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SUBSTANTIVE REVIEW

A Systematic Review of the Social Network Strategy to Optimize HIV Testing in Key Populations to End the Epidemic in the United States

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Abstract

The United States (U.S.) has a plan to end the HIV epidemic by 2030. The plan's first pillar prioritizes HIV testing. Social Network Strategy (SNS) is an intervention to reach persons not routinely testing for HIV. We conducted a systematic review of SNS to understand its implementation to optimize HIV testing in the U.S. among key populations. The eligibility criteria included peer-reviewed papers based in the U.S. and focused on HIV testing. We identified and thematically analyzed 14 articles to explore factors associated with successful implementation. Key themes included: (1) social network and recruiter characteristics; (2) strategies for and effectiveness of recruiting key populations; (3) use of and types of incentives; (4) trust, confidentiality, and stigma concerns; and (5) implementation plans and real-world guidance. Cohort studies indicated that SNS detects more incident HIV cases. Partnerships with health departments are critical to confirm new diagnoses, as are developing plans that support recruiters and staff. SNS is a promising strategy to optimize HIV testing among key populations.

Keywords HIV testing · Social network strategy · Implementation · Public health practice · End the HIV Epidemic

Introduction

We are currently in an unprecedented era as policymakers apply the latest advances in HIV treatment and prevention science to end the HIV epidemic in the United States (U.S.). During the 2019 State of the Union Address, the President announced a plan to end the U.S. HIV epidemic by reducing new infections by 75% in five years and 90% in 10 years [1]. To achieve these goals, the plan is organized around four key pillars: diagnose, treat, protect, and respond. The first, *diagnose,* focuses on improving early and timely detection of HIV cases. *Treat* stresses rapid linkage to HIV care, and initiation of antiretroviral therapy to achieve viral suppression, thus eliminating onward transmission [2, 3]. *Protect* emphasizes protecting those at risk for HIV from becoming infected using novel prevention methods such as pre-exposure prophylaxis [4–7]. Lastly, *respond* highlights a rapid response to growing HIV infection clusters and prevention of new ones [8, 9]. Ultimately, the success of the plan hinges on effective strategies to promote HIV testing, the first step in the HIV treatment and prevention cascades [10–12].

Of the estimated 1.2 million adults and youth living with HIV in the U.S., approximately one out of seven individuals do not know their status, and 45% aged 13–24 years are unaware of their status [13]. The Centers for Disease Control & Prevention (CDC) currently recommend routine testing during clinical encounters [8] and testing through several non-clinical settings and approaches [9]. These include voluntary counseling and testing sites hosted by trusted community-based organizations as well as venue-based testing, such as at gay Pride events. In addition, public health disease intervention specialists interview those recently diagnosed with HIV to notify sexual partners and encourage them to pursue HIV testing [14–16]. Moreover, self-testing at home has emerged as an important strategy, gaining even greater traction during the COVID-19 pandemic given limits to in-person visits [17–19]. The majority of tests performed

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in non-clinical settings in the U.S. occur in the context of CDC-supported HIV counseling, referral and testing (CRT) services with over 3.2 million tests conducted annually, yielding an overall test positivity of 1% [10]. The efficiency and acceptability of any non-clinical testing approach are of particular importance to jurisdictions seeking to invest limited resources in methods with higher case detection rates, especially for key populations at higher risk for HIV acquisition, such as men who have sex with men (MSM), who are encouraged to test at least once annually or more frequently [20].

Recent reviews have pointed to the promise of social network strategy (SNS) to efficiently reach key populations for HIV testing [21]. SNS builds on over 40 years of epidemiologic and interventional studies that have leveraged social networks for participant recruitment, including snowball sampling, respondent-driven sampling (RDS), and long-chain peer referral [22–24]. SNS is grounded in the idea that members of a social network share the same or similar risks for HIV, tend to trust each other, and may be more willing to adopt behaviors endorsed by members of their network. SNS enlists an initial group of persons at elevated risk or living with HIV as "seeds." These seeds are then tasked with recruiting other persons within their social networks (i.e., network associates) to test for HIV and engage in prevention or treatment services. Seeds receive training and education to help them identify network associates and motivate others to pursue testing, and they often receive incentives to support their recruitment efforts. This method has been shown to effectively detect new HIV positive cases at rates of 5% or higher [25].

There is a strong theoretical underpinning for how social networks might optimize HIV testing. Social Network Theory studies the relationships and interactions of social groups, communities, and their various networks [26]. Centrality, which identifies how densely connected an individual is to others in their network, is fundamental to the success of the strategy [27] and prioritizes recruiters who are better connected to their social networks. Egocentric networks are tightly connected to one individual, who knows many others, whereas socio-centric networks connect multiple people in a network who, in turn, may be connected to numerous others [28]. Egocentricity is important in the selection of initial seeds, and successful propagation to subsequent waves requires sufficient socio-centricity. In addition, SNS applies the Theory of Planned Behavior, which identifies social norms and pressures as levers in influencing attitudes toward testing, testing intentions, and perceived control of the behavior [29].

While prior studies have documented the efficiency of SNS for HIV case detection, little is known about the facilitators and barriers to SNS implementation or what factors may influence SNS programs' operational success. To speed the translation of evidence to public health practice, we conducted a systematic review of the SNS literature to identify these characteristics and offer recommendations for community-based organizations and public health agencies considering this approach.

Methods

We conducted a systematic review of the published literature using PubMed and Web of Science databases aligned with the PRISMA criteria [30]. We used a combination of the following terms: "social" and "network" and "strategy"; and "HIV" or "human immunodeficiency virus;" and "United;" and "States". The eligibility criteria for inclusion in the review were as follows: included key populations, such as MSM, person using intravenous drugs, and racial or ethnic minorities; were peer-reviewed, empirical evaluations; were based in the U.S., and focused on SNS specifically applied to HIV testing. We included publications dated from 1981, the start of the social network literature, through June 2020.

Based on these criteria, we identified a total of 979 papers from PubMed and Web of Science to review. We conducted our systematic review of these articles separately for each database. We did not pool databases and remove duplicates at the onset, as we used it as a screening quality metric to assess overlap in our screening between the databases. Therefore, the numbers presented hereafter may include duplicates (from Web of Science and PubMed). Based on the inclusion criteria, we removed a total of 411 studies that were not based in the U.S, 351 papers because they were not focused on HIV testing, and 173 papers because they were not SNS-specific (e.g., they instead focused on respondent-driven or snowball sampling). We excluded an additional eight studies because they were not empirical studies and removed five more because they were not SNS and were missing HIV testing as an outcome. We explicitly included studies that discussed facilitators and barriers of this approach. After combining the two sets of reviews (n = 31 studies), we removed 17 duplicates, leaving a total of 14 unique studies to include in our analysis (Fig. 1). Given that 55% of the studies were present after reviewing both databases, we believe this supports the quality of our screening and review processes. The papers left for inclusion were published between 2009 and 2018.

Analysis of Papers

We used thematic analysis to analyze the key factors associated with successful implementation of SNS. We identified themes to understand who SNS reaches for testing and the facilitators and challenges to successful SNS implementation [31]. First, the first author (KS) began to familiarize

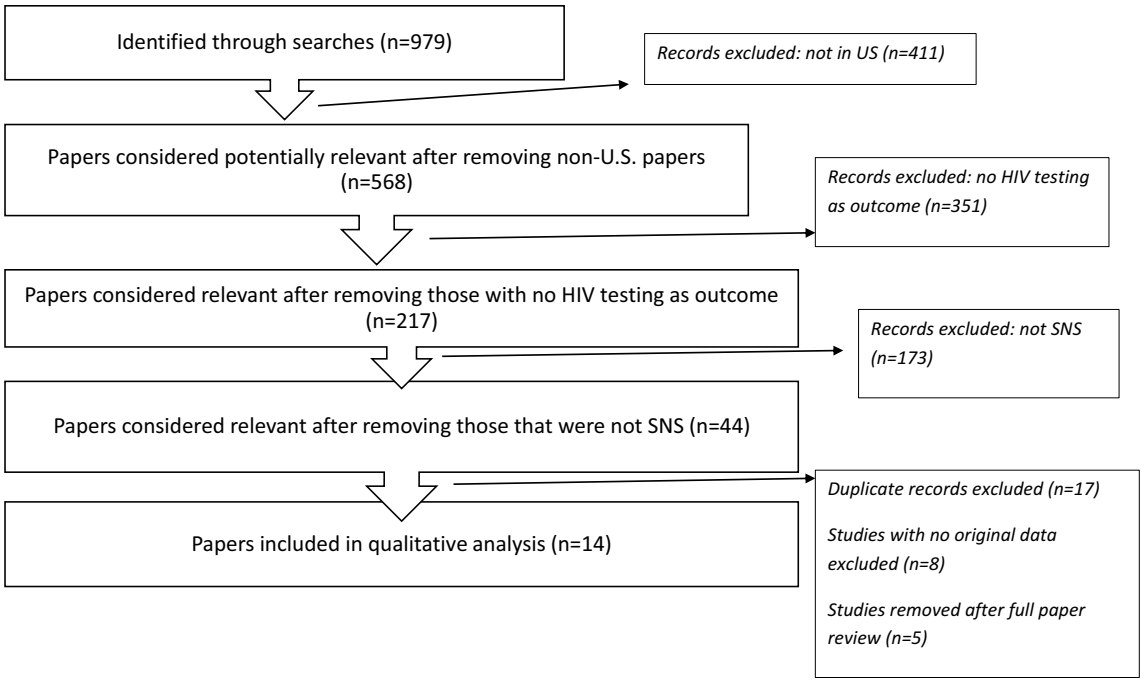

Fig. 1 Diagram of systematic review search and excluded research articles

himself with the findings and main conclusions. Next, KS analyzed the methodological approaches, results, and discussions to understand which priority populations were of primary interest, the studies' locations, and risk of bias. We assessed the risk of bias by exploring potential threats to studies' internal and external validity. For example, we evaluated study designs (e.g., cross-sectional, cohort), presence of comparison groups, and confounding analyses.

KS then extracted the quantitative metrics that typically accompany SNS, including (1) total number of recruiters; (2) the total number of network associates (recruits) recruited; (3) network indices, defined as the number of network associates recruited divided by the total number of recruiters; and (4) new HIV positivity rates (i.e., number of new cases of HIV detected). New cases were determined by reviewing epidemiological surveillance data in some studies, others were cohort studies, and others relied on self-reported knowledge of serostatus. We incorporated this variation in the results. We developed the key themes, both a priori and *posteriori*. For the a priori themes, we were guided by SNS theory and its critical components, including working with recruiters, incentives, and trust and confidentiality. *Posteriori* factors were determined by the thematic review itself, including real-world implementation factors, the collaboration required to implement SNS, and the strategy's sustainability. The key themes included: (1) social network and recruiter characteristics; (2) strategies for and effectiveness of recruiting key populations; (3) use of and types of incentives; (4) trust, confidentiality, and stigma concerns; and (5) implementation plans and real-world guidance. KS also identified several subthemes under these main themes to expand upon the findings.

Results

SNS and HIV Detection Rates

Half of all the studies were cohort studies [32–38], and the other half were cross-sectional [39–45]. The majority, nine (out of 14) studies, detected an HIV positivity rate over 1%. Of these nine studies, five were cohort studies and four were cross-sectional studies. In the five studies that did not demonstrate HIV rates above 1%, one study was a cohort study in a low-prevalence area (0.49% positivity rate) [33]. In another, SNS was implemented by an infectious disease clinic and emergency department in a cohort study (1% positivity rate) [35]. Another two were cross-sectional studies in larger geographic areas and focused on Latinx communities (positivity rates of 0.26, 0.37% respectively); these two studies did not achieve their desired sample size [40, 41]. The last was a cross-sectional study that had a 0% positivity after confirming diagnoses with the health department [42]. Six studies (five cohort, one cross-sectional), out of 14, utilized clinical or health department data to validate the positivity rates [33–35, 37, 38, 42]. Table 1 describes the relevant studies, including the study location, study metrics, and the key populations reached.

Table 1 Characteristics of U.S. Studies Reviewed, Positivity Rates of New Infections and Network Metrics, 2009–2018

Author	Year	Priority population	Study design	Number of recruiters[a]	Number recruited[b]	Network index[c]	Positivity, previously unknown	Incentives offered to recruiters and network associates[d]
Baytop et al.	2014	Black gay, bisexual and other men who have sex with men	Cross sectional	–	147 Total tested	–	9.5%	$20 per recruited associate $20 for testing for HIV
Boyer et al.	2013	Latinx women	Cross sectional	153	382	2.5	0.26%	$40–50 for recruiter and network associate when assessment completion $10–20 for recruiter per recruited associate
Boyer et al.	2014	Latinx youth	Cross sectional	311	501	1.6	0.37%	$24–50 for assessment completion $35–60 for being a recruiter $15–25 for recruiter per recruited associate
Ellen et al.	2013	Black gay, bisexual and other men who have sex with men	Cross sectional	14	22	2	0%	$10 for recruiter per recruited associate that tests $5 for network associate when they tested for HIV
Gaiter et al.	2013	Black women	Cohort study	–	963 Total tested	–	2.1%	None
Halkitis et al.	2011	Black gay, bisexual and other men who have sex with men	Cross sectional	70	109	2.59	19.3%	$10 for recruiter per recruited associate $20 for network associated when they tested for HIV
Kimbrough et al.	2009	Black gay, bisexual and other men who have sex with men Persons who inject drugs, Persons living with HIV At-risk heterosexuals	Cross sectional	422	3,172	7.5	4.4–8.7%	$10 for recruiter per recruited associate $5 for network associated when they tested for HIV
Lightfoot et al.	2018	Gay, bisexual and other men who have sex with men Latinx[e] African Americans	Cross sectional	24	131	5.5	6.2%	$100 for recruiter for attending training $150 for distribution of five self-test kits $50 for distribution of three more self-test kits $25 Amazon gift card for network associate when they HIV self-tested

Table 1 (continued)

Author	Year	Priority population	Study design	Number of recruiters[a]	Number recruited[b]	Network index[c]	Positivity, previously unknown	Incentives offered to recruiters and network associates[d]
McCree et al.	2013	Black gay, bisexual and other men who have sex with men	Cohort	Baltimore: 14 New York City: 70 Washington, DC: 14 Total: 108	Baltimore: 149 New York City: 109 Washington, DC: 22 Total: 280	Baltimore: 10.6 New York City: 1.56 Washington, DC: 1.57 Total: 2.59	Baltimore: 11% New York City: 19% (could include duplicates) Washington, DC: 0%	Baltimore: $5 per recruited associate that tested for HIV Washington, DC: $20 for recruiter $20 for network associate that tested for HIV New York: $4 Metrocard and $10 for recruiter when network associated recruited $4 Metrocard and $20 for network associate when they tested for HIV
McGoy et al.	2018	Black gay, bisexual and other men who have sex with men	Cohort	262	1,752	6.7	9%	$20 for recruiter per network associate that tested for HIV $20 for network associate when they tested for HIV
Rentz et al.	2017	Sex with a person living with HIV Gay, bisexual and other men who have sex with men Persons who inject drugs Persons involved in transactional sex Heterosexual persons with more than one new sex partner since last HIV test	Cohort	586	485	0.8	1%	$10 for each recruiter $10 for recruiter when network associate tested for HIV $10 for each network associate when they tested for HIV and two bus tokens
Schuman et al.	2018	Low prevalence area	Cohort	N/A	1,232	–	0.49%	$10 for recruiter when network associated tested for HIV $10 for network associate when they tested for HIV

Table 1 (continued)

Author	Year	Priority population	Study design	Number of recruiters[a]	Number recruited[b]	Network index[c]	Positivity, previously unknown	Incentives offered to recruiters and network associates[d]
Shrestha et al.	2010	Gay, bisexual and other men who have sex with men Persons who inject drugs Persons living with HIV At-risk heterosexuals	Cohort	92	817	8.9	6% average Boston: 5.1% Philadelphia, 2 sites: 9.8% and 4.5% Washington, D.C.: 8.7%	Incentives provided but no details present
Zulliger et al.	2017	Gay, bisexual and other men who have sex with men	Cohort	–	58	–	3.5%	Cost-utility study

[a]Includes all recruiters, including network associates who became recruiters, not just the original recruiters or seeds

[b]Number of persons recruited does not mean all were eligible or tested for HIV

[c]Network index is calculated as: total # of recruits/total # number of recruiters

[d]Incentives were offered to recruiters and network associates. Recruiters received incentives for participating as recruiters and usually per network associate that tests for HIV. Network associates (recruits) were given incentives when they tested for HIV

Factors That Influence the Implementation of SNS

While most published studies document the ability of SNS to uncover undiagnosed HIV cases, various factors promote successful implementation (Table 2).

The thematic analysis of the 14 studies identified five major areas related to SNS implementation: (1) social network and recruiter characteristics; (2) strategies for and effectiveness of recruiting key populations; (3) use of and types of incentives; (4) trust, confidentiality, and stigma concerns, and (5) implementation plans and real-world guidance. These and the respective subthemes are summarized in Table 3.

Social Network and Recruiter Characteristics

SNS relies on recruiters to engage with their social networks and persuade persons to test for HIV. From a program's inception, implementers must clearly define the priority populations, learn about the connectivity of networks, and appreciate recruiters' centrality in their networks. From the reviewed papers, there was a range of network indices, a standard SNS measurement. The network index is defined as the number of network associates recruited divided by the total number of recruiters. Across all the studies, the network index ranged from 0.8 to 10.6 (Table 1). The wide range of indices reflects the variability in recruiters' centrality within the network and success in recruiting network associates. For example, in one study, 32% of recruiters accounted for 91% of linked network associates [44].

SNS assumes people will have similar HIV statuses or associated risks, and sociodemographics. Many of the reviewed papers, 12 out of the 14, indicated that network associates who tested comprised of key populations, including MSM, those having condomless sex, and persons who have not tested before [32–35, 38–44, 46]. Two papers indicated that recruiters' demographics, such as race, ethnicity, and gender, were not associated with the demographics of those recruited [44, 46]. Three studies did show that PLHIV recruiters were more likely to recruit network associates that tested positive for HIV [40, 44, 46]. To optimize HIV testing efficiency, the review of papers underscores the importance of working with recruiters who intimately know their networks, can foster trusting relationships, and have similar risk factors.

Strategies for and Effectiveness of Recruiting Key Populations

Many of the studies discussed the facilitators and barriers to effective recruiting. One theme that arose was the need to understand the risk factors of the network. One of the studies described the need to explicitly examine the sexual

Table 2 Qualitative and quantitative social network strategy study results and risk of bias assessments (n = 14), 2009–2018

Author	Year	Priority population	Main findings	Risk of bias
Quantitative studies				
Baytop et al.	2014	Black gay, bisexual and other men who have sex with men	Younger persons were more likely to test through SNS, as compared to alternate venue testing (AVT) Heterosexually identified men had greater odds of testing via SNS Men that never tested before, had higher odds of testing with SNS and AVT Men who had unprotected sex in last 6 months had 3–8 greater odds of testing via SNS, as compared to standard of care Positivity rates did not vary by strategy, although there is a low sample size of positive cases	Cross sectional study Convenience sample Statistical analyses are unadjusted Small sample size of new HIV cases Comparator groups exist (standard of care, AVT, SNS) improves internal validity
Boyer et al.	2013	Latinx women	41 women recruited two network associates 63 women recruited three or more network associates 381 network associates recruited 30% of women were recruited by women living with HIV, 32% by unknown status, and 38% by women that were HIV negative Logistic regression showed that HIV stigma was a barrier to recruiting network associates and testing Knowledge about the epidemiologic profile within the community was associated with successful recruitment	Cross sectional study Convenience sample No comparator groups Unadjusted statistical analyses of facilitators and barriers to recruitment Small sample size of new HIV cases
Boyer et al.	2014	Latinx youth	10.5% recruited via AVT refused to participate, as compared to 0.2% with SNS 311 SNS recruiters recruited 812 network associates SNS participants were more likely to be younger, female, have a lower level of education, and report use of public insurance and financial instability SNS participants were more likely to identify as heterosexual, have sex with persons who sell drugs and have sex with persons who were formerly incarcerated (male or female) SNS participants were more likely to have sex with a female who had a diagnosed STI One out of three SNS participants, as compared to three out of four AVT, were linked to care SNS participants endorsed the role their peers had on them testing SNS participants were more likely to report barriers to testing before the study	Cross sectional study Convenience sample Diverse geographies Recruitment goals were not met at study sites Unadjusted statistical analyses Comparator groups exist, which helps improve internal validity

Table 2 (continued)

Author	Year	Priority population	Main findings	Risk of bias
Ellen et al.	2013	Black gay, bisexual and other men who have sex with men	33% of SNS participants identified as gay, as compared to 72% of AVT participants stating they were gay SNS participants had less than one male sexual partner in the last 6 months, as compared to 2.6 among AVT participants SNS participants mean number of female partners was 2.1, as compared to 1.2 in AVT The 36.4% preliminary positivity rate among SNS participants was reduced to zero after reconciling with health department surveillance data	Cross sectional study Convenience sample Small sample size of HIV cases among SNS participants Health department data used to confirm incident HIV diagnoses Comparator groups exist, which helps improve internal validity
Gaiter et al.	2013	Black women	46% of women were recruited by targeted outreach, 35% by AVT, and 19% by SNS SNS recruited the largest proportion in Dayton, Ohio (39%), as compared to targeted outreach in New York City (50%) and Baltimore (73%), and 42% by AVT in Houston After adjusting for site, more HIV positive diagnoses were discovered by SNS (2.4%), as compared to AVT and targeted outreach (1.7% each) After adjusting for site, SNS participants, as compared to the other testing strategies were: 35 years of age or older, live in non-permanent housing, report unprotected sex with a man living with HIV or unknown status, had more than 10 sexual partners, shared injection equipment with partners, used of drugs such as cocaine and heroin, and had concerns about a recent exposure	Cohort study Diverse geographies Each of the four project sites conducted all three recruitment strategies (alternative venue testing, targeted outreach, and SNS) Adjusted statistical analyses; adjusted for site-level variable and known sexual & drug behavior risk factors Issues with data entry related to linkage to care Comparator groups exist, which helps improve internal validity

Table 2 (continued)

Author	Year	Priority population	Main findings	Risk of bias
Halkitis et al.	2011	Black gay, bisexual and other men who have sex with men	70 recruiters named 2.59 men, of which 1.47 men were tested for HIV 59% of SNS network associates self-identified as gay, as compared to 68% in AVT 41% of SNS network associates identified as bisexual, as compared to 32% in AVT 19.3% (n = 21) positivity rate among SNS participants, as compared to 6.3% (n = 25) positivity rate in AVT [OR = 0.28, 95% CI = (0.15, 0.52)] No statistical difference in positivity between SNS and partner services. [OR = 1.43, 95% CI = (0.56, 3.64]) SNS participants were more likely to report female and transgender partners ($p < 0.05$) SNS participants were more likely to report unprotected receptive and insertive anal sex with all sexual partners, as compared to AVT ($p < 0.05$) SNS participants reported more unprotected vaginal intercourse ($p < 0.05$) Adjusted logistic regression showed that AVT testing had a 72% lower odds of detecting a positive test result, as compared to SNS	Cross sectional Convenience sample Self-reported HIV testing Adjusted statistical analyses Adjusted for known sexual behavior risk factors such as number of male partners, number of insertive and receptive unprotected acts of sex Comparator groups exist, which helps improve internal validity
Kimbrough et al.	2009	Gay, bisexual and other men who have sex with men People who inject drugs Persons living with HIV At-risk heterosexuals	Protocolized study of implementation of SNS 424 eligible recruiters recruited 3,230 network associates, of which 422 recruiters and 3,172 network associates were included for analyses Network index (number of network associates/number of recruiters) was 7.4 Recruiter HIV serostatus was associated with positivity among network associates, and particularly among MSM recruiters ($p < 0.01$) Recruiter race, ethnicity, gender, and age were not significantly associated with prevalence of HIV diagnoses among network associates 32% of the recruiters, recruited approximately 91% of linked network associates, and 88% of HIV positive diagnoses 74% of PLHIV diagnosed during the study were linked to care	Cross sectional Diverse geographies Diverse key populations, including homeless, Black and Hispanic MSM, transgender, etc No comparator groups Protocol provided Intensive ongoing technical assistance No adjusted analyses

Table 2 (continued)

Author	Year	Priority population	Main findings	Risk of bias
McGoy et al.	2018	Black gay, bisexual and other men who have sex with men	Significant training and monitoring of recruiters CDC SNS guidelines used Average network index was 6.7 (1,752 network associates / 262 recruiters), while one agency had an index of 15.4, the other two were 5.0 and 5.2 Network associates recruited were MSM, non-Hispanic Black, and younger 9.0% of network associates tested positive for HIV (n = 158) Positivity rates varied by agency, 13% at agency one, 8.6% at agency two, and 4.5% at agency three ($p < 0.001$) 50.6% of network associates testing positive were newly diagnosed Of the 80 new PLHIV, 55% were linked to care	Cohort study No comparator groups 45% of newly diagnosed lost to follow-up Health department data used to confirm incident HIV positive diagnoses No adjusted statistical analyses Sample size goal of 3,000 was not reached (n = 2,700) Staff turnover at agencies hindered activities
Rentz et al	2017	Sex with a person living with HIV Gay, bisexual and other men who have sex with men People who inject drugs Persons involved in transactional sex Heterosexual persons with more than one new sex partner since last HIV test	Limited training of recruiters 587 recruiters enrolled and a total of 482 network associates tested Five network associates (out of 482) tested positive, positivity rate of 1% 50% of SNS network associates had never tested for HIV before Network associates were identified as at risk for HIV	Cohort study Low prevalence area Clinic data used to confirm incident HIV diagnoses No adjusted statistical analyses Comparator groups exist, which helps improve internal validity

Table 2 (continued)

Author	Year	Priority population	Main findings	Risk of bias
Shrestha et al.	2010	Gay, bisexual and other men who have sex with men People who inject drugs Persons living with HIV At-risk heterosexuals	Philadelphia, 2 sites: average of 25 and 17 recruiters per site per year for two years 136 and 330 network associates tested Three and 15 network associates were diagnosed with HIV 9.8 and 4.4% positivity rates Boston: average of 26 recruiters per year for two years 228 network associates tested 12 network associates diagnosed with HIV 5.1% positivity rate Washington, D.C.: average of 24 recruiters per year for two years 123 network associates tested 11 network associates diagnosed with HIV 8.7% positivity rate Total annual cost of social network programs: Philadelphia: $133,789 & $156,401, sites 1 and 2, respectively Boston: $189,935, $833 average cost per associate tested Washington, D.C.: $171,748, $1,395 average cost per associate tested Fixed costs ranged from 72–85%, predominately program management, start-up costs, facilities, and utilities	Cohort study Cost effectiveness study Retrospective cost data introduces recall bias Cost estimates included, although incomplete Estimates from other jurisdictions used
Zulliger et al.	2017	Gay, bisexual and other men who have sex with men	Three cities in three states contributed four quarters of the SNS costs and HIV testing 58 individuals were tested, resulting in a total of two new diagnoses, both of whom were in Houston No individuals were newly diagnosed in Chicago or Oakland, so these programs were not cost-effective The Houston SNS strategy was cost-saving	Cohort study No information on network statistics, such as number of recruiters, network associates, etc Cost-utility analysis Cost per Quality Adjusted Life Year (QALY) Cost per HIV diagnosis Health department data used to confirm incident HIV diagnoses Unadjusted statistical analyses Comparator groups exist, which helps improve internal validity Small sample sizes of those who received an HIV diagnosis for SNS analysis

Table 2 (continued)

Author	Year	Priority population	Main findings	Risk of bias
Mixed-methods or qualitative studies				
Lightfoot et al.	2018	Gay, bisexual and other men who have sex with men Latinx African Americans	36 recruiters identified, of which six were ineligible, and two lost to follow-up 28 recruiters enrolled and trained, of which one was lost to follow-up and three discontinued participation 24 recruits provided 131 HIV self-test kits to network associates Six network associates became recruiters and distributed an additional 30 kits to new network associates Demographic information of testers in the study were comparable to County-level data of testers ($p > 0.05$) Participants with HIV diagnoses in the study were less likely to report previous HIV test and having tests that were more than a year ago ($p < 0.001$) As compared to County-level testing program (1.5% positivity), SNS distribution of testing kits had 6.2% positivity rate ($p < 0.001$) PLHIV recruiters had a greater proportion of network associates who tested positive for HIV ($p = 0.02$); no other differences by demographics existed Qualitative debriefs suggest that: Recruiters had to plan or schedule testing kit distribution, Hesitancy among straight identified network associates, Recruiters felt prepared to address confidentiality related concerns, and Network associates approved of being able to test at home	Cross sectional Formative research and pilot study that informed the final program details and implementation Recruiter trainings provided Duplication challenges with county data Small sample sizes No adjusted statistical analyses Mixed-methods study Comparator group to county-level data, which helps improve internal validity
McCree et al.	2013	Black gay, bisexual and other men who have sex with men	Washington, D.C. site: 24 recruiters and 149 network associates tested 30% of the 149 men tested positive, of which 11% were newly identified Harlem site: 70 recruiters and 109 network associates tested 19% tested positive, unable to reconcile prior diagnosis with the NYC Department of Health Baltimore: 14 recruiters and total of 22 network associates tested 8 (36%) tested positive, but none were newly identified	Cohort study Mixed-methods study No comparator groups Implementation study Health department data used to confirm incident HIV positive diagnoses

Table 2 (continued)

Author	Year	Priority population	Main findings	Risk of bias
Schuman et al.	2018	Low prevalence area	Staffing and implementation plans were developed at onset Recruiters were trained and monitored over time CDC SNS guidelines used Recruiters limited to 20 network associates, then relieved 265 recruiters recruited a median of three network associates (range 1–63), protocol broken 19,095 total tests performed, of which 1,232 were SNS participants SNS, as compared to counseling, testing, and referral (CTR), recruited younger persons, more Black persons, and those who were MSM or PWID ($p < 0.001$) SNS, as compared to CTR, were more likely to report testing for the first time ($p < 0.001$) SNS positivity rate was 0.49%, as compared to 0.48% for CTR Qualitative assessment indicated that incentives might have influenced recruitment (i.e., recruiters more active when needing funds) and testing more than once among network associates Staff burden was high, SNS was layered on top off other work responsibilities, which might have challenged implementation	Cohort study High number of re-testers in short amount of time Health department data used to confirm incident HIV positive diagnoses No adjusted statistical analyses Qualitative assessment of implementation present Comparator groups exist, which helps improve internal validity

Table 3 Themes and subthemes related to implementation of SNS, 2009–2018

Theme	A priori *established**	Subthemes	Studies that support theme
Social network and recruiter characteristics	×	Socio-centric connected social network is important to cultivate with recruiters (as exemplified with wide range of network indices) Homophily—like with like—can support recruiting key populations in terms of HIV risk, behaviors, and testing history—but not necessarily demographics Recruiters, who are generally peers, are endorsed as a benefit of SNS	Baytop et al. 2014 Boyer et al. 2013 Ellen et al. 2013 Gaiter et al. 2013 Halkitis et al. 2011 Kimbrough et al. 2009 Lightfoot et al. 2018 McGoy et al. 2018 Rentz et al. 2017 Schuman et al. 2018
Strategies for and effectiveness of recruiting key populations	×	Strategies to recruit were diverse, including use of social media apps, recruiting friends, family, and acquaintances, and local venues Partnerships with community-based organizations are important to find effective recruiters and networks Risk assessments with recruiters and their networks are important to support finding the "right" recruiters Use of peers in SNS supports encouragement of HIV testing among network associates	Baytop et al. 2014 Boyer et al. 2014 Ellen et al. 2013 Gaiter et al. 2013 Halkitis et al. 2011 Lightfoot et al. 2018 McGoy et al. 2018 Rentz et al. 2017 Schuman et al. 2018
Use of and types of incentives	×	Incentives are important considerations for effective recruitment Incentives may inadvertently create self-interest (e.g., repeat testers) Incentives should match the needs of recruiters and network associates Incentives are diverse, including cash, gift cards, and transportation vouchers	Baytop et al. 2014 Boyer et al. 2013 Boyer et al. 2014 Ellen et al. 2013 Halkitis et al. 2011 Kimbrough et al. 2009 Lightfoot et al. 2018 McCree et al. 2013 McGoy et al. 2018 Rentz et al. 2017 Schuman et al. 2018 Shrestha et al. 2010
Trust, confidentiality, and stigma concerns	×	Recruiting requires trust among network members Fears exist about the confidentiality of testing and the potential for an HIV positive status Stigma creates challenges and fears around testing	Boyer et al. 2013 Lightfoot et al. 2018 McGoy et al. 2018
Implementation plans and real-world guidance		Engagement with stakeholders across community and institutions Collaboration with community-based organizations are important Collaborations with health departments for confirmation of new diagnoses Staff and organizational considerations Up front training that is not time consuming and burdensome Clear definitions of staff roles Dedicated staff to support SNS is important Considerations of financial implications of implementation including testing, staffing, start-up costs—high fixed cost Attention to accessibility and availability of HIV testing and follow-up services Most studies implemented SNS for 12 months or less—which challenges understanding the durability of the strategy	Boyer et al. 2013 McCree et al. 2013 McGoy et al. 2018 Rentz et al. 2017 Schuman et al. 2018 Shrestha et al. 2010 Zulliger et al. 2017

*Theme established from the Centers for Disease Control Social Network Strategy framework

risks of the social network before beginning to recruit [40]. A cohort study in an CTR designated emergency department in a low prevalence area found that many recruiters brought in family members and acquaintances, which indicates no identifiable risk [35]. Relatedly, recruiter comfort with discussing HIV and risks is important. In a cross-sectional study, recruiters that recruited more than two network associates found that recruiters who indicated that telling girlfriends about knowing HIV status and the high rates of HIV in their community was associated with successful recruitment [40]. Barriers in this study included lack of time, difficulty in speaking about HIV, concerns about network associate believing recruiter was HIV positive, and girlfriends were afraid to know their HIV status [40]. The review of studies indicates that having the "correct" recruiter is important to the success of SNS.

Another theme was that SNS implemented in collaboration with community organizations were better equipped to find effective recruiters. In total, eight studies worked with community-based organizations (CBOs) for recruitment [32–34, 36, 39, 42–44]. Anecdotally, one agency in a cohort study, indicated they used social media to recruit network associates; this agency had the largest network index (number of network associates / number of recruiters) [34]. A study by Kimbrough noted that partnership with CBOs was important for successful and effective recruitment [44]. In a cross-sectional study, the recruiters were identified by the health department, which may have recruited different seeds and networks, as compared to community organizations [42]. In another study they described a more expansive strategy for locating recruiters including through local support groups, local gay bars, word of mouth, and through CBOs [46]. Most studies found that partnerships with CBOs supported finding effective recruiters.

Lastly, the use of social peers helped to improve the effectiveness of SNS to get people to test. In a cross-sectional study, 65% of SNS participants agreed that encouragement from peers was a facilitator to testing, as compared to 42% in AVT ($p < 0.0001$) [41]. In a qualitative study, peer recruiters reported positive experiences with distributing HIV test kits, with most stating the training prepared them and that they were motivated to help their community to test [46]. Studies that did explore the importance of peers indicated how peers help to improve HIV testing in SNS.

Use of Incentives

Incentives were used in 13 out of the 14 studies; however, there was a wide range of incentives offered, their purpose, and to whom the incentives were given. The first type of incentive was for the recruiters. For recruiters, in 10 studies, the range of incentives was $10–25 per network-associate recruited [33–35, 38–44]. In four of the studies, the network associates had to complete their HIV test for the recruiter to receive the incentive [33–35, 38]. Four studies also gave recruiters separate incentives for agreeing to recruit, which ranged from $10 [35] in one study, $20 in another study [38], $35–60 in another [41], and $100 in a study when the recruiter finished training [46]. Network associates also received an incentive when they tested, which ranged from $5–25 [33–35, 38, 40, 43, 44, 46]. The types of incentives offered varied, for example cash, Visa and Amazon gift cards, and transportation vouchers.

There were also challenges with incentives. One study, with many repeat testers, indicated that interest in the incentives might have been the prime motivating factor for recruiters and network associates [33]. In this study, some recruiters exceeded the 20 contacts specified by their protocol (range 1–63). In two other studies, one cross-sectional and one cohort, there were concerns that the incentives inadvertently resulted in a high number of individuals already living with HIV [38, 43]. In another cohort study, after feedback from participants, the incentive amounts were increased to align with other local testing services. This increase appeared to improve participation [38]. In one cohort study, researchers did not provide incentives, yet reached a 2.1% positivity rate [32]. In total, 13 studies that offered incentives to promote successful recruitment indicated the potential utility of incentives, which was particularly useful when the incentives were aligned with participants' needs [33–44, 46]. Overall, the majority of studies used incentives. Many described their benefits, but additional examination is needed to better understand their utility and potential pitfalls.

Trust, Confidentiality and Stigma Concerns

SNS leverages the trust between recruiters and network associates to encourage testing. However, stigma and marginalization can impede the utility of SNS to reach key populations. One study that focused on testing among Latinx women found that stigma remained a barrier to testing [40]. In four studies, SNS recruited heterosexual-identifying MSM, a highly stigmatized key population [39, 41–43]. Another study used SNS to distribute HIV self-testing kits to further reduce barriers to testing and concerns with confidentiality [46]. Qualitative results from this study indicated high levels of acceptability to test at home, as compared to the clinic, because of the opportunity for additional privacy and anonymity. However, there was no comparison group or adjusted analysis for this study. The review of studies supports SNS as a strategy that can reduce barriers to HIV testing by leveraging trust within networks; however, stigma associated with HIV testing remains.

Implementation Plans and Real-World Considerations

The papers in this review highlighted the importance of SNS program organizers to engage with relevant stakeholders prior to implementation. All but one of the SNS programs reviewed represented a collaboration between CBOs and/or health departments. Health departments were able to reference surveillance records to reconcile whether the positivity rates were incident or prevalent cases. Of the 14 papers, eight studies (six cross-sectional and two cohort) relied on self-report to "confirm" an incident diagnosis rather than health department or clinical records, which makes the studies subject to recall bias [32, 37, 39–41, 43, 44, 46]. Health departments are a crucial collaborating partner for SNS to cross check HIV surveillance data when assessing positivity rates.

Implementation of an SNS program requires thoughtful consideration and planning for how to balance SNS requirements with the organization's existing policies and programs. Four studies highlighted that engagement with organizational leadership and staff is key to the success of SNS programs [33, 38, 42, 44]. The four studies found that staff described difficulty taking on additional SNS-associated job duties such as tracking referrals, linking recruiters to network associates, training and supporting recruiters and supplying incentives. Also, SNS training and coaching of recruiters may be time-intensive [38, 44]. In another study, at four different sites, it was reported that SNS was least familiar to staff, it required more training, and implementation was more time consuming, as compared to AVT or targeted outreach [32]. However, SNS, when implemented by CBOs, reduces the number of persons who need to be recruited to find a undiagnosed case of HIV, as compared to other testing strategies [44]. Another cross-sectional study indicated that staffing changes and other logistical challenges hampered SNS efforts [41]. The review of papers elucidated the importance of dedicating staff and resources in order to support successful and efficient implementation of SNS. Relatedly, in the review, two of the studies conducted cost analyses. One of the studies, which had a limited number of HIV diagnoses (two positive cases out of 24 tested), showed that SNS was cost-saving for one site in the study, as compared to venue-based and voluntary counseling and testing [37]. The other study included retrospective cost data and matched unavailable cost data (e.g., mobile van costs, staff wages, and time spent on counseling and testing activities) to other similar jurisdictions. In their analyses, 72–85% of the fixed costs were related to program management, start-up costs, facilities, and utilities, which they anticipated reducing as the program matures [36]. The largest variable cost was on identifying and training recruiters. There could be other potential costs, such as home-testing kits, depending on the testing strategy used, and various incentive costs.

Risk of Bias

There were biases with some of the studies that may limit interpretation of results. As described earlier, half the studies (n = 7) were cross-sectional, of which six relied on self-report to determine positivity rates. Recall bias may pose a challenge with validity in the cross-sectional studies. Five of the seven cross-sectional studies included comparison group analyses [39, 41–43, 45] and four of the seven cohort studies included comparison groups [32, 33, 35, 37]. Five cohort studies reconciled their diagnoses with health department data, which improves validity of their positivity results [33–35, 37, 38]. Twelve out of the 14 studies did not have adjusted statistical analyses, which doesn't address issues of confounding (Table 2). Only two studies focused on cost, one of which had limited numbers of persons HIV testing making the sample size small. The three mixed-method studies were robust and included quantitative and qualitative assessments that explored not only the metrics and the yield of the strategy, but the processes behind SNS. Many of the studies, especially the cross-sectional ones, were of limited duration (i.e., less than 12 months); therefore, the durability of the response is difficult to assess.

Discussion

HIV status awareness is essential to advance HIV treatment and prevention. Our systematic review of the published literature to evaluate SNS's role in detecting new HIV cases confirmed, through health department surveillance and cohort studies, that positivity rates exceeded those using standard HIV counseling, referral and testing (1% positivity). Our thematic analysis revealed that successful SNS implementation was fostered by effectively tapping into densely connected socio-centric networks, offering incentives that align with recruiter and network needs, and leveraging strong organizational leadership and buy-in from staff. In many of the studies, SNS was able to reach key populations at heightened risk for HIV, including heterosexual-identifying MSM, persons who have never tested, and persons engaged in sexual and substance use risk behaviors.

Our findings align with other research that synthesized strategies to improve HIV testing, including a review of 15 global studies that used SNS. Campbell and colleagues noted that SNS increased HIV positivity rates from 4 to 31% across the 15 studies, nine of which were in the U.S. [21]. Campbell et al.'s synthesis found that SNS was particularly helpful to organizations and communities that historically had limited success reaching key populations for HIV testing [21]. However, that study did not examine whether positivity rates were from incident or prevalent cases. This was a strength of our analysis, in which we were able to

draw from cohort studies and studies that collaborated with health departments to confirm new HIV diagnoses. Additionally, success of SNS may hinge on a small percentage of recruiters. For example, in one study in our review, 34% of recruiters did not recruit any network associates, and 32% of recruiters accounted for 91% of all linked network associates [44]. The wide range of network indices found in the review of studies, 0.8 to 10, indicated that certain recruiters may be better connected to their networks, and thus more successful in recruitment. Understanding the recruiter and their role in their network is important for the success of SNS. More explicit use of social network theories during enlistment of recruiters may be beneficial [26].

Implementation of SNS must also explore its relationship to other real-world factors that may influence its ability to reach key populations for HIV testing. For example, having explicit implementation plans, dedicated staff to SNS, and understanding how SNS overlays onto services is important (e.g., HIV testing hours). Many of the reviewed studies were 12 months or shorter, which contains challenges with understanding the durability of the public health practice. While SNS helps find new cases of HIV, testing is only the first step in the U.S. "End the HIV Epidemic" plan [1]. Linkage to treatment and prevention services are critical to fully leveraging the benefit of SNS. Understanding the underlying systems of care for persons living with HIV and those who are negative is critical to the success of SNS. As uncovered by one of the reviewed studies, 60% of those who tested positive during SNS were still not engaged in care, and it took a month to link the other 40% to care [34]. The underlying systems of HIV care and prevention, including adjacent services, such as substance use, mental health, serve as the foundation for SNS's success. Research has extensively described how collaboration with diverse stakeholders and inclusion of a multiplicity of services are critical to HIV care and prevention (47).

There are limitations to this systematic review. First, a key question in the field of SNS is defining to what extent concordance in race and ethnicity, gender identity, sexual orientation, among other factors, may be the most relevant to consider when selecting recruiters. Some studies found no variation in network associate's demographics based on the recruiter's demographics, whereas others did. Secondly, the first author was the only reviewer of the systematic review. However, the findings and tables used for analysis were shared and discussed among coauthors to ensure the accuracy of the interpretation of findings and the review. Search terms and exported search data was shared with the senior author in order to confirm the interpretation of study inclusion. In addition, 55% of the studies were found in both databases after conducting the review on each database separately. Another limitation is the caution needed to interpret the positivity rates, which is particularly true for the cross-sectional studies that relied on self-report. The cohort studies that confirmed cases with health department data and included comparator groups provide the most robust evidence for the improved reach of SNS. Lastly, many of the studies relied on convenience samples, which creates selection bias and limits the generalizability of the findings outside the study populations reviewed.

Conclusion

SNS is a promising approach to increase case detection that underpins the U.S. plan to end the HIV epidemic by 2030. SNS programs that make use of available HIV surveillance data, engage relevant stakeholders, and dedicate sufficient resources to program staff and meaningful incentives for participants are well positioned to improve HIV testing efficiency with key populations.

Author's Contributions JF and KS conceptualized the article. KS performed the systematic review and analyses. KS drafted article with help of JF. GNR, EK, JF provided critical feedback and revisions on manuscript drafts and tables.

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Data Availability Data are available within the tables of the article.

Declarations

Conflict of interest All authors declare they have no conflicts of interest.

Consent for participate This study does not involve human participants, and informed consent was therefore not required.

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