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
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-centrivity. 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
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<sup>a</sup> | Number recruited<sup>b</sup> | Network index<sup>c</sup> | Positivity, previously unknown | Incentives offered to recruiters and network associates<sup>d</sup> |
|-----------------|------|-------------------------------------------------------------------------------------|--------------|-----------------------------------|----------------------------|---------------------------|-------------------------------|-------------------------------------------------------------------|
| 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 recruiter 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 recruiter 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 recruiter 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 recruiter 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                              | Cross sectional 422 | 3,172 7.5 | 4.4–8.7% | $10 for recruiter per recruiter 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<sup>e</sup> 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 |
| Author          | Year | Priority population                                                                 | Study design | Number of recruiters<sup>a</sup> | Number recruited<sup>b</sup> | Network index<sup>c</sup> | Positivity, previously unknown | Incentives offered to recruiters and network associates<sup>d</sup> |
|-----------------|------|-------------------------------------------------------------------------------------|--------------|----------------------------------|-----------------------------|-----------------------------|-------------------------------|-------------------------------------------------|
| McCree et al.   | 2013 | Black gay, bisexual and other men who have sex with men                               | Cohort       | Baltimore: 14                    | Baltimore: 149              | Baltimore: 10.6             | Baltimore: 11% (could include duplicates) | Baltimore: $5 per recruited associate that tested for HIV |
|                 |      | New York City: 70                                                                  |              | New York City: 109               | New York City: 109          | New York City: 1.56         | Washiington, DC: 0%              | Washington, DC: $20 for recruiter                |
|                 |      | Washington, DC: 14                                                                 |              | Washington, DC: 22               | Washington, DC: 22          | Washington, DC: 1.57        | Washington, DC: 0%              | New York: $4 Metrocard and $10 for recruiter when network associated recruited |
|                 |      | Total: 108                                                                         |              | Total: 280                       | Total: 280                  | Total: 2.59                 |                               | $4 Metrocard and $20 for network associate when they tested for HIV |
|                 |      |                                                                                     |              |                                  |                             |                             |                               | $20 for recruiter per network associate that tested for HIV |
|                 |      |                                                                                     |              |                                  |                             |                             |                               | $20 for network associate when they tested for HIV |
|                 |      |                                                                                     |              |                                  |                             |                             |                               | $10 for each 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%                            | $10 for each recruiter                     |
|                 |      |                                                                                     |              |                                  |                             |                             |                               | $10 for recruiter when network associated tested for HIV |
| Rentz et al.    | 2017 | Sex with a person living with HIV                                                    | Cohort       | 586                              | 485                         | 0.8                         | 1%                            | $10 for each network associate when they tested for HIV |
|                 |      | Gay, bisexual and other men who have sex with men                                   |              |                                  |                             |                             |                               | $10 for each network associate when they tested for HIV |
|                 |      | Persons who inject drugs                                                            |              |                                  |                             |                             |                               | $10 for each network associate when they tested for HIV |
|                 |      | Persons involved in transactional sex                                               |              |                                  |                             |                             |                               | $10 for each network associate when they tested for HIV |
|                 |      | Heterosexual persons with more than one new sex partner since last HIV test          |              |                                  |                             |                             |                               | $10 for each network associate when they tested for HIV |
| 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 |

<sup>a</sup> Number of recruiters varies by city.

<sup>b</sup> Number recruited includes duplicates.

<sup>c</sup> Network index is calculated using the formula: \( \sum_{i=1}^{n} x_i / \sum_{i=1}^{n} y_i \), where \( x_i \) is the number of recruiters recruited from group \( i \) and \( y_i \) is the number of people from group \( i \) who tested for HIV.

<sup>d</sup> Incentives offered include financial rewards for recruiting and testing 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 |
| 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 |
| Gaißer 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 |
| 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 |
| 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 = 1,581) 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 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 |
| Author          | Year | Priority population                                                                 | Main findings                                                                                                                                                                                                 | Risk of bias                                                                                   |
|-----------------|------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Shrestha et al. | 2010 | Gay, bisexual and other men who have sex with men                                   | Philadelphia, 2 sites:                                                                                                                               | Cohort study                                                                             |
|                 |      | People who inject drugs                                                             | average of 25 and 17 recruiters per site per year for two years                                                                                     | Cost effectiveness study                                                                 |
|                 |      | Persons living with HIV                                                             | 136 and 330 network associates tested                                                                                                              | Retrospective cost data introduces recall bias                                               |
|                 |      | At-risk heterosexuals                                                               | Three and 15 network associates were diagnosed with HIV                                                                                            | Cost estimates included, although incomplete                                               |
|                 |      |                                                                                     | 9.8 and 4.4% positivity rates                                                                                                                      | Estimates from other jurisdictions used                                                    |
|                 |      |                                                                                     | 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                                           |                                                                                               |
| 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                                                           | Cohort study                                                                             |
|                 |      |                                                                                     | 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                                                                                                           |                                                                                               |
|                 |      |                                                                                     |                                                                                                                                                    |                                                                                               |

*Table 2 (continued)*
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 |
| Author       | Year | Priority population | Main findings                                                                                                                                                                                                 | Risk of bias                                                                                           |
|--------------|------|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| Schuman et al. | 2018 | Low prevalence area | Staffing and implementation plans were developed at onset<br>Recruiters were trained and monitored over time<br>CDC SNS guidelines used<br>Recruiters limited to 20 network associates, then relieved<br>265 recruiters recruited a median of three network associates (range 1–63), protocol broken<br>19,095 total tests performed, of which 1,232 were SNS participants<br>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)<br>SNS, as compared to CTR, were more likely to report testing for the first time (p < 0.001)<br>SNS positivity rate was 0.49%, as compared to 0.48% for CTR<br>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<br>Staff burden was high, SNS was layered on top of other work responsibilities, which might have challenged implementation | Cohort study<br>High number of re-testers in short amount of time<br>Health department data used to confirm incident HIV positive diagnoses<br>No adjusted statistical analyses<br>Qualitative assessment of implementation present<br>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) | Baytop et al. 2014          |
|                                                    |                        | Homophily—like with like—can support recruiting key populations in terms of HIV risk, behaviors, and testing history—but not necessarily demographics | Boyer et al. 2013          |
|                                                    |                        | Recruiters, who are generally peers, are endorsed as a benefit of SNS    | 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 | Baytop et al. 2014          |
|                                                    |                        | Partnerships with community-based organizations are important to find effective recruiters and networks | Boyer et al. 2014           |
|                                                    |                        | Risk assessments with recruiters and their networks are important to support finding the “right” recruiters | Ellen et al. 2013           |
|                                                    |                        | Use of peers in SNS supports encouragement of HIV testing among network associates | 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      | Baytop et al. 2014          |
|                                                    |                        | Incentives may inadvertently create self-interest (e.g., repeat testers) | Boyer et al. 2014           |
|                                                    |                        | Incentives should match the needs of recruiters and network associates   | Ellen et al. 2013           |
|                                                    |                        | Incentives are diverse, including cash, gift cards, and transportation vouchers | Gaiter et al. 2013          |
| Trust, confidentiality, and stigma concerns        | ×                      | Recruiting requires trust among network members                        | Boyer et al. 2013           |
|                                                    |                        | Fears exist about the confidentiality of testing and the potential for an HIV positive status | Lightfoot et al. 2018       |
|                                                    |                        | Stigma creates challenges and fears around testing                       | McGoy et al. 2018           |
| Implementation plans and real-world guidance       |                        | Engagement with stakeholders across community and institutions         | Boyer et al. 2013           |
|                                                    |                        | Collaboration with community-based organizations are important         | McCree et al. 2013          |
|                                                    |                        | Collaborations with health departments for confirmation of new diagnoses| McGoy et al. 2018           |
|                                                    |                        | Staff and organizational considerations                                  | Rentz et al. 2017           |
|                                                    |                        | Up front training that is not time consuming and burdensome            | Schuman et al. 2018         |
|                                                    |                        | Clear definitions of staff roles                                        | Shrestha et al. 2010        |
|                                                    |                        | Considerations of financial implications of implementation including testing, staffing, start-up costs—high fixed cost | Zulliger et al. 2017        |
|                                                    |                        | 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 |                |

*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.

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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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