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Research Report

Promotion of couples' voluntary HIV counseling and testing in Lusaka, Zambia by influence network leaders and agents: a cohort study

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Running Head: Couples' voluntary HIV counseling and testing promotions

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ABSTRACT

Objectives: Hypothesizing that predictors of CVCT promotions can be identified to increase CVCT uptake, this study identified predictors of successful CVCT promotion in Lusaka, Zambia.

Design: Cohort study

Setting: Lusaka, Zambia

Participants: 68 influential network leaders [INLs] identified 320 agents [INAs] who delivered 29119 CVCT invitations to heterosexual couples

Intervention: The CVCT promotional model used INLs who identified INAs who in turn conducted community-based promotion and distribution of CVCT invitations from July 2004-December 2005.

Primary outcome measure: The primary outcome of interest was couple testing (yes/no) after receipt of a CVCT invitation. INA, couple, and invitation characteristics predictive of couples' testing were evaluated accounting for two-level clustering.

Results: INAs delivered 29119 invitations resulting in 1727 couples testing (6% success rate). In multivariate analyses, INA characteristics significantly predictive of CVCT uptake included promoting in community-based (adjusted odds ratio [aOR]=1.3; 95% confidence interval [CI]=1.0-1.8) or health (aOR=1.5; 95%CI=1.2-2.0) networks versus private networks, being employed in the sales/service industry (aOR=1.5; 95%CI=1.0-2.1) versus unskilled manual labor, owning a home (aOR=0.7; 95%CI=0.6-0.9) versus not, and testing for HIV with a partner (aOR=1.4; 95%CI=1.1-1.7) or alone (aOR=1.3; 95%CI=1.0-1.6) versus never testing. Cohabiting couples were more likely to test (aOR=1.4; 95%CI=1.2-1.6) than non-cohabiting couples. Context characteristics predictive of CVCT uptake included inviting couples (aOR=1.2;

95%CI=1.0-1.4) versus individuals, the woman (aOR=1.6; 95%CI=1.2-2.2) or couple (aOR=1.4; 95%CI=1.0-1.8) initiating contact versus the INA, the couple being socially acquainted with the INA (aOR=1.6; 95%CI=1.4-1.9) versus having just met, home invitation delivery (aOR=1.3; 95%CI=1.1-1.5) versus elsewhere, and easy invitation delivery (aOR=1.8; 95%CI=1.4-2.2) versus difficult as reported by the INA.

Conclusions: This study demonstrated the ability of influential people to promote CVCT and identified agent, couple, and context-level predictors of CVCT uptake in Lusaka, Zambia. We encourage the development of CVCT promotions in other sub-Saharan African countries to support sustained CVCT dissemination.

ARTICLE SUMMARY

Article Focus

- Given preliminary findings from Zambia and Rwanda suggesting successful community-based promotion, we hypothesize that predictors of CVCT promotions can be identified to increase CVCT uptake in Lusaka, Zambia.
- This study evaluated the ability of community-based activities to promote CVCT and identified predictors of CVCT uptake in Lusaka, Zambia.

Key Messages

- Here, we demonstrated not only the feasibility of CVCT promotions using influential network agent and leaders (INAs and INLs) to promote CVCT, but also identified practical INA, couple, and invitation-level predictors of CVCT uptake.
- The predictors of CVCT uptake included: recruiting INAs who have tested with partners, focusing invitations on INA acquaintances, issuing invitations to couples and in a discreet location, and utilizing INAs from non-governmental and health networks.

Strengths and Limitations

- These predictors can be used to enhance CVCT promotions in Zambia and may be extended as a framework to other locales, with adaptation based on location-specific predictors of CVCT promotions
- Country-specific differences in CVCT promotions indicate that more research into country-specific predictors of CVCT may be necessary for successful CVCT promotions in other locales.

BACKGROUND

In 2009, 68% of the global HIV-positive population resided in sub-Saharan Africa, equating to roughly 22.5 million cases. Zambia has one of the largest HIV burdens, with roughly 980 000 prevalent and 76 000 incident cases in 2009,[1] and HIV prevalence is roughly twice as high in urban (20%) versus rural (<10%) Zambia.[2]

Heterosexual transmission is the primary cause of incident HIV infections in sub-Saharan Africa where discordant couples (an HIV+ and HIV- partner) in long-term relationships represent the largest group at-risk for HIV.[1, 3] In urban Zambia, roughly 60% of new

infections occurred between married/cohabiting heterosexual couples [3], and 17% of pregnant couples in Lusaka were discordant.[4]

Knowledge of HIV serostatus is critical for transmission prevention. According to the 2007 Zambia Demographic and Health Survey, although most adults know where to receive an HIV test, only 35% of women and 20% of men have ever tested and received results.[2] Voluntary HIV counseling and testing [VCT] is an evidence-based strategy to increase serostatus awareness, decrease high-risk behavior, and decrease transmission.[5] Couples' VCT [CVCT], in which both partners are tested and mutually disclose results, addresses issues with disclosure, allows for risk-reduction planning based on partner serostatus, and decreases high-risk behavior.[6-8] However, though CVCT effectively targets the highest at-risk group in sub-Saharan Africa, it has not been widely disseminated due to lack of demand and subsequent lack of funding. Lack of demand primarily results from insufficient knowledge about the possibility of couple serodiscordance and CVCT services.[8-11]

The Zambia-Emory HIV Research Project [ZEHRP], based in Lusaka, provides CVCT services. ZEHRP and other groups have shown clinic and community-based CVCT promotions can increase CVCT awareness and demand.[4, 11-14] Social networks and community leaders are critical in changing perceptions towards HIV/AIDS and other health issues in sub-Saharan Africa;[15-18] at ZEHRP, CVCT promotional efforts are directed by influential network leaders [INLs] and agents [INAs], based in the Social Networks and Social Support Theory.[19] This study assessed the ability of INLs and INAs to promote CVCT and identified predictors of CVCT uptake in Lusaka.

METHODS

INL and INA recruitment and training

ZEHRP CVCT promotions maximize program impact by utilizing two existing social networks levels -- INLs and INAs. INL and INA recruitment and training methods are described elsewhere.[13, 20] Briefly, INLs were identified from CVCT consensus meetings and national/citywide umbrella referrals from four social networks (faith-based/religious, health, private, and community-based/non-governmental organizations [CBO/NGO]). INLs identified INA candidates from their respective networks, and final selection was made after interviewing with experienced ZEHRP counselors. Enrolled INAs received four-day training in HIV/AIDS health advocacy/outreach, social networking, CVCT promotions, and observation of successful door-to-door ZEHRP promotional strategies. INLs and INAs completed demographic questionnaires and were offered CVCT or VCT.

CVCT promotions

CVCT promotional activities took place from July 2004-December 2005 in two randomly selected neighborhoods as described elsewhere.[21] Briefly, of eight neighborhoods assessed as potential sites, three were selected based on similar population size, infrastructure, and with consideration of geographic distance to minimize spillover effects. Two of these were randomly assigned to CVCT promotions while the third had no promotions. Given the catchment areas of these two neighborhoods (99 280 and 85 022 individuals), it was assumed that couples would rarely receive multiple invitations. INAs distributed invitations to couples or individuals within their neighborhoods which detailed CVCT facility directions and procedures. Couples could be cohabiting or non-cohabiting. Invitations included a unique ID, INA identifier, and a receipt portion that the INA retained and submitted bi-weekly. The receipt portion contained the invitation ID and space to record the date, time, place of invitation, relationship of the INA and

recipient, recipient description (man, woman, or couple), recipients' age(s), residence, marital status, and INA's perception of the difficulty of invitation delivery.

Before March 18, 2005, INAs received $0.21/invitation issued and an additional $4.20/couple attending CVCT. Beginning March 19, 2005, payment/invitation was reduced to $0.11 and payment/couple attending CVCT was increased to $5.25 to deter fraudulent invitation delivery. In addition to fixed CVCT sites, which could serve 30 couples/day, a mobile HIV testing unit, which could serve an additional 30 couples/day, was available for nine months in one neighborhood and then nine months in the other. Mobile testing sites were selected based on facility (churches, schools, and community centers) availability. For perspective, Purchasing Power Parity in Zambia, an adjusted measure of per-capita-income number, is $1500/year,[22] and the proportion of Zambians living on less than $1/day is 63.6%.[23]

CVCT procedures

CVCT procedures are described elsewhere.[13] Briefly, couples participate in group counseling, joint pre-test counseling, and, for those testing, confidential informed consent procedures, phlebotomy, two rapid HIV tests,[24] and joint post-test counseling and test result delivery. CVCT services were free and transportation to testing sites was reimbursed. Invitation receipts were collected from INA-invited couples and the invitation ID was linked to the couple ID number. The study was approved by the Emory University IRB and the University of Zambia Research Ethics committee. Informed consent was obtained from all study participants.

Statistical analysis

Counts (percentages) for categorical variables and means (standard deviations) for continuous variables were calculated for INL, INA, couple, and invitation-level characteristics. Number of invitations distributed was tabulated by INA characteristic as were success rates (the number

couples tested/number invitations distributed). Analyses were stratified by couple cohabitation status to identify differences in CVCT uptake and predictors of success. INAs not achieving ≥1.5% success were excluded from analyses to prevent inclusion of INAs systematically returning fraudulent receipts.

Crude odds ratios [ORs], 95%CIs, and p-values evaluated associations between INA-level characteristics predictive of successful invitations. Generalized estimating equation [GEE] methods evaluated the association between couple and invitation-level characteristics predictive of successful invitations. Since couple and invitation-level data are clustered at two-levels, within individual INAs and INLs, GEE methods accounted for non-independence of observations.

INA, couple, and invitation-level variables significant (Bonferroni corrected p-value=0.002) in univariate analyses were entered into a multivariate logistic regression model, and variables were examined for multi-collinearity. GEE methods accounted for clustering of couple and invitation-level characteristics within individual INAs and INLs. Data analysis was conducted with SASv9.2 (North Carolina, USA).

RESULTS

INL characteristics

Sixty-eight INLs were recruited from CBO/NGO, faith-based, health, and private sector networks. Average INL age was 45 (inter-quartile range [IQR]=36-52), and 68% were men. Average years living in Lusaka was 25 (IQR=15-34), and 72% were married. Almost all INLs understood Nyanja and/or Bemba or English, roughly half owned their home, and most had previously tested for HIV (Table 1).

INA characteristics associated with couples' testing (Tables 1-2)

INLs recruited 320 INAs (excluding 70 INAs with <1.5% success), and overall, INAs distributed 29 119 invitations with 1727 couples tested for an average of 91 invites/INA and 5 couples tested/INA. INAs affiliated with CBO/NGOs distributed more than average invitations/INA and were more likely to successfully invite cohabiting couples relative to private network INAs. Health network INAs also distributed a high number of average invitations/INA and were more successful among all couples relative to private network INAs (Tables 1-2).

Most INAs were women, and performance with respect to invitations delivered, success rates, and average number of couples tested was similar by gender (Table 1). Average INA age was 37 (IQR=29-44), and older INAs were significantly more successful among cohabiting, but less successful among non-cohabiting, couples relative to younger INAs (Table 2). The average number of years living in Lusaka was 21 (IQR=11-30) (data not shown), and years living in Lusaka significantly predicted successful invitation among cohabiting couples (Table 2).

Married INAs were significantly more successful among cohabiting couples relative to divorced, widowed, or single INAs (Table 2). Divorced INAs had very low success rates among non-cohabiting couples (Table 1). Among INAs with a partner, years of current relationship had a similar effect as age, with longer unions associated with significantly decreased success among non-cohabiting couples.

Seventy-four percent of INAs were sales/service industry employees, and these INAs were significantly more successful among cohabiting and non-cohabiting couples relative to unskilled manual laborers. Professional and agricultural sector employees were also more successful among non-cohabiting couples (Table 2). Eighty percent of INAs could read English

(Table 1), and this was associated with successful invitations among non-cohabiting couples only.

Over half of INAs rented their home. The 38% who owned a home were less successful than those who rented or lived in housing provided by others; with stratification this remained significant only among cohabiting couples (Table 2). Two percent of INAs had housing provided by an employer and were substantially more successful among cohabiting couples (Table 1).

Only 57% of INAs reported having tested for HIV with a partner (22%) or alone (35%) (Table 1). INAs testing for HIV with a partner were more successful among all couples, and testing alone was associated with higher success among non-cohabiting couples relative to never testing (Table 2).

Seventy INAs did not achieve 1.5% success and were excluded from analyses. These INAs distributed 125 invitations/INA and were similar to INAs in the analysis by gender (χ^2 test of association=0.8, p=0.4), age (t-statistic=-1.9, p=0.06), and network (χ2=3.7, p=0.3).

Of 29 119 invitations, 9707 (33.3%) were delivered prior to March 19, 2005 (prior to the incentive structure change) and 19 412 (66.7%) were delivered on/after that date. Of the 1727 couples who tested, 939 were invited prior to March 19, 2005 and 788 were invited on/after that date, an invitation success rate of 9.7% prior to and 4.1% after the incentive change (p<0.0001). Prior to the incentive change, the number of invites distributed/INA increased steadily from 112 to 247, and the number of couples tested/INA increased from 3 to 7. After the incentive change, invites/INA dropped to 42, but the number of couples tested/INA increased from 5 to 7. It should be noted that fewer INAs were trained by the end of March as INA enrollment became more selective and more productivity was expected per INA.

Couple and invitation characteristics associated with couples' testing (Table 3)

The mean age of men was 33 and of women was 27 years. Couples' testing were slightly older than those not testing ($p<0.001$). Most couples were cohabiting, and these were significantly more likely to test versus non-cohabiting couples. The mean duration of relationship was 6 years, and tested couples had been together on average one year longer than non-tested couples.

INAs initiated contact 93% of the time, though in the rare instances when the couple or the woman initiated contact with the INA, the couple was more likely to test. Inviting a couple together also resulted in increased testing. Couples who were family members or social acquaintances of the INA were more likely to test versus those previously unacquainted. Ease of invitation delivery (operationalized as not being time-consuming, requiring long explanations, challenging because of invitee resistance or scheduling conflicts) was also associated with couples' testing. Interestingly, though public endorsements were predictive of testing during a pilot study [13], they were not associated with increased uptake of testing in this larger study. Similarly, the presence of mobile units was not associated with increased testing.

Multivariate model of couples' testing predictors (Table 4)

Age of the man and woman were collinear and woman's age was excluded from the multivariate model. Couple cohabitation status was an effect measure modifier, and multivariate analyses were stratified by cohabitation status. All adjusted ORs [aORs] presented below were statistically significant in multivariate analyses accounting for two-level clustering.

Health sector INAs were most successful (aOR=1.5) followed by CBO/NGO INAs (aOR=1.3) relative to private sector INAs. Married INAs were more successful versus others among cohabiting couples (aOR=1.3). Sales/service industry employees (aOR=1.5) versus unskilled manual laborers were more successful overall. Among non-cohabiting couples, INAs who could read English were more successful (aOR=2.0) whereas among cohabiting couples,

INAs owning homes were less successful (aOR=0.7). INAs who had tested for HIV with a partner were more successful among all couples (aOR=1.4), while those who had tested for HIV alone were more successful among non-cohabiting couples (aOR=2.1), versus INAs who had never tested. Cohabiting couples were more likely to test (aOR=1.4) versus non-cohabiting couples.

Invitation-level predictors of testing among cohabiting couples included inviting the couple versus the woman alone (aOR=1.3); also couple (aOR=1.4) versus INA initiated contact was predictive. Being socially acquainted with the INA (aOR=1.6) versus having just met was predictive among all couples, while home CVCT invitation delivery (aOR=1.4) versus elsewhere, and easy invitation delivery (aOR=1.9) versus difficult were predictive among cohabiting couples.

DISCUSSION

In an African capital city where very few couples have jointly tested for HIV, a promotional program using INLs and INAs prompted approximately 100 couples/month to seek CVCT. INA network, occupation, marital status, and testing history, as well as couple cohabitation status and the INA-invitee relationship, influenced invitation success. Invitations delivered to the couple, in the home, and invitations initiated by the woman partner were also significant CVCT uptake predictors.

CBO/NGO and health network INAs were more successful than faith-based or private sector INAs. CBO/NGO networks included parent teacher, legal aid, skills training, and health information organizations. Health networks included clinical officers, nurses, home healthcare visitors, community health workers, neighborhood health committee members, and traditional birth attendants. Previous studies have similarly demonstrated the ability of influential people to

effectively disseminate information and change attitudes and behaviors towards HIV in sub-Saharan Africa.[16-18] Unlike health and CBO/NGO INAs, private sector INAs may have been preoccupied with income generation and/or did not have similar opportunities to integrate CVCT promotions into their daily routine. The poor performance of faith-based INAs was surprising given Zambia is strongly religious; however, though religious leaders have opportunities to promote from the pulpit, the stigma associated with sexually transmitted infections [STIs] may inhibit open discussion of CVCT.[17, 25]

Cohabiting couples were more likely than non-cohabiting couples to test, and married INAs delivered more successful invitations than unmarried INAs. Fear of stigma among married couples is common,[9, 26, 27] and perhaps married INAs were able to more successfully overcome this barrier. INAs who previously tested for HIV with a partner were also more successful than those who had not tested, likely due to their firsthand knowledge of CVCT procedures and ability to speak personally to perceived CVCT barriers.

INAs socially acquainted with the invitee were more successful versus those previously unacquainted with the invitee. The strength of INA-invitee relationship may facilitate open discussion of CVCT and engender confidence. INAs inviting the couple together versus either partner alone, thereby removing pressure for one partner to propose testing to the other, were also more successful. Previous studies support the effectiveness of couple-level targeted prevention strategies.[13, 28-31]

Though most invitations were initiated by INAs, when the woman partner initiated contact with the INA, CVCT uptake increased. This finding likely reflects pre-existing motivation to discuss or participate in CVCT.

Invitations delivered in the home versus community were more effective. Previous studies indicate that home and workplace HIV counseling and testing promotions are more successful in Zambia, Uganda, and Malawi relative to community locations.[32-35] These findings are likely due to increased discretion and comfort associated with home settings.

Results from a similar study using both INLs and INAs in Kigali, Rwanda highlight country-specific similarities and differences. Similar to Zambia, Rwandan health INAs were more successful relative to private network INAs. Married Rwandan INAs were more successful than single INAs, and cohabiting couples were more likely to test than non-cohabiting couples in univariate analyses. We similarly found that invitations delivered to couples socially acquainted with the INA, woman partner initiated contact, and invitations delivered in the home were more successful in multivariate analyses in Rwanda. In contrast to this study, Rwandan faith-based INAs were more successful in univariate analyses relative to private network INAs, and the overall INA success rate in Rwanda was higher (18%). Mobile units were also associated with increased testing in Rwanda.[20]

Kigali and Lusaka, though both capital cities, differ in several important ways: Kigali has a monolingual population of 800 000 with easy and inexpensive transportation. In contrast, Lusaka's 1.7 million inhabitants represent all 73 Zambian languages/dialects, the city is large, and transportation is expensive. Another study in the Bemba-speaking Copperbelt region of Zambia combined INA promotions with mass media strategies in two cities of 600 000 each and obtained success rates between those found in Lusaka and Kigali.[14] These linguistic and infrastructural differences highlight the importance of testing and adapting network-based promotional models to different environments.

Results from a pilot study of promotions in Lusaka with 33 INAs (no INLs) showed that, while invitation-level predictors were similar to those found in this larger study, the small sample size did not allow simultaneous detection of INA, couple, and invitation-level characteristics in hierarchical analysis.[13] Similarly, the Copperbelt study described previously did not examine INA, couple, or invitation-level predictors of success.[14]

Overall, this study demonstrated the feasibility of CVCT promotions in Lusaka, and we believe success rates could be considerably increased by utilizing the modifiable predictors of CVCT uptake identified: recruiting INAs who have tested with partners, focusing invitations on INA acquaintances, issuing invitations to couples and in a discreet location, and utilizing INAs from CBO/NGO and health networks. It should be noted that most of the statistically significant aORs are close to the null suggesting cautious interpretation of these associations. More research is especially needed to encourage faith-based leaders in Zambia to more effectively promote CVCT.

CONCLUSION

CVCT is an evidence-based testing strategy shown to reduce transmission of HIV and other STIs and to help prevent unintended pregnancies in sub-Saharan Africa. However, CVCT has yet to be widely implemented in this region.[4, 6, 7, 36-40] Here, we demonstrated not only the feasibility of CVCT promotions using INAs and INLs, but also identified practical INA, couple, and invitation-level CVCT uptake predictors. These predictors can be used to enhance CVCT promotions in Zambia and may be extended as a framework to other locales, with adaptation based on location-specific predictors of CVCT promotions.

Contributorship statement

Kristin M Wall – made substantial contributions to the analysis and interpretation of data, drafting the article and revising it critically for important intellectual content, and gave final approval of the version to be published

William Kilembe - made substantial contributions to study conception and design, revising the article critically for important intellectual content, and gave final approval of the version to be published

Azhar Nizam – made substantial contributions to the analysis and interpretation of data, revising the article critically for important intellectual content, and gave final approval of the version to be published

Cheswa Vwalika – made substantial contributions to study conception and design, revising the article critically for important intellectual content, and gave final approval of the version to be published

Michelle Kautzman – made substantial contributions to study conception and design, revising the article critically for important intellectual content, and gave final approval of the version to be published

Elwyn Chomba - made substantial contributions to study conception and design, revising the article critically for important intellectual content, and gave final approval of the version to be published

Amanda Tichacek - made substantial contributions to study conception and design, revising the article critically for important intellectual content, and gave final approval of the version to be published

Gurkiran Sardar - made substantial contributions to study conception and design, revising the article critically for important intellectual content, and gave final approval of the version to be published

Deborah Casanova - made substantial contributions to data aquisition, revising the article critically for important intellectual content, and gave final approval of the version to be published

Faith Henderson - made substantial contributions to data aquisition, revising the article critically for important intellectual content, and gave final approval of the version to be published

Joseph Mulenga - made substantial contributions to data aquisition, revising the article critically for important intellectual content, and gave final approval of the version to be published

David Kleinbaum - made substantial contributions to the analysis and interpretation of data, revising the article critically for important intellectual content, and gave final approval of the version to be published

Susan Allen - made substantial contributions to study conception and design, revising the article critically for important intellectual content, and gave final approval of the version to be published

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Competing interests

The authors have no competing interests, including relevant financial interests, activities, relationships, and affiliations.

Data sharing statement

There is no additional data available.

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Table 1 INL and INA characteristics by invitations distributed, success rate, and couple cohabitation status

	INL (N=68)		INA (N=320)		Invitations Distributed	Couples Tested	Average invites/INA	Average couples tested/INA	Success Rate (%)	% invitations given to cohabiting couples	% couples tested who are cohabiting	Success Rate (%)	
	N	%	N	%								Cohab Couples	Non-Cohab Couples
Total	**68**		**320**		**29119**	**1727**	**91**	**5**	**6%**	**81%**	**87%**	**6%**	**4%**
Network													
Private	16	24%	73	23%	5592	302	77	4	5%	79%	82%	6%	3%
Religious	19	28%	62	19%	5530	282	89	5	5%	85%	95%	6%	4%
Health	12	18%	95	30%	9529	617	100	6	6%	80%	86%	7%	5%
CBO/NGO	21	31%	90	28%	8468	526	94	6	6%	82%	87%	7%	4%
Gender													
Man	46	68%	131	41%	11620	700	89	5	6%	81%	85%	6%	5%
Woman	22	32%	189	59%	17499	1027	93	5	6%	82%	88%	6%	4%
Relationship status													
Married	49	72%	208	65%	18814	1178	90	6	6%	82%	88%	7%	4%
Divorced	5	7%	21	7%	2033	86	97	4	4%	82%	94%	5%	1%
Single	7	10%	38	12%	2902	131	76	3	5%	74%	83%	5%	3%
Widow	7	10%	45	14%	4212	303	94	7	7%	83%	84%	7%	7%
Missing	0	0%	8	3%	1158	29	145	4	3%	78%	79%	3%	2%
Occupation													
Professional/technical/ managerial	28	41%	68	21%	5605	330	82	5	6%	80%	81%	6%	5%
Sales/service	22	32%	163	51%	11462	793	70	5	7%	81%	88%	7%	5%
Agricultural	1	1%	6	2%	739	43	123	7	6%	75%	77%	6%	5%
Unskilled manual labor	12	18%	42	13%	5352	278	127	7	5%	84%	90%	6%	3%
Do not work for money	2	3%	33	10%	4912	253	149	8	5%	82%	90%	6%	3%
Missing	3	4%	8	3%	1049	30	131	4	3%	82%	100%	3%	0%
Read English													
Yes	64	94%	265	83%	23744	1439	90	5	6%	81%	86%	6%	4%

No	4	6%	55	17%	5375	288	98	5	5%	82%	92%	6%	2%
Housing													
Provided by employer (free)	5	7%	6	2%	372	38	62	6	10%	83%	95%	12%	3%
Rental home	22	32%	166	52%	16341	985	98	6	6%	81%	86%	6%	4%
Free housing by other means	10	15%	26	8%	1611	113	62	4	7%	80%	89%	8%	4%
Own home	30	44%	120	38%	10583	585	88	5	6%	82%	87%	6%	4%
Missing	1	1%	2	1%	212	6	106	3	3%	62%	100%	5%	0%
Ever tested for HIV													
Yes with partner	41	60%	71	22%	6274	303	88	4	5%	82%	93%	5%	2%
Yes alone	14	21%	113	35%	10424	608	92	5	6%	81%	87%	6%	4%
No	13	19%	135	42%	12207	802	90	6	7%	81%	85%	7%	5%
Missing	0	0%	1	0%	214	14	214	14	7%	86%	86%	7%	7%

Table 2 Bivariate association between INA characteristics and couples' testing by couples' cohabitation status

INA characteristics	All Couples				Cohabiting Couples				Non-cohabiting Couples			
	Odds Ratio	95% CI		p-value	Odds Ratio	95% CI		p-value	Odds Ratio	95% CI		p-value
Network												
Private	Ref				Ref				Ref			
CBO/NGO	1.23	1.06	1.43	0.01	1.21	1.03	1.42	0.02	1.35	0.88	2.06	0.17
Health	1.29	1.12	1.49	0.001	1.25	1.07	1.46	0.01	1.56	1.04	2.35	0.03
Religious	1.06	0.90	1.26	0.48	1.07	0.90	1.27	0.47	1.02	0.63	1.66	0.94
Gender												
Male	Ref				Ref				Ref			
Female	0.97	0.88	1.07	0.58	1.01	0.91	1.12	0.84	0.79	0.60	1.03	0.09
Age (per year increase)	1.01	1.00	1.01	0.07	1.01	1.00	1.01	0.002	0.98	0.96	0.99	0.001
Years living in Lusaka (per year increase)	1.01	1.00	1.01	<0.001	1.01	1.01	1.01	<0.001	1.00	0.99	1.01	0.80
Relationship status												
Other (divorced, widowed, single)	Ref				Ref				Ref			
Married	1.19	1.07	1.32	0.001	1.22	1.09	1.36	0.001	0.96	0.73	1.26	0.75
Years of relationship (per year increase)*	1.00	0.99	1.01	0.97	1.01	1.00	1.01	0.09	0.95	0.93	0.97	<0.001
Occupation												
Unskilled manual labor	Ref				Ref				Ref			
Professional	1.14	0.97	1.35	0.11	1.02	0.86	1.22	0.82	2.25	1.42	3.57	0.001
Sales/service	1.36	1.18	1.56	<0.001	1.31	1.13	1.52	<0.001	1.73	1.12	2.67	0.01
Agricultural	1.13	0.81	1.57	0.48	0.95	0.66	1.38	0.79	2.24	1.01	4.97	0.05
Do not work for money	0.99	0.83	1.18	0.92	0.99	0.82	1.18	0.87	1.09	0.63	1.88	0.76
Read English												
No	Ref				Ref				Ref			
Yes	1.14	1.00	1.30	0.05	1.06	0.92	1.21	0.44	2.12	1.35	3.33	0.001
Housing												
Other housing (rental, free)	Ref				Ref				Ref			
Own home	0.89	0.80	0.98	0.02	0.89	0.79	0.99	0.03	0.88	0.66	1.16	0.36

Ever tested for HIV												
No	Ref				Ref				Ref			
Yes with partner	1.39	1.21	1.59	<0.001	1.26	1.09	1.45	0.002	2.97	1.85	4.78	<0.001
Yes alone	1.22	1.06	1.41	0.01	1.13	0.97	1.31	0.11	2.42	1.48	3.95	<0.001

*Among those with a partner

Table 3 Bivariate association between couple and invitation characteristics and couples' testing accounting for clustering within INAs and INLs

	All couples		Couples not tested		Couples tested		Odds Ratio	95% CI		p-value
	N	%	N	%	N	%				
Couple Characteristics										
Age of man (mean, SD)	33.25	9.03	33.16	8.99	34.61	9.43	1.01	1.01	1.02	<0.001
Age of woman (mean, SD)	27.12	7.75	27.03	7.72	28.60	8.15	1.02	1.02	1.03	<0.001
Relationship of couple										
Not cohabiting	5275	18%	5058	19%	217	13%	Ref			
Cohabiting	23664	82%	22161	81%	1503	87%	1.58	1.38	1.81	<0.001
Years of relationship (mean, SD)	6.27	6.42	6.22	6.35	7.18	7.38	1.02	1.01	1.03	<0.001
Number of children (mean, SD)	2.04	2.16	2.04	2.16	2.06	2.12	1.01	0.99	1.03	0.29
Invitation Characteristics										
Invitee (1st contact)										
Woman	8934	31%	8426	31%	508	30%	Ref			
Couple	8567	30%	7972	29%	595	35%	1.24	1.08	1.43	0.002
Man	11467	40%	10851	40%	616	36%	0.91	0.81	1.03	0.13
Who initiated contact?										
INA	26620	93%	25103	93%	1517	89%	Ref			
Couple	527	2%	475	2%	52	3%	1.71	1.34	2.18	<0.001
Man	877	3%	811	3%	66	4%	1.18	0.88	1.58	0.26
Woman	690	2%	624	2%	66	4%	1.59	1.20	2.10	0.001
Relationship to INA										
Just met/unknown	19688	68%	18749	69%	939	55%	Ref			
Co-worker	287	1%	269	1%	18	1%	1.35	0.89	2.06	0.16
Family	1697	6%	1525	6%	172	10%	2.08	1.75	2.49	<0.001
Social acquaintance (neighbor, friend, church member)	7186	25%	6601	24%	585	34%	1.64	1.43	1.87	<0.001

Place of invitation										
Community	9828	34%	9339	35%	489	29%	Ref			
Couple home	15460	54%	14532	54%	928	55%	1.41	1.23	1.61	<0.001
INA home	1636	6%	1461	5%	175	10%	2.25	1.87	2.71	<0.001
Couple or INA work	1812	6%	1702	6%	110	6%	1.21	0.97	1.51	0.09
Public endorsement										
No	18148	63%	17080	63%	1068	62%	Ref			
Yes	10715	37%	10066	37%	649	38%	1.04	0.92	1.17	0.53
Delivering invitation										
Difficult/somewhat difficult	3030	10%	2912	65%	118	0.4%	Ref			
Easy	25860	89%	1599	35%	24261	99.5%	1.60	1.33	1.93	<0.001
Mobile unit present at time of invitation										
No	14268	49%	13713	50%	909	53%	Ref			
Yes	14622	51%	13679	50%	818	47%	1.12	0.89	1.39	0.33
Neighborhood of invitation										
Neighborhood 1	13705	47%	12911	47%	794	46%	Ref			
Neighborhood 2	15414	53%	14481	53%	933	54%	0.97	0.79	1.18	0.74

Community: church/mosque, clinic, market, street/public place, social gathering

Table 4 Multivariate model of INA level, couple level, and invitation level characteristics associated with couples' testing

	All Couples				Cohabiting Couples				Non-cohabiting Couples			
	Odds Ratio	**95% CI**		**p-value**	**Odds Ratio**	**95% CI**		**p-value**	**Odds Ratio**	**95% CI**		**p-value**
INA characteristics												
Network												
Private	Ref				Ref				Ref			
Religious	1.01	0.71	1.43	0.95	1.01	0.73	1.40	0.94	1.16	0.49	2.77	0.74
Health	1.53	1.15	2.04	0.004	1.48	1.11	1.97	0.01	1.80	0.96	3.35	0.07
CBO/NGO	1.34	1.01	1.77	0.04	1.31	0.98	1.76	0.07	1.53	0.84	2.79	0.16
Years living in Lusaka	1.01	1.00	1.02	0.14	1.01	1.00	1.02	0.07	1.01	0.99	1.04	0.24
Age (per 1 year increase)	1.00	0.99	1.02	0.79	1.00	0.99	1.02	0.53	0.99	0.97	1.01	0.35
Marital status												
Other (divorced, widowed, single)	Ref				Ref				Ref			
Married	1.23	0.99	1.53	0.06	1.28	1.02	1.60	0.03	1.06	0.70	1.62	0.77
Occupation												
Unskilled manual labor	Ref				Ref				Ref			
Professional	1.19	0.77	1.84	0.45	1.06	0.69	1.64	0.79	1.98	0.92	4.27	0.08
Sales/service	1.45	1.01	2.10	0.05	1.37	0.94	1.99	0.11	1.67	0.88	3.19	0.12
Agricultural	1.14	0.65	2.01	0.64	0.97	0.55	1.72	0.93	1.68	0.60	4.67	0.32
Do not work for money	0.95	0.62	1.45	0.81	0.95	0.62	1.45	0.80	0.69	0.26	1.82	0.45
Reads English												
No	Ref				Ref				Ref			
Yes	1.18	0.90	1.55	0.22	1.15	0.87	1.51	0.32	1.98	1.05	3.72	0.03
Housing												
Other housing (rental, free)	Ref				Ref				Ref			
Own home	0.74	0.59	0.92	0.01	0.73	0.58	0.91	0.01	0.93	0.62	1.38	0.71
Ever tested for HIV												
No	Ref				Ref				Ref			
Yes with partner	1.36	1.07	1.72	0.01	1.29	1.01	1.66	0.04	2.13	1.27	3.57	0.004
Yes alone	1.28	1.00	1.64	0.05	1.21	0.94	1.56	0.15	1.92	1.10	3.35	0.02
Couple Characteristics												

Age of man (per 1 year increase)	1.00	1.00	1.01	0.30	1.01	1.00	1.02	0.10	1.03	1.00	1.05	0.02
Years of relationship (per 1 year increase)	1.01	0.99	1.02	0.35	1.02	1.01	1.03	<0.001	0.45	0.37	0.55	<0.001
Relationship of couple						n/a				n/a		
Not cohabiting	Ref											
Cohabiting	1.39	1.19	1.63	<0.001								
Invitation Characteristics												
Invitee (1st contact)												
Individual (Woman/Man)	Ref				Ref				Ref			
Couple	1.20	1.04	1.39	0.01	1.27	1.09	1.49	0.003	0.82	0.52	1.28	0.38
Who initiated contact?												
INA	Ref				Ref				Ref			
Couple	1.35	1.03	1.78	0.03	1.43	1.05	1.94	0.02	0.94	0.27	3.20	0.92
Man	1.22	0.89	1.67	0.22	1.26	0.90	1.75	0.18	1.00	0.47	2.12	1.00
Woman	1.60	1.17	2.19	0.003	1.53	1.10	2.12	0.01	1.54	0.73	3.27	0.26
Relationship to INA												
Just met/unknown	Ref				Ref				Ref			
Co-worker	1.48	0.89	2.43	0.13	1.47	0.84	2.55	0.18	1.11	0.27	4.56	0.89
Social acquaintance (neighbor, friend, church member, family)	1.62	1.41	1.87	<0.001	1.60	1.37	1.87	<0.001	1.60	1.15	2.24	0.01
Place of invitation												
Other (Community or couple/INA work)	Ref				Ref				Ref			
Couple or INA home	1.30	1.14	1.48	<0.001	1.39	1.21	1.61	<0.001	0.93	0.68	1.27	0.65
Delivering invitation												
Difficult/somewhat difficult	Ref				Ref				Ref			
Easy	1.75	1.41	2.17	<0.001	1.87	1.47	2.37	<0.001	1.15	0.67	1.99	0.61

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, explain how loss to follow-up was addressed
		(*e*) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) Summarise follow-up time (eg, average and total amount)
Outcome data	15*	Report numbers of outcome events or summary measures over time
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

Promotion of couples' voluntary HIV counseling and testing in Lusaka, Zambia by influence network leaders and agents

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Research Report

Promotion of couples' voluntary HIV counseling and testing in Lusaka, Zambia by influence network leaders and agents

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Running Head: Couples' voluntary HIV counseling and testing promotions

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ABSTRACT

Objectives: Hypothesizing that couples' voluntary counseling and testing (CVCT) promotions can increase CVCT uptake, this study identified predictors of successful CVCT promotion in Lusaka, Zambia.

Design: Cohort study

Setting: Lusaka, Zambia

Participants: 68 influential network leaders [INLs] identified 320 agents [INAs] who delivered 29,119 CVCT invitations to heterosexual couples

Intervention: The CVCT promotional model used INLs who identified INAs who in turn conducted community-based promotion and distribution of CVCT invitations in two neighborhoods over 18 months, with a mobile unit in one neighborhood crossing over to the other mid-way through.

Primary outcome: The primary outcome of interest was couple testing (yes/no) after receipt of a CVCT invitation. INA, couple, and invitation characteristics predictive of couples' testing were evaluated accounting for two-level clustering.

Results: INAs delivered invitations resulting in 1727 couples testing (6% success rate). In multivariate analyses, INA characteristics significantly predictive of CVCT uptake included promoting in community-based (adjusted odds ratio [aOR]=1.3; 95%CI=1.0-1.8) or health (aOR=1.5; 95%CI=1.2-2.0) networks versus private networks; being employed in the sales/service industry (aOR=1.5; 95%CI=1.0-2.1) versus unskilled manual labor; owning a home (aOR=0.7; 95%CI=0.6-0.9) versus not; and having tested for HIV with a partner (aOR=1.4; 95%CI=1.1-1.7) or alone (aOR=1.3; 95%CI=1.0-1.6) versus never having tested. Cohabiting

couples were more likely to test (aOR=1.4; 95%CI=1.2-1.6) than non-cohabiting couples. Context characteristics predictive of CVCT uptake included inviting couples (aOR=1.2; 95%CI=1.0-1.4) versus individuals; the woman (aOR=1.6; 95%CI=1.2-2.2) or couple (aOR=1.4; 95%CI=1.0-1.8) initiating contact versus the INA; the couple being socially acquainted with the INA (aOR=1.6; 95%CI=1.4-1.9) versus having just met; home invitation delivery (aOR=1.3; 95%CI=1.1-1.5) versus elsewhere; and easy invitation delivery (aOR=1.8; 95%CI=1.4-2.2) versus difficult as reported by the INA.

Conclusions: This study demonstrated the ability of influential people to promote CVCT and identified agent, couple, and context-level factors associated with CVCT uptake in Lusaka, Zambia. We encourage the development of CVCT promotions in other sub-Saharan African countries to support sustained CVCT dissemination.

ARTICLE SUMMARY

Article Focus

- Given preliminary findings from Zambia and Rwanda suggesting community-based promotion of CVCT is effective, we hypothesize that predictors of successful promotions can be identified to increase CVCT uptake in Lusaka, Zambia.
- This study evaluated the ability of community-based activities to promote CVCT and identified predictors of CVCT uptake in Lusaka, Zambia.

Key Messages

- Here, we demonstrated not only the feasibility of CVCT promotions using influential network agent and leaders (INAs and INLs) to promote CVCT, but also identified INA, couple, and invitation-level predictors of CVCT uptake.
- The predictors of CVCT uptake included: recruiting INAs who have tested with partners, focusing invitations on INA acquaintances, issuing invitations to couples and in a discreet location, and utilizing INAs from non-governmental and health networks.

Strengths and Limitations

- These predictors can be used to enhance CVCT promotions in Zambia and may be extended as a framework to other locales, with adaptation based on location-specific predictors of CVCT promotions.
- Country-specific differences in CVCT promotions indicate that more research into site-specific predictors of CVCT may be necessary for successful CVCT promotions in other locales.

BACKGROUND

In 2009, 68% of the global HIV-positive population resided in sub-Saharan Africa, equating to roughly 22.5 million cases. Zambia has one of the largest HIV burdens, with roughly 980 000 prevalent and 76 000 incident cases in 2009,[1] and HIV prevalence roughly twice as high in urban (20%) versus rural (<10%) areas.[2]

Heterosexual transmission is the primary cause of incident HIV infections in sub-Saharan Africa where discordant couples (an HIV+ and HIV- partner) in long-term relationships represent the largest group at-risk for HIV.[1, 3] In urban Zambia, roughly 60% of new

infections occurred between married/cohabiting heterosexual couples [3], and 17% of pregnant couples in Lusaka were discordant.[4]

Knowledge of HIV serostatus is critical for transmission prevention. According to the 2007 Zambia Demographic and Health Survey, although most adults know where to receive an HIV test, only 35% of women and 20% of men have ever tested and received results.[2] Voluntary HIV counseling and testing [VCT] is an evidence-based strategy to increase serostatus awareness, decrease high-risk behavior, and decrease transmission.[5] Couples' VCT [CVCT], in which both partners are tested and mutually disclose results, addresses issues with disclosure, allows for risk-reduction planning based on partner serostatus, and decreases high-risk behavior.[6-8] However, though CVCT effectively targets the highest at-risk group in sub-Saharan Africa, it has not been widely disseminated due to lack of demand and supply, and lack of funding. Lack of demand primarily results from insufficient knowledge about the possibility of couple serodiscordance and CVCT services.[8-11]

The Zambia-Emory HIV Research Project [ZEHRP], based in Lusaka, provides CVCT services. ZEHRP and other groups have shown clinic and community-based CVCT promotions can increase CVCT awareness and demand.[4, 11-14] Social networks and community leaders are critical in changing perceptions towards HIV/AIDS and other health issues in sub-Saharan Africa. [15-18] At ZEHRP, CVCT promotional efforts are directed by influential network leaders [INLs] and agents [INAs], based on the Social Networks and Social Support Theory.[19] This study assessed the ability of INLs and INAs to promote CVCT and identified predictors of CVCT uptake in Lusaka.

METHODS

INL and INA recruitment and training

ZEHRP CVCT promotions maximize program impact by utilizing two existing social networks levels -- INLs and INAs. INL and INA recruitment and training methods are described elsewhere.[13, 20] Briefly, INLs were identified from CVCT consensus meetings and national/citywide umbrella referrals from four social networks (faith-based/religious, health, private, and community-based/non-governmental organizations [CBO/NGO]). INLs identified INA candidates from their respective networks, and final selection was made after interviewing with experienced ZEHRP counselors. INLs and INAs completed IRB-approved written informed consents, completed demographic questionnaires, and selected a network category that best described their role when promoting CVCT. Enrolled INAs received four-day training in HIV/AIDS health advocacy/outreach, social networking, CVCT promotions, and observation of successful door-to-door ZEHRP promotional strategies. During training, INLs and INAs were offered CVCT or VCT.

CVCT promotions

CVCT promotional activities took place from July 2004-December 2005 in two randomly selected neighborhoods as described elsewhere.[21] Briefly, of eight neighborhoods assessed as potential sites, two were selected based on similar population size, infrastructure, and with consideration of geographic distance to minimize spillover effects. CVCT promotions and services were implemented in these neighborhoods, and a mobile unit operated in one neighborhood and crossed over to the other mid-way through the study. Given the catchment areas of these two neighborhoods (99,280 and 85,022 individuals), it was assumed that couples would rarely receive multiple invitations. INAs distributed invitations to couples or individuals within their neighborhoods that detailed CVCT facility directions and procedures. Couples

could be cohabiting or non-cohabiting. Invitations included a unique ID, INA identifier, and a receipt portion that the INA retained and submitted bi-weekly. The receipt portion contained the invitation ID and space to record the date, time, place of invitation, relationship of the INA and recipient, recipient description (man, woman, or couple), recipients' age(s), residence, marital status, and INA's perception of the difficulty of invitation delivery.

Before March 18, 2005, INAs received $0.21/invitation issued and an additional $4.20/couple attending CVCT. Beginning March 19, 2005, payment/invitation was reduced to $0.11 and payment/couple attending CVCT was increased to $5.25 to deter fraudulent completion of invitation receipts. In addition to fixed CVCT sites, which could serve 30 couples/day, a mobile HIV testing unit, which could serve an additional 30 couples/day, was available for nine months in one neighborhood and then nine months in the other. Mobile testing sites were selected based on facility (churches, schools, and community centers) availability. For perspective, Purchasing Power Parity in Zambia, an adjusted measure of per-capita-income number, is $1500/year,[22] and the proportion of Zambians living on less than $1/day is 63.6%.[23]

CVCT procedures

CVCT procedures are described elsewhere.[13] Briefly, couples participate in group counseling, joint pre-test counseling, and, for those testing, confidential informed consent procedures, phlebotomy, rapid HIV testing,[24] and joint post-test counseling and test result delivery. CVCT services were free and transportation to testing sites was reimbursed. Invitation receipts were collected from INA-invited couples and the invitation ID was linked to the couple ID number. The study was approved by the Emory University IRB and the University of Zambia Research Ethics committee. Informed consent was obtained from all study participants.

Statistical analysis

Counts (percentages) for categorical variables and means (standard deviations) for continuous variables were calculated for INL, INA, couple, and invitation-level characteristics. Number of invitations distributed was tabulated by INA characteristic as were success rates (the number couples tested/number invitations distributed). Analyses were stratified by couple cohabitation status to identify differences in CVCT uptake and predictors of success. INAs not achieving ≥1.5% success were excluded from analyses to prevent inclusion of INAs systematically returning fraudulent receipts.

Crude odds ratios [ORs], 95%CIs, and p-values evaluated associations between INA-level characteristics predictive of successful invitations. Generalized estimating equation [GEE] methods evaluated the association between couple and invitation-level characteristics predictive of successful invitations. Since couple and invitation-level data are clustered at two-levels, within individual INAs and INLs, GEE methods accounted for non-independence of observations.

INA, couple, and invitation-level variables significant (Bonferroni corrected p-value=0.002) in univariate analyses were entered into a multivariate logistic regression model, and variables were examined for multi-collinearity. GEE methods accounted for clustering of couple and invitation-level characteristics within individual INAs and INLs. We fit the marginal multilevel logistic regression model using PROC GENMOD. GEE analysis methods with an exchangeable correlation structure accounted for two-level clustering of couple and invitation level characteristics within individual INAs and INLs. We hypothesized a priori that an exchangeable correlation structure would be appropriate since couples within a cluster should not

be increasingly/decreasingly correlated. We also considered other correlation structures, such as unstructured. Data analysis was conducted with SASv9.2 (North Carolina, USA).

RESULTS

INL characteristics

Sixty-eight INLs were recruited from CBO/NGO, faith-based, health, and private sector networks. Average INL age was 45 (inter-quartile range [IQR]=36-52), and 68% were men. Average years living in Lusaka was 25 (IQR=15-34), and 72% were married. Almost all INLs understood Nyanja and/or Bemba or English, roughly half owned their home, and most had previously tested for HIV (Table 1).

INA characteristics associated with couples' testing (Tables 1-2)

INLs recruited 320 INAs (excluding 70 INAs with <1.5% success), and overall, INAs distributed 29,119 invitations with 1727 couples tested for an average of 91 invites/INA and 5 couples tested/INA. INAs affiliated with CBO/NGOs distributed more than average invitations/INA and were more likely to successfully invite cohabiting couples relative to private network INAs. Health network INAs also distributed a high number of average invitations/INA and were more successful among all couples relative to private network INAs (Tables 1-2).

Most INAs were women, and performance with respect to invitations delivered, success rates, and average number of couples tested was similar by gender (Table 1). Average INA age was 37 (IQR=29-44), and older INAs were significantly more successful among cohabiting, but less successful among non-cohabiting, couples relative to younger INAs (Table 2). The average number of years living in Lusaka was 21 (IQR=11-30) (data not shown), and years living in Lusaka significantly predicted successful invitation among cohabiting couples (Table 2).

Married INAs were significantly more successful among cohabiting couples relative to divorced, widowed, or single INAs (Table 2). Divorced INAs had very low success rates among non-cohabiting couples (Table 1). Among INAs with a partner, years of current relationship had a similar effect as age, with longer unions associated with significantly decreased success among non-cohabiting couples.

Seventy-four percent of INAs were sales/service industry employees, and these INAs were significantly more successful among cohabiting and non-cohabiting couples relative to unskilled manual laborers. Professional and agricultural sector employees were also more successful among non-cohabiting couples (Table 2). Eighty percent of INAs could read English (Table 1), and this was associated with successful invitations among non-cohabiting couples only.

Over half of INAs rented their home. The 38% who owned a home were less successful than those who rented or lived in housing provided by others; with stratification this remained significant only among cohabiting couples (Table 2). Two percent of INAs had housing provided by an employer and were substantially more successful among cohabiting couples (Table 1).

Only 57% of INAs had tested for HIV with a partner (22%) or alone (35%) (Table 1). INAs testing for HIV with a partner were more successful among all couples, and testing alone was associated with higher success among non-cohabiting couples relative to never testing (Table 2).

Seventy INAs did not achieve 1.5% success and were excluded from analyses as their invitation receipts were suspected to have been fraudulently completed. These INAs distributed 125 invitations/INA and were similar to INAs in the analysis by gender (χ^2 test of association=0.8, p=0.4), age (t-statistic=-1.9, p=0.06), and network (χ2=3.7, p=0.3). The average

success of these 70 INAs was 0.57%, and when adding these INAs to those included in the analysis, overall INA success was 4.97%.

Couple and invitation characteristics associated with couples' testing (Table 3)

The mean age of men was 33 and of women was 27 years. Couples' testing were slightly older than those not testing (p<0.001). Most couples were cohabiting, and these were significantly more likely to test versus non-cohabiting couples. The mean duration of relationship was 6 years, and tested couples had been together on average one year longer than non-tested couples.

INAs initiated contact 93% of the time, though in the rare instances when the couple or the woman initiated contact with the INA, the couple was more likely to test. Inviting a couple together also resulted in increased testing. Couples who were family members or social acquaintances of the INA were more likely to test versus those previously unacquainted. Ease of invitation delivery (operationalized as not being time-consuming, requiring long explanations, challenging because of invitee resistance or scheduling conflicts) was also associated with couples' testing. Interestingly, though public endorsements were predictive of testing during a pilot study [13], they were not associated with increased uptake of testing in this larger study. Similarly, the presence of mobile units was not associated with increased testing.

Multivariate model of couples' testing predictors (Table 4)

Age of the man and woman were collinear and woman's age was excluded from the multivariate model. Couple cohabitation status was an effect measure modifier, and multivariate analyses were stratified by cohabitation status. All adjusted ORs [aORs] presented below were statistically significant in multivariate analyses accounting for two-level clustering.

Health sector INAs were most successful (aOR=1.5) followed by CBO/NGO INAs (aOR=1.3) relative to private sector INAs. Married INAs were more successful versus others

among cohabiting couples (aOR=1.3). Sales/service industry employees (aOR=1.5) versus unskilled manual laborers were more successful overall. Among non-cohabiting couples, INAs who could read English were more successful (aOR=2.0) whereas among cohabiting couples, INAs owning homes were less successful (aOR=0.7). INAs who had tested for HIV with a partner were more successful among all couples (aOR=1.4), while those who had tested for HIV alone were more successful among non-cohabiting couples (aOR=2.1), versus INAs who had never tested. Cohabiting couples were more likely to test (aOR=1.4) versus non-cohabiting couples.

Invitation-level predictors of testing among cohabiting couples included inviting the couple versus the woman alone (aOR=1.3); also couple (aOR=1.4) versus INA initiated contact was predictive. Being socially acquainted with the INA (aOR=1.6) versus having just met was predictive among all couples, while home CVCT invitation delivery (aOR=1.4) versus elsewhere, and easy invitation delivery (aOR=1.9) versus difficult were predictive among cohabiting couples.

DISCUSSION

In an African capital city where very few couples have jointly tested for HIV, a promotional program using INLs and INAs prompted approximately 100 couples/month to seek CVCT. INA network, occupation, marital status, and testing history, as well as couple cohabitation status and the INA-invitee relationship, influenced invitation success. Invitations delivered to the couple, in the home, and invitations initiated by the woman partner were also significant CVCT uptake predictors.

CBO/NGO and health network INAs were more successful than faith-based or private sector INAs. CBO/NGO networks included parent teacher, legal aid, skills training, and health

information organizations. Health networks included clinical officers, nurses, home healthcare visitors, community health workers, neighborhood health committee members, and traditional birth attendants. The private sector included individuals who were self-employed or those involved in providing the public with goods or services. Previous studies have similarly demonstrated the ability of influential people to effectively disseminate information and change attitudes and behaviors towards HIV in sub-Saharan Africa.[16-18] Unlike health and CBO/NGO INAs, private sector INAs may have been preoccupied with income generation and/or did not have similar opportunities to integrate CVCT promotions into their daily routine. The marginal performance of faith-based INAs was surprising given Zambia is strongly religious; however, though religious leaders have opportunities to promote from the pulpit, the stigma associated with sexually transmitted infections [STIs] may inhibit open discussion of CVCT.[17, 25]

Cohabiting couples were more likely than non-cohabiting couples to test, and married INAs delivered more successful invitations than unmarried INAs. Fear of stigma among married couples is common,[9, 26, 27] and perhaps married INAs were able to more successfully overcome this barrier with their fellow married couples. INAs who previously tested for HIV with a partner were also more successful than those who had not tested, likely due to their firsthand knowledge of CVCT procedures and ability to speak personally to perceived CVCT barriers.

INAs socially acquainted with the invitee were more successful versus those who were previously unacquainted. The strength of INA-invitee relationship may facilitate open discussion of CVCT and engender confidence. INAs inviting the couple together versus either partner alone, potentially removing pressure for one partner to propose testing to the other, were also

more successful. Previous studies support the effectiveness of couple-level targeted prevention strategies.[13, 28-31]

Though most invitations were initiated by INAs, when the woman partner initiated contact with the INA, CVCT uptake increased. This finding likely reflects pre-existing motivation to discuss or participate in CVCT.

Invitations delivered in the home versus community were more effective. Previous studies indicate that home and workplace HIV counseling and testing promotions are more successful in Zambia, Uganda, and Malawi relative to community locations.[32-35] These findings are likely due to increased discretion and comfort associated with home settings.

Results from a similar study using both INLs and INAs in Kigali, Rwanda highlight country-specific similarities and differences. Similar to Zambia, Rwandan health INAs were more successful relative to private network INAs. Married Rwandan INAs were more successful than single INAs, and cohabiting couples were more likely to test than non-cohabiting couples in univariate analyses. We similarly found that invitations delivered to couples socially acquainted with the INA, woman partner initiated contact, and invitations delivered in the home were more successful in multivariate analyses in Rwanda. In contrast to this study, Rwandan faith-based INAs were more successful in univariate analyses relative to private network INAs, and the overall INA success rate in Rwanda was higher (18%). Mobile units were also associated with increased testing in Rwanda.[20] We were surprised that the mobile unit was not predictive of testing in this analysis as in Rwanda, not because of mitigated transportation costs, which were reimbursed, but because of the increased convenience and decreased time commitments engendered by mobile testing. More research is needed to determine why the mobile testing units did not increase uptake.

Kigali and Lusaka, though both capital cities, differ in several important ways: Kigali has a monolingual population of 800,000 with easy and inexpensive transportation. In contrast, Lusaka's 1.7 million inhabitants represent all 73 Zambian languages/dialects, the city is large, and transportation is expensive. Another study in the Bemba-speaking Copperbelt region of Zambia combined INA promotions with mass media strategies in two cities of 600,000 each and obtained success rates between those found in Lusaka and Kigali.[14] These linguistic and infrastructural differences highlight the importance of testing and adapting network-based promotional models to different environments.

Results from a pilot study of promotions in Lusaka with 33 INAs (no INLs) showed that, while invitation-level predictors were similar to those found in this larger study, the small sample size did not allow simultaneous detection of INA, couple, and invitation-level characteristics in hierarchical analysis.[13] Similarly, the Copperbelt study described previously did not examine INA, couple, or invitation-level predictors of success.[14]

The exclusion of the 70 INAs who did not achieve 1.5% success was considered necessary in order to determine the INA-level predictors of successful invitation delivery among INAs not returning fraudulent invitation receipts. We acknowledge that this exclusion may discount INAs who were poor performers in addition to INAs returning fraudulent receipts thereby reducing the generalizability of our findings to more productive INAs..

Overall, this study demonstrated the feasibility of CVCT promotions in Lusaka, and we believe success rates could be considerably increased by utilizing the modifiable predictors of CVCT uptake identified: recruiting INAs who have tested with partners, focusing invitations on INA acquaintances, issuing invitations to couples and in a discreet location, and utilizing INAs from CBO/NGO and health networks. It should be noted that most of the statistically significant

aORs are close to the null suggesting cautious interpretation of these associations. More research is especially needed to encourage faith-based leaders in Zambia to more effectively promote CVCT.

CONCLUSION

CVCT is an evidence-based testing strategy shown to reduce transmission of HIV and other STIs and to help prevent unintended pregnancies in sub-Saharan Africa. However, CVCT has yet to be widely implemented in this region.[4, 6, 7, 36-40] Here, we demonstrated not only the feasibility of CVCT promotions using INAs and INLs, but also identified practical INA, couple, and invitation-level factors which were marginally though significantly predictive of CVCT uptake in these analyses. These predictors can be used to enhance CVCT promotions in Zambia and may be extended as a framework to other locales, with adaptation based on location-specific predictors of CVCT promotions.

Contributorship statement

Kristin M Wall – made substantial contributions to the analysis and interpretation of data, drafting the article and revising it critically for important intellectual content, and gave final approval of the version to be published

William Kilembe - made substantial contributions to study conception and design, revising the article critically for important intellectual content, and gave final approval of the version to be published

Azhar Nizam – made substantial contributions to the analysis and interpretation of data, revising the article critically for important intellectual content, and gave final approval of the version to be published

Cheswa Vwalika – made substantial contributions to study conception and design, revising the article critically for important intellectual content, and gave final approval of the version to be published

Michelle Kautzman – made substantial contributions to study conception and design, revising the article critically for important intellectual content, and gave final approval of the version to be published

Elwyn Chomba - made substantial contributions to study conception and design, revising the article critically for important intellectual content, and gave final approval of the version to be published

Amanda Tichacek - made substantial contributions to study conception and design, revising the article critically for important intellectual content, and gave final approval of the version to be published

Gurkiran Sardar - made substantial contributions to study conception and design, revising the article critically for important intellectual content, and gave final approval of the version to be published

Deborah Casanova - made substantial contributions to data aquisition, revising the article critically for important intellectual content, and gave final approval of the version to be published

Faith Henderson - made substantial contributions to data aquisition, revising the article critically for important intellectual content, and gave final approval of the version to be published

Joseph Mulenga - made substantial contributions to data aquisition, revising the article critically for important intellectual content, and gave final approval of the version to be published

David Kleinbaum - made substantial contributions to the analysis and interpretation of data, revising the article critically for important intellectual content, and gave final approval of the version to be published

Susan Allen - made substantial contributions to study conception and design, revising the article critically for important intellectual content, and gave final approval of the version to be published

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Competing interests

The authors have no competing interests, including relevant financial interests, activities, relationships, and affiliations.

Data sharing statement

There is no additional data available.

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Table 1 INL and INA characteristics by invitations distributed, success rate, and couple cohabitation status

	INL (N=68)		INA (N=320)		Invitations Distributed	Couples Tested	Average invites/INA	Average couples tested/INA	Success Rate (%)	% invitations given to cohabiting couples	% couples tested who are cohabiting	Success Rate (%)	
	N	%	N	%								Cohab Couples	Non-Cohab Couples
Total	**68**		**320**		**29119**	**1727**	**91**	**5**	**6%**	**81%**	**87%**	**6%**	**4%**
Network													
Private	16	24%	73	23%	5592	302	77	4	5%	79%	82%	6%	3%
Religious	19	28%	62	19%	5530	282	89	5	5%	85%	95%	6%	4%
Health	12	18%	95	30%	9529	617	100	6	6%	80%	86%	7%	5%
CBO/NGO	21	31%	90	28%	8468	526	94	6	6%	82%	87%	7%	4%
Gender													
Man	46	68%	131	41%	11620	700	89	5	6%	81%	85%	6%	5%
Woman	22	32%	189	59%	17499	1027	93	5	6%	82%	88%	6%	4%
Relationship status													
Married	49	72%	208	65%	18814	1178	90	6	6%	82%	88%	7%	4%
Divorced	5	7%	21	7%	2033	86	97	4	4%	82%	94%	5%	1%
Single	7	10%	38	12%	2902	131	76	3	5%	74%	83%	5%	3%
Widow	7	10%	45	14%	4212	303	94	7	7%	83%	84%	7%	7%
Missing	0	0%	8	3%	1158	29	145	4	3%	78%	79%	3%	2%
Occupation													
Professional/technical/ managerial	28	41%	68	21%	5605	330	82	5	6%	80%	81%	6%	5%
Sales/service	22	32%	163	51%	11462	793	70	5	7%	81%	88%	7%	5%
Agricultural	1	1%	6	2%	739	43	123	7	6%	75%	77%	6%	5%
Unskilled manual labor	12	18%	42	13%	5352	278	127	7	5%	84%	90%	6%	3%
Do not work for money	2	3%	33	10%	4912	253	149	8	5%	82%	90%	6%	3%
Missing	3	4%	8	3%	1049	30	131	4	3%	82%	100%	3%	0%
Read English													
Yes	64	94%	265	83%	23744	1439	90	5	6%	81%	86%	6%	4%

No	4	6%	55	17%	5375	288	98	5	5%	82%	92%	6%	2%
Housing													
Provided by employer (free)	5	7%	6	2%	372	38	62	6	10%	83%	95%	12%	3%
Rental home	22	32%	166	52%	16341	985	98	6	6%	81%	86%	6%	4%
Free housing by other means	10	15%	26	8%	1611	113	62	4	7%	80%	89%	8%	4%
Own home	30	44%	120	38%	10583	585	88	5	6%	82%	87%	6%	4%
Missing	1	1%	2	1%	212	6	106	3	3%	62%	100%	5%	0%
Ever tested for HIV													
Yes with partner	41	60%	71	22%	6274	303	88	4	5%	82%	93%	5%	2%
Yes alone	14	21%	113	35%	10424	608	92	5	6%	81%	87%	6%	4%
No	13	19%	135	42%	12207	802	90	6	7%	81%	85%	7%	5%
Missing	0	0%	1	0%	214	14	214	14	7%	86%	86%	7%	7%

INL: influential network leader
INA: influential network agent

Table 2 Bivariate association between INA characteristics and couples' testing by couples' cohabitation status

INA characteristics	All Couples				Cohabiting Couples				Non-cohabiting Couples			
	Odds Ratio	95% CI		p-value	Odds Ratio	95% CI		p-value	Odds Ratio	95% CI		p-value
Network												
Private	Ref				Ref				Ref			
CBO/NGO	1.23	1.06	1.43	0.01	1.21	1.03	1.42	0.02	1.35	0.88	2.06	0.17
Health	1.29	1.12	1.49	0.001	1.25	1.07	1.46	0.01	1.56	1.04	2.35	0.03
Religious	1.06	0.90	1.26	0.48	1.07	0.90	1.27	0.47	1.02	0.63	1.66	0.94
Gender												
Male	Ref				Ref				Ref			
Female	0.97	0.88	1.07	0.58	1.01	0.91	1.12	0.84	0.79	0.60	1.03	0.09
Age (per year increase)	1.01	1.00	1.01	0.07	1.01	1.00	1.01	0.002	0.98	0.96	0.99	0.001
Years living in Lusaka (per year increase)	1.01	1.00	1.01	<0.001	1.01	1.01	1.01	<0.001	1.00	0.99	1.01	0.80
Relationship status												
Other (divorced, widowed, single)	Ref				Ref				Ref			
Married	1.19	1.07	1.32	0.001	1.22	1.09	1.36	0.001	0.96	0.73	1.26	0.75
Years of relationship (per year increase)*	1.00	0.99	1.01	0.97	1.01	1.00	1.01	0.09	0.95	0.93	0.97	<0.001
Occupation												
Unskilled manual labor	Ref				Ref				Ref			
Professional	1.14	0.97	1.35	0.11	1.02	0.86	1.22	0.82	2.25	1.42	3.57	0.001
Sales/service	1.36	1.18	1.56	<0.001	1.31	1.13	1.52	<0.001	1.73	1.12	2.67	0.01
Agricultural	1.13	0.81	1.57	0.48	0.95	0.66	1.38	0.79	2.24	1.01	4.97	0.05
Do not work for money	0.99	0.83	1.18	0.92	0.99	0.82	1.18	0.87	1.09	0.63	1.88	0.76
Read English												
No	Ref				Ref				Ref			
Yes	1.14	1.00	1.30	0.05	1.06	0.92	1.21	0.44	2.12	1.35	3.33	0.001
Housing												
Other housing (rental, free)	Ref				Ref				Ref			
Own home	0.89	0.80	0.98	0.02	0.89	0.79	0.99	0.03	0.88	0.66	1.16	0.36

Ever tested for HIV												
No	Ref				Ref				Ref			
Yes with partner	1.39	1.21	1.59	<0.001	1.26	1.09	1.45	0.002	2.97	1.85	4.78	<0.001
Yes alone	1.22	1.06	1.41	0.01	1.13	0.97	1.31	0.11	2.42	1.48	3.95	<0.001

*Among those with a partner
INL: influential network leader
INA: influential network agent

Table 3 Bivariate association between couple and invitation characteristics and couples' testing accounting for clustering within INAs and INLs

	All couples		Couples not tested		Couples tested		Odds Ratio	95% CI		p-value
	N	%	N	%	N	%				
Couple Characteristics										
Age of man (mean, SD)	33.25	9.03	33.16	8.99	34.61	9.43	1.01	1.01	1.02	<0.001
Age of woman (mean, SD)	27.12	7.75	27.03	7.72	28.60	8.15	1.02	1.02	1.03	<0.001
Relationship of couple										
Not cohabiting	5275	18%	5058	19%	217	13%	Ref			
Cohabiting	23664	82%	22161	81%	1503	87%	1.58	1.38	1.81	<0.001
Years of relationship (mean, SD)	6.27	6.42	6.22	6.35	7.18	7.38	1.02	1.01	1.03	<0.001
Number of children (mean, SD)	2.04	2.16	2.04	2.16	2.06	2.12	1.01	0.99	1.03	0.29
Invitation Characteristics										
Invitee (1st contact)										
Woman	8934	31%	8426	31%	508	30%	Ref			
Couple	8567	30%	7972	29%	595	35%	1.24	1.08	1.43	0.002
Man	11467	40%	10851	40%	616	36%	0.91	0.81	1.03	0.13
Who initiated contact?										
INA	26620	93%	25103	93%	1517	89%	Ref			
Couple	527	2%	475	2%	52	3%	1.71	1.34	2.18	<0.001
Man	877	3%	811	3%	66	4%	1.18	0.88	1.58	0.26
Woman	690	2%	624	2%	66	4%	1.59	1.20	2.10	0.001
Relationship to INA										
Just met/unknown	19688	68%	18749	69%	939	55%	Ref			
Co-worker	287	1%	269	1%	18	1%	1.35	0.89	2.06	0.16
Family	1697	6%	1525	6%	172	10%	2.08	1.75	2.49	<0.001
Social acquaintance (neighbor, friend, church member)	7186	25%	6601	24%	585	34%	1.64	1.43	1.87	<0.001
Place of invitation										
Community	9828	34%	9339	35%	489	29%	Ref			
Couple home	15460	54%	14532	54%	928	55%	1.41	1.23	1.61	<0.001
INA home	1636	6%	1461	5%	175	10%	2.25	1.87	2.71	<0.001
Couple or INA work	1812	6%	1702	6%	110	6%	1.21	0.97	1.51	0.09

Public endorsement										
No	18148	63%	17080	63%	1068	62%	Ref			
Yes	10715	37%	10066	37%	649	38%	1.04	0.92	1.17	0.53
Delivering invitation										
Difficult/somewhat difficult	3030	10%	2912	65%	118	0.4%	Ref			
Easy	25860	89%	1599	35%	24261	99.5%	1.60	1.33	1.93	<0.001
Mobile unit present at time of invitation										
No	14268	49%	13713	50%	909	53%	Ref			
Yes	14622	51%	13679	50%	818	47%	1.12	0.89	1.39	0.33
Neighborhood of invitation										
Neighborhood 1	13705	47%	12911	47%	794	46%	Ref			
Neighborhood 2	15414	53%	14481	53%	933	54%	0.97	0.79	1.18	0.74

Community: church/mosque, clinic, market, street/public place, social gathering
INL: influential network leader
INA: influential network agent

Table 4 Multivariate model of INA level, couple level, and invitation level characteristics associated with couples' testing

	All Couples				Cohabiting Couples				Non-cohabiting Couples			
	Odds Ratio	**95% CI**		**p-value**	**Odds Ratio**	**95% CI**		**p-value**	**Odds Ratio**	**95% CI**		**p-value**
INA characteristics												
Network												
Private	Ref				Ref				Ref			
Religious	1.01	0.71	1.43	0.95	1.01	0.73	1.40	0.94	1.16	0.49	2.77	0.74
Health	1.53	1.15	2.04	0.004	1.48	1.11	1.97	0.01	1.80	0.96	3.35	0.07
CBO/NGO	1.34	1.01	1.77	0.04	1.31	0.98	1.76	0.07	1.53	0.84	2.79	0.16
Years living in Lusaka	1.01	1.00	1.02	0.14	1.01	1.00	1.02	0.07	1.01	0.99	1.04	0.24
Age (per 1 year increase)	1.00	0.99	1.02	0.79	1.00	0.99	1.02	0.53	0.99	0.97	1.01	0.35
Marital status												
Other (divorced, widowed, single)	Ref				Ref				Ref			
Married	1.23	0.99	1.53	0.06	1.28	1.02	1.60	0.03	1.06	0.70	1.62	0.77
Occupation												
Unskilled manual labor	Ref				Ref				Ref			
Professional	1.19	0.77	1.84	0.45	1.06	0.69	1.64	0.79	1.98	0.92	4.27	0.08
Sales/service	1.45	1.01	2.10	0.05	1.37	0.94	1.99	0.11	1.67	0.88	3.19	0.12
Agricultural	1.14	0.65	2.01	0.64	0.97	0.55	1.72	0.93	1.68	0.60	4.67	0.32
Do not work for money	0.95	0.62	1.45	0.81	0.95	0.62	1.45	0.80	0.69	0.26	1.82	0.45
Reads English												
No	Ref				Ref				Ref			
Yes	1.18	0.90	1.55	0.22	1.15	0.87	1.51	0.32	1.98	1.05	3.72	0.03
Housing												
Other housing (rental, free)	Ref				Ref				Ref			
Own home	0.74	0.59	0.92	0.01	0.73	0.58	0.91	0.01	0.93	0.62	1.38	0.71
Ever tested for HIV												
No	Ref				Ref				Ref			
Yes with partner	1.36	1.07	1.72	0.01	1.29	1.01	1.66	0.04	2.13	1.27	3.57	0.004
Yes alone	1.28	1.00	1.64	0.05	1.21	0.94	1.56	0.15	1.92	1.10	3.35	0.02
Couple Characteristics												

Age of man (per 1 year increase)	1.00	1.00	1.01	0.30	1.01	1.00	1.02	0.10	1.03	1.00	1.05	0.02
Years of relationship (per 1 year increase)	1.01	0.99	1.02	0.35	1.02	1.01	1.03	<0.001	0.45	0.37	0.55	<0.001
Relationship of couple						n/a				n/a		
Not cohabiting	Ref											
Cohabiting	1.39	1.19	1.63	<0.001								
Invitation Characteristics												
Invitee (1st contact)												
Individual (Woman/Man)	Ref				Ref				Ref			
Couple	1.20	1.04	1.39	0.01	1.27	1.09	1.49	0.003	0.82	0.52	1.28	0.38
Who initiated contact?												
INA	Ref				Ref				Ref			
Couple	1.35	1.03	1.78	0.03	1.43	1.05	1.94	0.02	0.94	0.27	3.20	0.92
Man	1.22	0.89	1.67	0.22	1.26	0.90	1.75	0.18	1.00	0.47	2.12	1.00
Woman	1.60	1.17	2.19	0.003	1.53	1.10	2.12	0.01	1.54	0.73	3.27	0.26
Relationship to INA												
Just met/unknown	Ref				Ref				Ref			
Co-worker	1.48	0.89	2.43	0.13	1.47	0.84	2.55	0.18	1.11	0.27	4.56	0.89
Social acquaintance (neighbor, friend, church member, family)	1.62	1.41	1.87	<0.001	1.60	1.37	1.87	<0.001	1.60	1.15	2.24	0.01
Place of invitation												
Other (Community or couple/INA work)	Ref				Ref				Ref			
Couple or INA home	1.30	1.14	1.48	<0.001	1.39	1.21	1.61	<0.001	0.93	0.68	1.27	0.65
Delivering invitation												
Difficult/somewhat difficult	Ref				Ref				Ref			
Easy	1.75	1.41	2.17	<0.001	1.87	1.47	2.37	<0.001	1.15	0.67	1.99	0.61

INA: influential network agent

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, explain how loss to follow-up was addressed
		(*e*) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) Summarise follow-up time (eg, average and total amount)
Outcome data	15*	Report numbers of outcome events or summary measures over time
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.