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REVIEW

Screening for HIV and linkage to care in adolescents: insights from a systematic review of recent interventions in high- versus low- and middle-income settings

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Introduction: Compared to adults, adolescents and young adults have a higher incidence of HIV infection, yet lower rates of HIV testing. Few evidence-based interventions effectively diagnose new HIV infections among adolescents while successfully providing linkage to care.
Methods: We conducted a systematic review of recent interventions to increase HIV testing among adolescents and young adults using data retrieved from PubMed and Google Scholar, and using abstracts presented at the International AIDS Society conferences and Conference on Retroviruses and Opportunistic Infections published between January 1, 2015, and April 28, 2018.
Results: We identified 36 interventions (N=14 in high- income countries and N=22 in low- and middle-income countries) that were published in the literature (N=28) or presented at conferences (N=8). Interventions were categorized as behavioral/educational, alternate venue/self-testing, youth-friendly services, technology/mobile health, incentives, or peer-based/community-based interventions. The studies consisted of randomized controlled trials (RCTs), prospective and retrospective observational studies, and quasi-experimental/pre–post evaluations with variable sample sizes. Study designs, populations, and settings varied. All categories showed some degree of acceptability, yet not all interventions were effective in increasing HIV testing. Effectiveness was seen in more than one RCT involving technology/mobile health (2/3 RCTs) and alternative venue/self-testing (3/3 RCTs) interventions, and only in one RCT each for behavioral interventions, community interventions, and incentives. There were no effective RCTs for adolescent-friendly services. Data were limited on the number of new infections identified and on the methods to increase linkage to care after diagnosis.
Conclusion: Future studies should include combinations of proven methods for engaging adolescents in HIV testing, while ensuring effective methods of linkage to care.
Keywords: adolescent, HIV, testing, interventions, barriers

Introduction

Worldwide in 2016, an estimated 2.1 million adolescents aged 10–19 years were living with HIV.[1] Globally, one-third of all new HIV infections occurs among adolescents.[2] Eighty percent of all adolescent HIV infections worldwide occur in sub-Saharan Africa where females are disproportionately affected compared to males.[1,3] In sub-Saharan Africa, less than a third of all adolescents have ever tested for HIV and only 20% of adolescent girls who are living with HIV know their HIV status.[1,3] There are limited evidence-based interventions targeting this population that effectively diagnose and link adolescents and young adults to care.

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In the US, more than 61,000 adolescents are living with HIV.[4] In 2016, of all the new HIV diagnoses among adolescents in the US, 81% were attributed to male-to-male sexual contact.[4] Despite the Centers for Disease Control and Prevention (CDC) recommendations for one-time HIV testing for all individuals aged 13–64 and annual testing in high-risk groups, testing rates among adolescents and young adults remain low.[4,5] Among high school aged men who have sex with men (MSM), only 21% ever had an HIV test.[4] Despite numerous interventions to increase HIV testing among high-risk adolescents and young adults, 44% of those living with HIV have not been tested and are unaware of their positive status.[4]

The Joint United Nations Programme on HIV and AIDS has set the target of 90-90-90 by the year 2020, describing the percentage goals for HIV testing, antiretroviral therapy (ART) initiation, and viral suppression, respectively.[1] In addition, the WHO has recommended moving to a treatment for all strategy to increase the number of individuals living with HIV who receive ART regardless of CD4 cell count or clinical stage.[6] Worldwide, adolescents are falling well short of the targeted testing, ART initiation, and viral suppression goals. In the care continuum, estimates of viral suppression among all adolescents living with HIV are <10%.[7,8] The largest drop off in the continuum of care for adolescents is in HIV testing and linkage to care where only 41% know their diagnosis.[4,8] The ultimate goal of HIV testing is diagnosing new infections, linking individuals to care, and achieving viral suppression; yet there are significant gaps in evidence-based interventions to improve HIV testing and linkage to care for adolescents.

Adolescents face numerous barriers to HIV testing as indicated in Table 1. One of the most common psychological barriers to HIV testing among adolescents is lack of perceived risk.[9,10] Other psychological barriers include fear of consequences of a positive test, worries about discrimination and rejection, stigma about HIV, sexual orientation, or gender identity.[9,11–17] In addition, there are structural barriers to HIV testing among adolescents including never being offered an HIV test, inconvenient hours, lack of insurance, and parental consent.[10,16,18–21] Mistrust of the health care system and perception of poor attitudes of health care providers also hinder HIV testing for adolescents.[11] Social factors such as socioeconomic status, gender, and race can also impede HIV testing in adolescents. Interventions to improve HIV testing among adolescents should target these barriers to increase HIV testing and linkage to care.

Improving HIV testing and linkage to care is now recognized as a global health priority, and as a result, several interventions have been developed specifically targeting HIV testing uptake among adolescents.[22] We conducted a systematic review of interventions published between 2015 and 2018 targeting HIV testing among adolescents to highlight the lack of evidence-based, successful interventions that find new HIV infections among adolescents and successfully link them to care.[23–25]

Table 1 Barriers to HIV testing for adolescents

Concerns about correct self-test operation[82]
Confidentiality using parental insurance/parental consent[16,19]
Conflicts with school hours[20]
Cost[21,82]
Drug use[24]
Fear of disclosure[15]
Fear of heterosexist bias[13,83]
Fear of job consequences[84]
Fear of rejection from partners/parents/peers[9,14–17,84]
Fear of results[9,15–17]
Inaccurate information from testing locations[20]
Inconvenience[18]
Lack of knowledge/low health literacy[12,15,17]
Lack of youth-friendly/Lesbian, Gay Bi, Trans (LGBT)-friendly spaces[15]
Lack of social support[82]
Never offered HIV test[10]
Patient-provider trust/communication[11,19,83]
Perceived healthy status/susceptibility/risk[9–12,14]
Privacy concerns[18,19,83]
Racial/ethnic differences[23,24]
Sex differences (male/female)[24]
Socioeconomic status[25]
Stigma, HIV-related[9,12–14,16,1]
Stigma, LGBT-related[13,23]

Methods

We performed a systematic review of HIV testing interventions targeting adolescents that were published between January 2015 and April 28, 2018. We adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[26] We initially searched peer-reviewed journals written in English that were located in PubMed and Google Scholar and published after 2010. We then narrowed our results to those published on or after January 1, 2015. Our target population was adolescents and young adults aged 10–24 years. However, we included studies that included individuals outside of this age range provided that the intervention was targeted toward adolescents and young adults. Keywords searched included HIV, testing, and at least one of the following age terms: adolescent, adolescence, teen, youth, or young adults.

In addition, we searched for abstracts presented at the International AIDS Society Conference (IAS) and at the Conference on Retroviruses and Opportunistic Infections

(CROI). We were able to search 2015–2018 CROI abstracts, but only 2015–2016 IAS abstracts were available online. Keywords searched included HIV and testing. Abstracts were then screened for at least one of the following age terms: adolescent, adolescence, teen, youth, or young adults.

Potential journal articles were uploaded into Covidence, a non-profit website working with the Cochrane database to improve systematic reviews. (www.covidence.org, Melbourne, Australia) Duplicates were removed. After initial screening of the title and abstract, two authors (BCZ and RJE) independently reviewed potential studies. Conflicts were resolved by reviewing the full text article and discussing inclusion/exclusion criteria. We excluded review articles, studies that did not include an intervention, that did not report primary data for HIV testing, or that were targeting children or adults outside our specified age range of 10–24 years. We then extracted data from the full text articles included in this review.

We used the PRISMA guidelines in assessing the strength of evidence and bias for clinical trials and evaluated random sequence generation, allocation concealment, blinding, and outcome reporting.[27] Randomized controlled trials (RCTs) were considered less biased than pre–post evaluations, and prospective and retrospective observational studies. Interventions that were evaluated and published in peer reviewed journals were considered less biased than abstracts from conference proceedings that could only be judged by study design. Observational studies were evaluated for bias using the GRADE guidelines and included an assessment of eligibility, controls, loss to follow-up, and outcome consistency.[28]

Results

Description of studies identified

Search results included 4,700 potential articles as indicated in the PRISMA flow-diagram in Figure 1. We excluded 85 duplicates,

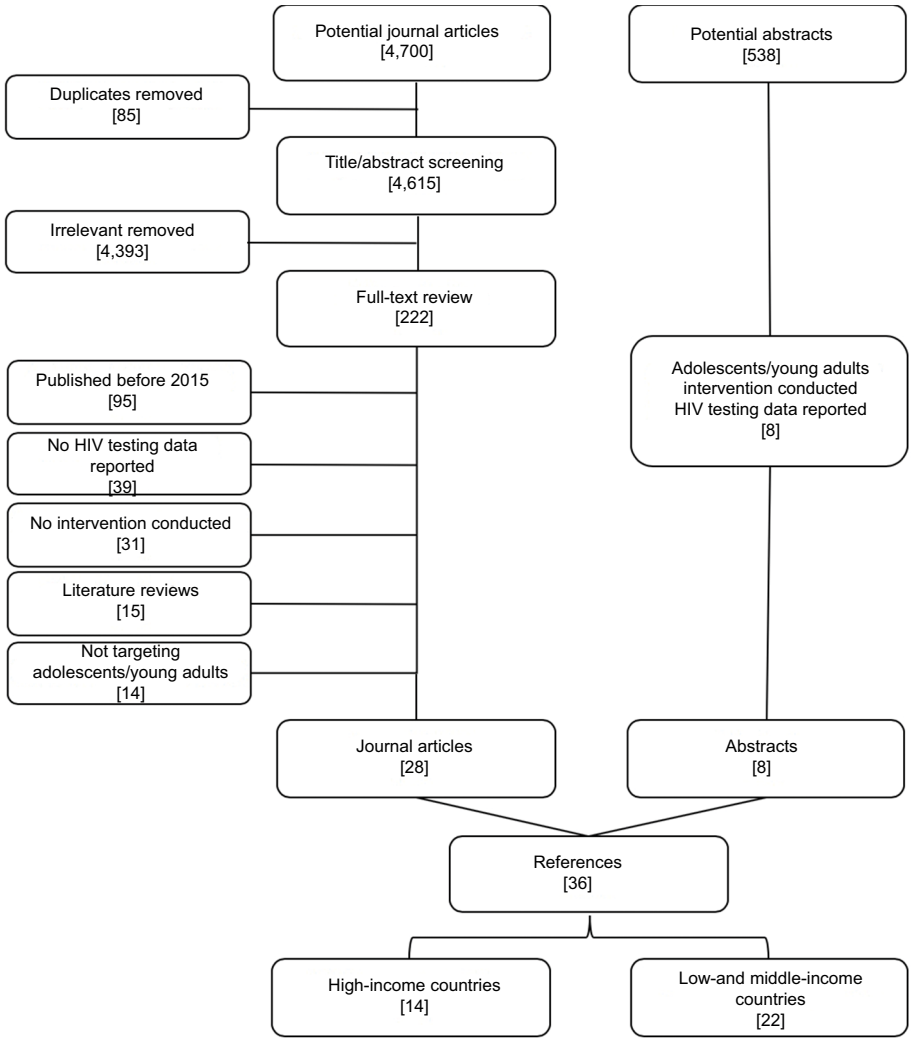

Figure 1 PRISMA figure of inclusion/exclusion criteria.

as well as 4,393 studies that were not relevant to adolescent HIV testing interventions. We reviewed 222 studies for eligibility based on the above criteria and excluded 194 of them: 95 were published between 2010 and 2014; 39 did not report primary data for HIV testing; 31 did not include an intervention involving adolescent HIV testing; 15 were literature reviews; and 14 were not targeting adolescents. We included 28 articles in our final review. In addition, among the 546 IAS and 292 CROI abstracts, 7 and 1 met our inclusion criteria, respectively. None of these were subsequently published in the literature.

We identified a total of 36 studies for this analysis. We separated the studies into those conducted in high-income countries (a total of 14 studies) and those conducted in low- and middle-income countries (a total of 22 studies) and arranged them by the type of intervention as indicated in Table 2. All of the studies from high-income countries took place in the US (N=14)[16,29–41] and will be referred to as US from here forward. The low- and middle-income countries included South Africa (N=6),[42–47] Kenya (N=4),[48–51] Bangladesh (N=2),[52,53] Zambia (N=2),[45,54] Liberia (N=1),[55] Ethiopia (N=1),[56] Malawi (N=1),[57] Mozambique (N=1),[58] Myanmar (N=1),[59] Ghana (N=1),[60] Indonesia (N=1),[61] Zimbabwe (N=1),[62] Uganda (N=1),[48] and Haiti (N=1)[63] with two studies taking place in more than one country.[45,48] The interventions were organized into six categories as defined in Table 3. The interventions to increase HIV testing among adolescents and young adults consisted of behavioral/educational interventions (N=4)[29,30,55,56], alternate venue/self-testing (N=11),[31–34,42–45,50,57,58] youth-friendly services (N=2),[59,60] technology/mobile health (N=9),[16,35–39,49,51,61] incentives (N=3),[53,54,62] and peer/community-based interventions (N=7).[40,41,46–48,52,63] The median sample size was 613 individuals (inter-quartile range=261–2,169). The types of studies included RCTs (N=13),[29,31,36,38,39,42,45,47,49,51,55,60,62] observational studies (N=15),[16,32–35,41,44,58,61] and quasi-experimental/pre–post evaluations (N=8).[30,37,40,46,52,54,56,59]

Among the studies in the US, three studies contained information on new HIV diagnoses (ranging from 0.6% to 11.3% with a median of 3.2%).[32,34,41] All contained information on linkage to care (ranging from 85% to 100%). In low- and middle-income countries, nine studies included information on new HIV infections (ranging from 0.6% to 9.4% with a median of 3.4%).[3,43–45,48,50,53,56,57] Of these, three included information on the number linked to care (ranging from 50% to 100% with an absolute of 97% [94/97]).[53,57,63]

Bias assessment

Of the 36 studies included in our review, 13 were RCTs and 23 were observational studies.[16,30,32–35,37,40,41,44,46,52,54,56,58,59,61] Three of the RCTs[39,42,62] and five of the observational studies[43,44,52,54,61] were presented in abstracts; these studies were excluded from the risk of bias assessment due to insufficient information. Five of the remaining observational studies were pre–post evaluations of an intervention.

Of the remaining ten RCTs, both random sequence generation and allocation concealment were discernible for four studies from their study methods.[36,51,55,60] Two studies reported random sequence generation only.[31,38] Four RCTs did not report either random sequence generation or allocation concealment.[29,45,47,49] Given the nature of the interventions, blinding of participants and personnel was rarely possible and was reported in only one RCT.[38] In that study, only participants were blinded to arm allocation and blinding of outcome assessors was not reported. All RCTs report HIV testing outcomes as predefined primary or secondary outcomes.

All of the remaining 17 observational studies reported eligibility criteria that were applied consistently for all participants. Only one observational study included a control group.[59] Four observational studies reported loss to follow-up data.[16,30,40,56] Loss to follow-up rates ranged from 16% to 43%. Implementation challenges were noted for higher loss to follow-up rates.[40,56]

Interventions

Below we report summaries of the individual interventions designed to increase HIV testing among adolescents separated by intervention category (behavioral/educational, alternative venue/self-testing, technology/mobile health, incentives, youth-friendly services, or peer/community) and country category (high-income versus low- and middle-income countries). Within each intervention category, interventions are listed beginning with the least biased (ie, RCTs followed by pre–post evaluations and observational studies). Interventions published in only abstract form are reported last.

Behavioral/educational interventions (N=4)

There were two interventions from the US that provided a combination of educational material and behavioral interventions targeting adolescents interacting with the criminal justice system[29,30] with one RCT.[29] Letourneau et al randomized 105 adolescents attending juvenile drug court to receive standard care compared to risk reduction therapy.[29] The intervention involved adolescent-parent dyads in 24 weekly, 60–90 minute sessions involving cognitive behavior therapy and behavior management training with contingency-contracting with a point earning system. At the end of the study, there

Table 2 Interventions to increase HIV testing among adolescents, published between January 1, 2015, and April 28, 2018

Interventions to increase adolescent HIV testing in high-income countries								
Authors	**Publication and date**	**Location**	**Number of subjects**	**Ages (target population)**	**Study type**	**Intervention description**	**Results of intervention on testing**	**Linkage to care**
Behavioral/educational interventions								
Letourneau, et al[29]	Journal of Substance Abuse Treatment, 2017	South Carolina, USA	105	11–17 (juvenile drug court attendees)	Randomized, controlled	Risk Reduction Therapy for Adolescents (RRTA, n=45) versus UC (n=60); RRTA: Family focused contingency management with adolescent-parent dyads (24 weekly sessions, 60–90 minutes each)	HIV testing prevalence increased from 16% to 25% for RRTA and decreased from 17% to 14% for UC baseline versus 12-month follow-up (not significant); non-significant between-group difference RRTA versus UC (OR 2.15, 95% CI 0.49–9.36)	None
Donenberg, et al[30]	Journal of Child and Family Studies, 2015	USA	54	13–17 (youth on probation)	Pre–post evaluation	Preventing HIV/AIDS among Teens (PHAT Life), an HIV-prevention program for teens on probation using group role-plays, videos, games, and skill development activities	HIV testing changes varied by sex (OR 2.99, P=0.11); 19% (n=6) of males reported being tested for HIV in the previous 6 months at baseline, compared to 41% (n=13) who reported an HIV test in the previous 3 months at follow-up; 36% (n=8) of females reported being tested for HIV at both time points; HIV testing increased for males (OR 2.99, 95% CI 1.42–6.31, *P*=0.004) but not for females (OR 1.00, 95% CI 0.33–3.06, *P*=1.00)	None
Alternative venue/self-testing								
Merchant, et al[31]	AIDS and Behavior, 2018	USA	425	18–24 (MSM)	Randomized	Randomized 1:1:1 for oral rapid test, mail-in blood test, or medical facility of choice	54% completed assigned test overall (62% oral test, 40% mail-in blood, 56% facility testing); oral and facility tests had greater completion rates than mail-in (P<0.01 each)	None

(*Continued*)

Table 2 (*Continued*)

Interventions to increase adolescent HIV testing in high-income countries								
Authors	**Publication and date**	**Location**	**Number of subjects**	**Ages (target population)**	**Study type**	**Intervention description**	**Results of intervention on testing**	**Linkage to care**
Holliday et al[32]	Journal of Health Care for the Poor and Underserved, 2017	USA	2,385	18–24 (African Americans attending historically black colleges and universities)	Observational, prospective	Campus and Community HIV and Addiction Prevention (CCHAP): HIV testing plus 1-hour interactive peer-led HIV and substance-use workshop, and environmental strategies	2,383 tested (99.9%); 15 HIV infections (0.6%)	15/15 (100%)
Miller et al[34]	JAMA Pediatrics, 2017	USA	3,301	13–24 (sexual minority males of color)	Observational, prospective	Multisite HIV testing program designed to encourage localized HIV testing programs focused on self-identified sexual minority males evaluating universal testing, targeted testing, and combination testing	Universal testing: 35 sexual minority males, 1 (0.1%) new HIV infection; targeted testing: 236 sexual minority males, 16 (3.2%) new HIV infections; combination testing: 693 sexual minority males, 39 (2.1%) new HIV infections	None
Buzi et al[33]	Public Health Reports, 2016	Texas, USA	34,299	13–23 (family planning clinic attendees)	Observational, retrospective	Implementation of routine opt-out testing versus opt-in testing	50% increase in HIV testing in opt-out testing; during opt-out, 0.3% were HIV infected	None

(*Continued*)

Table 2 (*Continued*)

Interventions to increase adolescent HIV testing in high-income countries								
Authors	**Publication and date**	**Location**	**Number of subjects**	**Ages (target population)**	**Study type**	**Intervention description**	**Results of intervention on testing**	**Linkage to care**
Technology/mobile health								
Bauermeister et al[36]	AIDS and Behavior, 2015	USA	130	15–24 (MSM)	Randomized, controlled	Full Get Connected! program versus testing site locator control; Get Connected! a tailored online HIV/STI testing intervention designed with input from a youth advisory board	32 (25%) received HIV testing, 32% in full intervention, and 29% in locator only (no significant difference)	None
Ybarra et al[38]	Pediatrics, 2017	USA	302	14–18 (MSM)	Randomized, controlled	Randomized 1:1 Guy2Guy intervention versus self-esteem control; Guy2Guy: 5–10 daily text messages for 5 weeks, content included HIV information, motivation, behavioral skills, HIV testing, healthy relationships	Intervention more likely to receive HIV testing compared to control: 55% versus 28% (OR 3.42, 95% CI 1.65–7.09, *P*=0.001)	None

(*Continued*)

Table 2 (*Continued*)

Interventions to increase adolescent HIV testing in high-income countries								
Authors	**Publication and date**	**Location**	**Number of subjects**	**Ages (target population)**	**Study type**	**Intervention description**	**Results of intervention on testing**	**Linkage to care**
Washington et al[39]	IAS, 2016	California, USA	142	18–30 (black MSM)	Randomized, controlled	Intervention versus control; intervention group watched five 60-second videos per week featuring vignettes from BMSM characters, and posted reflections using chat feature; control group viewed standard HIV text information	Retention rates of 71% for intervention group and 78% for control group; BMSM in intervention group was 7 times more likely to have tested for HIV (OR =7.00, 95% CI 1.72–28.33, *P*=0.006)	None
Dowshen et al[37]	AIDS and Behavior, 2015	Pennsylvania, USA	At least 1,500 interacted with campaign	13–17 (primary target); 18–24 (secondary target)	Pre–post evaluation	IknowUshould2 campaign to improve STIs/HIV knowledge and testing; included traditional media (print ads, t-shirts, radio, hotline) and new media (website, Facebook, Twitter, Instagram, YouTube)	Significant increase in proportion of CHOP Family Planning clinic visits at which HIV test was conducted (5.4% versus 19.0%, *P*<0.01)	None
Aronson et al[35]	Journal of Mobile Technology in Medicine, 2016	New York, USA	100	18–24 (youth in ED who declined HIV testing)	Observational, prospective	Tablet-based sexual risk and substance abuse questionnaire and video on HIV testing; high-risk participants enrolled in weekly text messages for 12 weeks	30 (30%) individuals agreed to HIV testing after using tablet; 21 (70%) agreed to receive text messaging	None

(*Continued*)

Table 2 (*Continued*)

Interventions to increase adolescent HIV testing in high-income countries								
Authors	**Publication and date**	**Location**	**Number of subjects**	**Ages (target population)**	**Study type**	**Intervention description**	**Results of intervention on testing**	**Linkage to care**
Solorio et al[16]	AIDS and Behavior, 2016	Washington, USA	50	18–30 (Latino MSM)	Observational, prospective	Tu Amigo Pepe pilot intervention: 16-week campaign included Spanish-language radio public service announcements, a website, social media outreach, a reminder system using mobile technology, print materials and a toll-free hotline	56% tested by the end of the campaign; 82% at baseline; 90% after campaign (OR 2.0; 95% CI 0.8–5.4; *P*=0.16)	None
Community/peer engagement								
Shelley et al[40]	AIDS Education and Prevention, 2017	USA	298	18–29 (MSM)	Pre–post evaluation	Mpowerment (MP): community-level, community mobilization intervention to reduce sexual risk behavior by addressing psychosocial factors at individual, interpersonal, social, and structural levels (1) core group, (2) formal outreach, (3) M-groups, (4) informal outreach, (5) publicity, and (6) the project space	Increase in HIV testing from baseline (53.6%) to 3-month follow-up (65.0%, PR =1.20, *P*<0.01) and 6-month follow-up: (70.2%, PR =1.28, *P*<.001)	None

(*Continued*)

Table 2 (*Continued*)

Interventions to increase adolescent HIV testing in high-income countries								
Authors	**Publication and date**	**Location**	**Number of subjects**	**Ages (target population)**	**Study type**	**Intervention description**	**Results of intervention on testing**	**Linkage to care**
Camacho-Gonzalez et al[41]	AIDS, 2017	Georgia, USA	435	18–24	Observational, prospective	Metropolitan Atlanta Community Adolescent Rapid Testing Initiative (MACARTI) intervention: combined nontraditional venue HIV testing, motivational interviewing, and case management	Identified 49 (11.3%) HIV infections	Higher for MACARTI compared to SOC (96% versus 57%, $P<0.001$)
Interventions to increase adolescent HIV testing in low- and middle-income countries								
Authors	**Publication and date**	**Location**	**Number of subjects**	**Ages (Target Population)**	**Study type**	**Intervention description**	**Results of intervention on testing**	**Linkage to care**
Behavioral/educational interventions								
Firestone et al[55]	Global Health: Science and Practice, 2016	Liberia	1,052	15–35 (out-of-school youth)	Randomized, controlled	HealthyActions intervention versus control; HealthyActions: 6-day intensive group learning on sexual and reproductive health	Control less likely to receive HIV test (OR 0.45, 95% CI 0.38–0.53, $P<0.001$)	None
Jani et al[56]	Journal of the International AIDS Society, 2016	Ethiopia	730	15–18	Pre–post evaluation	Three-month client-centered, counselor-delivered psychosocial intervention involving individual, group, and creative arts therapy counseling sessions	HIV testing increased by 80% for females (AOR 1.8, 95% CI 1.13–2.97) and by 630% for males (AOR 7.3, 95% CI 2.6–20.7)	None

(*Continued*)

Table 2 (*Continued*)

Interventions to increase adolescent HIV testing in low- and middle-income countries								
Authors	**Publication and date**	**Location**	**Number of subjects**	**Ages (target population)**	**Study type**	**Intervention description**	**Results of intervention on testing**	**Linkage to care**
Alternate venue/self-testing								
Shanaube et al[45]	AIDS, 2017	Zambia and South Africa	15,456	15–19	Community-randomized, controlled	PopART for Youth (P-ART-Y): door-to-door combination prevention delivered by trained community health workers	72.3% accepted intervention; HCT uptake was 80.6%; 135 (1.6%) new HIV infections diagnosed; control arm data was not yet available	None
Pettifor et al[42]	CROI, 2018	South Africa	284	18–24 (females only)	Randomized, controlled	Randomized into standard of care arm with invitation to local clinic for free HCT (n=144) or choice arm offering free HCT or self-testing (n=140); five self-testing kits or five testing invitations given to each woman, one for herself and four for peer referrals	96% randomized to choice arm chose self-testing; 97% who returned for 3-month follow-up from choice arm reported testing compared to 48% from HCT arm (RR 2.00, 95% CI 1.66–2.40); more peer referrals from choice arm (66% of total peer referrals)	None
Hector et al[58]	PloS One, 2018	Mozambique	496	16–20	Observational, prospective	Assisted oral self-testing	299 (60%) oral self-tests; 1.7% HIV-infected	None
Ahmed et al[57]	Tropical Medicine and International Health, 2017	Malawi	165	1–24 (only >15–24 data reported in this row)	Observational, prospective	Home- or facility-based HIV testing and counseling offered for untested children of known adults living with HIV	Home-based: 2/156 new HIV diagnoses (1.3%); facility-based: 5/9 new HIV diagnoses (55.6%)	Home-based: 1/2 (50%); Facility-based: 3/5 (60%)

(*Continued*)

Table 2 (*Continued*)

Interventions to increase adolescent HIV testing in low- and middle-income countries								
Authors	**Publication and date**	**Location**	**Number of subjects**	**Ages (target population)**	**Study type**	**Intervention description**	**Results of intervention on testing**	**Linkage to care**
Mugo et al[50]	Sexually Transmitted Infections, 2015	Kenya	1,490	18–29	Observational, prospective	Pharmacy workers referred clients purchasing medicine for fever, sexually transmitted infection symptoms, diarrhea, or body pains	353 (24%) were tested for HIV; 14 (4.0%) were newly diagnosed with HIV	None
Fatti et al[43]	IAS, 2016	South Africa	4,800	10–19	Observational, prospective	Three testing strategies employed as part of combination program in two districts: index client trailing, door-to-door testing, and campaign testing at events; routine HIV testing program data used	4,756 (99.1%) consented to HIV testing; first HIV test for 90% of males and 85.7% of females (P<0.0001); 7.5% of females tested HIV+ compared to 3.9% of males (P<0.0001); HIV positivity was higher at campaigns (9.4%) than through index client trailing (6.0%) or door-to-door testing (5.9%) (P=0.019)	None
Rousseau-Jemwa et al[44]	IAS, 2016	South Africa	1,285	12–24	Observational, prospective	Nurse-led, counselor-supported Tutu Teen Truck (TTT) mobile clinic offering HTC services at targeted locations (taxi ranks, shopping/ community centers, sports fields, opposite schools)	45.6% had no prior HIV test before TTT; 2.7% were newly diagnosed	None

(*Continued*)

Table 2 (*Continued*)

Interventions to increase adolescent HIV testing in low- and middle-income countries								
Authors	**Publication and date**	**Location**	**Number of subjects**	**Ages (target population)**	**Study type**	**Intervention description**	**Results of intervention on testing**	**Linkage to care**
Technology/mobile health								
Njuguna et al[49]	Sexually Transmitted Diseases, 2016	Kenya	600	18–24 (females only)	Community-randomized, controlled	Randomized by college to SMS intervention or control; intervention: weekly SMS on HIV and reproductive health topics	HIV testing within 6 months: 67% from the intervention arm and 51% from the control arm (HR 1.57, 95% CI 1.28–1.92)	None
Mugo et al[51]	PloS One, 2016	Kenya	410	18–29 evaluated for acute HIV infection	Randomized, controlled	Randomized 1:1 to enhanced versus standard appointment reminders to return for repeat HIV testing; standard reminders: a dated appointment card; enhanced reminders: a dated appointment card plus SMS and phone call reminders, or in-person reminders for participants without a phone	Repeat test attendance was 41% (85/207) for standard group and 59% (117/199) for the enhanced group (RR 1.4, 95% CI 1.2–1.7)	None
Nevendorff, et al[61]	IAS, 2016	Indonesia	Not specified	Unspecified (young key population)	Retrospective, observational	YKP-friendly training for service providers; YKP sensitization workshop for outreach workers; online communication platform developed	66% increase in HIV testing of YKPs compared to baseline data	67% increase in YKP receiving ART compared to baseline data

(*Continued*)

Table 2 (*Continued*)

Interventions to increase adolescent HIV testing in low- and middle-income countries								
Authors	**Publication and date**	**Location**	**Number of subjects**	**Ages (target population)**	**Study type**	**Intervention description**	**Results of intervention on testing**	**Linkage to care**
Incentives								
Dakshina et al[62]	IAS, 2016	Zimbabwe	2,796	8–17	Randomized, controlled	Households with eligible children were randomized to one of three arms: 26% standard of care (no monetary incentive; n=735), 41% monetary prize draw (10, 5, or 0 USD with probability of picking as 0.06, 0.07, and 0.90, respectively; n=1,155), and 32% monetary incentive (2 USD; n=906)	Overall 35.7% of those eligible were tested; 15% in SOC arm, 37% in prize draw arm, and 48% in monetary incentive arm attended HIV testing; significantly more adolescents attended HIV testing with monetary incentive	None
Chapman et al[54]	IAS, 2015	Zambia	1,813	11–17 (orphans and vulnerable children)	Pre–post evaluation	Survey before and after participation in the STEPS program (Sustainability through Economic Strengthening, Prevention, and Support); 86% response rate at endline (1,813/2,099)	More likely to report having had an HIV test after STEPS (21% pre versus 28% post)	None
Oyewale et al[53]	Current Opinions in HIV and AIDS, 2016	Bangladesh	239	15–24 (MSM and transgender individuals)	Observational, prospective	Effectiveness of voucher scheme to access HIV testing	160 (76%) tested; 1 HIV infection	1/1 (100%)

(*Continued*)

Table 2 (*Continued*)

Interventions to increase adolescent HIV testing in low- and middle-income countries								
Authors	**Publication and date**	**Location**	**Number of subjects**	**Ages (target population)**	**Study type**	**Intervention description**	**Results of intervention on testing**	**Linkage to care**
Youth-friendly services								
Aninanya et al[60]	PloS One, 2015	Ghana	2,664	15–17	Community-randomized, controlled	26 communities randomized to intervention or comparison; Intervention: school- based curriculum, out-of-school outreach, community mobilization, and health-worker training in youth-friendly health services; comparison: only community mobilization and health-worker training	9.7% increase in testing with intervention (OR 1.16, 95% CI 0.85–1.58, *P*>0.05)	None
Aung et al[59]	Journal of Adolescent Health, 2017	Myanmar	613	15–24 (MSM)	Non-randomized, community controlled	Link Up intervention townships versus control townships; Link Up intervention: community- and clinic-based services that were youth friendly and tailored to meet the specific needs of YMSM including peer education and outreach and youth MSM-friendly clinic	HIV testing increased from 45% to 57% for Link Up and stayed the same for control at 29%; no significant difference between Link Up and control (AOR 1.45, 95% CI 0.66–3.17, *P*=0.35)	None

(*Continued*)

Table 2 (*Continued*)

Interventions to increase adolescent HIV testing in low- and middle-income countries								
Authors	**Publication and date**	**Location**	**Number of subjects**	**Ages (target population)**	**Study type**	**Intervention description**	**Results of intervention on testing**	**Linkage to care**
Peer/community interventions								
Rotheram-Borus et al[47]	AIDS and Behavior, 2016	South Africa	142	18–25 (unemployed males)	Community-randomized, controlled	Randomized neighborhoods to immediate intervention or delayed control; Intervention: Grassroot Soccer program with trained coaches, random rapid diagnostic tests for alcohol/drugs, and vocational training	29% testing in immediate versus 24% in delayed (no significant difference)	None
Hershow et al[46]	Sport in Society, 2015	South Africa	1,953	12–16 (females only)	Pre–post evaluation	Survey before and after participation in SKILLZ Street intervention developed by Grassroot Soccer (GRS); SKILLZ Street: Female coaches deliver an afterschool education program consisting of 10, 2 hour biweekly sessions	69% tested for HIV	None

(*Continued*)

Table 2 (*Continued*)

Interventions to increase adolescent HIV testing in low- and middle-income countries								
Authors	**Publication and date**	**Location**	**Number of subjects**	**Ages (target population)**	**Study type**	**Intervention description**	**Results of intervention on testing**	**Linkage to care**
Hossain et al[52]	IAS, 2016	Bangladesh	1,005	18–24 (female sex workers)	Pre–post evaluation	Link Up peer outreach intervention at select brothels compared to comparison brothels without intervention	68% in intervention brothels reported contact with peer educator; significantly higher odds of HIV testing uptake (AOR 1.76, 95% CI 1.04–2.96) and receipt of HIV test results (AOR 6.56, 95% CI 1.79–24.12) with peer educator contact; multivariate analyses showed no significant difference between improvement at intervention sites versus comparison sites	None
Reif et al[63]	AIDS Patient Care and STDs, 2016	Haiti	3,425	10–24	Observational, prospective	Community-based adolescent HIV testing campaign with community sensitization and active recruitment by CHWs	3,348 (98%) accepted an HIV test; HIV prevalence was 2.65% (n=89)	89/89 (100%)
Kadede et al[48]	AIDS, 2016	Uganda and Kenya	116,326	10–24	Observational, prospective	SEARCH hybrid strategy: 2-week community health campaign that included HIV testing, followed by home-based testing of community health campaign nonparticipants	86,421 (88%) adolescents tested for HIV; 1,843 (2.1%) diagnosed positive	None

Abbreviations: UC, Usual Care; PR, prevalence ratio; ART, antiretroviral therapy; RRTA, risk reduction therapy for adolescents ; PHAT, preventing HIV/AIDS among teens, MSM, men who have sex with men; JAMA, Journal of the American Medical Association; STI, sexually transmitted infection, ED, emergency department; BMSM, black men who have sex with men; SMS, short messaging service; YKP, young key population; ART, antiretroviral therapy; SOC, standard of care.

Table 3 Categories of HIV testing interventions

Category	Definition	Examples
Behavioral/ educational	Interventions that provided information on HIV and/or focused on behavioral change	• Cognitive behavior therapy • Behavior management training
Alternative venue/self-testing	Interventions that provided HIV counseling and testing outside of traditional health care facilities	• Mobile testing vans • In-home testing • Oral, home self-testing
Technology/ mobile health	Interventions using social media, internet, or mobile phones	• Text messaging • Online chat groups
Incentives	Interventions that provided monetary or coupon reimbursement for HIV testing	• Cash • Prize draw
Youth-friendly services	Interventions that focused explicitly on targeting services for an adolescent population	• Health-worker training • Youth-friendly facilities
Peer/community	Interventions that used interactions with trained community members, peers, or groups	• Youth soccer programs • Community testing campaigns or events

was no difference in HIV testing in the intervention group (25%) compared to those in standard care (14%) (95% CI 0.49–9.36). This RCT did not report random sequence generation, allocation concealment, or blinding.

In an uncontrolled observational study, Donenberg et al enrolled 54 adolescents aged 13–17 years who had been arrested into the program Preventing HIV/AIDS among Teens (PHAT life), which used group format role plays, videos, and games as an HIV prevention program.[30] There was no change in HIV testing among females, while there was a significant increase in testing from 19% at baseline to 41% (P=0.004) at the end of the intervention for males. Both programs were labor intensive, required multiple visits over time and did not significantly increase HIV testing for the defined populations at the end of the program nor did they report the number of new HIV infections diagnosed.

In low- and middle-income countries, two studies provided educational materials and behavioral interventions[55,56] with one RCT.[55] In Liberia, 1,052 out-of-school adolescents and young adults aged 15–35 years were randomized to receive standard care versus HealthyActions, a 6-day intensive group learning on sexual and reproductive health.[55] At the completion of the study, participants in the control group (42%) were less likely to undergo HIV testing (OR 0.45; 95% CI 0.38–0.53; P<0.001) than the intervention group (88%). This RCT included both random sequence generation and allocation concealment but was not blinded.

A separate non-controlled observational study in Ethiopia enrolled 730 adolescents aged 15–18 years in a 3-month client-centered, counselor-delivered psychosocial intervention that involved individual, group, and creative arts therapy counseling sessions.[56] At the end of the study, both females (AOR 1.8; 95% CI 1.13–2.97) and males (AOR 7.3; 95% CI 2.6–20.7) were more likely to have received an HIV test compared to before enrollment. The authors did not report on the number who tested positive or linkage to care. Both of these interventions were labor and training intensive and required multiple visits over time.

Alternate venues/self-testing (N=11)

In the US, there were four studies involving alternative venue testing strategies for adolescents[31–34] with only one RCT.[31] Merchant et al randomized 425 MSM aged 18–24 to perform an oral rapid self-test, self-mail in blood test, or testing at a local medical facility.[31] Of those enrolled, only 54% completed their assigned test. Oral self-testing (62%) and facility-based testing (56%) were superior (P<0.01 each) to mail in blood testing (40%). This RCT reported random sequence generation but did not report allocation concealment or blinding nor did they report the number of HIV diagnoses or linkage to care.

The alternative strategies investigated by the non-RCT studies included testing on campus at historically black colleges and universities,[32] opt-out testing at family planning clinics,[33] and targeted testing tailored to sexual minority men.[34] All of these strategies reported increased HIV testing among adolescents. An observational study evaluating the provision of HIV testing on campus among 2,385 students attending historically black colleges and universities over a 2-year period detected new HIV infections in 0.6% of those tested.[32] The investigators were able to link 100% (N=15) of individuals newly diagnosed with HIV to care. A separate observational study of 3,301 sexual minority men of color aged 13–24 found that targeted testing detected the highest number of new HIV infections (6.3%) compared to universal testing (0.1%) and combination of universal and targeted test-

ing (5.6%).[34] This study was not controlled or blinded, and did not report on loss to follow-up. A retrospective analysis evaluated the historical effect of opt-out testing compared to opt-in testing among 34,299 individuals aged 13–23 years attending family planning clinics.[33] They found a 50% increase in HIV testing during the opt-out period with 0.3% new HIV diagnoses.

In low- and middle-income countries, there were seven studies evaluating alternative HIV testing strategies[42–45,50,57,58] with two RCTs.[42,45] A community RCT in Zambia and South Africa involving 15,456 adolescents aged 15–19 years found that door-to-door testing had high uptake (81%) with 1.6% of those tested newly diagnosed with HIV.[45] This RCT did not include random sequence generation, allocation concealment, or blinding. In South Africa, an RCT involving 284 females aged 18–24 years showed that home-based self-testing had higher uptake (97%) than referrals to local clinic (48%) (RR 2.00, 95% CI 1.66–2.40).[42] This study was reported in abstract form.

There were five non-RCT studies that evaluated alternative venue HIV testing among adolescents.[43,44,50,57,58] In an observational study of 496 individuals aged 16–20 years from Mozambique, uptake of oral self-testing was 60% with 1.7% newly diagnosed with HIV.[58] A prospective, observational study of 165 adolescents aged 15–24 years in Malawi evaluated untested adolescents with known HIV-infected adult family members by use of household testing and found 9.7% new HIV infections with 77% successfully linking to care.[57] A prospective, observational study offering HIV testing to 1,490 symptomatic youth aged 18–29 years presenting to pharmacies in Kenya found low uptake for testing (24%); however, of those tested, 4% were newly diagnosed with HIV.[50] A prospective, observational analysis of 4,800 adolescents in South Africa aged 10–19 years evaluated three testing strategies: index client trailing, door-to-door testing, and campaign testing at events.[43] In this study, 4,756 (99.1%) agreed to HIV testing. Diagnosing new HIV infections was highest with testing campaigns (9.4%), followed by index client trailing (6.0%) and door-to-door testing (5.9%; P=0.019). Another South African observational study that evaluated 1,285 youth aged 12–24 years utilizing mobile HIV testing trucks specifically targeting adolescents found a high uptake of first-time HIV testers (45.6%) and found 2.7% of individuals testing to be newly diagnosed with HIV.[44]

Technology/mobile health (N=9)

In the US, there were six technology or mobile health interventions[16,35–39] with three RCTs.[36,38,39] Ybarra et al randomized 302 MSM aged 14–18 years to receive a self-esteem control versus Guy2Guy program that involved daily text messaging for 5 weeks providing HIV information, motivation and behavioral skills, the importance of HIV testing, and healthy relationships. Individuals randomized to the intervention were more likely to undergo HIV testing (OR 3.42; 95% CI 1.65–7.09; P=0.001).[38] This RCT included random sequence generation but did not report allocation concealment or blinding. Washington et al randomized 142 black MSM aged 18–30 years old to watch five 60-second videos per week that included vignettes from black MSM characters and to participate in reflections using a group chat feature compared to a control group that received standard information via text messaging. Individuals in the intervention group were more likely to undergo HIV testing compared to the control group (OR 7.0; 95% CI 1.72–28.33; P=0.0006).[39] This RCT was reported in abstract form. Bauermeister et al randomized 130 MSM aged 15–24 years to use of an online HIV site testing locator or Get Connected!, a tailored online HIV/sexually transmitted infection intervention with a website, where the logo and online materials were designed with input from a youth advisory board.[36] When randomized to the intervention or use of an online testing site locator, there was no statistical difference in HIV testing rates in those receiving the full intervention (32%) compared to those receiving the testing locator only (29%, P>0.05 exact not reported). This RCT reported both random sequence generation and allocation concealment. None of these studies reported on the number of new HIV diagnoses or linkage to care.

Among the non-randomized studies in the US evaluating technology, Dowshen et al reported an observational pre/post evaluation of the IknowUshould2 campaign which used traditional media (print/radio) and technology-based media such as websites, Facebook, Twitter, Instagram, and YouTube to promote HIV testing among 1,500 adolescents who interacted with the campaign.[37] Over the 9 months of the program, there was a significant increase in visits to a family planning clinic for HIV testing (5.4%–19%; P<0.01). This study did not control for temporal differences or other possible confounding factors. Solorio et al reported an observational evaluation of 50 Latino MSM using the Tu Amigo Pepe intervention, a 16-week campaign in the US that included Spanish-language radio announcements, a website, social media outreach, text message reminders, and a toll-free hotline.[16] The intervention did not significantly increase HIV testing (90%) from baseline (82%) (OR 2.0; 95% CI 0.8–5.4; P=0.16). Neither study reported the number of new HIV infections or linkage to care. Aronson et al conducted a tablet-based intervention

for 100 young adults aged 18–24 presenting an emergency department who had declined HIV testing.[35] After the intervention, 30% of youth tested and 70% agreed to participate in a 12-week program of weekly text messages.

In low- and middle-income countries, there were three interventions using technology or mobile health[49,51,61] including two RCTs.[49,51] In Kenya, a randomized text messaging trial involving 600 women aged 18–24 found that women in the intervention group were more likely (67%) to receive HIV testing within 6 months compared to control (51%) (HR 1.57; 95% CI 1.28–1.92).[49] This RCT did not include random sequence generation, allocation concealment, or blinding nor did they report the number of new HIV diagnoses. Another RCT in Kenya randomized 410 individuals aged 18–19 years who were evaluated for acute HIV infection to receive appointment reminders via text message compared to enhanced reminders including dated appointment cards, text message reminders, and phone call reminders to increase repeat HIV testing.[51] Repeat HIV testing was 41% in the standard group and 59% in the enhanced group (RR 1.4; 95% CI 1.2–1.7). This RCT reported both random sequence generation and allocation concealment but did not report the number of new HIV diagnoses.

In a retrospective observational study from Indonesia, a combination intervention that included key-population-friendly services and outreach with an online communication forum found a 66% increase in HIV testing compared to baseline and a 67% increase in those receiving ART compared to baseline.[61]

Incentives (N=3)

Three studies involved interventions that provided incentives to adolescents for undergoing HIV testing, all of which were conducted in low- and middle-income countries: Bangladesh,[53] Zambia,[54] and Zimbabwe[62] with only one RCT.[62] Dakshina et al randomized 2,796 individuals aged 8–17 years in Zimbabwe into three arms: standard of care (no incentive) versus a prize draw (6% chance of getting $10, 7% chance of getting $5, and 90% of getting $0) versus a guaranteed monetary incentive of $2.[62] Overall 35.7% of individuals were tested: 15% in the standard of care; 37% in prize draw; 48% in monetary incentive. The investigators identified 11 new HIV infections: 4 (0.3%) in the monetary incentive arm, 7 (0.8%) in the prize-draw arm, and 0 in the standard of care arm. This RCT was reported in abstract form; therefore, a full bias assessment could not be conducted.

An observational pre/post evaluation in Zambia evaluated 1,813 orphans and vulnerable children aged 11–17 years who participated in the STEPS program (Sustainability through Economic Strengthening, Prevention and Support).[54] Individuals enrolled in the program were more likely to have had an HIV test after the program (28%) compared to prior to the intervention (21%). The authors did not report the number of infections identified or linkage to care. An observational study in Bangladesh evaluated 239 MSM and transgender individuals aged 15–24 years in using a voucher system to access HIV testing.[53] Of the vouchers distributed, 160 (76%) were returned for testing and 1 (0.6%) individual was found to be HIV infected and subsequently linked to care.

Youth-friendly services (N=2)

There were two interventions involving the use of youth-friendly services to improve HIV testing among adolescents, both in low- and middle-income countries: Myanmar[59] and Ghana[60] with one RCT.[60] A community randomized trial in Ghana evaluated 2,664 adolescents aged 15–17 years who participated in youth-friendly health services, school-based curriculum, outreach, and community mobilization with health-worker training in youth-friendly service compared to control with community mobilization and youth-friendly services only.[60] Compared to the control, adolescents receiving the full curriculum had a 9.7% increase in HIV testing, which was not statistically significant (OR 1.16; 95% CI 0.85–1.58). This RCT reported both random sequence generation and allocation concealment.

A non-randomized, controlled study in Myanmar evaluated 613 MSM aged 15–24 years who participated in the Link Up intervention compared to control townships.[59] The intervention consisted of community and clinic-based youth-friendly services and included peer education, outreach, and a youth-/MSM-friendly clinic. HIV testing increased from 45% to 57% in the intervention group and was unchanged at 29% in the control group (OR 1.45; 95% CI 0.66–3.17). Neither study reported on the number of new HIV diagnoses during the intervention nor did they discuss linkage to care.

Peer/community interventions (N=7)

In the US, there were two non-randomized, non-controlled studies that evaluated community interventions to increase HIV testing among adolescents. Mpowerment, a community-level mobilization intervention targeting MSM of color aged 18–29 years, found increased testing from 54% at baseline to 70% at 6 months ($P<0.001$), but it did not report the number of newly diagnosed or linked to care.[40] Metropolitan Atlanta Community Adolescent Rapid Testing Initiative (MACARTI) combined non-traditional venue HIV testing, motivational

interviewing, and case management targeting youth and identified 11.3% of testers with new HIV infections, 96% linked to care compared to 57% under standard of care ($P<0.001$).[41]

In low- and middle-income countries, five studies assessed community- or peer-focused interventions[46–48,52,63] with one RCT.[47] A community randomized trial in South Africa evaluated the Grassroot Soccer program that included trained coaches, educational/vocational training, and use of rapid HIV diagnostics. Among the 142 males, the program did not increase HIV testing (29%) compared with delayed enrollment into the program (24%).[47] This RCT did not report random sequence generation, allocation concealment, or blinding.

In a separate observational study of the Grassroot Soccer intervention among 1,953 females, 69% of participants tested for HIV; however, there was no comparison or control group.[46] Neither study reported on the number of new HIV diagnoses or linkage to care. In Bangladesh, an observational study of the Link Up peer outreach program targeted HIV testing among 1,005 young adult female sex workers working in brothels, but it did not find a significant difference in HIV testing in brothels that had the intervention compared to those that did not participate in the intervention.[52] In Haiti, an observational evaluation of a community-based adolescent HIV testing campaign tested 3,348 individuals, of whom 98% offered testing.[63] They diagnosed 89 (2.7%) new HIV infections, all of which were linked to the clinic the same day. In Uganda and Kenya, an observational study of a combination approach of community-based testing followed by home-based HIV testing for community members not participating in the campaign tested 86,421 (88%) of adolescents.[48] The authors reported that 1,843 (2.1%) individuals were newly diagnosed with HIV; however, they did not report on linkage to care.

Discussion

In this systematic review of HIV testing interventions among adolescents in high- versus low-/middle-income settings, we found 36 studies including 13 RCTs; yet only six studies discussed linkage to care. The primary purpose of screening for any disease is early diagnosis, so that diagnosed individuals can be promptly treated; this is true for HIV testing. Therefore, it is important that interventions to increase HIV testing not only address barriers to HIV testing but also include methods to effectively link newly diagnosed individuals to care.

Interventions that use technology and mobile health can address psychological barriers such as perceived risk, stigma, disclosure, and fear of rejection to increase HIV testing in adolescents. In the US, there were two RCTs and one pre–post evaluation that evaluated interventions using mobile health and technology to target key populations that significantly increased HIV testing among adolescents.[37–39,64] In low- and middle-income countries, two RCTs and one retrospective observational study found that text messaging interventions targeting high-risk key populations significantly increased HIV testing among adolescents.[49,51,61] In most settings, adolescents and young adults found text messaging and mobile health technology interventions acceptable and feasible.[35–39,65–68] However, these interventions did not address structural barriers to HIV testing and none of the nine studies reported the numbers of new HIV diagnoses or linkage to care. Linking newly HIV diagnosed individuals is critical to improving the continuum of care among adolescents living with HIV.[7,8]

Non-traditional HIV testing venues and oral self-testing can overcome structural barriers such as inconvenience, insurance, and parental consent to improve HIV testing among adolescents.[69] In the US, one RCT and three observational studies found high levels of acceptability, but they offered limited data on linkage to care, which is particularly important for alternative venue testing.[31–34,69] Oral self-testing was an acceptable HIV testing method among adolescents and could be a method employed to expand HIV testing programs; however, there are limited data on linkage to care after self-testing among adolescents.[31,58] Within traditional health care venues, opt-out testing appears to improve HIV testing among adolescents compared to opt-in testing and may increase HIV testing over provider-initiated counseling and testing in high-prevalence areas.[33,70,71] In low- and middle-income countries, door-to-door and mobile HIV testing was found to be feasible, acceptable, and led to large numbers of adolescents obtaining HIV testing; however, data on linkage to care is absent in those studies.[43–45] In Malawi, door-to-door contact tracing of children born to HIV-infected mothers was a high yield method for detecting perinatal HIV in children and younger adolescents and could be expanded to other high HIV prevalence countries.[57] Providing flexible, alternative strategies outside of traditional health care settings appears to be an acceptable, feasible, and effective method of increasing HIV testing among adolescents in the US and low- and middle-income countries. In low- and middle-income countries, alternative testing sites such as home self-testing, in-home door-to-door testing, testing campaigns, and pharmacy-based testing appear

to be acceptable and feasible alternatives for HIV testing among adolescents; however, little is known about linkage to care after new HIV diagnosis in alternative venues. Of the eleven interventions involving alternative venue HIV testing, only two evaluated linkage to care, limiting the generalizability of these approaches.[32,57]

Community testing events and mobilization have the potential to overcome structural and psychosocial barriers by easing access, making testing normative, and providing social support; therefore, they have the ability to test large numbers of individuals and can be used to target high-risk, key populations.[40,41,46,48,52,57,63] The only RCT in this category did not find efficacy in increasing HIV testing.[47] However, six observational studies reported high levels of HIV testing in community interventions. In addition, two interventions reported successful linkage to care after HIV testing, making this an important component for future HIV testing modalities for adolescents.[41,57,63]

Other HIV testing interventions had mixed results and lower quality evidence for increasing HIV testing among adolescents. Interventions that involved behavioral change or education in the US were labor and resource intensive and showed variable results.[29,30] These interventions appeared to be more effective in low- and middle-income countries compared to the US; however, none of these studies discussed the number of newly diagnosed HIV infections nor the number linked to care. Offering incentives for HIV testing among adolescents can address motivation for HIV testing but does not overcome many structural or psychosocial barriers to HIV testing, and sustainability may be challenging.[53,54,62] In addition, there is limited data on the effectiveness of incentives on linkage to care after HIV testing. The specific use of youth-friendly testing facilities can address some structural and psychosocial barriers to HIV testing; however, these interventions did not have statistically superior effects compared to traditional testing sites.[59,60]

Though critical to informing the implementation and scale-up of effective interventions, none of the studies reported resource utilization or costs related to HIV testing or the intervention. With resource utilization and cost data, health policy models can project the long-term impact of interventions beyond the time-horizon of traditional studies. This type of analysis is particularly important when considering testing interventions among youth, in whom the effects of HIV infection and treatment may not manifest for years or decades.[5] Few studies have reported on the cost-effectiveness of adolescent-specific prevention or testing interventions.[72–76] Such information is invaluable for policymakers to understand optimally deploying combinations of universal and targeted testing in specific settings and warrants more study moving forward.[77]

Current studies are exploring alternative methods and venues to improve HIV testing and linkage to care among high-risk adolescents.[78] Mpower is an ongoing community-level intervention in the targeting young MSM using peer educators to engage high-risk youth to increase HIV testing.[79] Other investigators are exploring the use of oral, self-testing with video counseling for transgender youth in the US.[80] In Kenya, a large-scale study is evaluating alternative testing venues (community versus home) and testing modalities such as oral self-testing, home testing, mobile testing, or facility-based testing.[81] Results of these studies may add valuable information for the development of multicomponent interventions to increase HIV testing among adolescents.

Future research should also focus on expanding the geographic reach of interventions for HIV testing among adolescents and young adults. In particular, this review did not identify any recently published interventions to increase HIV testing in Latin America or in high-income countries other than the US. Although the majority of HIV infections among adolescents occur in sub-Saharan Africa, HIV affects adolescents globally. It is important that effective interventions are identified that address culture-specific barriers and target local at-risk populations.[3]

Conclusion

To diagnose more HIV infections among adolescents, it is important to target high-risk populations, minimize barriers to HIV testing, and make testing easier and more widely available. One intervention is unlikely to address all of the barriers to HIV testing among adolescents and would be unlikely to succeed across all settings. Therefore, future interventions should utilize multiple components and expand on the successful use of mobile health technology, alternate venue testing, and community mobilization while stressing the importance of linkage to care. High-quality RCTs are needed to identify optimal combinations of interventions that increase HIV testing among adolescents while focusing on diagnosing new HIV infections and providing linkage to care.

Author contributions

All authors contributed to data analysis, drafting or revising the article, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

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