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# A systematic review of developments in mHealth smartphone applications for Transgender and Gender Diverse individuals



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Transgender and gender diverse (TGD) individuals face significant healthcare barriers, resulting in inequities and unmet needs. Mobile health (mHealth) applications offer promising solutions by providing accessible, cost-effective, personalized, and gender-affirming care. This systematic review, conducted using PRISMA 2020 guidelines and the PICO framework, screened 5005 records from 4 databases and included 11 articles. The review aimed to identify key features of mHealth apps developed for TGD individuals, focusing on theoretical frameworks, design strategies, and their approaches to addressing healthcare barriers. Key challenges in developing mHealth apps include implementing systemic changes in healthcare settings to combat stigma and discrimination, grounding app development in TGD-specific theoretical frameworks, adequately addressing stressors and protective factors, and overcoming methodological limitations that hinder the evaluation of health outcomes. Overcoming these challenges requires rigorous research methodologies, inclusive designs, reliance on evidence-based TGD frameworks, and stronger collaboration among researchers, healthcare providers, and TGD communities.

The terms transgender and gender diverse (TGD) refer to individuals whose gender identity does not align with the sex assigned to them at birth. These broad categories include individuals who may identify within the binary system (as male or female), embrace a non-binary identity, or not align with any gender at all[1,2]. TGD individuals face significant structural, interpersonal, social, and legal barriers within healthcare systems[3]. These barriers hinder access to gender-affirming care and perpetuate health inequities by failing to address TGD-specific health needs[4,5]. The gender minority stress model links chronic stressors such as stigma, victimization, and societal discrimination to adverse health outcomes in TGD individuals, including increased risks of anxiety, depression, self-harm behaviors, suicidality[2,6], trauma[7,8], substance abuse[9], and stress-related health issues over the lifespan[10]. Addressing these challenges is essential to ensure that TGD people have access to gender-affirming pathways and affirming care.

Mobile health (mHealth) applications offer innovative solutions to bridge these gaps in healthcare. These digital tools can be designed specifically to deliver competent, affirming care by providing resources tailored to the unique needs of TGD people. Additionally, they educate both healthcare professionals and users, equipping providers with training to reduce discrimination and improve care quality. For TGD users, mHealth apps provide accurate information that combats misinformation and fosters informed decision-making.

One of the key advantages of mHealth apps is their accessibility via smartphones, making them especially effective for individuals in areas where gender-affirming care is unavailable[11]. They also help standardize care across regions with differing policies, reducing barriers such as unequal insurance coverage and restrictive regulations[12–14]. For socioeconomically disadvantaged groups, these apps present scalable, cost-effective solutions. Furthermore, their ability to offer privacy and discretion protects users in unaccepting environments or those not yet out, reducing the risk of stigma and rejection. Functionalities such as diagnostic support, decision-making tools, behavior change facilitation, and treatment adherence aids make mHealth apps effective for chronic care management[15,16]. Research has shown their effectiveness in improving symptoms, enhancing treatment adherence, and reducing hospitalizations[17], underscoring their potential to enhance access to gender-affirming care.

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Despite their potential, existing mHealth applications often fail to adequately address the needs of TGD individuals. Many apps lack inclusivity, offering limited customization options that may restrict users to binary gender identities. Some platforms enforce "real name policies", requiring identity verification through official documentation which prevents users from selecting their preferred names or pronouns[18], leading to privacy violations, misgendering, or the risk of being outed[19]. Facial recognition technologies also pose challenges, as they often rely on datasets that fail to represent diverse gender presentations, resulting in misclassification or exclusion of TGD users[20]. Algorithmic biases in content recommendations and advertising further perpetuate discrimination, while inadequate moderation on forums exposes users to cyberbullying and transphobia[21,22]. Moreover, many mHealth apps operate on assumptions of binary anatomy, excluding individuals with diverse medical experiences.

A growing body of literature has emerged that warrants systematic examination. Existing reviews have predominantly concentrated on specific domains, such as HIV prevention[23,24], or on applications developed outside academic contexts that lack a robust theoretical foundation[23]. Considering the rapid evolution of digital health technologies, numerous innovations may have occurred in the relatively short period since the most recent review on this subject[25]. To bridge this gap and incorporate newly developed applications, we conducted the present systematic review. Our analysis focused primarily on mHealth applications originating from academic environments, given their theoretical grounding and methodological rigor. Nevertheless, we also investigated commercially developed applications, frequently created by allies of TGD communities or community members themselves, through searches on platforms such as Google Play and the Apple App Store. These results are presented in Supplementary Table I, as no standardized methodology currently exists for their retrieval from the scientific literature.

This study presents a comparative analysis of 11 mHealth applications developed for TGD individuals. We classify the apps based on their effectiveness in addressing four key healthcare barriers: structural, interpersonal, economic, and informational. This classification provides clear guidance for researchers and developers aiming to enhance healthcare accessibility for TGD people. Our analysis identifies two distinct trends: apps designed to reduce the impact of stressors and those that promote resilience factors. We outline potential strategies to further develop both approaches. By systematically organizing and comparing app features and their underlying theoretical frameworks, this review offers practical insights for researchers, developers, and policymakers to develop solutions that meet TGD needs while implementing evidence-based strategies to improve user engagement, satisfaction, and overall app effectiveness. A comprehensive quality assessment was conducted to identify existing gaps and limitations, offering recommendations to address these shortcomings and support the selection of appropriate implementation protocols. Furthermore, this review takes a forward-looking approach, proposing future research directions and practical improvements to strengthen current practices. Unlike previous reviews, this study addresses a wider range of health needs. To the best of our knowledge, this is the first comprehensive review of its kind, offering a foundational reference for advancing mHealth interventions for TGD individuals.

## Results

### Need to strengthen provider networks and challenge stigma and discrimination in healthcare settings

The reviewed applications commonly targeted structural barriers (e.g., limited access to healthcare in underserved areas), interpersonal barriers (e.g., experiences of stigma and misgendering), economic barriers (e.g., high costs and lack of insurance), and informational barriers (e.g., limited awareness of inclusive, evidence-based resources), as summarized in Table 1. Educational content and skill-building modules were central components of these interventions, designed to enhance health literacy, self-efficacy, and user empowerment. This allows patients to overcome misinformation and make informed decisions about their health. Key strategies to achieve these goals included the use of gamification and interactive techniques, such as role-playing scenarios, to increase user engagement, support mental health management[26,27], and promote communication strategies[27].

Several mHealth apps specifically addressed the prevention and management of sexually transmitted infections (STIs), aiming to bypass health inequities stemming from systemic barriers such as stigma and discrimination in healthcare settings[26–31]. These barriers often limit access to preventive care, contributing to higher rates of STIs among TGD individuals. By incorporating features such as HIV prevention education, self-testing guidance, and PrEP information, these apps enhanced self-care and accessibility. While the reviewed apps address key barriers, they primarily focus on individual-level interventions, often overlooking systemic factors such as provider education and structural discrimination. A notable limitation is the insufficient integration of mHealth apps with healthcare providers. These gaps underscore the need to actively challenge stigma within healthcare settings, foster therapeutic alliances, and strengthen connections between users and providers.

### Lack of TGD-specific theoretical frameworks

A variety of theoretical frameworks informed the development of mHealth applications to ensure alignment between functionalities, user needs, and targeted health outcomes. Behavioral, cognitive, and empowerment models underpinned features aimed at facilitating personalized interventions, goal setting, and risk reduction[26–28]. Gamification strategies were integrated to enhance sustained user engagement through interactive components and reward systems[27]. Human-centered and participatory design methodologies were employed to optimize usability, foster inclusivity, and ensure relevance to the target community[26,29,32–35]. Iterative development approaches, including the AGILE and Health-ITUES models, supported continuous integration of user feedback, thereby improving accessibility, adaptability, and overall user experience[26,27,33–35]. Details about specific frameworks can be found in Table 2.

The reviewed studies demonstrate progress in integrating technical and theoretical frameworks to guide app development. However, many apps lack clear theoretical grounding, limiting their ability to comprehensively address TGD health needs. Notably, only one study employed a theoretical framework specifically developed for TGD individuals[10,32], while the remaining studies failed to incorporate approaches that adequately address the unique experiences and challenges faced by these people.

### Failure to implement systemic healthcare changes and underexploration of stressors and protective factors

Many applications aimed to reduce stigma and discrimination by incorporating tools such as feedback systems and peer navigation mechanisms[27–29,34–36], through which individuals could support each other in identifying competent and affirming healthcare providers[28,29,36], overcoming barriers to HIV care[30], and navigating discriminatory scenarios in clinical settings. These modules were designed to develop effective communication strategies and increase awareness of personal triggers, emotions, and responses[27].

Other applications focused on fostering pride and community connection by incorporating interactive modules[27] or tools that promoted peer support networks[34,35]. These platforms facilitated connections with trusted individuals, provided opportunities to report incidents of discrimination or violence, and allowed users to share experiences within supportive and affirming environments.

Mental health support was another key focus of these interventions[28,29,32], with applications offering resources to reduce social isolation and real-time monitoring of stressors and suicide risk factors[32] to aid in suicide prevention.

The reviewed apps highlight progress in addressing stigma and fostering community connection but lack a focus on systemic healthcare changes, such as integrating gender-affirming, evidence-based practices into medical settings, improving policy advocacy, and expanding access to legal

**Table 1 | Healthcare accessibility**

| Authors | Structural | Interpersonal | Economic | Knowledge and information |
|---|---|---|---|---|
| **Chiang**[36] | TranZap provides a centralized platform to locate gender-affirming healthcare providers, helping individuals access care. | Allows users to share feedback on healthcare providers, enabling others to find gender-affirming services. | N.A. | Provides information about healthcare providers and user experiences. |
| **Dubov**[32] | TransLife offers resources to find local healthcare providers and services. | N.A. | N.A. | Provides tailored resources for TGD people. |
| **Jones**[29] | Transpire includes resources for identifying trans-competent healthcare providers and allows users to order home testing kits for HIV and STIs, reducing logistical barriers and enabling privacy in healthcare management. | Features inclusive and affirming language tailored to transmasculine users. | Offers tools to explore cost-effective options for PrEP and HIV prevention. | Provides comprehensive and centralized sexual health information (e.g., HIV, STIs, PrEP) tailored to transmasculine needs. |
| **Jones**[28] | Transpire provides a services locator, improving access to HIV prevention; Enables ordering of at-home test kits and other products, bypassing logistical and facility-based barriers. | Incorporates inclusive and affirming language. | Offers free access to HIV and STI self-test kits, condoms, and lubricants. | Provides educational resources on HIV, PrEP, STI prevention, gender-affirming care, mental health, and substance use. Offers self-administered health assessments to set healthcare goals. |
| **Kuhns**[27] | LifeSkills Mobile enhances access by providing education on healthcare navigation and offering risk-reduction tools for young transgender women. | N.A. | N.A. | Provides detailed, inclusive information on HIV prevention, PrEP, and safer practices tailored for young transgender women. |
| **Morse**[33] | TGHIR App provides resources for TGD healthcare and wellbeing. | N.A. | N.A. | Provides information on TGD health topics. |
| **Rael**[31] | SMARTtest provides resources on clinics offering confirmatory testing for HIV and syphilis, helping users locate care. | N.A. | Offers cost-effective testing options by integrating INSTI Multiplex kits. | Delivers clear, step-by-step guidance on using self-testing kits and interpreting results. |
| **Raulino**[34] | N.A. | Addresses stigma and discrimination by enabling students to report bullying or violence and promoting direct, respectful communication with educators. | N.A. | Offers resources to raise awareness about TGD individuals. |
| **Starks**[35] | U-Signal addresses structural barriers by providing wearable technology to enhance safety, enabling transgender people of color (TPOC) to manage risks in underserved or unsafe areas. | Reduces interpersonal challenges by allowing users to notify trusted friends (instead of law enforcement) in emergencies, avoiding stigma and discrimination. | N.A. | Provides a centralized platform for safety management, empowering users with tools to track and share location and safety status. |
| **Sun**[26] | Trans Women Connected provides an interactive map to locate trans-competent healthcare, educational, and social services. | N.A. | N.A. | Delivers educational resources on HIV, PrEP, and healthy relationships tailored to the needs of transgender women. |
| **Wilson**[30] | Addresses structural barriers by using peer-based navigation to connect young transgender women to HIV prevention and care services. | Peer navigators reduce stigma and mistrust by fostering a supportive, affirming relationship. | N.A. | Improves HIV-related knowledge and testing behaviors through digital interactions. |

Overview of how mHealth apps address structural, interpersonal, economic, and informational healthcare barriers for TGD individuals.

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**Table 2 | mHealth features**

| Authors | mHealth | App Functionalities | Theoretical Frameworks | Community Consultation | Measurement Tools | Outcomes | Follow-Up | Limitations |
|---|---|---|---|---|---|---|---|---|
| **Chiang**[36] | TranZap is a community-driven mobile health application designed to provide information on healthcare providers. It allows transgender individuals to share feedback to help users find gender-affirming providers. | • Users can leave written reviews of healthcare providers;<br>• Allows to search healthcare providers by location, specialty, center, and name and see corresponding reviews. | N.R. | Community engagement throught social media interactions and word-of-mouth feedback. | • Feedback;<br>• Metadata from the app. | • The intended outcome is to improve access to gender-affirming healthcare providers by making it easier for transgender individuals to find and share information about healthcare experiences. | N.A. | • The app has not been tested with participants. There are no documented outcomes related to its usability or effectiveness. |
| **Dubov**[32] | TransLife is a mobile app designed to prevent suicide within the transgender community. | • Dashboard displaying progress updates and information;<br>• Practical coping tips for managing emotions;<br>• Mood logger with user's mood history;<br>• Sleep quality and energy level tracking;<br>• Option to create and publish events;<br>• Access to resources such as health providers and services. | Meyer Minority Stress framework. | Community engagement at the developmental stage. | • Interviews based on: System Usability Scale (SUS) and Standardized User Experience Percentile Rank Questionnaire (SUPR-Q);<br>• Focus Groups;<br>• Metadata from the app. | • TransLife was perceived as engaging and supportive, aiding mental self-care, self-awareness, and trigger identification;<br>• Participants noted the app's community-building aspect and its ability to link users with local resource;<br>• Many users were inconsistent in mood tracking;<br>• User feedback suggests incorporating transgender-specific news, gamification, and customized mood-related activities. | One evaluation conducted three weeks after app installation. | • Generalizability is limited due demographic characteristics and small sample size;<br>• Potential selection bias due to respondent-driven sampling;<br>• The study lacked comparison with standard methods for assessing suicide risk with RCT;<br>• No mental health assessment was conducted prior to the study. |
| **Jones**[29] | Transpire: a mHealth app adapted from HIV prevention for cisgender men to transmasculine individuals, offering comprehensive features; | • Information about pre-exposure prophylaxis (PrEP), HIV, and STIs;<br>• Allows to order HIV and STI self-test kits, condoms, and lube free of charge;<br>• Resources related to health insurance, substance use, and mental health.<br>• Additional resources related to hormones and gender-affirming surgery, identify trans-competent health care providers, information on condoms. | Participatory design. | Community engaged process with an advisory board of transmasculine people. | Web-based in-depth interviews | • Identified themes include sexual behavior, app experiences and feedback, and pre-exposure prophylaxis (PrEP);<br>• Participants found the Transpire app acceptable, citing it as an informative source, enhancing knowledge about HIV, STIs, and PrEP, and valuing its inclusive language. | Consistent usage observed over 3 months. | • Limited generalizability due to lack of demographic representation and COVID-19 pandemic impact;<br>• The study primarily focused on usability and user engagement, without directly measuring the app's efficacy in reducing HIV risk. |

**Table 2 (continued) | mHealth features**

| Authors | mHealth | App Functionalities | Theoretical Frameworks | Community Consultation | Measurement Tools | Outcomes | Follow-Up | Limitations |
|---|---|---|---|---|---|---|---|---|
| **Jones**[28] | Transpire is an adapted HIV prevention smartphone app designed to address the prevention needs of transgender men and other transmasculine individuals regarding HIV and sexually transmitted infections (STIs) | • Access to HIV and STI prevention information;<br>• Order HIV and STI at-home self-test kits, condoms, and lube;<br>• Mental health and substance use resources and provider locators;<br>• Self-administered health assessments to set healthcare-related goals | Principles of social cognitive theory (self-efficacy, goal setting, outcome expectations). | Community-engaged research design with a community advisory boards (CABs) of transmasculine people. | • System Usability Scale (SUS);<br>• Metadata from the app;<br>• Self-reported uptake of prevention services;<br>• Lifetime history of HIV testing (assessed at baseline);<br>• HIV testing, diagnoses of STIs, and PrEP initiation during the 3-month follow-up period were assessed in the final survey. | • Mean SUS score: 72.4, meeting acceptability criteria;<br>• During 3-month follow-up: 32% conducted HIV test, 4% initiated pre-exposure prophylaxis;<br>• Mean app use sessions: 4.5 per user over 3 months, with mean total time of 11.0 minutes. | Evaluation before app usage and three months post-installation. | • Limited generalizability due to lack od demographic representation and COVID-19 pandemic impact;<br>• The study primarily focused on usability and user engagement, without directly measuring the app's efficacy in reducing HIV risk. |
| **Kuhns**[27] | LifeSkills Mobile is a web app that uses Information-Motivation-Behavioral skills model to offer HIV education, reduce risk, and improve behavioral skills, targeting individuals at high HIV risk. | • Module-Based Learning: with four modules (TransPride, Breaking down barriers, Educating yourself, Protecting yourself) each focusing on different aspects of HIV prevention and awareness;<br>• Activities: including scenarios, educational material, games, and role plays, with goal setting and tracking. | • Health Information Technology Usability Evaluation Model (Health-ITUEM);<br>• Elements of gamification: educational games and persuasive games;<br>• Empowerment theory and Information-Motivation-Behavioral skills model. | Community- engaged approach with an expert advisory group and feedback from young transgender women. | • Think-aloud protocol with debriefing interviews;<br>• Post-Study System Usability Questionnaire (PSSUQ);<br>• Health Information Technology Usability Evaluation Scale (Health-ITUES);<br>• Demographic and technology use survey;<br>• Client Satisfaction Questionnaire (CSQ). | • Usability ratings were in good to excellent range, with a mean of 4.59 (SD 0.86) on the Health-ITUES scale;<br>• Satisfaction and accessibility were high, with a mean of 4.63 (SD 0.90) on the PSSUQ scale (range 1-5);<br>• The app received ratings ranging from good to excellent for its quality. | Pre-post use test. | • Generalizability is limited due demographic characteristics and small sample size;<br>• The study participants were recruited from a registry of individuals who had participated in previous studies, potentially leading to selection bias;<br>• The study primarily focused on usability and user engagement, without directly measuring the app's efficacy in reducing HIV risk. |
| **Morse**[33] | "TGHIR" is a mobile app to provide credible health and wellness information for people who are TGD. | • Health and wellness information content;<br>• Back-end system (database, search engine, and communication platform);<br>• Front-end mobile app that allows users to create accounts, search for information, and access/view the curated TGHIR resources;<br>• 97 credible health information resources divided in 16 categories. | • Participatory design approach;<br>• Agile software development methodology;<br>• 4-phase structured approach for design and evaluation. | • Community consultation with focus groups, co-design sessions, and feedback from a Community Advisory Board (CAB);<br>• Partnership with an LGBTQ community-based advocacy organization. | • Single item from the System Usability Scale;<br>• Cognitive walk-throughs;<br>• User version of the Mobile Application Rating Scale. | • The TGHIR app demonstrated high usability;<br>• 90% of its features received ratings of good to excellent, with the remaining 10% rated as okay;<br>• The overall quality score was initially 4.13 (SD 0.29) and increased to 4.25 (SD 0.35) in the second evaluation. | 2 evaluation: after 2 weeks and after 4 weeks from the installation of the app. | • Generalizability is limited due demographic characteristics and small sample size;<br>• Some information resources were local, potentially less useful for those outside the area. |

**Table 2 (continued) | mHealth features**

| Authors | mHealth | App Functionalities | Theoretical Frameworks | Community Consultation | Measurement Tools | Outcomes | Follow-Up | Limitations |
|---|---|---|---|---|---|---|---|---|
| **Rael**[31] | SMARTtest is a smartphone app to accompany the INSTI Multiplex©, a one-minute, dual blood-based HIV/syphilis rapid test. | • Instructions on how to administer the INSTI Multiplex© test:<br>• Results interpretation;<br>• Information on available services if user tests positive for HIV or syphilis;<br>• Scanning feature to capture an image of their completed test. | N.R. | N.A. | • INSTI Multiplex® for HIV and syphilis;<br>• Computer-assisted self-interview (CASI) before app installation;<br>• CASI after app installation;<br>• In-depth interview. | • The app was deemed easy to use and convenient, but requires refinement;<br>• On average, participants used 4.3 INSTI Multiplex kits for self-testing and 2.3 kits for testing potential sexual partners;<br>• 81.8% of participants reported using the SMARTtest app during the study. | Evaluation before app usage and three months post-installation. | • Generalizability is limited due demographic characteristics and small sample size;<br>• Participants were recruited through geospatial sexual networking apps potentially leading to selection bias. |
| **Raulino**[34] | This application aimed at assisting transgender high school students in communicating with their schools and the transgender community. | • Enables messaging between students and school/support institutions;<br>• Provides access to published stories with details and comments;<br>• Allows students to report incidents to school administration or LGBTQIA+ community NGOs. | • Designed based on Garrett's five-plane framework;<br>• Guidelines from the Material Design visual language;<br>• The Glassmorphism design trend;<br>• DECIDE Framework. | N.A. | • Online questionnaire;<br>• Think Aloud protocol;<br>• Post-evaluation System Usability Scale (SUS);<br>• Semi-structured interview. | • Prototype rated with good usability: 86.66 on SUS questionnaire;<br>• Participants find functionalities capable of meeting their needs;<br>• Information provided is understandable and aligns with target audience's prior experiences;<br>• Overall positive experience, with interest in using the solution. | 1 single test. | • Generalizability is limited due to demographic characteristics and small sample size;<br>• Remote development context: difficulties in communication and adaptation to online collaboration tools;<br>• Recruitment strategy through social media might introduce bias. |
| **Starks**[35] | A prototype wearable technology called U-signal (smartwatch app) and a smartphone app aim to enhance physical safety, reduce violence, and foster community among TPOC. | • Smartwatch:<br>– Sends out SOS emergency message;<br>– Records GPS location.<br>• Mobile app:<br>– Notifies friends when user arrives safely;<br>– Displays user's location on map with options to signal if they are okay or need help;<br>– Enables following friends for community building;<br>– Allows self-tracking for retracing or documenting incidents. | • Human-centered design (HCD);<br>• Reflective Design Approach | Community engagement with interviews. | In-depth interviews (20-40 minutes) through Facebook messaging and FaceTime. | Participants acknowledged the prototype's community need for safety support but suggested enhancing accessibility, such as voice commands and multiple languages. | 1 single test. | • Generalizability is limited due demographic characteristics and small sample size;<br>• Recruitment strategy through social media might introduce bias. |

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**Table 2 (continued) | mHealth features**

| Authors | mHealth | App Functionalities | Theoretical Frameworks | Community Consultation | Measurement Tools | Outcomes | Follow-Up | Limitations |
|---|---|---|---|---|---|---|---|---|
| **Sun**[26] | Trans Women Connected: a mobile health app for HIV prevention and sexual health in transgender women. | • Vision board;<br>• Pre-Exposure Prophylaxis (PrEP) education;<br>• Interactive map;<br>• Information about sexual health, sexual pleasure, supports for healthy relationships and transgender-specific resources. | • Cognitive behavioral theory;<br>• Iterative development. | Community-driven design, involving transgender women through focus groups, interviews, usability tests, and an advisory panel of transgender women of color. | • Think-aloud protocol for usability testing;<br>• Pre and posttests;<br>• Task success and completion time;<br>• Feedbacks (open-ended questions). | • High usability and acceptability with average ratings of 5.9 out of 7;<br>• Rated highly for attractiveness, usefulness, and connectivity among transgender women;<br>• Improved self-efficacy in finding LGBTQ-friendly services;<br>• Increased intention to seek online social support and knowledge about PrEP;<br>• Enhanced intentions to utilize services, goal-setting abilities, and social support. | Pre-post test. | • Limited generalizability due to small sample size and geographical restrictions on recruitment;<br>• Inability to measure behavior change due to the short-term evaluation;<br>• The study primarily focused on usability and user engagement, without directly measuring the app's efficacy in reducing HIV risk. |
| **Wilson**[30] | Mobile health methods, integrating peer navigation with digital technologies (social media and text messaging) to interact with participants to overcome barriers in accessing HIV prevention and care for young trans women. | • Weekly digital interactions with peer-navigators;<br>• Asynchronous text messages in between sessions. | • Peer navigation;<br>• Anti-Retroviral Treatment and Access to Services (ARTAS) intervention. | Design and implementation informed by inputs from an advisory group comprising young trans women. | • Group-Based Medical Mistrust Scale (GBMMS);<br>• Patient Health Questionnaire (PHQ)-4;<br>• Alcohol Use Disorders Identification Test-Concise (AUDIT-C);<br>• Smoking and Substance Involvement Screening Test (ASSIST);<br>• HIV Knowledge Scale (HKQ-10). | • Improvements in all three areas of intervention, including HIV testing, PrEP use and HIV care engagement with lasting effects nine months post intervention;<br>• All participants not living with HIV engaged in PrEP by the end of the intervention;<br>• Improvements observed in ART use and viral load suppression among participants living with HIV. | Follow-up visits at 3, 6, 9, and 12 months. | • Generalizability is limited due demographic characteristics and small sample size;<br>• Recruitment strategy might introduce bias. |

This table outlines the functionalities of mHealth apps designed for transgender and gender - diverse (TGD) individuals, along with their theoretical frameworks, community consultation methods, measurement tools, outcomes, follow- up periods, and study limitations. Definition of gender identities and sexual orientation are those reported by authors. N Number, M Mean, SD Standard deviation, N.R. not reported, N.A. not applicable.

and financial resources. Moreover, they underexplore protective factors, relying primarily on community connectedness and pride.

### Key methodological limitations and insufficient evaluation of health outcomes

An overview of the quality assessment, based on total MMAT scores, is presented in Table 3. The distribution of scores included one study[33] rated as very low (40%), two studies[28,36] rated as moderate (60%), four studies[26,27,30,34] rated as moderate-high (80%), and four studies[28,29,31,32,35] rated as high (100%). Despite these generally positive rankings, we identified significant limitations. While most studies reported high usability and satisfaction scores, they often lacked rigorous evaluation of health outcomes. Common issues included the absence of baseline measurements, short exposure and follow-up periods, small and geographically limited samples, and reliance on self-reported data. None of the studies included control groups, which limited meaningful comparisons with standard care. Moreover, among the studies utilizing mixed methods[26,27,33,34], none adequately justified their choice of this approach. Additionally, studies employing quantitative non-randomized designs[28–30] failed to address confounders in their design and analysis. Data related to the study design and methodology are summarized in Table 4.

The studies predominantly evaluated usability and user satisfaction. Across these measures, the apps consistently demonstrated high usability and acceptability, indicating strong alignment with user expectations and needs. Follow-up methodologies varied, including interviews, surveys, and app usage data, with evaluation periods ranging from short-term assessments[27,32,33] to long-term follow-ups[28–31]. Details of the measurement metrics can be found in Table 2.

However, direct health and well-being outcomes were infrequently measured. The only study reporting significant health changes[28]demonstrated

**Table 3 | Overview of study quality assessment using the MMAT**

| First author | Category ofstudy design | Methodologicalquality criteria | Yes | No | Can't tell |
|---|---|---|---|---|---|
| **Chiang**[36] | 1.Qualitative | S1: Are there clear research questions? | X | | |
| | | S2: Do the collected data allow to address the research question? | X | | |
| | | 1.1. Is the qualitative approach appropriate to answer the research question? | 1 | | |
| | | 1.2. Are the qualitative data collection methods adequate to address the research question? | 1 | | |
| | | 1.3. Are the findings adequately derived from the data? | 1 | | |
| | | 1.4. Is the interpretation of results sufficiently substantiated by data? | | | 1 |
| | | 1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation? | | | 1 |
| | | **Total items scored** | **3** | | **2** |
| **Dubov**[32] | 1.Qualitative | S1: Are there clear research questions? | X | | |
| | | S2: Do the collected data allow to address the research question? | X | | |
| | | 1.1. Is the qualitative approach appropriate to answer the research question? | 1 | | |
| | | 1.2. Are the qualitative data collection methods adequate to address the research question? | 1 | | |
| | | 1.3. Are the findings adequately derived from the data? | 1 | | |
| | | 1.4. Is the interpretation of results sufficiently substantiated by data? | 1 | | |
| | | 1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation? | 1 | | |
| | | **Total items scored** | **5** | | |
| **Jones**[29] | 1.Qualitative | S1: Are there clear research questions? | X | | |
| | | S2: Do the collected data allow to address the research question? | X | | |
| | | 1.1. Is the qualitative approach appropriate to answer the research question? | 1 | | |
| | | 1.2. Are the qualitative data collection methods adequate to address the research question? | 1 | | |
| | | 1.3. Are the findings adequately derived from the data? | 1 | | |
| | | 1.4. Is the interpretation of results sufficiently substantiated by data? | 1 | | |
| | | 1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation? | 1 | | |
| | | **Total items scored** | **5** | | |
| **Jones**[28] | 3.Quantitative non-randomized | S1: Are there clear research questions? | X | | |
| | | S2: Do the collected data allow to address the research question? | X | | |
| | | 3.1. Are the participants representative of the target population? | 1 | | |
| | | 3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)? | 1 | | |
| | | 3.3. Are there complete outcome data? | | | 1 |
| | | 3.4. Are the confounders accounted for in the design and analysis? | | | 1 |
| | | 3.5. During the study period, is the intervention administered (or exposure occurred) as intended? | 1 | | |
| | | **Total items scored** | **3** | | **2** |
| **Kuhns**[27] | 5.Mixed methods | S1: Are there clear research questions? | X | | |
| | | S2: Do the collected data allow to address the research question? | X | | |
| | | 5.1. Is there an adequate rationale for using a mixed methods design to address the research question? | | 1 | |
| | | 5.2. Are the different components of the study effectively integrated to answer the research question? | 1 | | |
| | | 5.3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted? | 1 | | |
| | | 5.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed? | 1 | | |
| | | 5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved? | 1 | | |

**Table 3 (continued) | Overview of study quality assessment using the MMAT**

| First author | Category ofstudy design | Methodologicalquality criteria | Yes | No | Can't tell |
|---|---|---|---|---|---|
| | | **Total items scored** | **4** | **1** | |
| **Morse**[33] | 5.Mixed methods | S1: Are there clear research questions? | X | | |
| | | S2: Do the collected data allow to address the research question? | X | | |
| | | 5.1. Is there an adequate rationale for using a mixed methods design to address the research question? | | 1 | |
| | | 5.2. Are the different components of the study effectively integrated to answer the research question? | | 1 | |
| | | 5.3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted? | | 1 | |
| | | 5.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed? | 1 | | |
| | | 5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved? | 1 | | |
| | | **Total items scored** | **2** | **3** | |
| **Rael**[31] | 1.Qualitative | S1: Are there clear research questions? | X | | |
| | | S2: Do the collected data allow to address the research question? | X | | |
| | | 1.1. Is the qualitative approach appropriate to answer the research question? | 1 | | |
| | | 1.2. Are the qualitative data collection methods adequate to address the research question? | 1 | | |
| | | 1.3. Are the findings adequately derived from the data? | 1 | | |
| | | 1.4. Is the interpretation of results sufficiently substantiated by data? | 1 | | |
| | | 1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation? | 1 | | |
| | | **Total items scored** | **5** | | |
| **Raulino**[34] | 5.Mixed methods | S1: Are there clear research questions? | X | | |
| | | S2: Do the collected data allow to address the research question? | X | | |
| | | 5.1. Is there an adequate rationale for using a mixed methods design to address the research question? | | 1 | |
| | | 5.2. Are the different components of the study effectively integrated to answer the research question? | 1 | | |
| | | 5.3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted? | 1 | | |
| | | 5.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed? | 1 | | |
| | | 5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved? | 1 | | |
| | | **Total items scored** | **4** | **1** | |
| **Starks**[35] | 1.Qualitative | S1: Are there clear research questions? | X | | |
| | | S2: Do the collected data allow to address the research question? | X | | |
| | | 1.1. Is the qualitative approach appropriate to answer the research question? | 1 | | |
| | | 1.2. Are the qualitative data collection methods adequate to address the research question? | 1 | | |
| | | 1.3. Are the findings adequately derived from the data? | 1 | | |
| | | 1.4. Is the interpretation of results sufficiently substantiated by data? | 1 | | |
| | | 1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation? | 1 | | |
| | | **Total items scored** | **5** | | |
| **Sun**[26] | 5.Mixed methods | S1: Are there clear research questions? | X | | |
| | | S2: Do the collected data allow to address the research question? | X | | |
| | | 5.1. Is there an adequate rationale for using a mixed methods design to address the research question? | | 1 | |
| | | 5.2. Are the different components of the study effectively integrated to answer the research question? | 1 | | |
| | | 5.3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted? | 1 | | |
| | | 5.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed? | 1 | | |
| | | 5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved? | 1 | | |
| | | **Total items scored** | **4** | **1** | |
| **Wilson**[30] | 3.Quantitative non-randomized | S1: Are there clear research questions? | X | | |
| | | S2: Do the collected data allow to address the research question? | X | | |
| | | 3.1. Are the participants representative of the target population? | 1 | | |
| | | 3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)? | 1 | | |
| | | 3.3. Are there complete outcome data? | 1 | | |
| | | 3.4. Are the confounders accounted for in the design and analysis? | | | 1 |
| | | 3.5. During the study period, is the intervention administered (or exposure occurred) as intended? | 1 | | |
| | | **Total items scored** | **4** | | **1** |

The table presents the quality assessment conducted using the MMAT (2018). The "Total items scored" column indicates the number of criteria rated as "Yes", No or Can't tell for each study. The MMAT is intended to provide a detailed presentation of individual criterion ratings to better inform the quality of included studies, rather than to calculate an overall score.

**Table 4 | Study Characteristics**

| Authors | Country | Study Design | Study Objective | SampleCharacteristics | Eligibility Criteria for Participant Inclusion | RecruitmentStrategy |
|---|---|---|---|---|---|---|
| **Chiang**[36] | United States | Qualitative study | Review existing resources for transgender healthcare and develop an app, "TranZap", to find gender-affirming providers. | N.A. | N.A. | N.A. |
| **Dubov**[32] | United States (Greater Los Angeles area) | Qualitative pilot study | Beta test the usability of the "TransLife mobile app", designed to prevent suicidal ideation among transgender individuals. | •N = 16 (n=8, male-to-female transwomen, n=6 female-to-male transmale, n=2 third gender (other));<br>•M age 33.4 ± SD: 9.5;<br>•Ethnic background: n=7 White, n=5 Hispanic or Latina, n=2 African American, and n=2 Asian;<br>•Other demographic characteristics: n=11 Highly educated, n=10 employed full time. | • Self-identifying as transgender people;<br>• Age ≥ 18 years old;<br>• Living in the Greater Los Angeles area;<br>• Owning a smartphone. | • Respondent-driven sampling. |
| **Jones**[29] | United States (Atlanta, Georgia, and Washington DC) | Qualitative pilot study | Assess the acceptability of the adapted app "Transpire" among transmasculine individuals. | • N = 25 (n = 22 transgender male, transmasculine, or trans man; N = 8 gender diverse, gender nonbinary, or genderqueer);<br>• Age range: 18-34;<br>• M age 25 (IQR 21-29);<br>• Ethnic background: non-Hispanic White (n=21);<br>• Other demographic characteristics: (n=16) private health insurance, (n=13) enrolled in school (n=1 general educational development program, n=7 enrolled in a 4-year college, and n=5 enrolled in graduate school); | • Age: 18-34 years;<br>• Self-identification on the transmasculine spectrum (transgender men, male, men), or another gender-diverse identity assigned female at birth;<br>• Planned to remain in the study area (Atlanta and Washington, DC) for the duration of the trial;<br>• Owned an Android or iOS smartphone;<br>• Could read and understand English without assistance;<br>• Reported having frontal/vaginal or anal sex with any partner in the past 12 months;<br>• Reported being HIV negative or never having been tested for HIV | • Social media (Facebook and Instagram);<br>• Flyers placed at community-based organizations that serve the trans community. |
| **Jones**[28] | United States (Atlanta, Washington) | Mixed method pilot study | Pilot testing the "HealthMindr app" for HIV prevention among transmasculine individuals to evaluate feasibility and acceptability. | • N = 60 (n=36 identified as transgender male, transmasculine, or trans men);<br>• Age range: 18-24;<br>• Ethnic background: (n=47) non-Hispanic white;<br>• Other demographic characteristics: n=44 from Atlanta, GA, n=16 from Washington, D.C. n=53 had at least some college education, n=41 had access to health insurance from a private or public (n = 9) source. | • Assigned female at birth and identified with a gender identity other than female; 18-34 years old, inclusive; Had frontal/vaginal or anal sex in the past 12 months; Had a mobile phone with iOS or Android operating system; Could read and understand English; Were HIV negative or of unknown serostatus; Were not currently on PrEP; Were not currently participating in another HIV prevention study. | • Social (e.g., Instagram) and sexual (e.g., Jack'd, Scruff) networking sites;<br>• Advertisements posted online;<br>• Advertisements in physical spaces (community partners serving transmasculine populations). |
| **Kuhns**[27] | United States | Mixed-Methods | Testing usability and acceptability of a mobile app adaptation of the LifeSkills intervention to reduce HIV risk among young transgender women. | • N = 10;<br>• Age range: 21-28:<br>• M age 24 y.o. ± SD: 3;<br>• Ethnic background: n=8 ethnic minority;<br>• Other demographic characteristics: n=6 ever traded sex; n=10 ever homeless; n=7 general Educational Development/high school diploma or less. | • Age: 16 - 29;<br>• Self-identification as transfeminine;<br>• History of condomless anal or vaginal sex;<br>• English speaking | • Recruitment from a registry of participants in previous studies. |
| **Morse**[33] | United States | Develop a mobile health information resource to aid transgender and gender diverse individuals in accessing and utilizing credible health information effectively. | • N = 13 (n=12 self-identify as transgender, nonbinary, or genderqueer). | • TGD or TGD allies and who wanted to contribute to design a TGD health information resource. | • Social media (Facebook posts in private transgender groups);<br>• Flyers posted at the Integrated Transgender Clinic at the University of Colorado Anschutz Medical Campus. | |

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**Table 4 (continued) | Study Characteristics**

| Authors | Country | Study Design | Study Objective | SampleCharacteristics | Eligibility Criteria for Participant Inclusion | RecruitmentStrategy |
|---|---|---|---|---|---|---|
| **Rael**[31] | United States (New York City) | Qualitative study | Test the "SMARTtest" app with transgender women. | • N = 11 (transgender women)<br>• M age 41.5;<br>• Ethnic background: n=6 Latinx, n=5 Black, and n=5 more than one ethnic background. | • Being HIV-negative gay and bisexual men (GBM) and transgender women (TW);<br>• Aged at least 18 years old;<br>• Have engaged in the following sexual behaviors in the last three months: anal intercourse with two or more male partners, three or more occasions of condomless anal intercourse with men who were living with HIV or of unknown HIV status, and rarely or never using condoms during anal intercourse | • Recruited in NYC in-person;<br>• Online using geospacial sexual networking apps targeted to sexual and gender minorities. |
| **Raulino**[34] | Brazil (São Paulo, Rio Grande do Sul, Ceará, and Bahia) | Mixed method | Develop and test an application to assist transgender high school students in school and community communication, addressing their specific needs. | • N = 6;<br>• Age range: 16-25<br>• Other demographic characteristics: n=1 first-year student, n=2 second-year students, and n=3 third-year students, from public and private schools). | • Women who identify as transgender or transvestites on social media;<br>• Age range of 14-18 years, extended up to 25 years still in high school;<br>• High school students. | • Social media (Instagram and Twitter). |
| **Starks**[35] | United States | Qualitative study | Understanding of how transgender women and non-binary people of color (TPOC) experience violence and manage safety, and providing a technological platform to reduce violence. | • N = 7 (3 trans women, 4 non-binary, and 2 femme). | N.R. | • Social media;<br>• Snowball sampling. |
| **Sun**[26] | United States (San Francisco, Miami, Atlanta, and Portland, Oregon) | Mixed-methods | Develop and evaluate the mobile app "Trans Women Connected". | • Usability testing<br>• N = 16 (n = 14 transgender women; n = 2 non binary);<br>• Age range: 19-52;<br>• M age 34,5 ± SD: 9,28;<br>• Ethnic background: n=2 Hispanic or Latinx, n=14 Non-Hispanic or Latinx. | • Self-identification as a transgender woman;<br>• Age: 18 to 55 years;<br>• English-speaking. | • Partnerships with community-based organizations;<br>• Flyers;<br>• Social media;<br>• Word of mouth in San Francisco and Portland. |
| **Wilson**[30] | Brazil (Rio de Janeiro) | Pilot intervention study with pre and post assessment. | Evaluation of an evidence-based peer and mHealth delivered systems navigation intervention for increasing human immunodeficiency virus (HIV) testing, pre-exposure prophylaxis (PrEP) and HIV care behaviors among young trans women | • N = 18 (Transwomen);<br>• Age range: 18-24;<br>• M age 21;<br>• Ethnic background: n=6 black; n=10 parda; n=4 white;<br>• Other demographic characteristics:<br>– n=5 HIV positive; n=13 HIV negative<br>– Schooling years: n=9 0-8years; n=11 8+years.<br>– Housing: n=4 own, n=9 rent, n=7 live with family.<br>– n=8 currently doing sex work | • Self-identification as trans woman;<br>• Aged between 18-24;<br>• Living in Rio de Janeiro, Brazil;<br>• Criteria for HIV prevention: not living with HIV and not on PrEP but had PrEP indication without any contraindication to use PrEP;<br>• Participants living with HIV: had an HIV diagnosis and at least one of the following: 1) not on ART, 2) detectable viral load (self-report), 3) not linked to health care, or 4) a missing visit in the past six months. | • Word of mouth;<br>• Peers;<br>• Community education team. |

This table focuses on the design and methodology of studies on mHealth applications for transgender and gender - diverse (TGD) individuals. It includes information on the country of study, study design, objectives, sample characteristics, eligibility criteria, and recruitment strategies.

Definition of gender identities and sexual orientation are those reported by authors. *N* Number, M Mean, SD Standard deviation, N.R. not reported.

that peer navigation led to increased HIV testing, PrEP uptake, and engagement in HIV care, with sustained effects observed up to nine months post-intervention.

These findings highlight the need for more rigorous and comprehensive evaluations of health outcomes in future research[26,28,29,32–34].

## Discussion

Our analysis identifies four key barriers to healthcare access for TGD individuals that these mHealth applications aim to address: structural, interpersonal, economic, and informational. (1) Structural barriers are addressed through features that help locate gender-affirming healthcare services using interactive maps to identify competent providers. Additionally, some apps offer self-administered diagnostic kits, enabling individuals to bypass healthcare facilities, thus facilitating access for underserved populations or those seeking greater privacy. However, these kits risk weakening connections with providers and limiting outreach to vulnerable groups. Telemedicine present a potential solution, enabling personalized care and addressing access barriers that are often influenced by regional policies and healthcare infrastructure. (2) To reduce interpersonal barriers, such as stigma and discrimination, many apps adopt inclusive and affirming language and incorporate community consultation approaches to gain valuable perspectives. Some apps also implement peer-navigation systems to foster supportive relationships, build trust, and alleviate anxiety associated with healthcare interactions. However, these apps often focus on the individual rather than educating the broader environment and healthcare providers, failing to address the stigma and discrimination encountered in physical spaces and thereby perpetuating these barriers. Future mHealth apps should address this gap by promoting the creation of safe physical spaces and implementing training programs for healthcare providers to reduce discriminatory practices. (3) Economic barriers are mitigated by providing low-cost or free solutions for prevention and treatment, including self-administered kits, which reduce expenses related to in-person healthcare visits. (4) Lastly, mHealth apps address informational barriers by offering accurate, contextualized educational resources. This is identified as a strength in the reviewed articles, as these tools empower users to make informed health decisions and enhance their self-management of care.

The present review identifies key features prioritized by researchers to develop mHealth applications specifically addressing TGD needs. The studies analyzed emphasize the importance of using theoretical frameworks to guide the development of effective interventions. However, these frameworks are not always clearly defined, and some apps lack explicit theoretical grounding, limiting their ability to comprehensively address complex health needs. Notable examples of the application of theoretical frameworks include Meyer's minority stress framework[10] and behavioral and cognitive theories that empower users through education, goal setting, and skill development activities, fostering empowerment, self-efficacy, and informed decision-making. Most studies adopt participatory approaches, actively involving TGD individuals in the design and development process. Such approaches have been shown to effectively address health disparities in marginalized populations by promoting changes in community practices, programs, and systems[37]. This is particularly important for TGD individuals, who have historically faced marginalization[38] and the medicalization of their identities, leading to distrust in academic and medical contexts[39]. By fostering trust and collaboration, participatory methods improve satisfaction with both processes and outcomes[40,41], ensuring solutions align with user needs.

Two theoretical frameworks that can be employed to understand the mental and physical health challenges faced by TGD individuals are the Gender Minority Stress Model[10] and the Social Safety Model[42]. The Gender Minority Stress Model suggests that chronic stress stems from societal stressors, both proximal and distal, that negatively impact mental and physical health. In contrast, the Social Safety Model highlights that adverse health outcomes result from a lack of social safety, which includes reliable connections, inclusion, and protection. Both models emphasize the need to reduce environmental stressors, particularly stigma and discrimination, while promoting social safety and protective factors. Research on the health of TGD individuals has historically prioritized the examination of risk factors, including body dysphoria and minority stress. More recently, however, there has been a paradigmatic shift toward recognizing and valuing positive experiences, such as gender euphoria, and moving away from pathologizing conceptualizations of TGD identities. Despite this emerging perspective, preventive interventions frequently continue to emphasize risk mitigation over the promotion of resilience at both individual and collective levels. The TRIM model[43] identifies protective factors: at the group level, these include social support, community belonging (in-person, online, or through media)[44], family acceptance, activism, and positive role models. At the individual level, factors such as self-worth, self-acceptance, pride, self-definition, hope, and gender affirmation pathways foster resilience. Integrating these elements into interventions could enhance support for TGD individuals. Two primary trends emerge from the mHealth apps reviewed: some focus on reducing stigma, discrimination, and violence, while others build support networks and foster community engagement. However, these apps primarily target individuals rather than addressing systemic issues. Since chronic stress is a societal product, rooted in the environments these individuals inhabit, a significant gap remains: mHealth interventions rarely promote environmental change, such as training competent professionals, reducing institutional discrimination, or fostering inclusive practices at a societal level. Future apps should integrate features that actively promote systemic change. Moreover, both the stressors and protective factors identified by the three models should be considered comprehensively to enable multifaceted interventions aimed at promoting the well-being of TGD individuals. This can be achieved by addressing issues such as internalized transphobia, promoting disclosure, reframing negative expectations for the future, fostering affirmation, and reducing victimization and rejection, while simultaneously expanding the focus on resilience factors identified by the TRIM model.

There are significant methodological limitations in the studies reviewed. Many report high usability and satisfaction scores on standardized metrics such as the System Usability Scale (SUS) and the Post-Study System Usability Questionnaire (PSSUQ), reflecting the success of these strategies in addressing usability challenges. However, while usability and user satisfaction are prioritized, rigorous evaluation of health outcomes is often lacking. A common limitation is the absence of baseline measurements, hindering the ability to assess changes over time and increasing the risk of outcome bias. In mental health-focused studies, failure to account for pre-existing conditions such as depression or anxiety may further confound intervention effects and undermine validity. Most studies have short exposure and follow-up periods, typically ranging from two weeks to three months, limiting long-term effect assessments. Discussions on statistical power are often absent, particularly in quantitative or mixed-method designs, with sample sizes frequently under 20 participants and recruitment confined to geographically limited areas, reducing generalizability. Convenience sampling predominates, potentially skewing results toward participants who are more technologically proficient and possess greater resource access. Many studies rely on self-reported data, which can introduce biases. Notably, none of the reviewed studies include control groups, limiting meaningful comparisons with standard care. This gap may stem from challenges in implementing randomized controlled trials (RCTs) for mHealth interventions tailored to TGD individuals, including recruitment difficulties, high costs, and ethical complexities. These barriers are exacerbated by a lack of supportive health policies, which often adopt a welfarist perspective, focusing on minimal provisioning rather than proactively supporting gender-affirming care. Addressing these challenges requires coordinated efforts among academic institutions, healthcare providers, and TGD organizations.

Despite the authors' efforts to incorporate intersectionality and develop resources tailored to specific groups, such as transgender people of color (TPOC), there remains considerable room for improvement in terms of diversity and representation. Many studies fail to adequately include a broad range of demographic groups. For example, non-binary individuals are

often underrepresented, despite their need for application features that explicitly affirm their identities, including gender-neutral language and tailored health resources. Similarly, the distinct needs of both older and younger TGD individuals warrant focused attention, necessitating the development of applications with supportive, age-appropriate interventions. A particularly notable gap is the underrepresentation of TGD individuals under the age of 18. Although digital interventions targeting minors do exist, as identified in the reviews by Skeen et al.[45] and Skeen and Cain[23], these are frequently developed outside academic settings (e.g., QueerViBE[46], Queer Doc[47], and Binder Reminder[48]) by private entities or community-based organizations. As such, they did not meet the inclusion criteria of our systematic review, which focused exclusively on peer-reviewed academic studies. To the best of our knowledge, following the completion of our database search, a study was published in which the MyPEEPS Mobile app, originally developed for same-sex-attracted adolescent males, was adapted for transmasculine youth aged 13 to 18[49]. The app was found to be highly usable and perceived as potentially effective in targeting HIV risk behaviors. The scarcity of studies within academic contexts may be driven by the ethical complexities associated with digital data collection involving minors[41]. Recruitment challenges further compound this issue, as accessing this population often requires collaboration with organizations, schools, or healthcare institutions, which adds procedural complexity. These barriers risk excluding a demographic that, as native digital users, stands to benefit significantly from mobile health interventions, thereby limiting the potential to address their unique needs effectively. Given the high prevalence of mobile technology use among adolescents, who now have unprecedented access to vast amounts of information but often possess limited capacity to assess the reliability of these sources compared to the past, future research should prioritize the development and evaluation of mHealth applications tailored to this age group. Additionally, many studies make implicit assumptions regarding technology access, presuming consistent availability of smartphones and stable internet connectivity, which may not reflect the lived realities of all TGD individuals.

To address existing limitations, future research should prioritize larger, more diverse samples through inclusive recruitment strategies, especially targeting rural and underserved populations. Employing rigorous study designs with baseline measurements, control groups, and validated outcome assessment tools will enhance methodological quality. Long-term follow-ups, supported by sustained funding and partnerships with public and private healthcare providers, are essential for evaluating sustainability and health impacts. Strengthening collaboration between academic institutions, developers, TGD communities, and policymakers is imperative, as lack of coordination can compromise healthcare outcomes[50]. This systematic review highlights progress in mHealth apps for TGD individuals, demonstrating their potential to reduce healthcare barriers through inclusive features and community-driven approaches. Academic apps primarily address public health issues such as HIV prevention and violence reduction, while commercial apps, Supplementary Table I, focus on everyday needs like tracking gender affirmation progress, mental health support, and voice training. Integrating both approaches could produce comprehensive, evidence-based tools that meet critical health needs and provide personalized support, ultimately enhancing the well-being of TGD individuals.

A limitation of this study is that the review protocol was not registered before its initiation.

## Methods

To effectively meet the unique needs of TGD individuals, mHealth apps must prioritize inclusivity and sensitivity in their design. To guide the development of mHealth apps that address these needs, we propose a systematic review focusing on the key features prioritized by researchers. Specifically, this review aims to:

- Identify common theoretical and technical frameworks used in apps development and design.
- Review the types of health outcomes measured in evaluations of these apps, including usability and acceptability, and assess their quality.
- Analyze how app features improve access to healthcare systems and help remove barriers.

### Information source

This systematic review followed the PRISMA 2020 guidelines[51] and employed a comprehensive search strategy across PubMed, Ebsco, Embase, and Scopus using Boolean operators. The PICO framework[52] was used to formulate precise search terms focusing on the Population (P), Intervention (I), and Outcomes (O), while excluding Comparisons (C) since the main focus of the research was to explore the design and development aspects of mobile health applications for TGD people. The Population included transgender and gender diverse individuals, with the following search terms: "transgender*", "transwom*", "transm*", "transsexual*", "gender divers*", "gender nonconform*", "genderqueer", "non-binary", and "gender dysphor*". Despite some terms being outdated or disrespectful, they were included to capture older studies or those from regions where these terms are still in use; The Intervention (I) terms focused on mobile health technologies, using "mobile application*", "smartphone application*", "mHealth", and "mobile health"; The Outcome (O) terms targeted the development and user evaluation of mHealth applications, using: "develop*", "design*", "beta test*", "usability", and "acceptability".

### Study selection and search strategy

A total of 5005 records were identified through database searches conducted on May 5, 2024. The databases included PubMed (n = 609), EBSCO (n = 252), Scopus (n = 2949), and Embase (n = 1195). After removing duplicates, 3569 records remained. These were then screened based on their titles and abstracts, with two authors, MB and MM, independently applying the inclusion criteria. During this stage, 3412 records were excluded as they did not meet the review's scope. No discrepancies occurred between the reviewers during this stage, as all articles with ambiguous eligibility were included for further screening. The remaining 157 records underwent additional screening based on their titles, abstracts, and preliminary full-text review. Discrepancies arose for two articles regarding whether apps with indirect contributions to well-being, such as those locating gender-neutral restrooms, should be classified as mHealth apps. After discussion and consultation with the third author, AG, it was determined that such apps did not meet the definition of mHealth apps and were excluded. In the final stage, 30 articles underwent full-text review. In cases where access to specific articles was restricted, the authors of those articles were contacted. This occurred for three articles: two were successfully obtained through correspondence with Jones[28,29], but the article by Baione[53] was excluded due to lack of response. Discrepancies also emerged regarding three studies that tested existing apps for feasibility with TGD individuals but did not specifically design or develop apps for their needs. These studies were excluded after discussion and consensus with AG, as the primary aim of the review was to evaluate the design and development of mHealth apps tailored to TGD individuals. Of the remaining studies, 21 articles were excluded for not meeting the inclusion criteria and were categorized with reasons for exclusion: "wrong population" (e.g., studies not involving TGD individuals), "apps for sexually transmitted diseases which were generally designed for broader populations and not specifically tailored to TGD individuals"), "not focused on TGD health" (if the primary focus was not on the health of transgender and gender-diverse individuals), "no app development involved" (e.g., protocols for future studies, or exploratory research that did not develop a smartphone mHealth app), and "article inaccessible" (if the criteria were met but the full article could not be accessed; attempts to contact the authors were unsuccessful). Two additional studies were identified through in-text citations, bringing the total to 11 articles that met the inclusion criteria and were included in the systematic review Fig.1.

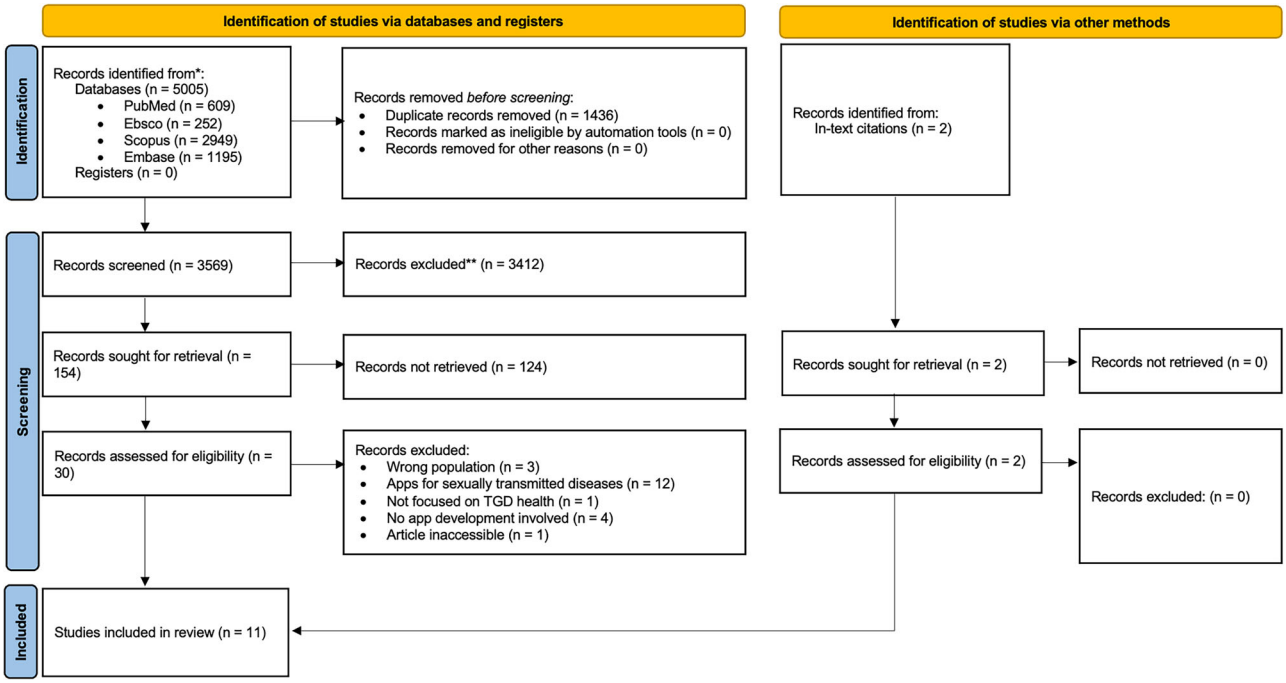


**Fig. 1 | PRISMA flowchart of the systematic search.** Illustrates the systematic review process based on the PRISMA 2020 guidelines, detailing the identification phase in which 5005 records were retrieved from four databases (PubMed, EBSCO, Scopus, and Embase) and an additional two records were identified through manual searches of in-text citations; the screening phase, during which 3569 records were assessed for relevance, resulting in 3412 exclusions and 154 records sought for retrieval, of which 124 were not retrievable; and the eligibility phase, where 30 records were evaluated for inclusion, with 19 excluded due to factors such as wrong population, focus on sexually transmitted diseases, lack of app development, non-relevance to transgender and gender-diverse health, or inaccessibility of articles, ultimately resulting in the inclusion of 11 studies in the review.

### Eligibility criteria

To be included in this systematic review, studies had to meet the following criteria: (a) involve mHealth smartphone applications, including web apps that could be installed on smartphones; (b) be specifically designed or adapted to support TGD individuals; (c) address physical or mental health concerns; and (d) focus on areas such as health monitoring, disease management, or access to health information, or any other purpose directly benefiting the health of TGD people. (e) Studies employing quantitative, qualitative, or mixed-methods approaches, including pilot and feasibility studies, were eligible, (f) provided they were peer-reviewed articles reporting outcome measures (study protocols were excluded). (g) Studies from any geographic location or publication date were included, (h) provided they were written in English, Italian, Portuguese, or Spanish (languages understood by the authors).

Criterion (a) was selected to ensure access to native smartphone functionalities, including push notifications, GPS, cameras, health sensors, real-time monitoring, and offline access. Smartphones, being widely accessible and often the primary tool for accessing digital resources, are essential for reaching diverse users across different geographic and socioeconomic contexts[54].

Exclusion criteria included: (a) apps not designed for TGD individuals; (b) apps focused on sexually transmitted disease interventions not tailored to TGD needs; (c) non-health-related apps for TGD individuals; and (d) apps solely for telemedicine, telehealth, or messaging interventions.

### Data extraction

The data extraction process was conducted independently by two reviewers, MB and MM, who extracted relevant information from each full-text article and assessed the risk of bias. Data related to study design and methodology were summarized in Table 4, while Table 2, presents a detailed overview of the types of mHealth apps examined, their functionalities, and the outcomes reported in the studies.

This systematic review included 11 studies[26–36] focused on developing and testing mHealth applications for TGD individuals. The apps addressed challenges such as gender-affirming healthcare access[36], HIV prevention and education[26–31], suicide prevention[32], credible health information[33], improved communication[34], and safety[35]. Most studies were conducted in the United States (n=9), with two conducted in Brazil. Participants were primarily young adults aged 18-34, although some studies included individuals aged 16-55[26,34]. Sample sizes ranged from 6 to 60, with ethnically diverse representation, including Black, Latinx, and Asian participants[27–32,34].

### Quality Assessment

We evaluated all the studies using the Mixed Methods Appraisal Tool (MMAT)[55], which assesses the methodological quality of qualitative, quantitative, and mixed-methods studies. The MMAT consists of five items, with responses categorized as "yes," "no," or "can't tell." Consistent with prior scoping reviews[56,57], we calculated quality based on the percentage of criteria met by each study. Ratings were classified as very low (20%), low (40%), moderate (60%), moderate-high (80%), and high (100%). The assessments were conducted independently by MB and MM, achieving a Cohen's kappa ($\kappa$=0.82), reflecting substantial agreement. Any discrepancies were resolved through discussion.

## Data availability

All data generated or analysed during this study are included in this published article

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## Author contributions

M.B.: Conceptualization, Data curation, Investigation, Methodology, Project administration, Writing—original draft. A.G.: Supervision, Writing - review & editing. M.M.: Conceptualization, Data curation, Investigation, Methodology, Project administration, Supervision, Writing—review & editing. All authors have read and approved the final version of the manuscript.

## Competing interests

The authors declare no competing interests.

## Additional information

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