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REVIEW

Digital Strategies Supporting Social Network Approaches to HIV Testing: A Scoping Review

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Abstract

Purpose of Review This review captured how digital strategies support social network approaches to promote HIV testing.

Recent Finding Overall, 29 studies were identified by searching PubMed and Embase for studies published up to June 2023. Existing studies revealed three types of digital strategies (social media ($n=28$), online information channels ($n=4$), and multifunctional digital platforms ($n=4$)) split into four major modes of digital strategy-supported social-network-based HIV testing promotion: 1) Online outreach and recruiting, 2) gathering and identifying key populations for HIV testing, 3) communicating and disseminating online HIV testing health interventions, and 4) assisting and facilitating HIV testing uptake and distribution.

Summary Social network approaches supported by digital strategies yielded advantages in HIV testing education and distribution, which increases HIV testing coverage among key populations. Studies are needed on how to facilitate the use of digital strategies for social network-based HIV testing, as well as how to integrate them with existing HIV testing approaches.

Keywords Digital strategy · Social network approach · HIV testing · Secondary distribution · Digital interventions

Introduction

HIV testing is vital for HIV prevention as it is the crucial point for the care continuum and declined transmission, critical to achieving the 95–95-95 targets of testing and treatment among people living with HIV by 2025 [1, 2]. However, the coverage of HIV testing in many settings is still low and needs to be improved. UNAIDS estimated that, in 2022, approximately 15% of people with HIV globally were unaware of their health status. About 50% of gay, bisexual, and other men who have sex with men (MSM) are estimated to be unaware of their infection in 2023. Key populations experienced a disproportionate burden from the HIV pandemic [3–5].

One method with the potential to enhance the coverage of HIV testing involves the utilization of social network approaches. These approaches are designed to activate social relationships or connections within key populations, including their networks of peers, friends, and sexual contacts [6, 7]. Previous studies indicated that compared to conventional clinic-based and provider-led venues, peer-driven outreach has demonstrated efficacy in reaching marginalized, underrepresented, and concealed populations, and individuals with undiagnosed infections [8]. The interventions carried out by community peer leaders also yielded low levels of stigma and had notable impacts on disseminating HIV-related information and augmenting HIV testing behaviors among MSM [9]. Furthermore, peer-based distribution of HIV self-testing kits or partner testing through social networks proved an effective way to increase testing coverage among key populations [10••]. Thus, social network approaches have been adopted by the WHO and US CDC as an effective strategy for improving HIV testing coverage, especially among key populations [11].

Digital strategies or digital health were defined as web 2.0 internet-based applications embedded in health interventions or health services, such as websites, smartphone

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apps, short message service (SMS) text messages, etc. Digital strategies have been widely used in sexual health services promotion with high feasibility and acceptability [12, 13], moreover, these strategies gained profound strength in maintaining and expanding social networks among key populations. For example, geographical-based mobile apps or websites could break virtual boundaries and facilitate social relationship construction [14, 15]. Equipped with instant communication technologies, online digital platforms easily surmount geographical and temporal constraints, demonstrating the ability to reach and gather target individuals and their networks. Integrating digital strategies with social network approaches has the potential to improve the effectiveness of these two strategies.

As digital strategies were increasingly implemented, several review studies have recapped the impacts on HIV testing by developing STI/HIV testing services [12], integrating gamification, tailoring and delivering motivational and interventional messages [16], and prototyping digital platforms [17]. However, the capacity to combine digital strategies, social networks, and HIV testing remained undersummarized. Thus, in this review, we aimed to examine how digital strategies could practically enhance HIV testing, specifically through the social network approaches grounded in the existing evidence.

Methods

Following the five steps of Arksey and O'Malley's' framework [18], we conducted a scoping review to reveal the abovementioned research questions. This model contained 1) identification of a research question, 2) identification of relevant articles, 3) article selection, 4) data charting, and 5) collating, summarizing, and reporting the results. This method could map the studies effectively to examine emerging evidence in a distinctive research area [19].

Searching Strategies

To summarize how HIV testing promotion using social network approaches is supported by digital strategies, our search encompasses studies published from 1947 to June 2023 on Embase and from 1996 to June 2023 on PubMed. Based on the existing relevant research [12, 20, 21], we combined the following search terms: "HIV Infection"; "HIV Testing"; "Diagnosis"; "Screen"; "Telecommunications"; "Internet"; "Web-based"; "Technology"; "M-Health"; "Social Networking"; "peer network" to optimize the accuracy of the selection process in the databases—the detailed search terms are listed in Supplementary Table 1.

Selection Criteria

The data extraction process was conducted using Covidence. Two authors (Z.Y. and W.C.) independently reviewed the studies to ascertain the eligibility of the research for the current study objectives and devised the data extraction criteria. When encountering uncertainty in determination, three authors (Z.Y., Y.D., and W. T.) processed the co-full-text review, deliberated on eligibility, and reached a consensus. To highlight the implementation value of the evidence, we inspected and included studies if their study designs or implementation mentioned 1) the use of social networks or social relationships to promote HIV testing, 2) the description or measurements of the HIV testing-related outcomes, and 3) the utilization of digital techniques. Review articles, study protocols, commentary, conference abstracts, and non-English publications were excluded.

Data Extraction

We categorize the promotion of HIV testing into HIV testing uptake, HIV testing services distribution, HIV testing results, and HIV testing experience, and integrate with the dimensions of knowledge, attitude, and practice according to the included studies' results and aims. Then, the social network approach was divided according to the types and the closeness of the relationship triggered within the process of HIV testing promotion (such as peers, friends, sexual partners, etc.). The names of the platforms or services were initially used to identify the digital strategies. Then, they were sequentially merged into the technology type based on their supporting functions to the research (such as social media, information channels, etc.).

Result

The initial search yielded 1010 research articles up to June 2023 after removing 39 duplicates. Nine hundred seventeen studies were excluded after the title and abstract screening, and 64 were further excluded after full-text screening. The main reasons for exclusion were the absence of HIV testing results, ineligible study types (i.e., study protocols or commentary, etc.), and a lack of key components of digital strategies or social networks. Consequently, 29 eligible studies were included in this review (Fig. 1).

Overview

Of the included studies, all of them were conducted in the last ten years (from 2013 to 2023), and over half of the

research was published after 2020 (58.6%, 17/29) [6, 10••, 22–24, 25••, 26••, 27–36]. Among the enrolled studies, the vast majority (96.6%, 28/29) included MSM as their study population [6, 8, 10••, 22–25••,26••, 28–39•, 40, 41, 42•, 43–47]. Other included studies also involved other sexual minority groups, such as transgender women (TGW) [37, 46], and female sex workers (FSW) [37, 38]. Only one study focused on male mountain porters and female bar workers as populations at high risk for HIV infection [27]. As for the study settings, 44.8% (13/29) of the studies were conducted in the US [6, 8, 22, 26••, 29, 35–37, 39•, 43, 44, 46, 47], followed by Asian countries such as China (34.5%, 10/29) [10••, 23, 24, 25••, 30–34, 40] and India (3.4%, 1/29)[42]. Only three studies were implemented in African countries [27, 28, 38], and another two studies in South America (Peru) [41, 45]. Regarding the study design, more than one-third (34.5%, 10/29) of the included research was cross-sectional studies [8, 10••, 22, 24, 27, 30, 32, 36, 37, 47], followed by eight (27.6% 8/29) randomized controlled trials [6, 25••, 26••, 35, 43–46], four (13.8%, 4/29) longitudinal studies [23, 39•, 41, 42] and three (10.3%,3/29) quasi-experimental studies[29, 33, 40]. One (3.4%,1/29) non-randomized control trial [28], one (3.4%, 1/29) retrospective cohort study [31], one (3.4%, 1/29) national pragmatic trial [34] and one (3.4%, 1/29) case study [38] measuring HIV self-testing distribution were also selected for review (Table 1).

HIV Testing

The included studies demonstrated two main types of social network-based interventions supported by digital strategies: the first is HIV health intervention, which promotes HIV testing through online HIV-related discussion and information dissemination within social networks; the second is HIV testing services distribution, which promotes HIV testing by directly distributing HIV testing kits or services through social networks. The aims of the studies include comparing the effectiveness of different modes (primarily between the digitally supported social-network-based intervention and non or standard of care), assessing the feasibility and acceptability of innovative testing promotion approaches, and cost-effectiveness studies.

Four primary HIV testing outcomes included: 1) HIV testing uptake and cognitive determinants (86.2%, 25/29), 2) HIV testing services distribution and cognitive determinants (51.7%, 15/29), 3) HIV testing results (62.1%, 18/29), and 4) HIV testing experience (6/29, 20.7%). The first outcome refers to the examination of whether HIV testing or HIV self-testing was performed among the participants, as well as the impact on the intention and efficacy of requesting or taking an HIV (self) test [8, 10••, 22, 24, 25••, 26••, 27–39•, 40, 42•, 43–46]. Studies focused on HIV testing distribution mainly investigated the behavior of distributing HIV testing kits or testing online request links to people in their social network, and the willingness to distribute, notify, and be notified of of available HIV testing services or the online request link for HIV testing service/testing kits [6, 8, 23, 24, 25••, 27, 30–33, 35–37, 39•, 47]. Most of the studies described the results of HIV testing, including test positivity and the proportions of new testers among the study population [6, 8, 10••, 22, 24, 25••, 27–31, 33–35, 38, 39•, 42•, 46]. In contrast, a few studies focused on detailed HIV testing experiences, such as the content and frequencies of HIV testing discussions during the intervention period or the testing preferences among the participants [22–24, 33, 41, 43].

Social Networks

Among the social network approaches, three forms of social network primarily used for HIV testing promotion were found. The first type of social network is that of LGBT community members [10••, 23, 24, 25••, 26••, 28, 29, 31–35, 37, 38, 40, 41, 42•, 43–46] who were connected on public platforms without any face-to-face connections. The second type is interpersonal social connections among the study population, such as sex partners [8, 10••, 23, 25••, 32, 36, 39•, 47], family members [8, 10••, 23, 27, 35, 47], friends [8, 10••, 23, 25••, 27, 32, 35, 39•, 47], and loved ones [27]. The third network type was based on social roles, such as coworkers [27] and neighbors [27]. Among those studies, eight of them integrated more than one type of social network into the study design [8, 10••, 23, 24, 25••, 27, 33, 35]. These studies predominantly triggered both community and interpersonal social connections of the participants to distribute HIV testing kits or health services.

Digital Strategies

Regarding digital support, most studies (96.6%, 28/29) adopted social media-based digital strategies [6, 8, 10••, 22–25••, 26••, 28–39•, 40, 41, 42•, 43–47], including general social media platforms (e.g., WhatsApp, Facebook, Line, WeChat, Internet chat rooms, etc.) [6, 8, 10••, 23, 24, 25••, 26••, 28, 30–34, 36–39•, 40, 41, 42•, 43–45], sexual minority-oriented apps (e.g., Grindr, Hornet, Jack'd, PlanetRomeo, A4A Radar, Scruff, etc.) [24, 28, 33, 36, 37, 42•, 46], online forums or social networking sites (e.g., Craigslist, etc.) [6, 22, 24, 26••, 35, 41, 44, 45], and websites for people living with or affected by HIV (e.g., POZ) [39•]. Some studies mentioned neither the name nor the category of the social platform [8, 29, 47]. In addition, various digital strategies such as SMS [27, 38], public websites [33], self-developed websites [29], web-based training [24], email [38], search engine [40], HIVST-specific apps [22] or app-based mini-program [25••] served as main [27] or supportive [22, 25••, 29, 33, 38, 40] tools to strengthen social

Table 1 Overview of eligible studies

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
Balán, Iván C	2021	Acceptability and Use of a Dual HIV/Syphilis Rapid Test and Accompanying Smartphone App to Facilitate Self-and Partner-Testing Among Cisgender Men and Transgender Women Who Have Sex with Men	Cross-sectional study	The United States of America	MSM or TGW	Social Media Platforms and Applications self-developed multifunctional digital platform	There are 77% of participants using the INSTI for HIV self-tested (mean = 3.7 times) and 54% of them had partner testing (mean = 1.6 times). Most of the participants were willing to use the INSTI. The supportive app(SMARTest) was highly accepted and valued for its functions. Seventy-eight percent would recommend the app to a friend. INSTI Multiplex as a self-test accompanied by the SMARTtest app might increase the frequency of HIV and syphilis testing
Chiou, Piao-Yi	2022	Sexual Partner Referral for HIV Testing Through Social Networking Platforms: Cross-sectional Study	Cross-sectional study	China	MSM	Social Media Platforms and Applications	28.2% of MSM were successfully persuaded to become index subjects combined referring 127 sexual partners via the Line app for rapid HIV testing and disclosing 40 sexual partners. The new HIV-seropositivity rate among tested sexual partners was 2.4%, which was higher than the rate in the group of standard VCT

Table 1 (continued)

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
Chiou, Piao-Yi	2021	Mobile HIV Testing Through Social Networking Platforms: Comparative Study	Quasi-experimental study	China	MSM	Social Media Platforms and Applications online information channels	The social networking model was more likely to reach MSM with HIV risk-taking behaviors compared with the traditional model The completion rate, the HIV-positive rates (incidence rate ratio 3.40, $P = .03$), and clinic referral rates (incidence rate ratio 0.03, $P = .006$) were significantly higher among those in the social networking VCT model than in the traditional VCT model
Das, Anjana	2019	Getting to the First 90: Incentivized Peer Mobilizers Promote HIV Testing Services to Men Who Have Sex With Men Using Social Media in Mumbai, India	Longitudinal survey	India	MSM	Social Media Platforms and Applications	In a 6-month period, 247 MSM were recruited and tested for HIV and syphilis, of whom 244 (99%) were first-time testers. And eight individuals (3.2%) tested positive for HIV

Table 1 (continued)

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
Galvan, Frank H	2022	Using social and sexual networking mobile applications to promote HIV testing, medical care and prevention services among Latino men who have sex with men in Los Angeles County, California, USA	Quasi-experimental study	The United States of America	Latino MSM	Social Media Platforms and Applications online information channels	359 participants were recruited. Of the 22 HIV-positive results from Proyecto Protégete, only 7 (32%) of them turned out to be newly diagnosed. The positivity rate was 1.71%, which is higher than the agency and county.(1.71% vs 1.25% vs 1.09%). For the 359 enrolled unique participants, the total number of HIV tests conducted for Proyecto Protégete was 428
Garofalo, Robert	2022	Evaluation of the iCARE Nigeria Pilot Intervention Using Social Media and Peer Navigation to Promote HIV Testing and Linkage to Care Among High-Risk Young Men A Non-randomized Controlled Trial	Non-randomized Controlled Trial	Nigeria	Nigerian youths and young MSM	Social Media Platforms and Applications	A total of 339 young men underwent testing for HIV; of these, 24 received second tests at least 3 months after an initial negative test result. In two 6-month follow-up periods, the intervention increased HIV testing by 42% and 31%, respectively, and seroprevalence increased compared with historical trends with odds ratios of 3.37 ($P = .002$) and 2.74 ($P = .02$), respectively

Table 1 (continued)

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
John, S. A	2020	High willingness to use novel HIV and bacterial sexually transmitted infection partner notification, testing, and treatment strategies among gay and bisexual men	Cross-sectional study	The United States of America	GBM	Social Media Platforms and Applications	Most (90.1%) were willing to give Patient-delivered partner therapy + HIVST to recent sex partners after STI diagnosis, and nearly all (96.4%) were willing to notify sex partners met online using an anonymous function within GSN apps. regardless of casual partner condomless anal sex engagement, partnered GBM had higher odds of reporting willingness to give PDPT + HIVST compared with single men who recently engaged in condomless anal sex with a casual partner
Ko, Nai-Ying	2013	Effects of Internet popular opinion leaders (iPOL) among Internet-using men who have sex with men	Quasi-experimental study	China	MSM	Social Media Platforms and Applications online information channels	MSM who visited the intervention website were more likely to receive HIV-related information ($P < .001$), discuss HIV issues with others ($P < .001$), review articles about HIV ($P < .001$), and be asked about or discuss HIV-related questions ($P < .001$). MSM that visited the intervention website were more likely to have HIV tests within 6 months ($P < .001$) and consistently use condoms during anal sex with online sex partners ($P = .004$)

Table 1 (continued)

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
Kwan, Tsz Ho	2023	Implementation Cascade of a Social Network-Based HIV Self-testing Approach for Men Who Have Sex With Men: Cross-sectional Study	Cross-sectional study	China	MSM	Social Media Platforms and Applications	Participants recruited by seeds were less likely to have previously been tested for HIV ($P = .03$) and have lower confidence in performing self-tests ($P = .045$). Of MSM who requested a self-test, 82% had uploaded their test results. Of the 200 participants who passed the web-based training, 55.5% eventually made at least one referral. Of 354 results returned, 1.1% were positive.(2 were confirmed to be true positives) Overall, the preferred modes of self-test support were instant messaging apps (49.7%), in-person (47.7%), and voice call (41.3%), while video calls and chatbots were preferred by 7.7% and 8.4%. More than a half preferred oral fluid self-tests, 23.3% preferred finger-prick self-test, and 17.6% showed no preference

Table 1 (continued)

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
Li, Shangcao	2021	Feasibility of Indirect Secondary Distribution of HIV Self-test Kits via WeChat Among Men Who Have Sex With Men: National Cross-sectional Study in China	Cross-sectional study	China	MSM	Social Media Platforms and Applications	Total of 2263 MSM met the criteria and successfully applied for HIVST. Overall, out of the 1816, 51 (2.81%) study participants had a reactive HIVST results, including 1422 (88.3%) IPs and 394 (21.7%) alters. More alters had condomless anal intercourse, a higher proportion of them had never previously tested for HIV, and they showed a greater willingness to distribute HIVST kits to their sexual partners ($P = .002$) than the IPs
Lightfoot, Marguerita A	2018	Using a Social Network Strategy to Distribute HIV Self-Test Kits to African American and Latino MSM	Cross-sectional study	The United States of America	African American and Latino MSM	Social Media Platforms and Applications	Peer-distributed HIVST to 143 social and sexual network members, of whom 110 completed the online survey. Compared with MSM who used the County's sponsored testing programs, individuals reached through the peer-based self-testing strategy were significantly more likely to have never tested for HIV ($P < 0.01$) and to report a positive test result ($P < 0.01$)

Table 1 (continued)

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
MacGowan, Robin J	2020	Effect of Internet-Distributed HIV Self-tests on HIV Diagnosis and Behavioral Outcomes in Men Who Have Sex With Men: A Randomized Clinical Trial	(RCT) Randomized Clinical Trial	The United States of America	MSM	Social Media Platforms and Applications	Of 2665 participants, 43 (16.6%) had never tested for HIV before enrollment. More ST participants reported testing 3 or more times during the trial than control participants ($P < .01$). The cumulative number of newly identified infections during the trial was twice as high in the ST participants as the control participants ($P = .02$), with the largest difference in HIV infections identified in the first 3 months ($P < .01$). The ST participants reported 34 newly identified infections among social network members who used the self-tests

Table 1 (continued)

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
Menacho, Luis A	2015	Feasibility of Recruiting Peer Educators to Promote HIV Testing Using Facebook Among Men Who have Sex with Men in Peru	Longitudinal survey	Peru	MSM	Social Media Platforms and Applications	The proportion of peer leaders comfortable using the Facebook tools did not significantly change after the training program. After training, the majority of peer leaders also rated themselves as comfortable discussing each of the topics (sexual partners, HIV, STIs, stigma, culture barriers). A significant increase were found in proportion of peer leaders who were comfortable discussing about sexual and about STIs after the training
Mulongo, Salva	2015	Applying Innovative Approaches for Reaching Men Who Have Sex With Men and Female Sex Workers in the Democratic Republic of Congo	Case study	Democratic Republic of Congo	MSM, female sex workers	Social Media Platforms and Applications online information channels	4,366 MSM and 21,033 FSW were provided with HIV testing and counseling services from October 2012 to June 2014. Of those tested, 1,406 FSW and 537 MSM were seropositive, a rate of 6.7% and 12.3%, respectively. 779 MSM visited St. Hilaire Health Center from October to December 2013, and 693 FSW also visited St. Hilaire during the same period

Table 1 (continued)

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
Ostermann, Jan	2022	Feasibility, Acceptability, and Potential Cost-Effectiveness of a Novel Mobile Phone Intervention to Promote Human Immunodeficiency Virus Testing Within Social Networks in Tanzania	Cross-sectional study	Tanzania	male mountain porters, female bar workers	online information channels	Assuming 1000 persons with characteristics similar to our study participants were offered the opportunity to facilitate confidential SMS-based HIV testing invitations, 1507 confidential SMS-based testing invitations could be sent to contacts within their social networks. Among SMS recipients, 638 would be very likely or somewhat likely to test for HIV. Given plausible assumptions (93% previously tested form HIV; 0.1% HIV incidence among prior testers; 3% HIV prevalence among first-time testers), these 638 CONSORT-attributable HIV tests would be expected to result in 1.93 new HIV diagnoses
Patel, Shilpa N	2023	Distribution of HIV Self-tests by Men Who have Sex with Men (MSM) to Social Network Associates	(RCT) Randomized Controlled Trial	The United States of America	GBMSM	Social Media Platforms and Applications online information channels	Among 995 who reported on their distribution of HIVSTs, 667 (67.0%) distributed HIVSTs to their social network associates (SNAs), which resulted in 34 newly identified HIV infections among 2301 SNAs (1.5%)

Table 1 (continued)

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
Rhodes, Scott D	2016	Using Social Media to Increase HIV Testing Among Gay and Bisexual Men, Other Men Who Have Sex With Men, and Transgender Persons: Outcomes From a Randomized Community Trial	(RCT) Randomized Controlled Trial	The United States of America	MSM and transgender persons	Social Media Platforms and Applications	At baseline, there was no difference in HIV testing rates between the intervention and comparison participants. The odds of past 12-month HIV testing at posttest compared to baseline for intervention participants was 2.9 times as high as the odds of testing at posttest compared with baseline for comparison participants
Sharma, Akshay	2017	Willingness to distribute free rapid home HIV test kits and to test with social or sexual network associates among men who have sex with men in the United States	Cross-sectional study	The United States of America	MSM	Social Media Platforms and Applications	A greater proportion indicated being likely to distribute free oral fluid (OF) tests compared to free fingerstick blood (FSB) tests (91% versus 79%), and almost three-fourths (72%) reported being likely to test with their friends or sex partners in the future

Table 1 (continued)

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
Sun, Christina J	2015	Acceptability and feasibility of using established geosocial and sexual networking mobile applications to promote HIV and STD testing among men who have sex with men	Cross-sectional study	The United States of America	MSM, female sex workers	Social Media Platforms and Applications	About two-thirds (63.8%) of participants reported that they wanted to receive sexual health information via an app. Non-white participants and participants who were not sure of their current HIV status, had low HIV testing self-efficacy, nd used poppers reported being significantly more willing to receive sexual health information via an app. Participants who used other prescription medications recreationally and had sex with women were significantly less willing. For each day drunk, the odds of acceptability of receiving sexual health information via an app decreased by 62%

Table 1 (continued)

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
Wesolowski, Laura	2019	Distribution of HIV Self-tests by HIV-Positive Men Who Have Sex with Men to Social and Sexual Contacts	Longitudinal survey	The United States of America	HIV positive MSM	Social Media Platforms and Applications	Most study participants (36/40, 90%) distributed at least one self-test during the course of the study. Of the 80 tests given to study participants, 74% (59/80) were distributed, 11% (9/80) were used by participants to test themselves, and 15% (12/80) were not used The distributors of the two tests with positive results indicated that neither recipient previously knew he was positive

Table 1 (continued)

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
Wu, Dan	2021	Social Media–Based Secondary Distribution of Human Immunodeficiency Virus/Syphilis Self-testing Among Chinese Men Who Have Sex with Men	Cross-sectional study	China	MSM	self-developed multifunctional digital platform Social Media Platforms and Applications	A total of 371 unique index men applied for 1150 kits, of which 1141test results were returned (99%). Among them, 1099 were valid test results; 810 (74%) were from 331 unique index men, and 289 tests (26%) were from 281 unique alters. Overall, 20 of 612 unique testers (3%) had a reactive HIV self-test result. Fifteen of them were alters, and 5 were indexes. Compared to index men, a higher proportion of alters were naive HIV testers ($P < .001$). The total HIV self-test reactivity rate was 3%, with alters having a significantly higher rate than indexes (5% vs 2%; $P = .008$)
Yang, Nancy	2021	Sexual Health Influencer Distribution of HIV/Syphilis Self-Tests Among Men Who Have Sex With Men in China: Secondary Analysis to Inform Community-Based Interventions	Retrospective cohort study	China	MSM, female sex workers	Social Media Platforms and Applications	Each sexual health influencer successfully encouraged 1.66 alters to self-test compared to 0.51 alters encouraged by each noninfluencer, and had twice as many alters who returned a test result compared to each noninfluencer

Table 1 (continued)

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
Young, Sean D	2013	Social networking technologies as an emerging tool for HIV prevention: a cluster randomized trial	(RCT) Randomized Controlled Trial	The United States of America	African American and Latino MSM	Social Media Platforms and Applications	Twenty-five of 57 intervention participants (44%) requested home-based HIV testing kits compared with 11 of 55 control participants (20%). Nine of the 25 intervention participants (36%) who requested the test took it and mailed it back compared with 2 of the 11 control participants (18%) who requested the test. More intervention participants requested an HIV testing kit than control participants. Of the 25 intervention participants who requested a testing kit, 9 returned it and 8 of them followed up to obtain their test results
Young, Sean D	2015	The HOPE social media intervention for global HIV prevention in Peru: a cluster randomised controlled trial	(RCT) Rluster randomised controlled trial	Peru	MSM	Social Media Platforms and Applications	43 participants (17%) in the intervention group and 16 (7%) in the control groups got tested for HIV. The odds of requesting a test and getting tested among participants in the intervention group was 2·79 times and 2·61 times those in the control group after adjustment for baseline covariates

Table 1 (continued)

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
Young, Sean D	2022	A Peer-Led Online Community to Increase HIV Self-Testing Among African American and Latinx MSM: A Randomized Controlled Trial	(RCT) Randomized Controlled Trial	The United States of America	African American and Latinx MSM	Social Media Platforms and Applications	Compared with the control groups (102 of 450, 23%), a greater proportion of participants in the intervention groups (130 of 450, 29%) accepted the offer for an HIV self-test ($P = 0.027$). The later phase (ie, waves 4, 5, and 6) showed significant intervention effects on increased odds of accepting the offer for the HIV test kits, greater odds of self-reported HIV home-testing
Young, Sean D	2014	Project HOPE: online social network changes in an HIV prevention randomized controlled trial for African American and Latino men who have sex with men	(RCT) Randomized Controlled Trial	The United States of America	racial/ethnic minority MSM	Social Media Platforms and Applications	A significant positive relation between increased network ties and using social media to discuss sexual behaviors showed in the interventio group. A positive trending relationship between increased network ties and likelihood of HIV testing, follow-up for test results, and participation displayed in online community discussions

Table 1 (continued)

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
Zhang, Wenran	2020	HIV Self-Testing Programs to Men Who Have Sex With Men Delivered by Social Media Key Opinion Leaders and Community-Based Organizations are Both Effective and Complementary: A National Pragmatic Study in China	National Pragmatic Study	China	MSM	Social Media Platforms and Applications	MSM reached by SMKOLs had a lower HIV seropositive rate, and higher proportion received antiretroviral treatment compared with CBO-recruited MSM (all $P < 0.05$). For the SMKOL group, among the 1957 MSM who applied for HIVST kits, 89.1% (1743/1957) met the eligibility criteria, and 89.6% (1561/1743) of those uploaded HIVST results. Of the MSM following the testing stage, 2.9% (45/1561) received HIVST-positive results, 82.2% (37/45) were linked to care, 33 (2.1%) were confirmed as HIV-seropositive

Table 1 (continued)

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
Zhao, Peipei	2023	Testing Together Behaviors in Secondary Distribution of HIV/Syphilis Self-testing Program Among Men Who have Sex with Men in China	Longitudinal survey	China	MSM	Social Media Platforms and Applications	138 index participants reported distributing HIVST kits to at least one alter, resulting in a total of 237 self-test kits. The majority of the distributors (107/138, 77.5%) tested with at least one alter, performing a total of 145 times testing together behaviors. More than half of the alters (138/264, 52.3%) tested with index participants simultaneously. A small number of index participants (25/371, 6.7%) and alters (23/264, 8.7%) reported some negative feelings or events when they distributed or received the self-test kit. Negative feelings, such as misunderstanding, shame, and mistrust were most frequently reported. Most of the negative feelings or events happened during or after testing together

Table 1 (continued)

First author's name	Published year	Title	Study type	Study setting	Target population	Digital strategies	Primary key results
Zhou, Yi	2022	Monetary incentives and peer referral in promoting secondary distribution of HIV self-testing among men who have sex with men in China: A randomized controlled trial	(RCT) Randomized Controlled Trial	China	MSM	self-developed multifunctional digital platform Social Media Platforms and Applications	Index participants in the control arm ordered a total of 222 kits, and testers returned 209 test results (returning rate: 94%), among which 144 results were from index participants self-testing, and 65 (31%, 65/209) results were from 58 unique alters. 18 testers were diagnosed with HIV, including 3 index participants (2 newly diagnosed with HIV) and 15 alters (13 newly diagnosed) Compared with index participants in the control group, index participants in intervention groups were more likely to motivate more unique alters to self-tested for HIV. The likelihood that the total number of newly tested alters motivated by index participants was significantly increased when index participants were in the SD-M group or SD-M-PR group, compared with the one in the control group

MSM, men who have sex with men; *TGW*, transgender women; *GBM,* gay and bisexual men; *GBMSM*, gay and bisexual men who have sex with men

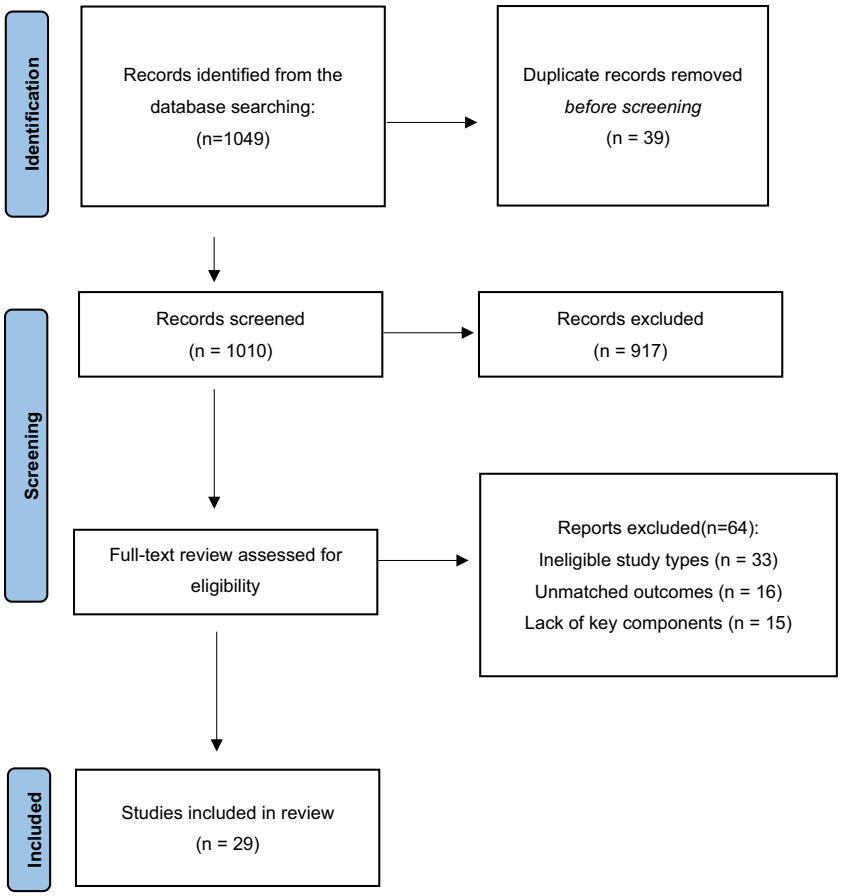

Fig. 1 Flowchart of the data extraction

network approach to HIV testing. According to the digital-based communication or interaction patterns in supporting social network approaches to HIV testing, we sorted the digital strategies into three main categories: social media platforms and applications, online information channels, and self-developed multifunctional digital platforms (See Fig. 2).

Social Media Platforms and Applications:

Social media-based strategies have been widely adopted to expand HIV testing among key populations, facilitating reaching and recruiting the target population and enabling communal interactions and exchange of HIV-related information among users, their social networks, and health workers [6, 8, 10••, 22–25••, 26••, 28–39•, 40, 41, 42•, 43–47]

Online Approach Facilitates Reaching and Recruiting the Target Population

Social media facilitated recruitment processes among key populations. Digital approaches such as banner ads on Facebook, online forums, or other social networking sites, and distinctive channels that consider regional and target users' preferences, yield significant strength in reaching uncovered participants.

In the included studies, three types of participants were recruited via the abovementioned channels. First, "peer leaders" [24, 33, 36, 42•] who mobilized or assisted others' participation in HIV testing. For example, the peer mobilization project named *Mulakat* in Mumbai [42•] used PlanetRomeo (the local MSM preferred social media site) to reach 5530 men and successfully recruit 247 participants, including 22 first-wave peer mobilizers. Those peer mobilizers provided coupons with unique codes to their social network to facilitate clinic-based HIV testing and reached 99% of first-time testers. Second, "index participants" [6, 8, 10••, 22, 23, 25••, 31, 32, 35, 39•, 47] were defined as those who directly distributed or were supposed to distribute the testing kits or testing request links within their networks, such as friends, sex partners, or community members. The online WeChat platform run by minority community-based organizations was used for reaching potential test distributors in several Chinese studies [10••, 23, 25••, 31, 32, 34].

In New York, a study recruited 48 cisgender men and transgender women who have sex with men by the combination of geospatial sexual networking applications, online forums, and offline centers, to screen their sexual partners using a smartphone-based HIV/syphilis test. Third, "intervention receivers" [22, 24, 26••, 27, 30–33,

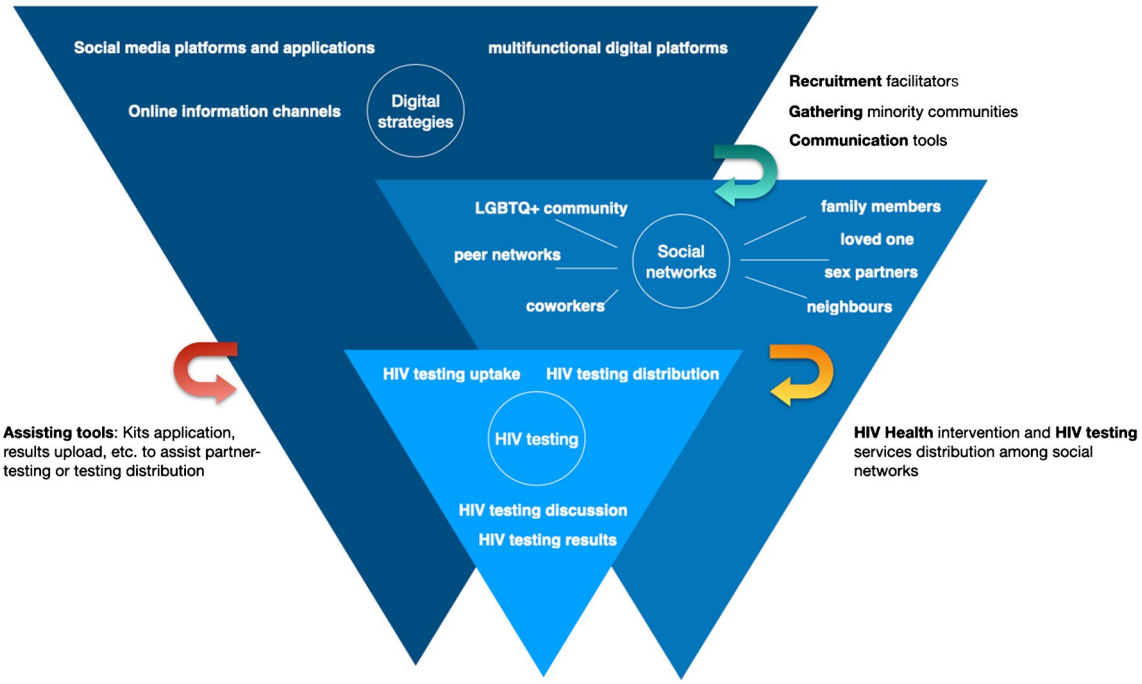

Fig. 2 The forms of digital strategies, social networks, and HIV testing promotion and their relationships Note: the arrow symbols refer to how digital strategies enhance the social networks approach (the green arrow), how the social networks approach supports HIV testing (the yellow arrow), and how digital strategies assist HIV testing (the red arrow).

36–38, 40, 42•, 45, 46] received or were supposed to receive the social network-based intervention, e.g. HIV testing/prevention-related messages, notifications, or invitations, from "peer leaders" or directly from program staff, or testing request links/testing kits from "index participants." In the series of HOPE projects, 900 African-American and Latino MSM in Los Angeles and 556 MSM in Peru were recruited through targeted banner ads on social networking sites (i.e., Facebook, Craigslist, and commonly used Peruvian gay websites) to receive peer leaders' information about HIV prevention and testing as the intervention [26••, 44, 45].

Social media outreach is an effective way to reach target populations. First, it gains high acceptability and efficiency in reaching populations at high risk for HIV. Of note, MSM from Mumbai extended a significant preference by recruiting from sexual minority-oriented apps [42•]. Moreover, compared to the traditional voluntary counseling and testing (VCT) model, social media outreach is more likely to precisely reach MSM who have the risk for HIV infection due to multiple sex partners, condomless sex, or substance use, or who do not test regularly [33]. Second, the cost of social media outreach is relatively low. WeChat-recruited sexual health influencers can encourage numerous alters to get self-tests [31]; thus, the average cost per person tested stimulated by social media key opinion leader index was relatively lower than in community-based organization (CBO) venues [34]. In contrast, social media outreach can lack the capacity to reach diverse participants such as older MSM[28].

Communicative Functions Support Health Information Delivery

Social media platforms with instant communication functions [6, 8, 10••, 22–25••, 26••, 28–39•, 40, 41, 42•, 43–47] allow online posting and facilitate the sharing and exchanging of online information, including recruitment messages, testing-related information, and links for HIV testing requests or appointments.

First, social media worked as a tool to reach or gather MSM community members for engagement in social network-based interventions. In some studies, "opinion leaders" were recruited to build [40] and/or operate [34, 40] public platforms on Facebook or WeChat to reach populations at high risk for HIV among social media users with HIV testing content. In other studies, existing [28, 46] or newly created [26••, 28, 41, 42•, 44] communication groups served as online communities to accommodate participants These online spaces such as gay dating apps or minority-friendly websites originally were designed for the key populations that fulfilled their daily needs, and were used for social-network-based HIV testing. Among those, privacy settings such as non-public

groups [26••, 28, 41, 44] (i.e., unable to be accessed or searched for by nongroup members) and concealment of group members' contact details [42•] were adopted to protect identifiable information of the participants. Second, program staff offered pre-testing [30, 33, 37, 38, 42•] and post-testing [32, 42•] discussions or counseling via social media. In studies where pre-testing communications were conducted, participants were provided with HIV prevention education [33, 37, 42•], information about available HIV testing services [33, 37, 38], encouragement to refer their peers [33, 38], assistance in making testing appointments [30], and easing of fears about testing[38]. On the other hand, post-testing communications mainly focused on follow-up services such as HIV prevention messaging [42•], test results interpretation, and linkage to clinical confirmatory testing and treatment [32].

Communication and education about HIV testing services through social media exhibited high acceptance for both intervention receivers and peer leaders. For the intervention receivers, one study in the US revealed that over three-fifths of participants believed that a gay dating app is a proper channel to receive HIV information from peer navigators [37], and most of the participants were willing to notify sex partners through geospatial sexual networking apps (eg, Grindr, Scruff, Tinder) and be notified to get counseling and testing [36]. Regarding online group discussions, a study from Young [44] showed participants who were randomly assigned to closed Facebook groups with peer leaders who discussed HIV prevention and testing had higher acceptance and engagement in the social networking community compared to peer leaders who discussed general health topics in the closed Facebook groups. For the peer leaders, a pre-and post-comparison study demonstrated that educational training on HIV-related epidemiology, stigma, and the use of Facebook significantly increased the willingness and knowledge of peer leaders to engage in online HIV prevention interventions [41]. After receiving online opinion leaders' intervention, participants were more likely to access HIV-related information online and discuss HIV-related topics with their friends [40]. Their willingness and behaviors to perform HIV testing or self-testing were significantly increased [26••, 35, 36, 45].

Online Information Channels:

Several online information channels were used to assist in implementing social network-based HIV testing interventions [27, 33, 38, 40]. Although these strategies did not directly exaggerate participants' social networks, they still showed connections with online or offline communities and promoted HIV testing among the key populations. Unlike general social media, these channels often support one-way online searching or messaging with limited user interactions. Likewise, these channels are grouped into three categories based on their functions:

Online Community Searching and Targeting:

Web-based search engines were used to identify online communities with high risk for HIV acquisition where social network approaches to promote HIV testing could be implemented. According to research conducted in Taiwan and China [40], standard search engines (i.e., Google, Yahoo, and Ping) were applied to identify the online virtual MSM community by using keyword searching methods (i.e., gay, AIDS, HIV, and other relevant search terms of interest.). After locating the online community, peer leaders were recruited from selected online communities to assist with participant recruitment for HIV testing. Then the selected peer leaders would conduct a 5-month intervention in those platforms identified by the search engine (such as Facebook) to promote the HIV testing performances of the participants [40].

Online Information Publicizing for Recruitment:

Aside from general social media, public websites could also support online recruitment. A study in Taiwan and China compared the HIV test positivity and confirmed diagnosis rates between participants recruited by the public website of a municipal hospital (control group) and participants recruited by social media (intervention group) [33].

Details of the upcoming testing for control group participants were posted daily on the public website of a municipal hospital, whereas designated HIV testing services were posted and could be booked for intervention group participants on social networking apps Results revealed that the HIV-positive and referral rates for confirmation diagnosis from the public website-based recruitment group (control group) were significantly lower than the social media-based group (intervention group) [33]. The public website-based control group was also less likely to reach people engaged in behaviors associated with HIV acquisition, including seeking sexual activity through social media, having multiple sexual partners and condomless anal intercourse, or using recreational drugs, and those who do not regularly test for HIV or have never tested, compared with the traditional model social media-based intervention group [33].

A self-developed website was also applied for recruitment in a U.S. study [29]. In the intervention arm, potential participants were directed to the recruitment website after clicking online advertisements on the asocial networking platform [29]. A series of questions on the website were then presented to screen participants for eligibility [29]. The website then

showed detailed information on HIV testing services to eligible participants' websites [29]. This recruitment approach presents equal effects on diagnosed newly identified HIV infections compared to the county's directly funded programs [29].

One-way Messaging for Recruitment:

SMS [27, 38] and emails [38] were used to recruit participants for HIV testing by a one-way information dissemination [38]. Among the two studies in Africa [27, 38], text messaging services were used alone [27] or together with social media [27] for participant recruitment. Emails [38] were utilized through a similar process. In a study conducted in the Democratic Republic of Congo emails and SMS, together with social media, were used to disseminate messages about upcoming testing services to MSM and FSW communities [38]. Another study in Tanzania solely used SMS to send mobile phone-based testing invitations to social and sexual network contacts of male mountain porters and female bar workers testing for HIV [27]. The study conducted in Congo showed the feasibility of reaching MSM and FSW through a combined notification strategy of SMS, email, and Facebook by reporting the number of people tested and the percentage who tested HIV-positive [38]. As for the cross-sectional study in Tanzania, the feasibility and acceptability of implementing the novel mobile intervention were measured by the proportion of participants willing to test for HIV and distribute the SMS-based confidential social network referrals for HIV testing.

Self-developed Multifunctional Digital Platforms

The self-developed digital multifunctional platform is a hybrid strategy that provides supportive functions for achieving HIV testing or kit distribution. These types of packages include mini-programs embedded in existing social media [10••, 25••], web-based platforms[24], or mobile apps [22] designed by the research teams for social network-based HIV testing interventions specifically. Two categories of self-developed digital packages were identified:

Mini Program Assisting Testing Applying and referral to social networks

Studies conducted in China demonstrated the usage of a self-developed mini-program based on the WeChat platform initiated by local community-based organizations [25••]. Mini-program is one type of single mobile native application with advanced features for the users built within the WeChat platform. This type of technology was achieved by releasing the privilege to third-party companies. This program contained two main advantages including instant loading and ease of use [48]. Embedded in WeChat, this mini-program was multifunctional and designed for the cascade of social network distribution of HIV self-test kits, including approaches to applying HIV self-testing kits online, paying refundable deposits, mailing testing kits, and uploading test results. Index participants were recruited to distribute HIV or dual HIV/syphilis self-testing kits to their friends (straight and gay friends), sexual partners, and family members. The distribution could be performed through direct HIV testing kit sharing in person or by forwarding the virtual link or code connected to the mini-program online [10••, 24]. Then, the "alters" (who received the distribution) could upload photos of their test results anonymously and privately to the online mini-program [25••] followed by a monetary incentive, which simplifies the process of social network distribution of HIV self-test kits (for the detailed process **see** Fig. 3). The high return rate of 99% (1141/1150) [10] and the high proportion of new testers (about 34% to 40%) among the alters present high effectiveness and acceptability of expanding HIV self-testing among MSM [10••, 25••]. Moreover, combined with online peer referral links, participants were more likely to motivate more unique alters to get self-tested [25••].

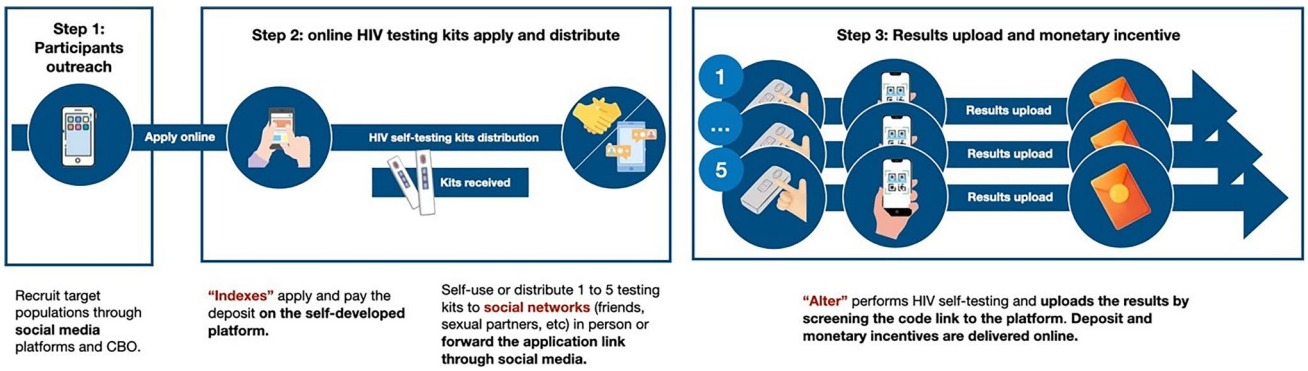

Fig. 3 The flow chart of how the developed mini program facilitates HIV testing expansion in the social network approach. Note: Bold Red showed how social networks were used in the process, and Bold Black showed how digital strategies were used in the process

Self-developed Platform for Testing Guidance and Health Education

With consideration of the needs of the participant, some research utilized user-centered applications supporting HIV testing mentoring and interpretation. In such a practice in the US [22], the SMARTest app provided optional voiceover or video step-by-step instructions on HIV self-testing, which were reported to increase the knowledge of HIV testing and comfort, as well as partner HIV/STI testing. Moreover, the app also provided support after HIV testing, with a scanning feature that translated testing results into words to allow users to save or send results to others, and location-based resources and information for follow-up HIV care. Like the SMARTest, a web-based platform implemented in Hong Kong provided four pages of web-based training prior to the peer referral process to cultivate basic information on HIV, HIV self-tests, and study logistics for the index. Over 50% of participants who passed the training eventually successfully distributed at least one HIV testing kit [24]. These applications with supportive functions gained high acceptability by the participants, and over 70% of participants were willing to recommend the application to their social networks [22]. However, studies also revealed the challenges of using self-developed platforms. First, users with HIV testing experience and confidence may not value the supportive functions. Second, concerns about the privacy of HIV test results and lack of confidence to perform HIV self-testing using the test-supporting platforms. Specifically, inaccessible internet, software misuse, and hardware issues limit the full benefits of digital supportive tools [22].

Policy and Research Implications

Our scoping review indicates several important policy and research implications.

First, using digital strategies to implement social-network-based HIV testing is still partial and limited. The existing studies mainly highlight the advantages of digital support on social network strategies or HIV testing solely, and contribute to particular components such as 1) reaching and recruiting, which indicates the potential of information outreach on different types of social platforms; 2) gathering and identifying, which values the online target population community building and offline geographical tagging; 3) communicating and intervening, which underscores the online intervention delivery and message. However, there remains a lack of comprehensive strategies for utilizing digital approaches to facilitate all the abovementioned steps of the study implementation. Practices such as incorporating HIV testing peer-referral applications linking social media-based systems [10••, 25••], and studies are needed to examine the effectiveness and costs of hybrid strategies.

Second, the social-network-based HIV testing interventions supported by a digital strategy may yield effectiveness on HIV testing expansion[49], and it is crucial to adapt them to a broader population and distinctive social network types. The majority of current studies focused on the population aged around thirty [45], tend to exclude and marginalize aging MSM who may encounter difficulties in embracing digital strategies [28]. Additionally, inadequate studies focused on certain key and vulnerable populations in the HIV pandemic, such as adolescent girls, young transgender women, and others. Peer-driven strategies are profoundly prevalent in reaching and delivering health services to sex partners of the key populations [47]. Therefore, the HIV self-testing distribution from those people who acquired HIV could be highly effective in pinpointing key targets, which need more studies to explore. As some studies have observed, there is a phenomenon of distributing interventions through (straight) friend networks [10••]. So, amicable networks, such as heterosexual women friends of key populations, may demonstrate potential feasibility [50].

Thirdly, our scoping review indicates that we may integrate digital-supported social network HIV testing interventions with existing services to facilitate these strategies' use. Existing findings demonstrated a concentration of US and Asian studies, revealing a global imbalance in adopting these strategies. Based on our findings, those practices were mainly conducted on globally prominent media platforms, such as Facebook, or WhatsApp, which gained the feasibility to be adopted in a greater range, even in those digital-underdeveloped countries [51]. Additionally, incorporating community-based venues, identified as comparably effective in recruitment and peer education [34, 43, 44], could be integrated into practice. There is a need for policies and research endeavors that extend the application to these underrepresented study sites.

Conclusion

In summary, multiple digital strategies could support social-network-based intervention to expand HIV testing coverage among the key population. Consortiums of digital functions and under-estimated social relationships were needed to supplement the existing practice scope globally.

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Author Contributions WT, ZY, and WC conceived the ideas. ZY and YD wrote the first draft of the manuscript. ZY, YD, and WT revised and finalized the manuscript. All authors contributed to the manuscript and approved the final version for submission.

Declarations

Competing Interests The authors confirmed no competing interests.

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- • Of importance
- •• Of major importance

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