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Feasibility, acceptability, and potential cost-effectiveness of a novel mobile phone intervention to promote HIV testing within social networks in Tanzania

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Abstract

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DECLARATIONS

The study protocol was approved by the Institutional Review Boards at Duke University and the University of South Carolina in the United States, the Ethics Review Committee at Kilimanjaro Christian Medical University College, and the National Institute for Medical Research.

COMPETING INTEREST

No potential competing interest was reported by the authors.

Among 145 individuals surveyed in Tanzania, 42% indicated willingness to test for HIV in response to a confidential, phone-based text message. On average, participants were likely to provide contact information for 1.5 members of their social networks, suggesting high feasibility and moderate acceptability of a novel mHealth HIV testing intervention.

Summary Statement

Preliminary data suggest that confidential SMS-based HIV testing invitations to social and sexual network contacts are feasible, moderately acceptable, and potentially cost-effective among two high risk populations in Tanzania.

Keywords

HIV testing; social networks; confidentiality; mHealth; sub-Saharan Africa

1 Background/Introduction

In order to end the HIV epidemic, persons with HIV (PWH) must become aware of their diagnosis, engage in care, and adhere to effective treatment. Consequently, UNAIDS set the ambitious “95-95-95” targets of diagnosing 95% of all PWH, initiating antiretroviral therapy for 95% those diagnosed, and attaining virologic suppression for 95% of those treated.(1, 2) Although significant progress has been made towards achieving these targets, advances remain uneven across sub-Saharan Africa. Nearly 17% of PWH in Tanzania are unaware of their serostatus,(3) and many hesitate to test because of fear, stigma, and discrimination.(4)

One promising approach for increasing HIV testing rates is using confidential mobile phone-based testing invitations to social and sexual network contacts of persons testing for HIV. Social and sexual networks play a critical role in HIV transmission and testing uptake, (5-7) and mobile phones provide opportunities for efficiently extending testing invitations to networks of HIV testers. Carefully designed Short Message Service (SMS) invitations could efficiently and discretely reach populations that are at the margins of the healthcare system. This approach aligns with WHO recommendations to promote equitable services and optimize impact for populations most likely to have higher numbers of sexual partners. (8)

Text messaging has been used to communicate health information across diverse settings, including promotion of sexually transmitted infection (STI) testing.(9) Leveraging the ubiquity of mobile phones, coupled with the low cost of text-based messaging, SMS interventions have been used to promote HIV testing among gay men in Australia(10), random mobile phone users in South Africa,(11) and young college women(12) and female sex workers(13) in Kenya.

To our knowledge, SMS interventions to promote HIV testing have not, however, probed the social networks of individuals at risk for HIV infection. Given the correlations of HIV risk behaviors within social networks,(14) which result from an individual’s tendency to choose partners similar to themselves (a property called homophily(15)), HIV testing strategies

that confidentially penetrate social networks of HIV testers create new opportunities for identifying at-risk individuals and linking them to care. Concurrently, the very low costs of SMS suggest that even a marginally effective intervention could be highly cost-effective. We explored the potential feasibility and acceptability of SMS-based confidential social network referrals for HIV testing (“*CONSORT*”) to reach the social network contacts of male mountain porters and female bar workers, two groups at high risk for HIV infection in the Kilimanjaro Region of Tanzania.(16)

2 Methods

As part of a study evaluating novel approaches to improve the uptake of HIV testing among high-risk populations in the Kilimanjaro Region of Tanzania ([ClinicalTrials.gov Protocol NCT02714140](https://clinicaltrials.gov/ct2/show/study/NCT02714140)),(17) we systematically recruited and surveyed members of two high risk populations to assess the feasibility and acceptability of *CONSORT*. Participants in the parent study comprised 773 women employed in randomly selected bars, restaurants, and guesthouses serving alcohol to patrons (“bars” and “female barworkers”, respectively) and 707 male porters supporting climbers of Mount Kilimanjaro (“male porters”) who were sequentially approached as they exited Mount Kilimanjaro National Park. Eligible participants were ages 18 to 49 and invited to come to the study offices for consent and enrollment. Acceptance rates in the parent study were 66.4% for female barworkers and 54.7% for male porters.

In the context of continuous data collection for the parent study, all study participants presenting at the study offices for in-person follow-up surveys between 5 February and 31 March 2020 were asked to complete a survey that assessed their demographic, social network, and HIV risk characteristics. We used a name generator/interpreter survey module to assess the size and composition of participants’ egocentric networks. A ‘name generator’ question asked each participant (“index”) to name family members, friends, loved ones, co-workers, neighbors, or other persons (their “alters”) from whom they have sought advice or help, or with whom they have discussed important matters. ‘Name interpreter’ questions, cycled through up to 5 named alters for each participant and assessed alters’ key characteristics (e.g., gender, relationship, communication frequency). *CONSORT* feasibility was probed by recording index participants’ knowledge of phone numbers for each alter. Acceptability was described by index participants’ likelihood of sending *CONSORT* messages to each alter, and their own likelihood of testing for HIV if they received a confidential testing invitation. Likelihood was assessed using a 4-point Likert scale (very likely; somewhat likely; somewhat unlikely; not likely). Preferences for *CONSORT* versus physical invitation cards were also assessed.

Descriptive statistics were used to analyze participants’ social networks and the potential feasibility and acceptability of *CONSORT*. Student’s *t*-tests and chi-squared tests assessed the statistical significance of differences between male and female participants. To account for the small sample size, confidence intervals around the estimated proportions were calculated using the Wilson method.(18) To characterize the potential impact and cost-effectiveness of *CONSORT*, sample estimates of acceptability were applied to a hypothetical

cohort of 1000 index participants whose characteristics were assumed to resemble those of the participants in this study.

3 Results

Sample characteristics

Participants comprised 113 female barworkers and 32 male porters. Most female bar workers were unmarried, whereas the majority of male porters were married (Table 1, **Panel A**). The numbers of lifetime and recent sexual partners were significantly higher for men than women. Nearly 4% of female barworkers reported being infected with HIV. Nearly one third of women and half of the men reported testing for HIV on two or fewer occasions in their lifetime.

Social network characteristics

Participants reported an average of 2.8 individuals with whom they discussed important matters in the past year (Table 1, **Panel B**). Additional information was collected for up to 5 of these “alters” (N=362). Male index clients were more likely to list male alters (74%); female index clients were more likely to list female alters (64%; $p<0.001$). Over 40% were family members, 33% friends, 15% partners, 7% colleagues. Contact frequency with alters was high (74% daily or almost daily). Index clients reported having spoken to 61% of alters about HIV.

Feasibility and acceptability of CONSORT

Index participants reported knowing a phone number for 96% of alters (Table 2). On average, each participant was likely to invite 2.1 contacts (84% of alters) for HIV testing using physical invitation cards, and 1.5 contacts (60% of alters) using *CONSORT*. When given the choice between the two, two-thirds preferred invitation cards, whereas 25% preferred *CONSORT*SMS. When asked “*If you received an SMS suggesting that you test for HIV but you do not know who suggested that you test, how likely is it that you would get tested for HIV?*”, 42% of index clients indicated that they would be somewhat or very likely to test for HIV.

Potential impact and cost-effectiveness of CONSORT

Our results allow for preliminary estimates of the potential impact and cost-effectiveness of *CONSORT*. Assuming 1000 persons with characteristics similar to our study participants were offered the opportunity to facilitate confidential SMS-based HIV testing invitations, 1,507 confidential SMS-based testing invitations could be sent to contacts within their social networks. Among SMS recipients, 638 would be very likely or somewhat likely to test for HIV. At a cost of Tsh1000 (~\$0.44) for 1000 SMS, the SMS cost per *CONSORT*-attributable HIV test would be approximately 0.1 cent. Given plausible assumptions (93% previously tested for HIV; 0.1% HIV incidence among prior testers; 3% HIV prevalence among first-time testers), these 638 *CONSORT*-attributable HIV tests would be expected to result in 1.93 new HIV diagnoses; the SMS cost per new HIV diagnosis would be approximately 34 cents.

4 Discussion

Among 145 individuals surveyed, we observed high feasibility and moderate acceptability of confidential SMS messaging to reach social network referrals for HIV testing. On average, each participant was very likely or somewhat likely to invite 2.1 network contacts using physical invitation cards, and 1.5 contacts using *CONSORT*SMS. More than 40 percent of participants indicated a willingness to test for HIV if they received a *CONSORT* invitation. Extrapolations of these estimates to a hypothetical cohort of 1000 index clients suggest a yield of more than 600 *CONSORT*-attributable HIV tests and 2 newly diagnosed HIV infections at an SMS cost of less than 1 US Dollar.

While other studies have explored the use of SMS messaging to promote HIV testing in sub-Saharan Africa,(11, 12, 19, 20) to our knowledge the feasibility and acceptability of using confidential SMS messaging to recruit social network referrals have not been explored. Prior work has shown that SMS messaging increased HIV testing among female sex workers(13) and college students(12) in Kenya and among a random sample of mobile phone users in South Africa.(11) Although each of these studies had limitations, taken together, they suggest that SMS messaging interventions can increase the uptake of HIV testing.

In addition to its low cost, we note other potential advantages of the *CONSORT* approach. First, chain referral methods, such as respondent-driven sampling, are a proven means of accessing hard-to-reach populations.(21) Reaching “populations that are left behind” is a priority of the global health sector strategy on STIs.(8) Additionally, the privacy and confidentiality afforded by mHealth technologies may overcome the stigma associated with personal invitations to test for HIV. Finally, because infrastructure and SMS messaging costs are low, *CONSORT* could be readily scaled within resource-limited settings and are extensible beyond HIV-messaging.

We note limitations. First, the sample may not be representative of the population of barworkers and porters, as enrollment and retention in the parent study was subject to self-selection. Second, our estimates may be subject to hypothetical bias and social desirability bias and may not be representative of other populations at increased risk of HIV infection. As such, these results are considered preliminary, but sufficient to prompt further feasibility and acceptability assessments of *CONSORT*.

In summary, we describe interest in *CONSORT* among mountain porters and bar workers in the Kilimanjaro Region of Tanzania. Given its low cost, capacity to reach hidden populations, and potential for widespread scalability, further study is warranted. Specifically, additional research should identify desirable healthcare provider- and client-side characteristics of *CONSORT*, including acceptable and effective content of SMS messages, evaluate feasibility and acceptability among clients presenting for testing, and provide preliminary estimates of its efficacy.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Characteristics of study participants and their social networks

Panel A. Index respondents ¹	All participants (n=145)	Female barworkers (n=113)	Male porters (n=32)	p-value ²
Age	31 (8.0)	31 (7.9)	34 (8.3)	0.102
Education	62 (42.8)	45 (39.8)	17 (53.1)	0.225
	83 (57.2)	68 (60.2)	15 (46.9)	
Marital status	79 (54.5)	68 (60.2)	11 (34.4)	0.015
	66 (45.5)	45 (39.8)	21 (65.6)	
# of sexual partners (lifetime)	20 (13.8)	20 (17.7)	0 (0.0)	<0.001
	28 (19.3)	24 (21.2)	4 (12.5)	
	45 (31.0)	40 (35.4)	5 (15.6)	
	52 (35.9)	29 (25.7)	23 (71.9)	
# of sexual partners (past 12 months)	112 (77.2)	93 (82.3)	19 (59.4)	0.003
	19 (13.1)	14 (12.4)	5 (15.6)	
	14 (9.7)	6 (5.3)	8 (25.0)	
Self-reported HIV serostatus	141 (97.2)	109 (96.5)	32 (100.0)	0.576
	4 (2.8)	4 (3.5)	0 (0.0)	
# of HIV tests (lifetime)	10 (7.1)	6 (5.5)	4 (12.5)	0.084
	40 (28.4)	28 (25.7)	12 (37.5)	
	47 (33.3)	36 (33.0)	11 (34.4)	
	44 (31.2)	39 (35.8)	5 (15.6)	
Number of alters ³ named by the index	2 (1.4)	1 (0.9)	1 (3.1)	0.064
	20 (13.8)	17 (15.0)	3 (9.4)	
	62 (42.8)	48 (42.5)	14 (43.8)	
	39 (26.9)	33 (29.2)	6 (18.8)	
	9 (6.2)	6 (5.3)	3 (9.4)	
	8 (5.5)	3 (2.7)	5 (15.6)	
	5 (3.4)	5 (4.4)	0 (0.0)	
Panel B. Alters ^{1,3}	Alters of all participants (n=362)	Alters of female barworkers (n=267)	Alters of male porters (n=86)	p-value ²
Gender	200 (55.2)	178 (64.5)	22 (25.6)	<0.001
	Female			

Panel A. Index respondents ¹	All participants (n=145)	Female barworkers (n=113)	Male porters (n=32)	p-value ²
Relationship to the index				
Male	162 (44.8)	98 (35.5)	64 (74.4)	
Neighbor	15 (4.1)	11 (4.0)	4 (4.7)	0.123
Friend	118 (32.6)	82 (29.7)	36 (41.9)	
Co-worker	25 (6.9)	18 (6.5)	7 (8.1)	
Family member	145 (40.1)	119 (43.1)	26 (30.2)	
Partner	55 (15.2)	44 (15.9)	11 (12.8)	
Other	4 (1.1)	2 (0.7)	2 (2.3)	
Contact frequency with the index				
Weekly or less	94 (26.0)	73 (26.4)	21 (24.4)	0.779
Daily or almost daily	268 (74.0)	203 (73.6)	65 (75.6)	
Index knows a phone number of the alter				
No	15 (4.1)	11 (4.0)	4 (4.7)	
Yes	347 (95.9)	265 (96.0)	82 (95.3)	
Index ever talked with the alter about HIV				
No	141 (39.0)	107 (38.8)	34 (39.5)	0.900
Yes	221 (61.0)	169 (61.2)	52 (60.5)	

¹For age, numbers represent means (with standard deviations in parentheses); all other variables are categorical in nature and numbers represent counts (with percentages in parentheses).

²p-values describe the statistical significance of differences between female barworkers and male porters; significance was evaluated using a t-test (for age) and Fisher's exact tests for all other variables.

³Alters were defined as family members, friends, loved ones, co-workers, neighbors, or other persons ("alters") from whom index participants have sought advice or help, or with whom they have discussed important matters.

Table 2.

Feasibility and potential acceptability of CONSORT

	All participants (n=362)			Female barworkers (n=267)			Male porters (n=86)		
	n (%)	95% CI	p-value ²	n (%)	95% CI	p-value ²	n (%)	95% CI	p-value ²
Feasibility and acceptability among alters¹									
Index knows phone number of the alter	15 (4.1)	[2.5;6.7]	0.761	11 (4.0)	[2.2;7.0]	0.761	4 (4.7)	[1.8;11.4]	0.761
Index would personally give the alter an HIV testing invitation card	347 (95.9)	[93.3;97.5]	0.001	265 (96.0)	[93.0;97.8]	0.001	82 (95.3)	[88.6;98.2]	0.001
Very likely	235 (64.9)	[59.9;69.7]		170 (61.6)	[55.7;67.1]		65 (75.6)	[65.5;83.4]	
Somewhat likely	68 (18.8)	[15.1;23.1]		59 (21.4)	[17.0;26.6]		9 (10.5)	[5.6;18.7]	
Somewhat unlikely	38 (10.5)	[7.7;14.1]		35 (12.7)	[9.3;17.1]		3 (3.5)	[1.2;9.8]	
Not likely	21 (5.8)	[3.8;8.7]		12 (4.3)	[2.5;7.4]		9 (10.5)	[5.6;18.7]	
Index would send a confidential SMS message with an HIV testing invitation to the alter	144 (41.4)	[36.3;46.6]	0.332	106 (40.0)	[34.3;46.0]	0.332	38 (45.8)	[35.5;56.4]	0.332
Somewhat likely	66 (19.0)	[15.2;23.4]		55 (20.8)	[16.3;26.0]		11 (13.3)	[7.6;22.2]	
Somewhat unlikely	71 (20.4)	[16.5;24.9]		56 (21.1)	[16.6;26.4]		15 (18.1)	[11.3;27.7]	
Not likely	67 (19.3)	[15.5;23.7]		48 (18.1)	[13.9;23.2]		19 (22.9)	[15.2;33.0]	
Index's preference for personally giving an invitation card vs. sending a confidential SMS HIV testing invitation to alter's mobile phone	235 (67.7)	[62.6;72.4]	0.131	171 (64.8)	[58.8;70.3]	0.131	64 (77.1)	[67.0;84.8]	0.131
Confidential SMS	87 (25.1)	[20.8;29.9]		73 (27.7)	[22.6;33.3]		14 (16.9)	[10.3;26.3]	
Neither	15 (4.3)	[2.6;7.0]		13 (4.9)	[2.9;8.2]		2 (2.4)	[0.7;8.4]	
No preference	10 (2.9)	[1.6;5.2]		7 (2.7)	[1.3;5.4]		3 (3.6)	[1.2;10.1]	
Acceptability among index participants¹									
Index client: Would test after receiving a CONSORT message	31 (21.53)	[15.6;28.9]	0.991	24 (21.24)	[14.7;29.7]	0.991	7 (22.58)	[11.4;39.8]	0.991
Very likely	30 (20.83)	[15.0;28.2]		23 (20.35)	[14.0;28.7]		7 (22.58)	[11.4;39.8]	
Somewhat likely	25 (17.36)	[12.0;24.4]		20 (17.70)	[11.8;25.8]		5 (16.13)	[7.1;32.6]	
Somewhat unlikely	58 (40.28)	[32.6;48.4]		46 (40.71)	[32.1;49.9]		12 (38.71)	[23.7;56.2]	
Not likely									

Abbreviations: CONSORT—confidential social network referral for HIV testing; SMS—short message system message; CI—confidence interval

¹Numbers represent counts (with percentages in parentheses).

²p-values describe the statistical significance of differences between female barworkers and male porters; significance was evaluated using Fisher's exact tests. Confidence intervals around the estimated proportions were calculated using a method by Wilson (1927).