Effects of a social network HIV/STD prevention intervention for MSM in Russia and Hungary: a randomized controlled trial

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Objective: To test a novel social network HIV risk-reduction intervention for MSM in Russia and Hungary, where same-sex behavior is stigmatized and men may best be reached through their social network connections.

Design: A two-arm trial with 18 sociocentric networks of MSM randomized to the social network intervention or standard HIV/STD testing/counseling.

Setting: St. Petersburg, Russia and Budapest, Hungary.

Participants: Eighteen 'seeds' from community venues invited the participation of their MSM friends who, in turn, invited their own MSM friends into the study, a process that continued outward until eighteen three-ring sociocentric networks (mean size = 35 members, $n = 626$) were recruited.

Intervention: Empirically identified network leaders were trained and guided to convey HIV prevention advice to other network members.

Main outcome and measures: Changes in sexual behavior from baseline to 3-month and 12-month follow-up, with composite HIV/STD incidence, measured at 12 months to corroborate behavior changes.

Results: There were significant reductions between baseline, first follow-up, and second follow-up in the intervention versus comparison arm for proportion of men engaging in any unprotected anal intercourse (UAI) ($P = 0.04$); UAI with a nonmain partner ($P = 0.04$); and UAI with multiple partners ($P = 0.002$). The mean percentage of unprotected anal intercourse acts significantly declined ($P = 0.001$), as well as the mean number of UAI acts among men who initially had multiple partners ($P = 0.05$). Biological HIV/STD incidence was 15% in comparison condition networks and 9% in intervention condition networks.

Conclusion: Even where same-sex behavior is stigmatized, it is possible to reach MSM and deliver HIV prevention through their social networks.

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Introduction

Men who have sex with men (MSM) are disproportionately vulnerable to HIV disease throughout the world, [1] including in regions where the disease is predominantly heterosexual or attributable to injection drug use [2] such as sub-Saharan Africa [3,4], countries of the former Soviet Union [5,6], and China [7–9]. Little is known about interventions that can reduce sexual HIV risk in regions where same-sex behavior is stigmatized and MSM are unlikely to seek out HIV prevention services even if they were available. Although considerable attention is now being appropriately directed to the use of biomedical strategies for prevention, interventions to reduce sexual risk behavior among MSM also remain critical.

Political support, open and tolerant social policies, well established nongovernmental organizations (NGOs), and the presence of visible gay communities in the West facilitate the use of a wide range of individual-level, group-level, and community-level HIV prevention programmes for MSM [10,11]. The situation is much more challenging in countries that are less tolerant of same-sex behavior. There has been recent movement in Russia toward intolerance of gay rights and recognition. Efforts to reach MSM face political, legal, and implementation challenges because men are unlikely to openly present themselves as gay or bisexual. Conservative trends in other countries in the region, including Hungary, have also lessened tolerance toward minorities [12,13]. New approaches are needed in this region to reach MSM and deliver interventions to reduce HIV risk behavior.

Interventions that operate through social networks hold promise for reaching vulnerable communities even when formal prevention infrastructure supports are limited [14]. Network methods have long been used to reach and reduce injection risk practices in community samples of drug users [15–17]. Network models for reducing sexual risk practices have not often been studied but are promising because MSM can potentially be reached through their social networks [18–20].

This approach is especially culturally pertinent to Eastern Europe where pronouncements from Soviet era authorities were often seen as untrustworthy, and people relied on their personal networks to gain trusted information and mutual support [21,22]. Informal network connections among individuals who are personally known and trusted continue to play a vital function in helping people in the region handle everyday challenges and determine best courses of action [23]. AIDS research in Russia has shown that the social network to which gay or bisexual men belong influences whether they engage in high-risk sex [24].

Prior research in the United States demonstrated that ‘popular opinion leaders’ within populations of gay men in small cities can be engaged to shift the risk behavior practices of other MSM in the same communities [25,26]. In contrast to the popular opinion leaders’ community intervention model, the present approach sought to recruit networks of interconnected friends and train empirically identified leaders within each network to deliver personally tailored ongoing risk-reduction counseling to their close friends. Such a process can serve to strengthen norms, attitudes, intentions, and skills for risk reduction in one’s immediate social environment. The present study also grows from a previous randomized HIV prevention social network intervention trial in Eastern Europe that recruited small clusters of friends (egocentric networks) and trained the single leader of each network to counsel his friends about risk reduction [27]. To create multiple sources and greater stability of behavior change support in the peer environment, it is possible to extend beyond small egocentric friendship clusters and to enroll and intervene with larger networks. Sociocentric networks are sets of individuals in a given community who are socially connected with one another and whose connectivity is determined primarily by shared social attributes, status, or characteristics.

This study was carried out from 2007 to 2012 in St. Petersburg, Russia and Budapest, Hungary. It is estimated that between 2600 and 4800 persons are living with HIV infection in Hungary, [28] majority MSM [29]. In Russia, almost 800 000 HIV infections have been diagnosed, primarily IDUs [30,31]. However, MSM constitute a significant proportion of infections, especially in large cities such as St. Petersburg. Surveillance studies in two Russian cities showed HIV prevalence among MSM of 4.6–8.3% [32].

The purposes of this study were to recruit 18 sociocentric networks of high-risk MSM from the community; randomize entire networks to either receive voluntary HIV/sexually transmitted disease (STD) testing and counseling alone or a social network intervention; and evaluate the effects of the network intervention on sexual risk characteristics and – to corroborate behavior change – incidence of HIV and other STDs.

Methods

Participants

MSM ‘seeds’ were identified in community venues such as bars, private parties, or cruising locations. To identify seeds, study staff observed ‘social circles’ [33] of MSM interacting with one another in the venues, and the circle’s center of attention was designated as a seed and invited to participate in the study. Each seed was asked to identify – by first name only – members of his close MSM friendship group. Seeds gave study invitation packets to each named friend, the first ‘ring’ of the network. When first-ring members were enrolled, they in turn invited their own close MSM friends, constituting the second network ring. Second-ring members invited their own friends to enroll, constituting the third and final ring of the sociocentric network. Other than the seed who was selected by study staff, individuals were eligible to participate if they were named and invited by a previously enrolled participant, were at least 18 years old, lived in the study city, and provided written informed consent at the baseline visit. Networks were eligible if at least half of first-ring members were recruited and if over 50% of members reported ever having sex with men in their baseline assessments. Figure 1 depicts one of this study's networks.

Randomized trial design

As shown in the Fig. 2 consort diagram, a total of 18 networks were enrolled (10 networks in Russia and eight networks in Hungary). Within country, pairs of networks were randomly allocated to the intervention and comparison condition after all members completed baseline assessments and HIV/STD testing, with equal numbers of networks in each country assigned to each condition. All participants completed self-administered behavioral questionnaires 3 months after the intervention and both behavioral assessment and repeat HIV/STD testing at 12-month follow-up. Participants received modest financial incentives to offset transportation costs and time spent attending assessment visits and – in the intervention condition – for attending intervention sessions.

Baseline measures

Assessments of sexual risk behavior and risk-related characteristics included demographic and health history information, as well as previously validated scales [24,34] that measured AIDS-related psychosocial characteristics theoretically linked with the adoption of safer behavior [35–38]. A 15-item true/false scale measured knowledge about AIDS risk behavior and risk-reduction steps (sample item: 'Most people who have the AIDS virus look sick'). All other scales had seven to 12 items and employed three-point Likert response formats to measure perceived safer sex peer norms ('Condom use is popular among my friends', Cronbach's $\alpha = 0.77$); attitudes toward condom use and safer sex ('I enjoy safer sex', Cronbach's $\alpha = 0.72$); risk-reduction behavioral intentions ('I would use a condom if my casual partner asks me not to', Cronbach's $\alpha = 0.79$); and risk-reduction self-efficacy ('Even in the middle of foreplay, I can easily suggest condom use', Cronbach's $\alpha = 0.62$).

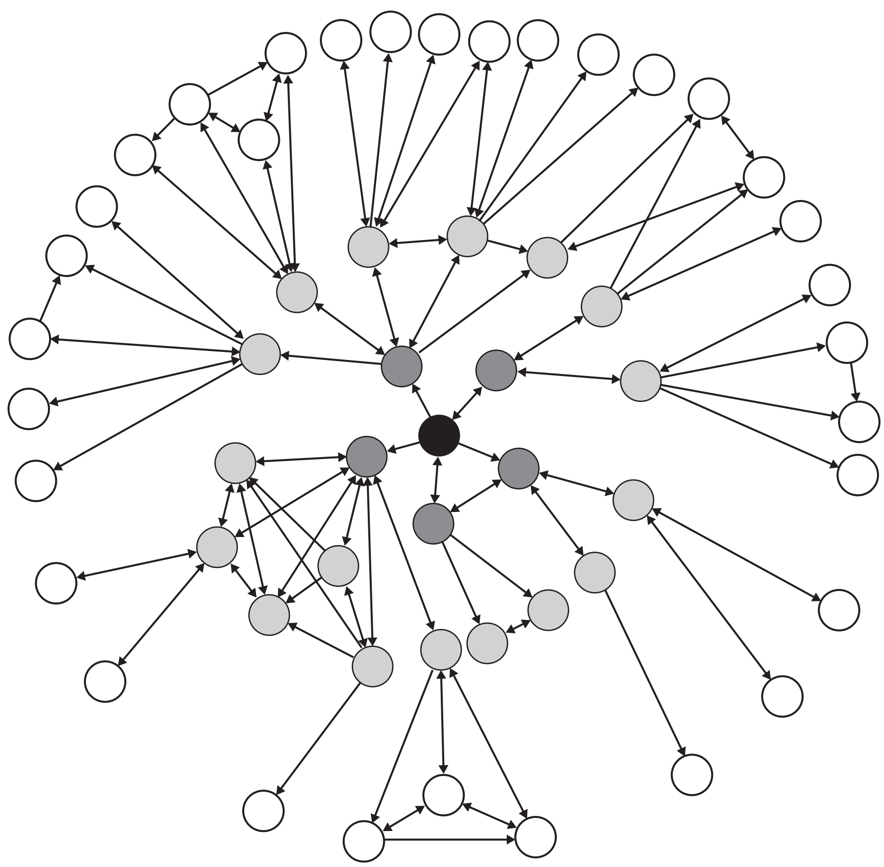

Fig. 1. Depiction of a three-ring sociocentric MSM social network in Hungary. The dark-shaded circle at the figure's center is the seed. First-ring, second-ring, and third-ring network members extending outward from the seed are shown by progressively lighter respective shading. Data visualization: Borgatti SP. NetDraw Graph Visualization Software. Harvard: Analytic Technologies, 2002.

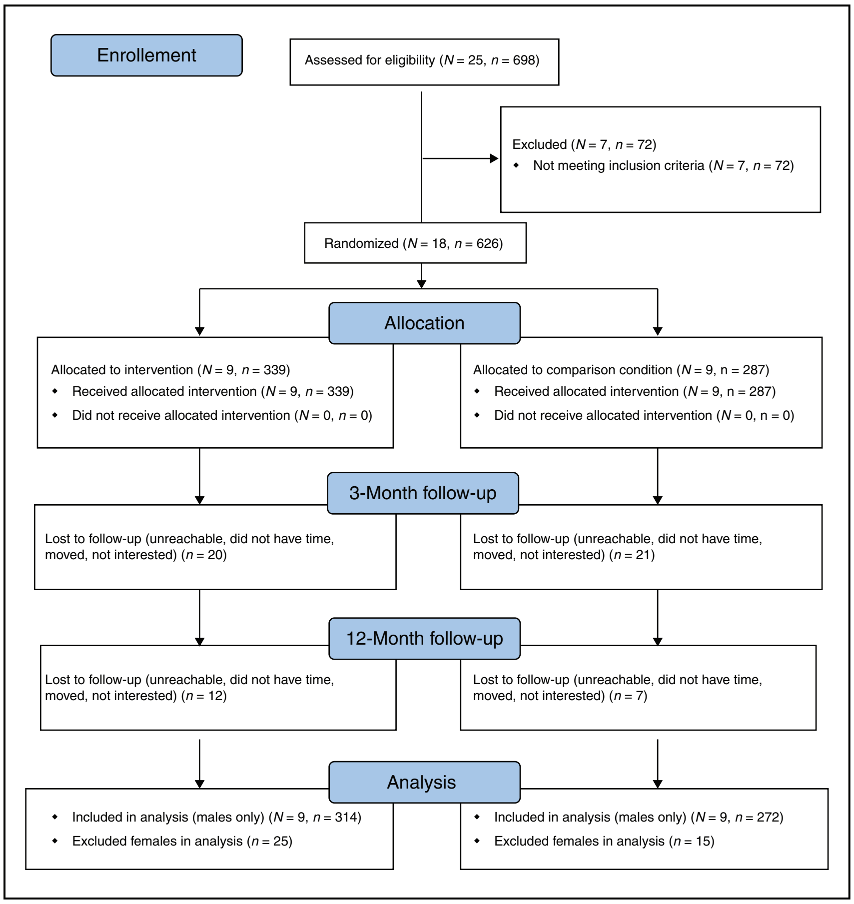

Fig. 2. Trial consort diagram. *N* = number of networks; *n* = number of participants.

Participants indicated their number of male and female sexual partners in the past 3 months. Separately for up to the five most recent partners of a sex, respondents described each partner's type (main or nonmain), number of times in the past 3 months when anal or vaginal intercourse took place, and number of those acts when condoms were used. Men with six or more partners of a sex summarized their sexual behavior with the additional partners. Substance use was assessed by asking how many days in the past month participants used alcohol and 13 illicit drugs.

Laboratory HIV/STD testing

HIV and syphilis testing were performed on blood samples obtained by venipuncture. Gonorrhea and chlamydia testing was performed by PCR on self-collected first-catch urine samples after not urinating for at least 4 h. DNA was extracted using Cobas Amplicor (F. Hoffmann - La Roche Ltd., Basel, Basel-Stadt, Switzerland) specimen preparation kits in Hungary and Amplisens (Central Research Institute of Epidemiology, RosPotrebNadzor, Moscow, Russia) fluorescence specimen kits in Russia. Amplification and detection steps were performed with Rotor-Gene 6000 (Corbett Research Pty Ltd., Sydney, Australia) in Russia and Cobas Amplicor CT/NG (F. Hoffmann - La Roche Ltd) with thermocycler GeneAmp 9600 (PerkinElmer, Inc., Waltham, Massachusetts, USA) in Hungary. Blood samples were first tested for syphilis by ELISA [Serodia TPPA (Fujirebio Inc., Tokyo, Japan) in Hungary and D-1856 (Vector Best ZAO, Novosibirsk, Novosibirsk Oblast, Russia) in Russia] followed, if positive, by rapid plasma reagin. Initial HIV testing was by ELISA at each site followed, if reactive on repeat ELISA, by confirmatory testing (HIV 1/2 Ag/Ab VIDAS HIV dou HIV 1/2 Ag + Ab in Hungary and Immunoblotting Assay HIV New LAV Blot + Assay in Russia) for final serostatus determination. Participants with an STD received immediate treatment, verified by study staff. Participants with HIV infection were referred to a medical provider for care. At the time of the study, standard of care by providers was the initiation of antiretroviral therapy (ART) at less than 350 $CD4^+$ or if an AIDS-related opportunistic illness was diagnosed. Participants who declined study HIV testing because they already knew they were HIV infected were coded as HIV positive at baseline.

Because all bacterial STDs were treated at baseline, any new STD at follow-up was an incident case. Any HIV infection at follow-up in a participant uninfected at baseline was also considered an incident case. A composite STD/HIV incidence variable represented the aggregate of any STD infection and any new HIV infection diagnosed at follow-up testing.

Identification of network leaders

Leaders were selected from throughout all rings of each network based on three criteria. When participants named their MSM friends at the baseline visit, they answered three sociometric questions about each friend (i.e. whether they often talk together to discuss important issues). Network members with the highest sociometric scores were first identified. Second, and among them, persons with highest 'betweenness centrality' (bridging otherwise unconnected network segments) were selected because they could serve as information exchange channels with others in the network [14]. To ensure intervention exposure, a map of each network was inspected to identify individuals unconnected to the selected leaders, with additional leaders then identified to 'cover' these clusters. Altogether, 30% ($n = 101$) of intervention condition network members were designated as leaders.

Risk reduction counseling

Each participant received an individual risk-reduction counseling session lasting approximately 20 min in conjunction with HIV/STD testing upon study entry. The session covered behaviors that confer HIV risk, behavior changes to reduce risk, and strategies to make risk-reduction steps. This was offered to ensure that all participants, regardless of study condition, received HIV prevention counseling upon study entry.

The network intervention

The intervention guided network leaders in giving personal HIV risk-reduction advice to their friends. Intervention facilitators were centrally trained and followed a manual. The intervention was delivered in 5 weekly 3-h group sessions attended by five to 11 leaders, followed by four booster sessions spaced over the next 3 months.

Theory [35–38] and research with MSM [24,34] have shown that risk knowledge, norms, attitudes, intentions, and self-efficacy influence the adoption of HIV-protective behavior. Consequently, the intervention taught network leaders to communicate messages that incorporated these theory-based constructs. Each session focused attention on delivering messages to friends based on a different construct. Because network members were their own close friends, leaders could tailor advice to the particular risk issues of each friend.

The facilitators used behavioral techniques to help network leaders gain skill and comfort in having these conversations. Following a warm-up activity, that day's session content topic was introduced, the theoretical construct was identified, and facilitators described how leaders' communications could help friends make risk-reduction behavior changes. Role plays allowed network leaders to generate examples and rehearse ways to communicate HIV prevention messages to network members. In each session, leaders gave feedback to one another to shape their skills, discussed HIV prevention communication experiences in the past week, and were reinforced for their efforts.

Monitoring intervention exposure

Each leader was given a list with the names of network members who had been linked to him based on the sociometric measures completed at baseline. The leader was assigned to talk with these individuals after each session. Occurrence of these conversations was measured from notations that leaders made when completing monitoring grids that were collected at the start of each session. In addition, all study participants reported at the baseline and 3-month follow-up assessments how many times a friend had talked to them about safer sex and about HIV/AIDS in the past 3 months. These two data sources corroborated intervention delivery from the perspectives of both the leaders and the network members.

Statistical methods

Mixed-effects multiple regression analyses (for linear, logistic, and Poisson distributions) compared baseline characteristics of the condition groups and also tested the significance of the social network intervention on repeated measures changes in sexual risk behavior and AIDS-related scales over time. Because all members of each social network were randomized together as an intact group to study conditions, responses for members of the same social network were correlated. To control for the interdependence of responses within the same network, network was incorporated as a random effect in each regression model.

Each baseline comparability regression model included fixed-effects for country and intervention condition assignment, and a random-effect for network. Intervention and comparison baseline models were tested for significance to evaluate the baseline comparability of the condition groups. Each outcome variable regression model included fixed-effects for condition assignment, country, and assessment period; all fixed-effect interactions; and random-effects for network and subject (repeated measures). The test of the intervention condition-by-period interaction was used to evaluate the overall impact of the social network intervention on change in the outcome variables over time (from baseline to 3-month and 12-month follow-up). Logistic and Poisson regression least squares estimates (on the logit and log scale, respectively) were back transformed to calculate adjusted 95% confidence intervals for each study condition group at each time period. Analyses were performed according to intention to treat. All networks and network members who were randomized were included in the primary analyses without any ad hoc imputation regardless of missing data, missing follow-ups, or attrition. Mixed-effect multiple regression analyses were performed using SAS macro Glimmix (version 9.3, SAS Institute, Inc., Cary, North Carolina, USA). Power calculations showed that accrual of 18 sociocentric networks (nine networks per condition with an average of 30 members and intraclass correlation of 0.08 among members) provides statistical power of 0.8 with α 0.05 for testing an impact of 20% or greater increase in consistent condom use.

Results

Participants

A total of 626 participants were found eligible, consented, and enrolled ($n=254$ in the 10 networks in Russia and $n=372$ in the eight networks in Hungary). Several participants named a small number of females as part of their MSM friendship group. Data from 40 females were not included in the outcome analysis. Networks ranged in size from nine to 65 members (mean = 35), with network size depending largely on the number of people named as friends by the seed and the number of friends named by members of subsequent rings.

Network leader session attendance, intervention exposure, and manipulation checks on intervention delivery

Network leaders attended a mean of 8.0 of nine intervention sessions and talked with each network member on a mean of 4.4 of the intervals (median = 5) between intervention sessions. Intervention condition network members reported that talk about safer sex topics with friends increased from a mean of five times at baseline to eight times at 3-month follow-up, significantly more than in the comparison arm (four times to four times; $P=0.05$). Conversations about AIDS tended to increase (from five times at baseline to seven times at follow-up) in intervention networks and remained unchanged (three to three times) in comparison networks ($P=0.07$).

Participants' demographic characteristics, substance use, sexual risk behavior, and HIV/STD prevalence at baseline

Table 1 presents participant demographic characteristics. No baseline imbalances across conditions were found. Participants in both countries were typically in their twenties, most were single, employed, and well educated or attending school. Over 61% of men had multiple partners in the past 3 months. More than 23% ever exchanged sex for money.

Almost all men used alcohol on an average of six of the past 30 days, with nearly half reporting being drunk in the past month (not shown). Nearly one-third of men reported using a drug, most commonly inhaled nitrites (poppers) and marijuana/hashish. Fewer than 2% of men reported recent use of injected drugs.

At baseline, 7% of men in the sample were HIV-infected based on either serological testing or self-report. Gonorrhea was the STD most commonly diagnosed at baseline laboratory testing (8% of men) with lower prevalence of chlamydia and syphilis. Altogether, 15% of participants had HIV infection or another STD diagnosed through baseline testing.

Intervention outcomes

Sexual risk behavior outcomes

As shown in Table 2, the proportion of intervention condition men who engaged in any unprotected anal intercourse (UAI) during the past 3 months declined from 54% at baseline to 38% at 3-month follow-up and 43% at 12-month follow-up, whereas the proportion of comparison men was largely unchanged over time ($P=0.036$). The proportion of men who engaged in UAI with a nonmain sexual partner declined significantly more in intervention condition networks than comparison networks (18 to 8 to 9% versus 23 to 21 to 21%, $P=0.042$), as well as the proportion reporting UAI with multiple partners (14 to 2 to 5% versus 19 to 17 to 13%, $P=0.002$). There was a trend for greater decline in mean number of UAI acts reported by men in intervention condition networks (12 to 7 to 10 versus 12 to 13 to 11, $P=0.07$). These declines in the intervention condition were not due to an overall reduction in sexual behavior. The mean number of anal intercourse acts and number of

Table 1. Baseline characteristics of the study sample by study condition.

Variable	Intervention ($n=314$)	Comparison ($n=272$)	Significance[a] P
Demographic characteristics			
Age, years, mean (SD)	29.0 (6.7)	26.9 (6.6)	0.22
Education, years, mean (SD)	15.2 (3.0)	14.6 (2.9)	0.18
Single marital status, % (n)	85.4% (268)	92.6% (252)	0.11
Permanently employed, % (n)	73.6% (231)	68.8% (187)	0.53
Being a student, % (n)[b]	27.9% (87)	31.6% (23)	0.54
Ever had an HIV test, % (n)	85.0% (267)	76.1% (207)	0.12
HIV+ status, % (n)[c]	7.0% (20)	7.4% (19)	0.86

[a]Mixed-effects logistic and linear regression model included the fixed-effect terms for condition (social network intervention versus comparison), country (Hungary versus Russia) and condition × country interaction, and the random-effect term network.
[b]Two intervention respondents missing. Denominator is 312.
[c]Forty-two participants (27 intervention and 15 comparison) declined testing. HIV+ at baseline includes those with positive laboratory tests and those not tested in the study but who were diagnosed previously.

Table 2. Changes in sexual risk behavior and AIDS-related psychosocial scales over time (baseline, and 3-month and 12-month follow-up) by study condition.

Variable	Baseline		3-month follow-up		12-month follow-up		Condition × period interaction[a]
	Intervention	Comparison	Intervention	Comparison	Intervention	Comparison	*P*
AIDS risk-related psychosocial scales							
AIDS risk knowledge and misconceptions	13.3 (12.9–13.6)[b]	13.0 (12.7–13.4)	14.0 (13.6–14.3)	13.6 (13.3–14.0)	14.1 (13.7–14.4)	13.8 (13.4–14.2)	0.86
Safer sex peer norms	10.5 (10.0–10.9)	10.3 (9.9–10.8)	10.8 (10.3–11.2)	10.5 (10.0–11.0)	11.0 (10.5–11.4)	10.7 (10.2–11.1)	0.89
Condom and safer sex attitudes	12.2 (11.6–12.8)	11.8 (11.2–12.5)	13.3 (12.7–14.0)	12.0 (11.4–12.7)	13.3 (12.7–14.0)	12.5 (11.8–13.2)	0.01
Risk-reduction behavior intentions	16.6 (16.0–17.3)	16.2 (15.6–16.9)	18.6 (18.0–19.3)	16.4 (15.8–17.1)	18.5 (17.9–19.2)	16.9 (16.2–17.5)	0.001
Risk-reduction self-efficacy (confidence)	14.8 (14.5–15.2)	14.8 (14.4–15.1)	15.8 (15.4–16.1)	15.2 (14.9–15.6)	15.9 (15.5–16.2)	15.4 (15.0–15.7)	0.08
Changes in overall sexual risk behavior in the past 3 months							
% Engaging in UAI	54% (47–61)[b]	58% (51–65)	38% (32–46)	57% (49–63)	43% (33–51)	56% (49–63)	0.036
% Engaging in UAI with nonmain partners[c]	18% (12–26)	23% (16–32)	8% (5–13)	21% (14–30)	9% (5–15)	21% (14–30)	0.042
Mean percentage of anal intercourse without condom use	39.4 (33.4–45.3)	39.0 (33.0–45.0)	27.0 (20.8–33.1)	42.9 (36.7–49.2)	31.0 (24.9–37.2)	40.4 (34.1–46.7)	0.001
% Who had UAI with multiple partners	14% (8–22)	19% (12–28)	2% (1–6)	17% (10–26)	5% (3–10)	13% (8–22)	0.002
Total number of UAI acts with all partners	11.8 (9.1–15.4)	11.9 (9.1–15.6)	7.2 (5.2–10.0)	12.6 (9.6–16.5)	9.6 (7.2–12.9)	11.2 (8.5–14.9)	0.07
Total number of anal intercourse acts with all partners	23.8 (19.1–29.7)	21.0 (16.7–26.5)	18.2 (14.3–23.1)	19.3 (15.2–24.7)	20.0 (15.8–25.3)	20.8 (16.4–26.4)	0.38
Total number of partners	4.6 (3.0–7.1)	4.5 (2.9–7.0)	3.8 (2.4–5.9)	3.6 (2.3–5.7)	4.4 (2.8–6.8)	4.2 (2.7–6.7)	0.99
Changes in sexual risk behavior levels among participants with multiple partners in the past 3 months at baseline[d]							
% Engaging in UAI	56% (44–67)[b]	71% (59–80)	34% (24–46)	63% (57–74)	45% (34–57)	64% (52–74)	0.21
Mean percentage of anal intercourse without condom use	34.7 (25.9–43.5)	40.6 (31.6–49.6)	22.9 (14.0–31.8)	44.5 (35.2–53.8)	30.1 (21.2–39.1)	42.0 (32.7–51.3)	0.033
% Who had UAI with multiple partners	22% (14–33)	33% (23–46)	2% (1–7)	23% (15–35)	8% (4–15)	18% (11–29)	0.007
Total number of UAI acts with all partners	9.7 (6.5–14.6)	11.6 (7.7–17.3)	4.8 (2.8–8.2)	12.4 (8.3–18.7)	9.3 (6.1–14.2)	12.6 (8.4–18.8)	0.048

UAI, unprotected anal intercourse.
[a]Mixed-effects repeated measures Poisson, logistic and linear regression model included condition (social network intervention versus comparison), country (Hungary versus Russia), time period (baseline and 3-month and 12-month follow-up) and fixed-effects interactions, and two random-effect terms (network and subject). Male network members (baseline, $n = 586$; 3-month follow-up, $n = 537$; and 12-month follow-up, $n = 530$). Test of condition × Replace T to become time period interaction *P* value.
[b]Estimated means, percents and associated 95% confidence intervals are back-transformed regression model least squares estimates.
[c]Nonmain partners include casual and commercial partners as well as any partners beyond the five most recent.
[d]Three hundred and sixty participants (200 intervention and 160 comparison) reported having multiple partners in the past 3 months at baseline.

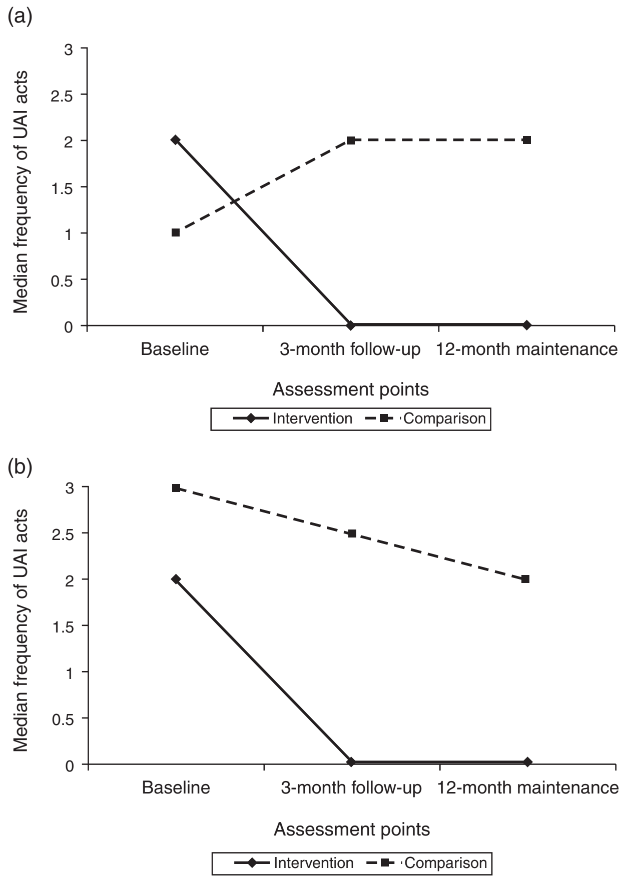

Fig. 3. (a) Changes in median frequency of unprotected anal intercourse in the past 3 months among all men in intervention and comparison networks (*n* = 586). (b) Changes in median unprotected anal intercourse in the past 3 months among intervention and comparison network members who reported multiple partners at baseline ($n = 360$). UAI = unprotected anal intercourse.

different partners reported by men remained stable over time at their baseline levels (numbers of anal intercourse acts, $P = 0.38$; numbers of partners, $P = 0.99$). As Fig. 3 depicts, the median frequency of UAI acts in the past 3 months among men in intervention networks decreased from 2.0 to 0 at both follow-ups but did not decrease among comparison group men.

Sexual partner concurrency increases risk for contracting HIV and other STDs [39,40]. Because nearly two-thirds of men reported multiple partners in the past 3 months at baseline, we further explored intervention effects for this critical subset of men. As shown in the bottom panel of Table 2, there were significant declines in the proportion of intervention versus comparison participants who practiced UAI with multiple partners (22 to 2 to 8 versus 33 to 23 to 18%, $P = 0.007$). The mean percentage of anal intercourse acts that were unprotected also significantly declined (35 to 23 to 30 versus 41 to 44 to 42, $P = 0.033$). Intervention effects for men with multiple partners were generally observed at 12-month follow-up. In addition, intervention condition men with multiple partners reduced their mean number of UAI acts (10 to 5 to 9 versus 12 to 12 to 13, $P = 0.048$), although this reduction was not sustained at the 12-month follow-up. As shown in the bottom panel of Fig. 3, median number of UAI acts for men with multiple partners at baseline declined to zero at both follow-up points.

To investigate whether behavioral effects were not due just to behavior changes made by leaders who attended the intervention, post hoc analyses were also performed with leaders' data removed. This analysis excluded data from 96 participants in the intervention arm at baseline, 90 participants at 3-month follow-up, and 88 at 12-month follow-up. The statistical power of leaders-excluded analyses was limited. However, similar patterns and direction of change always corresponded with those found in the full-sample analyses. For example, a significant difference over time favored the intervention condition in proportion of men who had UAI with multiple partners (11 to 2 to 3%) over the comparison condition (19 to 17 to 13%, $P = 0.011$), as well as a trend for greater reduction in the intervention condition for mean percentage of anal intercourse acts unprotected by condoms (38 to 30 to 33 versus 39 to 43 to 40%, $P = 0.057$).

AIDS risk-related psychosocial scale outcomes

Risk reduction behavioral intentions became significantly stronger among intervention participants than comparison condition men ($P = 0.001$). Safer sex attitudes improved over time among intervention condition men ($P = 0.01$), and there was a trend ($P = 0.08$) for greater risk-reduction self-efficacy among men in intervention condition networks.

Corroborative HIV/STD incidence outcomes

Three percent ($n = 8$) of men in intervention networks relative to 5% ($n = 11$) of comparison participants contracted HIV infection during the 12-month follow-up period. Five percent ($n = 21$) of intervention-arm participants were diagnosed with syphilis, gonorrhea, or chlamydia at follow-up relative to 8% ($n = 28$) in the comparison group. Nine percent ($n = 28$) of intervention and 15% ($n = 37$) of comparison men had an incident HIV or STD infection on the aggregate biological measure.

Discussion

Although MSM throughout the world are at high risk for contracting HIV infection, few well controlled trials of HIV prevention interventions with MSM have been conducted outside Western countries, and fewer still have examined both behavioral and disease incidence outcomes. In many world regions, homosexuality is highly stigmatized and

MSM face social risks if they were to publically identify themselves as gay or bisexual. Yet, MSM are often connected with one another in their social networks, and it is possible to harness these networks to reach and also deliver HIV prevention intervention to MSM [18].

The intervention reduced the proportion of network members who reported engaging in any UAI with male partners, unprotected intercourse with nonmain partners, and unprotected intercourse with multiple partners, together with increased condom use. These changes were accompanied by stronger risk-reduction behavioral intentions and more positive condom attitudes, and were further corroborated by biologically measured HIV/STD incidence. By training and engaging leaders high in sociometric status and network interconnections to counsel other network members in risk reduction, the intervention probably functioned to strengthen supports, skills, and intentions for protective behavior within the network. This mechanism of action is verified because increased talk with friends about safer sex was observed only within intervention condition networks.

We believe that this is the first randomized, controlled trial of an HIV prevention intervention undertaken with sociocentric networks. By recruiting to outward three rings from each seed, the study's methodology allowed the intervention to be delivered to social units larger and more stable than small egocentric clusters of friends who might drift away from one another over time. In the present method, network members are likely to receive HIV prevention messages from multiple friends, increasing behavior change support. At the same time, networks in the study's intervention condition included both leaders who attended training and network members who did not. The trial lacked the statistical power to conclusively determine the extent to which behavior change diffused within intervention condition networks. Further, all participants in this study were MSM who had social connections with other gay men. MSM in relatively homophobic environments may not always have gay friends or belong to gay networks, and these men will not be easily reached.

Over the past several years, promising biomedical HIV prevention strategies have emerged including antiretroviral therapy (ART) as a means of prevention [41,42]. However, ART scale-up and coverage will not be immediate or complete, especially in post-Soviet countries where a smaller proportion of PLH are on ART than in sub-Saharan Africa [43]. The benefits of ART for reducing HIV incidence may also be eroded without concurrent efforts to prevent STD coinfection that can facilitate HIV transmission [44]. For these reasons, as well as for the prevention of hepatitis C infection, [45] sexual risk reduction among MSM remains critical. Because HIV infections are often clustered in social networks, [46] network-level interventions can also potentially be adapted to address new objectives related to biomedical prevention such as strengthening peer norms to support regular HIV testing and encouraging care entry among HIV-infected persons in the community who are not in treatment, a problem common in the West [47] and also Eastern Europe [48].

This study has several limitations. Although some risk-reduction behavior changes were well maintained, others showed evidence of attenuation at 12-month follow-up. We are uncertain whether discussions about risk reduction declined following the end of the intervention, whether persons' friendship networks changed, or whether ongoing booster sessions would strengthen or further increase behavior change. As has become clear in the field, no single-intervention approach is sufficient in isolation, and combination or multilevel interventions are needed. These will increasingly combine behavioral and biomedical prevention methods.

Not all initial seeds agreed to participate and not all of their network members could be recruited. Because networks – not individuals – were the units of randomization, the study had limited statistical power. Sexual practices were assessed by behavioral self-reports that could have been inaccurate, a concern lessened by evidence of reduced HIV/STD incidence. However, the disease incidence outcome must be considered corroborative before that limited power. Gonorrhea and chlamydia were measured by urine PCR that would detect urethral disease but miss rectal and oral/pharyngeal infections. Thus, the study may have underestimated the true incidence of STDs among men in both conditions. Finally, this study provided modest financial incentives for participation, to minimize attrition. We were unable to state whether networks could be as successfully engaged without using some type of incentive.

Community-level interventions undertaken in openly gay-identified venues have been shown to reduce high-risk sexual practices [25,26]. The present study establishes that interventions can also be successfully delivered outside of gay venues at the level of social networks and have the potential to reach MSM in the community.

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Y.A.A. and J.A.K. together conceptualized and designed the study, obtained funding, established its protocols, oversaw the study, and drafted the manuscript. Y.A.A. and J.T. oversaw data collection, intervention activities, and implementation of the study protocol, respectively, at the Russia and Hungary sites. T.L.M. was the study's senior biostatistician and, together with W.J.D., performed the statistical analyses. L.M. was the study Coinvestigator in Hungary, and A.V.K. and T.P.T. were the study project coordinators in Russia and Hungary, respectively. A.M.

performed the analyses used to identify leaders within the social networks at both sites. This study followed a protocol that was approved by the institutional review boards of each participating institution. Written informed consent was obtained from all participants.

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Conflicts of interest

The authors have no conflicts of interest.

References

1. Morris SR, Little SJ. **MSM: resurgent epidemics.** *Curr Opin HIV AIDS* 2011; **6**:326–332.
2. Beyrer C, Baral SD, Walker D, Wirtz AL, Johns B, Sifakis F. **The expanding epidemics of HIV type 1 among men who have sex with men in low and middle-income countries: diversity and consistency.** *Epidemiol Rev* 2010; **32**:137–151.
3. Beyrer C, Trapence G, Motimedi F, Umar E, Lipinge S, Dausab F, *et al*. **Bisexual concurrency, bisexual partnerships, and HIV among Southern African men who have sex with men.** *Sex Transm Infect* 2010; **860**:323–327.
4. Sanders EJ, Graham SM, Okuku HS, van der Elst EM, Muhaari A, Davies A, *et al*. **HIV-1 infection in high-risk men who have sex with men in Mombassa, Kenya.** *AIDS* 2007; **21**:2513–2520.
5. Balakiryeva ON, Bondar TV, Kasyanczuk MG. *Monitoring behaviours of men having sex with men as a component of second generation surveillance.* Kiev: International HIV/AIDS Alliance; 2008.
6. Joint United Nations Programme on HIV/AIDS. *Together we will end AIDS.* Geneva: UNAIDS; 2012.
7. Chow EP, Wilsin DP, Zhang L. **HIV and syphilis co-infection increasing among men who have sex with men in China: A systematic review and meta-analysis.** *PLoS One* 2011; **6**:e22768.
8. Ma X, Zhang Q, He X, Sun W, Yue H, Chen S, *et al*. **Trends in prevalence of HIV, syphilis, hepatitis C, hepatitis B, and sexual risk behavior among men who have sex with men. Results of 3 consecutive respondent-driven sampling surveys in Beijing, 2004 through 2006.** *J Acquir Immune Defic Syndr* 2007; **45**:581–587.
9. Feng LG, Ding XB, Lu RR, Zhang W, Pan CB, Yi HR, *et al*. **Correlation between high-risk behavior and STD/AIDS prevalence among men who have sex with men.** *J Trop Med* 2007; **7**:483–486.
10. Herbst JH, Sherba RT, Crepaz N, Deluca JB, Zohrabyan L, Stall RD, *et al*. **A meta-analytic review of HIV behavioral interventions for reducing sexual risk behavior of men who have sex with men.** *J Acquir Immune Defic Syndr* 2005; **39**:228–241.
11. Johnson WD, Holtgrove DR, McClellan WM, Flanders WD, Hill AN, Goodman M. **HIV intervention research for men who have sex with men: a 7-year update.** *AIDS Educ Prev* 2005; **17**:568–589.
12. Enyedi ZS, Fabian Z, Sik E. **Is prejudice growing in Hungary? Changes in anti-Semitism, anti-Roma feeling, and xenophobia over the last decade.** *Equality Diversity Inclusion* 2011; **30**:356–378.
13. Takacs J, Dombos T, Meszaros GY, Toth TP. **Don't ask, don't tell, don't bother: homophobia and the heteronorm in Hungary.** In: Trappolin L, Gasparini D, Wintemute R,editors. *Confronting homophobia in Europe: social and legal perspectives* Oxford: Hart Publishing; 2012. pp. 79–105.
14. Valente TW. **Network interventions.** *Science* 2012; **337**:49–53.
15. Broadhead RS, Heckathorn DD, Weakliem DL, Anthony DL, Madray H, Mills RJ, *et al*. **Harnessing peer networks as an instrument for AIDS prevention: results from a peer-driven intervention.** *Public Health Rep* 1998; **113 (Suppl 1)**:42–57.
16. Trotter RT, Bowen AM, Baldwin JA, Price LJ. **The efficacy of network-based HIV/AIDS risk reduction programs in mid-sized towns in the United States.** *J Drug Issues* 1996; **26**:591–605.
17. Latkin CA, Mandell W, Vlahov D, Oziemkowska M, Celentano DD. **The long-term outcome of a personal network-oriented HIV prevention intervention for injection drug users: the SAFE Study.** *Am J Community Psychol* 1996; **24**:341–364.
18. Amirkhanian YA. **Social networks, sexual networks and HIV risk in men who have sex with men.** *Curr HIV/AIDS Rep* 2014; **11**:81–92.
19. Lau JT, Tsui HY, Lau MM. **A pilot clustered randomized control trial evaluating the efficacy of a network-based HIV peer education intervention targeting men who have sex with men in Hong Kong, China.** *AIDS Care* 2013; **25**:812–819.
20. Zhang H, Wu Z, Zheng Y, Wang J, Zhu J, Xu J. **A pilot intervention to increase condom use and HIV testing and counseling among men who have sex with men in Anhui.** *China J Acquir Immune Defic Syndr* 2010; **53 (Suppl 1)**:S88–S92.
21. Mars G, Altman Y. **The cultural basis of Soviet Georgia's second economy.** *Soviet Studies* 1983; **35**:546–560.
22. Wedel J. *The private Poland: an anthropologist's look at everyday life.* New York: Facts on File Publications; 1986.
23. Rona-Tas A. **Sustainability of social networks in the Eastern European postcommunist transformation [in Russian].** In: Shannin T. editor. *Informal economy: Russia and the world* Moscow: Logos: ; 1999. pp. 396–411.
24. Amirkhanian YA, Kelly JA, Kirsanova AV, DiFranceisco W, Khoursine RA, Semenov AV, *et al*. **HIV risk behaviour patterns, predictors, and sexually transmitted disease prevalence in the social networks of young men who have sex with men in St. Petersburg, Russia.** *Int J STD AIDS* 2006; **17**:50–56.
25. Kelly JA, St. Lawrence JS, Stevenson LY, Hauth AC, Kalichman SC, Diaz YE, *et al*. **Community AIDS/HIV risk reduction: the effects of endorsements by popular people in three cities.** *Am J Public Health* 1992; **82**:1483–1489.
26. Kelly JA, Murphy DA, Sikkema KJ, McAuliffe TL, Roffman RA, Solomon LJ, *et al*. **Randomised, controlled, community-level HIV prevention intervention for sexual-risk behaviour among homosexual men in US cities.** *Lancet* 1997; **350**:1500–1505.
27. Amirkhanian YA, Kelly JA, Kabakchieva E, Kirsanova AV, Vassileva S, Takacs J, *et al*. **A randomized social network HIV prevention trial with young men who have sex with men in Russia and Bulgaria.** *AIDS* 2005; **19**:1897–1905.
28. UNAIDS. *UNAIDS report on the global AIDS epidemic.* Geneva: UNAIDS; 2013.
29. European Centre for Disease Control and Prevention/WHO Regional Office for Europe. *HIV/AIDS surveillance in Europe 2012.* Stockholm: European Centre for Disease Control and Prevention; 2013.
30. Russian Federal AIDS Center. *HIV Infection. Bulletin #38 [in Russian].* Moscow: Russian Federal AIDS Center; 2013, http://www.hivrussia.org/files/bul_38.pdf (accessed 26 December 2014)..
31. Russian Federal AIDS Center. *Statement on HIV infection in the Russian Federation in 2013.* Moscow: Russian Federal AIDS Center; 2014, www.hivrussia.org/news/index.shtml#43. (accessed 26 December, 2014).
32. Russian Federal Service for Supervision of Consumer Rights Protection and Human Welfare. *National report of the Russian Federation on implementation steps of the Declaration of Commitment on HIV/AIDS.* Moscow: Russian Federal Service for Supervision of Consumer Rights Protection and Human Welfare; 2010. p. 28.
33. Kadushin C. **The friends and supporters of psychotherapy: on social circles in urban life.** *Am Sociol Rev* 1966; **31**:786–802.
34. Csepe P, Amirkhanian YA, Kelly JA, McAuliffe TL, Mocsonoki L. **HIV risk behavior among gay and bisexual men in Budapest, Hungary.** *Int J STD AIDS* 2002; **13**:192–200.
35. Bandura A. *Social foundation of thought and action: a social cognitive theory.* Englewood Cliffs: Prentice Hall; 1986.
36. Kelly JA. *Changing HIV risk behavior.* New York: Guilford; 1995.
37. Fishbein M, Ajzen I. *Belief, attitude, intentions, and behaviors: an introduction to theory and research.* Reading: Addison Wesley; 1975.

38. Fisher JD, Fisher WA. **Changing AIDS-risk behaviour.** *Psychol Bull* 1992; **111**:455–474.
39. Lyons A, Hosking W. **Prevalance and correlates of sexual partner concurrency among Australian gay men aged 18-39 years.** *AIDS Behav* 2014; **18**:801–809.
40. Choi KH, Hudes ES, Steward WT. **Social discrimination, concurrent sexual partnerships, and HIV risk among men who have sex with men in Shanghai, China.** *AIDS Behav* 2008; **12 (Suppl 4)**:S71–S77.
41. Cohen MS, Chan YQ, McCauley M, Gamble T, Hosseinipour MC, Kumarasamy N, *et al*. **Prevention of HIV-1 infection with early antiretroviral therapy.** *N Engl J Med* 2011; **365**:493–505.
42. Grant RM, Lama JR, Anderson PL, McMahan V, Liu AY, Vargas L, *et al*. **Preexposure chemoprophylaxis for HIV prevention in men who have sex with men.** *N Engl J Med* 2010; **363**:2587–2599.
43. UNAIDS. Together we will end AIDS: Report preceding the Nineteenth International Conference on AIDS; 2012. http://www.aidsmap.com/UNAIDS-Africans-with-HIV-more-likely-to-get-ARVs-than-Eastern-Europeans/page/2440134/. (accessed 26 December, 2014).
44. Phillips AN, Cambiano V, Nakagawa F, Brown AE, Lampe F, Rodger A, *et al*. **Increased HIV incidence in men who have sex with men despite high levels of ART-induced viral suppression: analysis of an extensively documented epidemic.** *PLoS One* 2013; **8**:e55312.
45. Bradshaw D, Matthews G, Danta M. **Sexually transmitted hepatitis C infection: the new epidemic in MSM.** *Curr Opin Infect Dis* 2013; **26**:66–72.
46. MMWR. **Use of social networks to identify persons with undiagnosed HIV infection: seven U.S. cities, October 2003-September 2004.** *MMWR Morb Mortal Wkly Rep* 2005; **54**:601–605.
47. MMWR. **Vital signs: HIV prevention through care and treatment-United States.** *MMWR Morb Mortal Wkly Rep* 2011; **60**:1618–1623.
48. Amirkhanian YA, Kelly JA, Kuznetsova AV, DiFranceisco WJ, Musatov VB, Pirogov DG. **People with HIV in HAART-era Russia: transmission risk behavior prevalence, antiretroviral medication-taking, and psychosocial distress.** *AIDS Behav* 2011; **15**:767–777.