied; psychological; social
Christella VoiceUp: voice modification toolkit (69), cf. *EVA: Exceptional Voice App*.	Smartphone app: iOS and Android	No	Cf. *EVA: Exceptional Voice App*.	n/a	Behavioral self-monitoring; biofeedback[†]	Embodied; psychological; social
EVA: Exceptional Voice App comprises a suite of tools, in "MTF" and "FTM" editions. Developed by a speech pathologist, *EVA* offers users educational modules and biofeedback tools to aid trans-feminine and trans-masculine users in modifying their voices to align with binary, cis-centric, norms (49).	Smartphone app: iOS and Android	No	*EVA* and interventions with equivalent functionality [e.g., *Christella VoiceUp* (69)] have not been subjected to formal outcomes evaluation. But formative research in HCI has interrogated the pathologizing and rigidly binary assumptions ingrained in these apps' features, calling their acceptability into question (70). Contrary to the assimilationist framing of these apps' primary outcomes, most trans-feminine participants (N=7, M_{age} =26.3) recounting their experiences with voice training were motivated by physical safety concerns and self-affirmation (71).	n/a	Behavioral self-monitoring; biofeedback	Embodied; psychological; social
PatchDay: hormone self-monitoring platform (72), cf. *Trans Memo*.	Smartphone app: iOS exclusive	No	No *PatchDay* formal outcomes evaluations have been reported.	n/a	Behavioral self-monitoring	Embodied; psychological
Project Moxie combines online HIV test counseling with self-administered rapid HIV testing via kits mailed to participants. The intervention, which deploys HIPAA-secure VSee videoconference software, combines MI and counseling, testing, and referral approaches to address HIV transmission risk and testing among TGE youth, with linkage to medical care and other services, as indicated (6).	Telemedicine/ online video counseling	Yes	*Project Moxie* recruited 202 participants, ages 15–24, who did not identify with the sex assigned to them on their birth certificate, to take part in a pilot study. While approximately half of participants assigned to the intervention took part in the counseling sessions, satisfaction with the counselors and the videoconference software, and willingness to repeat and recommend the intervention, were both uniformly high among this cohort. Willingness to use PrEP saw increases in both the intervention and control samples. Gains in STI testing were shown at 3 months in the intervention sample (73).	MI (74)	HIV testing and counseling; remote video counseling	Psychological
QueerDoc: online-only gender-affirming telemedicine practice (75), cf. *QMed*.	Telemedicine/ online video counseling	No, but PrEP and STI testing are offered	Cf. *QMed*.	n/a	Remote video counseling	Embodied; psychological
QMed [aka *QueerMed*] is a telemedicine practice that offers specialized trans-affirmative healthcare to TGE youth across the southeastern U.S., with a focus on serving adolescents in rural settings. Deploying HIPAA-secure videoconference software, TGE and gender-questioning young people can be evaluated for hormone therapy, and connected to labs for bloodwork and mental health counseling, as indicated (76).	Telemedicine/ online video counseling	No	*QMed* and practices with equivalent models of care [cf. *QueerDoc* (75)], have not been subjected to formal outcomes evaluation. But their feasibility for rural TGE patients may be hampered by unreliable Internet connectivity, a state-by-state patchwork of medical licensure among practitioners, and inconsistent telemedicine parity laws, which require insurers to compensate providers at rates equivalent to an in-office visit, by state (77).	n/a	Remote video counseling	Embodied; legal; psychological
QueerViBE is a private web-based platform that provides trans-masculine and nonbinary youth with 6 interactive YouTube tutorials, of 6–12 minutes, which aim to subvert hegemonic cis-centric norms of masculinity and thus to validate the identities and expressions of its users. Its content is theoretically grounded in a discursive analysis of focus group data obtained from sexual and gender-minority male youth (n=28, ages 16–24).	Internet/webapp	No	In a preliminary RCT, which recruited trans-masculine, nonbinary, gender-questioning, and intersex participants (N=156, ages 15–21), *QueerViBE* showed significant improvements in the trial's primary outcome variables: At 1-month follow-up, individual and collective self-esteem, wellbeing, and positive trans identity were elevated among *QueerViBE* users compared to a waitlist control group. But, to date, no sustained outcomes have been measured (44).	CBT (74); hegemonic masculinities (78); heterosexual matrix (79); invalidation and microaggressions (80); policing masculinities (81); power and representation (82,83)	Psychological; social
Refuge Restrooms maps publicly accessible single-occupancy and gender-neutral restrooms for TGE and intersex users who may feel uncomfortable or be targets of harassment and violence in binary gendered toilet facilities (47). Listings on *Refuge Restrooms* can be submitted, rated, and commented upon by users. It is open source, and offers features closely equivalent to its now-inoperative forebears [cf. *GotYourBack* (84); *TranSquat* (85)] and platforms of equivalent functionality (cf. *Safe Transgender Bathroom App* (86). As well, the *Refuge Restrooms* database is now available as a contact on the *YO* messaging app, allowing users to send a "YO" to the database and, in response, receive a hyperlocal listing of safe restrooms based on their present location (87).	Internet/webapp; smartphone app: iOS and Android	No	No *Refuge Restrooms* formal outcomes evaluations have been reported.	n/a	Geolocational tracking and networking; personal safety; TGE-curated brick-and-mortar resources; user-generated content	Psychological; social

Table 3 *(continued)*

Table 3 (continued)

Name, description	Modality	HIV prevention– and/or care-focused	Evidence summary	Explicit theoretical grounding	Key/unique features	Gender affirmation dimension
Safe Transgender Bathroom App: gender-neutral/single-occupancy restroom locator (86), cf. *Refuge Restrooms*.	Smartphone app: iOS exclusive	No	No *Safe Transgender Bathroom App* formal outcomes evaluations have been reported.	n/a	Geolocational tracking and networking; personal safety; TGE-curated brick-and-mortar resources; user-generated content[‡]	Psychological; social
ShotTraX: hormone self-monitoring platform (88), cf. *Trans Memo*.	Smartphone app: iOS and Android	No	No *ShotTrax* formal outcomes evaluations have been reported.	n/a	Behavioral self-monitoring	Embodied; psychological
Solace LGBT, a smartphone app, presents users with a customizable menu of common gender-transition goals, e.g., updating legal documents, acquiring new wardrobes, and accessing hormone replacement therapies with necessary multidisciplinary assessments and diagnostic prerequisites by U.S. state or territory. The app includes a progress tracker (cf. *TransTracks* (89), for equivalent functionality) that encourages users to monitor their progress toward selected goals; a passcode system to protect their privacy; integration with *Respite*, an aggregator of news relevant to TGE communities; and Solace Child Mode, for parents and guardians of TGE legal minors (48).	Smartphone app: iOS and Android	No	No *Solace LGBT* formal outcomes evaluations have been reported.	n/a	Behavioral self-monitoring; TGE-curated brick-and-mortar resources; TGE-curated informative resources[§]	Embodied; legal; psychological; social
Spokane Trans Map is a smartphone app focused on an interactive map of Spokane, Washington, allowing TGE contributors to signify TGE-friendly businesses with green markers, and TGE-hostile businesses with red markers, based on their personal experiences. Single-occupancy restrooms are mapped as well. A project of the *Solace LGBT* developer, *Spokane Trans Map* is exclusive to that city (90).	Smartphone app: iOS and Android	No	No *Spokane Trans Map* formal outcomes evaluations have been reported.	n/a	Personal safety; TGE-curated brick-and-mortar resources; user-generated content	Psychological; social
TechStep: webapp provides users a customizable profile; a "wall" on which to post personal updates, photos, videos, and to respond to other users' posts; multimedia content curated by TGE youth; resources for HIV testing, PrEP, PEP, hormone therapy, housing, legal, and abuse support services; and a customizable behavior tracker, which prompts users to administer PrEP, hormones, or to monitor any behavior they may specify. User interactions are moderated for harassment, threats, and sexual networking, and de-anonymizing content. Gamification elements allow users to unlock new customization options with routine use of *TechStep*'s features. These features reflect the insights of TGE youth focus groups, convened prior to the webapp's development (43). Resources are currently limited to the trial's subject recruitment venue cities.	Internet/webapp	Yes	The *TechStep* 3-arm RCT study, which includes the webapp, SMS, and eCoach components (*see below*), is actively enrolling HIV-negative participants that are at risk of HIV acquisition and who do not identify with their assigned sex (target N=250, ages 15–24). Primary outcome variables include reduced sexual risk behaviors and PrEP uptake, with follow-up assessments at 3, 6, and 9 months post-enrollment, compared to a static TGE-tailored and HIV/STI- informative website. Secondary outcomes include experienced transphobia, housing precarity, and other structural factors as moderators of sexual risk (43).	IMB model (91)	Behavioral self-monitoring; content moderation; customizable user profiles; gamification; HIV testing and counseling; social networking; TGE-curated brick-and-mortar resources; TGE-curated informative resources; user-generated content	Embodied; legal; psychological; social
TechStep: SMS presents participants with 3 text messages daily for 90 days, grounded in Social Support Theory (social support), Social Cognitive Theory (self-efficacy), and the Health Belief Model (health-protective behaviors and health threats). Each theory corresponds to 90 distinct messages along the HIV Prevention Continuum, for a total library of 270 messages. The text messages cover holistic understandings of health and wellness, linkage to HIV prevention services, and PrEP uptake and adherence (43).	SMS/text message	Yes	Immediate and sustained effects will be compared to those of the *TechStep: webapp* (*see above*) condition on the RCT's primary outcomes of interest (43).	Health belief model (92); socio-cognitive theory (93,94); social support theory (94,95)	HIV testing and counseling; TGE-curated informative resources	Psychological; social
TechStep: eCoaching is an online counseling intervention tailored toward *TechStep: webapp* and *TechStep: SMS* users who could benefit from a more intensive model of care. At the trial's 3-month assessment, *TechStep* users engaging in refractory sexual risk behaviors may be re-randomized to the "eCoaching" intervention. Its 5–8 sessions, which rely on HIPAA-secure Zoom videoconference software and novel integrated platforms for both eCoach and user, combine an MI approach with adapted elements of CBT. The intervention aims to build communication, self-regulation, self-monitoring, and problem-solving skills, tailored toward the needs and experiences of high-risk TGE youth (43).	Telemedicine/online video counseling	Yes	*TechStep: webapp* and *TechStep: SMS* participants who meet criteria for HIV risk behaviors at the 3-month follow-up will be randomized to either be stepped up to the more intensive eCoaching intervention or stay in their current study arms. Outcomes will be evaluated on between-group differences on sexual risk between a more versus less intensive intervention for high-risk TGE youth (43).	MI, CBT (74)	Behavioral self-monitoring; remote video counseling	Psychological; social

Table 3 (continued)

Table 3 *(continued)*

Name, description	Modality	HIV prevention– and/ or care-focused	Evidence summary	Explicit theoretical grounding	Key/unique features	Gender affirmation dimension
Text Me, Girl! aims to improve health outcomes among young adult HIV-seropositive trans women. Specifically, recipients were sent 3 text messages daily (from a library of 270) within a customizable timeframe. Similar to *TechStep: SMS* (*see above*), but for young adult trans women living with HIV, the *Text Me, Girl!* message content was theoretically grounded in Social Support Theory (social support), Social Cognitive Theory (self-efficacy), and the Health Belief Model (health-protective behaviors and health threats). Community insights informed the messages' content, via an iterative process the included feedback from a culturally diverse community advisory board comprising trans-feminine stakeholders (96).	SMS/text message	Yes	*Text Me, Girl!* enrolled 130 young adult (ages 18–34) trans women living with HIV. At baseline, only 35% of participants were virally suppressed, and only 5% reported their ART medication adherence as "excellent." By 18-month distal follow-up, 52% of the participants were virally suppressed and 38% had achieved "excellent" ART adherence. ART uptake also significantly increased from 49% at baseline to 77% at 18-month distal follow-up. Multivariate analyses indicated that increased engagement in *Text Me, Girl!* was associated with significantly increased likelihood of attending a HIV doctor visit in the past six months, and increased probability of achieving an undetectable viral load. Multivariable results also indicated that retention in *Text Me, Girl!* was associated with significantly improved ART adherence, and significantly increased likelihood of achieving an undetectable viral load (97).	Health belief model (92); socio-cognitive theory (93,94); social support theory (94,95)	TGE-curated informative resources	Psychological; social
they2ze combines regularly updated multimedia curated by TGE youth; resources for employment services, food, emergency financial assistance, online peer forums, hormones, PrEP, and PEP access, and HIV testing, counseling, and care; "Gender 101" pages providing outbound links to evidence-based information on gender-affirming surgeries, and fertility and immigration concerns for TGE communities. Educational modules for providers, aiding them in building a trans-affirmative practice, are included. *they2ze* incorporates the insights of a community advisory board of TGE youth. Currently, resources are limited to the San Francisco Bay Area (98).	Smartphone app: iOS and Android	Yes	No *they2ze* formal outcomes evaluations have been reported.	n/a	TGE-curated informative resources; TGE-curated brick-and-mortar resources; HIV testing and counseling; Provider education	Embodied; legal; psychological
Trans Memo [aka *Testo Memo*] provides TGE users a simple interface to set reminders to administer their hormones. It includes options to monitor supplies and track the regularity and adherence of hormone administration over time (99). Its features are functionally near-equivalent to similar platforms such as *PatchDay* (72) and *ShotTraX* (88).	Smartphone app: Android exclusive	No	No *Trans Memo* formal outcomes evaluations have been reported.	n/a	Behavioral self-monitoring	Embodied; psychological
Trans Pelvic Health [aka *Kegel Nation*] is a prototype that enables users recovering from gender-affirming genital reconstructive surgeries to track pelvic floor exercises, urinary frequency and urgency, and regularity of douching and dilating the neovagina, as indicated. Its features are adaptable to surgical procedures typically undertaken by both trans-masculine and trans-feminine individuals (100).	Smartphone app: iOS exclusive	No	A small usability and acceptability study (N=10, ages 40–70) recorded high ease of use. But it is unclear whether the participants were members of the app's target population (100).	n/a	Behavioral self-monitoring	Embodied
TransTracks: gender transition progress tracker (89), cf. *Solace LGBT* (48).	Smartphone app: iOS and Android	No	No *TransTracks* formal outcomes evaluations have been reported.	n/a	Behavioral self-monitoring	Embodied; psychological
Trans Women Connected is an mHealth app undergoing iterative prototyping at the time of writing. Its functionality is grounded in qualitative formative research with trans-feminine communities, and its developers, UX specialists, and engineers worked in tandem with an expert advisory panel of trans women of color leaders in service provision. The most recently reported prototype incorporates a vision board permitting users to set personal goals across structural domains such as schooling, employment, and housing (as well as motivations such as "making a difference"), allowing its trans-feminine target users to collage their own photos and/or create original images and text; educational video modules on PrEP, and a map of local PrEP providers; and an interactive resource map that taps users' smartphone GPS to show them local providers of medical, social, legal, educational, employment, and housing services (101).	Smartphone app: iOS and Android	Yes	Formative work comprised a series of 4 focus groups and 20 individual interviews (N=57) with trans women in 4 cities across the U.S. Those findings emphasized the importance of structural determinants of trans women's health, their holistic understandings of their sexual health, and desires for supportive bonds with other trans women (101). These insights informed the current prototype, which underwent usability and acceptability evaluations with trans-female testers (N=16). Ratings overall were high, with significant post-test increases in self-efficacy to access LGBTQ+ services, intention to seek online support, and PrEP knowledge. Following further prototyping, including plans to embrace elements of CBT and the Gender Affirmation Framework, *Trans Women Connected* will be evaluated in a forthcoming cluster RCT (102).	Unspecified	HIV testing and counseling; TGE-curated informative resources; TGE-curated brick-and-mortar resources; User-generated content	Embodied; legal; psychological; social

Table 3 *(continued)*

Table 3 *(continued)*

Name, description	Modality	HIV prevention– and/or care-focused	Evidence summary	Explicit theoretical grounding	Key/unique features	Gender affirmation dimension
[unnamed telehealth intervention, Washington DC]. Deploying the HIPAA-secure *Digigone* videochat app, alongside texting, emailing, and telephone options, this telehealth intervention provided Washington, DC-based trans women of color with 24-hour access to local peer health consultants, a model that has shown success in serving other populations with unique healthcare needs (103). The aim of the intervention was to leverage telehealth and mobile technology toward overcoming the structural barriers faced by many trans women of color when they try to secure healthcare access. The peer consultants provided "one-stop shopping" for vetted information and specialty referrals—including housing, legal, and educational programs—in response to queries by users (103), with monthly consultant-initiated check-ins in the absence of any other contacts. Physicians were available at all times to address emergencies or urgent issues beyond the purview of the consultants.	Telemedicine/online video counseling	No, but HIV care was among the referrals available	The intervention was grounded in insights provided by trans women of color and healthcare providers specializing in their needs (N=22, including 4 trans-female providers) in the Washington, DC, area. The qualitative data focused on housing stability as a key determinant of health and wellbeing, the primacy of hormone access among healthcare needs, and pervasive experiences of discrimination, stigma, and medical mistrust. In turn, the peer-delivered telehealth model was adapted to provide users with convenience, individualized care, and relief from unwelcoming healthcare settings (103). In a small (N=25) feasibility study enrolling trans women of color with experiences of encountering structural barriers to care in the prior 6 months, the 3-month intervention was linked to significant increases in intention to seek TGE-responsive care, and intentions to seek specialty, mental health, and HIV care among users with depressive symptoms (104).	n/a	HIV testing and counseling; remote video counseling; TGE-curated brick-and-mortar resources; TGE-curated informative resources	Embodied; legal; psychological; social
U-Signal is a prototype that combines smartphone and smartwatch functionalities to support the safety of trans-feminine and nonbinary users. By tapping the smartwatch screen, *U-Signal* can be subtly activated, sending an SMS or voice-recorded alert to a user's social network, and communicating their GPS coordinates consistently thereafter. Customizable user profiles and social networking functionalities are included (45).	Smartphone, smartwatch	No	The app's features were based on 9 initial interviews and 7 follow-up interviews with trans women, and trans-feminine and nonbinary people of color. Their feedback suggests high acceptability, with the bypassing of police and medics in favor of peer networks portrayed as "everyone's favorite" feature. Concerns around expense and accessibility, particularly for non-English speakers, were raised (45).	n/a	Customizable user profiles; Geolocational tracking and networking; Personal safety; social networking	Psychological; social

Evidence summaries are as of May 2020. "Explicit theoretical grounding" includes widely embraced therapeutic orientations. [†], *Biofeedback* refers to functions that directly record behavioral data (e.g., steps taken daily), distinct of storing manually input self-monitored behavioral data. [‡], *User-generated content* refers to posts and comments supplied by users, similar to social media, which may encompass a range of multimedia and informative resources, but are not integrated into a platform's pre-existing core features. [§], *TGE-curated informative resources* refers to educational modules and/or outbound links (distinct of offline, i.e., "brick-and-mortar," resources) that are tailored or approved by TGE stakeholders and integrated into their respective platforms' core features. CBT, cognitive behavioral therapy; FTM, female to male; MI, motivational interviewing; MTF, male to female; RCT, randomized controlled trial; TGE, transgender and gender-expansive.

messages, demonstrated significant outcomes for increased antiretroviral treatment (ART) uptake, excellent ART adherence, and viral suppression among trans-feminine young adults (ages 18–34) living with HIV (97). As of May 2020, *TechStep*, with its *webapp*, *SMS*, and *eCoaching* platforms (which we reviewed independently) are in the midst of a randomized controlled trial to determine their efficacy in reducing behavioral risk for HIV/STI acquisition and encouraging PrEP uptake and adherence (43). The *they2ze* app, developed by the nonprofit YTH [Youth + Tech + Health (98)], and the *QueerDoc* telehealth service (75), both include linkages to HIV services. However, as of this writing, no data regarding intervention outcomes or efficacy have been reported for either platform.

The other platforms (n=15) whose primary aims did not focus explicitly on HIV prevention or care have not presented evaluation data to establish their efficacy or effectiveness. Many appeared to be early in development and pilot testing; thus, qualitative feasibility and acceptability data provided by small groups of target users was most commonly provided. For instance, *U-Signal*, an integrated smartphone-smartwatch platform designed to enable peer-to-peer alerts of imminent personal safety risks among trans-feminine and nonbinary communities of color, showed strong acceptability among seven TGE interviewees who reviewed the prototype (45). *Trans Pelvic Health*, a prototype iOS app that tracks key aspects of self-administered aftercare for gender-affirming genital surgeries (e.g, vaginoplasty), such as urinary frequency and routine Kegel exercises, show satisfactory preliminary usability among 10 pilot users, though it is unclear if these users were TGE (100). The exception was *QueerViBE*, which comprises a series of online educational modules, grounded in discursive analysis of TGE youth focus groups, and aiming to evoke self-esteem and positive transgender identity among its trans-masculine and nonbinary users, *QueerViBE* demonstrated preliminary efficacy using an RCT design; however, the study lacked follow-up measures beyond one month (44).

Theoretical grounding

Among the 24 platforms, six described their theoretical groundings, which were mostly focused on HIV (n=5), with the exception of *QueerViBE*. The two SMS-enabled interventions reviewed, *TechStep*: *SMS* and *Text Me, Girl!*, were grounded in the Health Belief Model, Social Cognitive Theory, and Social Support Theory, aiming to

identify health-protective behaviors and health threats, bolster individuals' self-efficacy, and embrace available instrumental, emotional, and informational supports, respectively (43,97). The *TechStep*: *webapp* intervention was developed based on the Information Motivation Behavioral Skills (IMB) model, which highlights the role of informational attainment and motivational drivers in the adoption of health-protective behaviors (91). Motivational interviewing (MI) guided both *Project Moxie* and *TechStep*: *eCoaching*; the latter of which employed a hybrid MI-Cognitive Behavioral Therapy (CBT) approach to empower TGE users through evoking their own capacities for self-determination and health-protective decision-making (6,43).

The only intervention not explicitly addressing HIV outcomes that provided evidence of a theoretical basis for development was *QueerViBE*, which, in line with its aims to enhance a multilevel framework of wellbeing, ranging from the individual to socio-political, integrates multiple social constructionist and queer theories. These include analyses on the social construction of masculinity (the platform was tailored for trans-masculine and nonbinary youth), its societally enforced norms (81), and their relations to visibility and power, interpreted through a Foucauldian lens (82,83). In addition, one module also incorporates CBT techniques, aiming to preserve users' self-esteem when confronted with intrusive and invalidating questions from cisgender peers (44).

Dimensions of gender affirmation

All but one of interventions profiled (n=23) sought to address psychological dimensions of gender affirmation, by providing linkage to mental health counseling or by attempting to boost user self-esteem and/or self-efficacy. Fifteen interventions had features and resources aiding in social affirmation, which included, for example, features connecting TGE peers and mentors, and activating community networks and crowdsourced knowledge. Embodied affirmation was addressed in another 15 interventions through guidance on accessing hormones and safely undertaking non-medical bodily affirmation options. In more than half the interventions reviewed (n=15), psychological and social affirmation co-occurred, typically through core features designed to enhance both social supports and agentic, individual, wellbeing. These were evident in the webapps with social networking features (*TechStep*: *webapp*, *Trans Women Connected*, *U-Signal*) and the SMS-enabled interventions (*TechStep*: *SMS* and *Text Me,*

Girl!). The embodied-psychological (n=13) and embodied-social (n=6) dimensions were less likely to co-occur. They appeared typically—though not exclusively—in the platforms that incorporate a broad range of resources for medical, mental health counseling, and community support referrals. Only six provided legal gender affirmation, typically through referrals to legal assistance options, with the exception of *QMed*, which provides required medical documents for legal gender-marker and name updates directly. Only *Solace LGBT*, *TechStep*: *webapp*, *Trans Women Connected*, and the Washington DC intervention engaged in all four dimensions recognized by the Reisner *et al.* (23) gender affirmation typology.

Key and unique features

The most frequently integrated features were behavioral self-monitoring (n=11), compilations of TGE-responsive brick-and-mortar resources (n=8), and informative content tailored by TGE stakeholders (n=7). *TechStep*: *webapp* and *they2ze*, both focused on HIV prevention and sexual health education among TGE users, were the most feature rich. HIV testing and counseling resources and remote video counseling were available almost exclusively within the HIV-prevention interventions, with the exception of the *QueerDoc* and Washington, DC–based telehealth interventions. Only *Refuge Restrooms*, *Safe Transgender Bathroom App*, the *Spokane Trans Map*, and *U-Signal* incorporate features designed to enhance personal safety: *Refuge Restrooms* (and similar platforms; see *Table 3*), through mapping all-gender and single-occupancy publicly accessible restrooms for users, who may fear harassment or violence in traditionally gendered spaces (47); and *U-Signal*, through its unique peer-to-peer alerts and the discretion with which they can be activated, silently, by smartwatch (45).

Discussion

TGE young people endure compounded vulnerabilities to stigma, social isolation, violence, and HIV (9). While the adoption of digitally networked technologies among TGE youth is widespread, their online social milieu can be both robustly supportive and a site of invalidation and abuse (42). A diverse array of mobile technologies aims to promote TGE users' health and wellbeing, primarily through gender-affirmative and HIV-prevention features. These interventions incorporate both traditional mHealth elements, such as behavioral tracking and hyperlocal

referrals, and highly innovative platform-specific features, tailored for a TGE user base. This review examined these interventions by evaluation methods, dimension of gender affirmation, feature profiles, and their respective evidence bases.

The most evident distinction between disciplines is the commitment to randomized controlled trials of efficacy, which was all but unique to the HIV-prevention interventions. These platforms, through government funding and accountability structures, and the involvement of university-affiliated investigators, require "gold-standard" evidence of their efficacy and effectiveness via longitudinal and resource-intensive trials (105). Translationally, this distinction is paramount, as future funding, widespread dissemination, and the resources for adaptation rely on established efficacy. For example, *Project Moxie*, *TechStep* (across modalities), *Text Me*, *Girl!*, and *Trans Women Connected* are supported by research infrastructures able to rigorously assess feasibility, acceptability, and efficacy outcomes (65). The app and webapp interventions focused on HIV prevention and care also possessed the most features among the interventions reviewed. Additionally, *they2ze*, *TechStep*, and *Trans Women Connected*, all integrate a spectrum of high-quality curated resources conscientiously tailored for their target TGE users.

On the contrary, the HIV-prevention interventions lack the unique, core affordances that have guided the conspicuously leaner non-HIV-focused platforms. *Refuge Restrooms* and *Safe Transgender Bathroom App*, for example, perform a single function (locate restrooms). But through this single function, they reliably create new possibilities for personal safety among their users. This leanness, even if it sacrifices functional heterogeneity, enables access for lower socioeconomic status and transient users, who may share devices, use lower-specification hardware, or be subject to intermittent connectivity and power outages (106). The features exclusive to the non-HIV-focused platforms focus on within-person drivers of gender affirmation. Some of these platforms are narrow in focus [*Trans Memo*, *Binder Reminder* (46,99)], whereas others seek to holistically address gender affirmation needs [*EVA*, *Solace*, *TransTracks* (48,49,89)], Others acknowledge the often-politicized meanings that TGE communities may attach to—or have imposed upon—their identities [*QueerViBE*, *U-Signal* (44,45)]. Together, the non-HIV-focused platforms included in this review illustrate the importance of routine self-validation and physical safety as critical needs for TGE youth. Thus, while low-threshold hormone access is a key

component of TGE wellbeing (as *QMed* recognizes), it is distinct, experientially, from the routinely accessible and cumulative validations these platforms aim to provide. While *TechStep*: *webapp* and other platforms offering peer-to-peer interactivity are potentially sources of routine social support, the unpredictable nature of user-generated content is unlikely to achieve the consistent benefits conveyed by such finely honed features as *QueerViBE*'s discursively grounded educational modules.

Similarly, while tips for physical safety may, or may not, be exchanged among socially networked peers, freedom from harassment and violence was the sole aim of *Refuge Restrooms* and *U-Signal* (45,47). Physical safety concerns often drive the uptake of *EVA* and other voice-training interventions (71). Mistrust of law enforcement is highly prevalent among TGE communities, and in particular among Black and Latinx trans communities (107), accounting for the peer-to-peer alerts enabled by *U-Signal*. Just as *QueerViBE*'s educational modules acknowledge the lived reality of stigmatization among its users, and their possible internalization of power asymmetries in a cissexist society, *U-Signal* acknowledges the mutually compounding systems of oppression of racism, sexism, and anti-transgender stigma for the trans-feminine users of color for whom it was designed. The HCI-derived, crowdfunded, and other non-HIV-focused interventions, in short, conceive their features in terms of resistance to the structural subordinations that drive health inequities among TGE communities. Interpreted through an imagined affordance lens, these features—and the expectations and new potentials they permit TGE users—can be understood as tools to ease the daily burden of these subordinations.

These new possibilities for self-validation, safety, and adaptive identity formation, highlight the promise of such innovative features to communities of users who share complex, distinct, and often overlapping needs. The concept of affordances, within psychology, referred originally to the instrumental possibilities of an environment, as recognized by a specific individual or group within it (50). Maintaining an imagined affordance–focused lens can aid in honing the aims of innovative features, and clarifying the insights provided by TGE communities throughout the evaluative cycle (e.g, formative, process). In short, what are the expectations and new potentials that TGE users desire of mobile, networked technologies? How does the provision of these new potentials address the health inequities endured by TGE youth, including their disparate risk of HIV acquisition? The realization of new potentials within

the digitally networked environment by TGE developers, investigators, and communities, should serve to inspire the future of government-backed and university-affiliated mHealth interventions tailored to meet their needs.

Advancing the field

The landscape of TGE-responsive mobile technology, mapped in this review, points to a number of promising directions.

Knowledge exchange

Future practice and research could focus on understanding how to balance and bridge fields that often operate in siloes. The innovations advanced by TGE private-sector developers and TGE-focused investigators in HCI and social informatics suggests that a cross-sectoral stakeholder engagement or knowledge exchange model of intervention development could elicit promising new insights, while ensuring proper crediting of community-derived innovations. One such example is the mHealth intervention *TreatYoSelf*. While not TGE-focused, it is exemplary of such an approach, leveraging the patient-clinician-designer framework of participatory design, and allying experts in HCI with clinician-investigators in adolescent HIV (108). In capturing imagined affordances, the openly utopian "future-making" workshop process can record both the structural barriers encountered by communities attempting to realize their potential—and activate their imaginations toward surmounting those barriers with highly speculative original technologies (109).

Theoretical synthesis

The creatively realized affordances shown by the non-HIV-focused platforms are not inherently at odds with the theoretical underpinnings of much HIV-focused mHealth. Peer-to-peer empowerment, behavioral self-monitoring, and tailored informational sources are embraced across disciplines, and their potential benefits could be catalyzed by a more thorough and thoughtful grounding in health behavior change theories.

Functional integration

With the HIV-focused platforms often feature rich, and the non-HIV-focused platforms often lean but highly innovative, opportunities for high-impact functional integration may present themselves. Some instances of such convergent functionality, aligning HIV- and non-HIV-

focused developments, are evident already: *TechStep*: *webapp*, for example, mimics the full functionality of *Trans Memo*, via its customizable behavioral trackers. But with accessibility for at-risk and under-resourced users tied to leanness [versus "feature creep" (110)], calibrating the balance versus over-proliferation of features will remain an important goal.

Outcomes evaluation

Multi-center longitudinal RCTs are often not accessible, nor appropriate, for all platforms. However, evaluations of desired outcomes, such as pre- and post-test designs, and explorations of acceptability, usability, and sustainable socio-cultural attunement (e.g, the incorporation of fast-evolving linguistic norms across TGE youth communities) can build a case for functional integration with feature-rich, evidence-based, mHealth interventions.

Limitations

There are several noteworthy limitations. The timeframe within which this review was conducted limited the state of the evidence we were able to present. With findings of acceptability, feasibility, and ultimately efficacy more fully reported, the foundations for the recommendations offered here may shift substantially. Similarly, we were unable to capture the abrupt scaling up of telemedicine opportunities, including for TGE patients, which has occurred in response to the COVID-19 pandemic of 2020 (66,67). Furthermore, time and resource constraints prevented us from undertaking the optional expert consultation exercises recommended by Arksey and O'Malley (52,53). Given the nascent and discontinuous advances we aimed to map in this review, such an exercise would be especially conducive to bridging knowledge bases. As such, our results should be understood as a selective and vision-setting overview of an evolving field, rather than an integrative review of methodology or efficacy.

Conclusions

TGE adolescents and emerging adults endure disproportionate rates of HIV-acquisition risk, violence, and emotional distress. While networked and mobile technologies carry risks of their own, their outsized adoption by TGE youth points toward promising mHealth modalities. By aligning the micro-targeted socio-cultural attunements of community-backed interventions with the robust scientific infrastructures of government-funded HIV prevention and care programming, strides in acceptability, feasibility, and lasting utility can be achieved.

Footnote

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