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ORIGINAL PAPER

Effects of a Short Message Service (SMS) Intervention on Reduction of HIV Risk Behaviours and Improving HIV Testing Rates Among Populations located near Roadside Wellness Clinics: A Cluster Randomised Controlled Trial in South Africa, Zimbabwe and Mozambique

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Abstract
Short Message Service (SMS) offers an innovative method of promoting sexual health to key and vulnerable populations who are users of mobile phones and are at high risk of HIV infection. This cluster randomised control trial tests the effectiveness of a SMS intervention in reducing HIV risk behaviours and improving HIV testing behaviours among truck drivers, sex workers and community residents located near Roadside Wellness Clinics (RWCs) in three southern African countries. The SMS arm received 35 HIV risk reduction and HIV testing SMSs over a 6-month period. The SMS intervention had no significant impact on sexual risk behaviours. However, participants in the SMS arm were more likely to have tested for HIV in the previous 6 months (86.1% vs. 77.7%; AOR 1.71, 95% CI 1.11–2.66). The results indicate that the general SMS intervention, which provide health promoting information, improved HIV testing rates in key and vulnerable populations in southern Africa.

Keywords Key populations · Sexual risk behaviour · Mobile-health · HIV testing

Introduction

HIV prevalence among key populations in southern Africa are estimated to be 10–20 times higher in comparison to general populations [1, 2]. More specifically, for sex workers HIV prevalence in 16 sub-Saharan African countries in 2012 was estimated at 37% [3]. Truck drivers who are considered to be a key population as they are disproportionately affected by the HIV epidemic in sub-Saharan Africa, in a 2003–2004 survey of 1896 long-distance truck drivers in South Africa, more than a quarter (26%) were HIV positive and only 38.2% had tested for HIV [4]. A 2009 study conducted in Mozambique in a clinic at a truck stop found that only a quarter of participants accepted HIV testing when offered and of those, 27% tested HIV positive [5]. A study at a truck stop in Inchope in Mozambique found an HIV prevalence of 15.4% among 328 long distance truck drivers [6]. These figures underscore the heightened HIV susceptability of truck drivers and sex workers in sub-Saharan Africa and the need for scaling up accessible and effective HIV intervention strategies.

Studies assessing the effectiveness of mobile-health (mHealth) interventions in Africa have provided substantial evidence for improving HIV outcomes and other chronic disease outcomes [7–10]. mHealth is defined as medical and

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public health practice supported by mobile devices (tablets, mobile phones, personal digital assistants and other wireless mobile devices) [11]. Studies conducted outside Africa focusing on key populations have demonstrated that mHealth interventions yield positive behavioural change in terms of reductions in unprotected sex acts and reduction in the number of non-primary partners amongst samples of African American adolescents [12], gay men in London and India [13, 14], drug users in China and Vietnam [15] and long distance truck drivers in India [16]. A mHealth intervention in the US indicated that HIV testing rates amongst HIV negative men more than doubled as compared to the control arm post the intervention [17].

A South African study targeting adults found that the receipt of 10 informational or motivational SMSs improved the uptake of HIV counselling and testing by 1.7-fold [18]. A 6 months Kenyan randomised control study that sought to increase HIV testing among women 18–24 years old through an (SMS) intervention found that within 6 months of follow-up, 67% of women from the intervention arm reported for HIV testing compared with 51% in the control arm [19]. A further study in Kenya [10] targeting sex workers revealed that a SMS intervention improved self testing for HIV.

The literature regarding the impact SMS interventions had on sexual risk behaviours is not as clear as the impact that SMS interventions have had on health service utilisation, specifically HIV testing and health facility attendance. A systematic review focusing on randomised controlled trials (RCTs) of sexual health interventions delivered by mobile technologies showed mixed results. Of the four studies that targeted sexual risk behaviours, only one study indicated that a SMS intervention improved condom usage among young people in Ireland attending a youth clinic. However, the sample was small and the findings were not statistically significant [20]. Another study not included in the systematic review, conducted among college students in China, showed that a SMS intervention was helpful in improving HIV knowledge, improving condom use and HIV testing behaviour [21]. A study in Los Angeles among Methamphetamine-using men who have sex with men showed that a SMS intervention reduced the number of unprotected anal intercourse acts with HIV positive partners [22]. Finally, a study exploring the efficacy of a SMS campaign to improve HIV knowledge and promote behaviour change among the general population in rural Uganda revealed limited positive sexual behaviour change [23].

The systematic review on mHealth technology conducted by Burns et al. [20] called for more high quality RCTs and a wider range of sexual behavioural measures to assess if SMS interventions can alter risky sexual behaviours. The literature review revealed a paucity of literature on the impact of SMS interventions in key populations and populations located in 'difficult- to-reach' and high HIV risk settings in sub-Saharan Africa. With this in mind, we conducted a RCT among populations (long distance truck drivers, sex workers and community residents) located near three Roadside Wellness Clinics (RWCs) located along major trucking routes in Mutare (Zimbabwe), Inchope, (Mozambique) and Bloemfontein (South Africa) to assess the efficacy of a SMS intervention in reducing HIV risk behaviours and increasing HIV testing rates.

Materials and Methods

Setting

The study was conducted in the vicinity of three RWCs run by the North Star Alliance (NSA) in South Africa (Bloemfontein), Zimbabwe (Forbes) and Mozambique (Inchope). NSA is an organisation providing health services to mobile populations located in remote areas across Africa, including sex workers, long distance truck drivers and residents residing near the clinics. These areas were known as hotspots areas for transmission of HIV. One clinic was located at Forbes, a border crossing between Mozambique and Zimbabwe; the second clinic was located at Inchope, located at the intersection of two major transport routes crossing Mozambique, and the third facility was near a truck stop at the intersection of major transport routes in Bloemfontein, South Africa. Previous research has indicated that resident and transient populations located close to major transport corridors are at higher risk for contracting HIV [24].

RWC data from 2014 to 2016 are reported for the three study sites [25]. Bloemfontein's RWC data (2014–2016) indicated that 12602 clients used the clinic, of whom 9% were community residents, (people who indicated that they lived in the area for more than 3 months, but did not self-identify as sex workers or long distance truck drivers), 88% were long distance truck drivers and 3% self-identified as sex workers. Data shows that 2853 of the clients had an HIV test with 78 (2.7% prevalence) testing HIV positive. In Forbes, the RWC's records show that from 2014 to 2016, 16056 individuals used the clinic, of whom 43% were community residents, 33% were long distance truck drivers, and 24% identified as sex workers. The Forbes RWC data show that 6316 people had an HIV test with 570 (9.0%) testing HIV positive. The Inchope RWC data indicates that from 2014 to 2016, 12949 clients used the clinic, with the majority being community residents (61%), 22% long distance truck drivers and 17% sex workers. Overall, 571 (4.8%) clients tested HIV positive of the 11822 clients who took an HIV test during this period. Given that there is no reliable data on the population sizes of long distance truck drivers, sex workers and community residents (the most common form of employment was clerical work, informal traders, construction work

and farm workers) near NSA sites between 2014 and 2016, denominators for HIV testing and HIV positive people is based on clinic attendance rates.

Recruitment

Long distance truck drivers and their assistants, sex workers and community residents who were near the RWCs (within a five-kilometre radius) between July 2016 and September 2017 were informed of the research and recruited for the study. Field workers introduced potential participants to the study. If interested, they were screened for study eligibility. The eligibility criteria included: (1) ≥ 18 years old, (2) self-identification as long distance truck driver including driver's assistant or a sex worker, or a community resident, (3) had to have one cell phone that is solely their phone, (4) expected to utilise the truck stop within 4–8 months after the baseline study, so that a follow-up interview could be conducted, (5) speak English or Portuguese, (6) able to read and sign a consent form, (7) able to receive a payment fee in the form of an air time voucher. Participants were informed that study participation involved the completion of one questionnaire on the day of recruitment (baseline) and one questionnaire approximately 6 months later. Participants were not informed about the specific research questions or the fact that they would be randomised to different study arms in order to avoid bias.

Randomisation and Interviews

Participants were interviewed within a 5-km radius of the three RWCs. Participants completed a baseline 20 min survey collecting demographic information, HIV testing history and sexual behaviours. Upon completing the baseline interview, the fieldworker opened a sealed envelope with the randomisation assignment. Participants were randomised to either the control arm or the SMS arm. Data was collected on electronic tablets and paper questionnaires. Participants received the equivalent of three United States Dollars airtime for completion of the baseline questionnaire and another ten United States Dollars airtime for completion of the second interview approximately 6 months later. Individuals in the SMS arm were then entered onto a SMS provider system within 2 days of completing the baseline survey.

Study Arms

Control Arm

Participants randomised to the control arm received basic HIV prevention information, verbally from the recruiters, (read from an information sheet) indicating importance of regular HIV testing and practicing safe sex.

SMS Arm

Participants randomised to the SMS arm received messages promoting regular HIV testing and advocating for safer sex practices. The SMS content was short and focused on promoting consistent condom use, reducing the number of sex partners and advocating for regular HIV testing. Acceptability of SMS content was tested through two focus groups among study populations at each site. Examples of messages included: "Protect yourself and your partners by regularly testing for STIs including HIV at your nearest clinic, you can live a healthy long life with HIV—getting tested is the first step" and "using condoms regularly will reduce your chances of contracting HIV and other STIs" (see Online Appendix 1 for all the messages sent).

Messages were sent out daily in the first week following recruitment and once weekly thereafter. The messages did not require participants to respond. The intervention consisted of 35 messages over a 29 week period (approximately 6 months). More than two-thirds (68%) of all the messages sent out were successfully delivered to the respondent's handset. Nearly a quarter (24%) of all the messages sent out expired before reaching the respondent's handset. This is caused by the handset being off or the handset being out of network reach. A small proportion (6%) of all the messages sent out remained undelivered. This is caused by the handset or subscriber identification module card being inactive. Two percent of participants had the wrong number recorded. Only one attempt was made by the service provider to deliver the message over a 48-h period. If the message was not delivered within this period, the SMS expired. According to the network operating companies, the mean number of messages received by the participants in the SMS arm was 17.9 (SD 10.1) and the median was 16. Messages were sent in English in Zimbabwe and South Africa and in Portuguese in Mozambique.

Sample Size and Power

We estimated that if self-reported behaviour and testing uptake as a result of the SMS intervention improved by 10% as experienced in similar studies [18], we would have 87% power to detect a 10% improvement in risk behaviours at a two-sided alpha of 0.05 with a minimum sample of 450 in each arm. The primary outcome was self-reported behaviour change over the two assessment periods.

Measures

The *socio-demographic characteristics* measured included current age, gender (male or female), marital status (married, cohabiting and unmarried), the type of study participant (sex worker, long distance truck driver or truck driver's assistant

and community resident), educational attainment (completed secondary school and did not complete secondary school) and study site (Bloemfontein, Forbes and Inchope).

The *HIV risk behaviours* measured included: condom use in the previous 6 months and condom use after alcohol consumption, with response options of always, sometimes and never used a condom. Consistent condom use was coded as 'always used a condom' and inconsistent condom use was coded 'sometimes used condoms'. Additional, HIV risk behaviour measures included engaging in sex under the influence of alcohol and engaging in sex in exchange of gifts or money [26]. We also asked for information on the type of sexual partner (husband or wife, regular partner, commercial sex partner or casual partner) of the participant.

HIV testing measures included whether respondents had ever tested for HIV and whether they had tested for HIV in the previous 6 months. Individuals were also asked about their HIV status and whether they had ever been diagnosed with a sexually transmitted infection.

The *knowledge, self-efficacy and perceptions* measures included HIV knowledge, which was measured by asking participants whether the following actions or steps can prevent the spread of HIV: using a condom, abstaining from sex and having only one sexual partner. The number of correct responses on the three items were summed into one index variable named HIV knowledge. Self-efficacy to practice safe sexual behaviour was measured using a scale consisting of six variables: can the participant talk about safe sex with a sexual partner, seek HIV testing on a regular basis, obtain condoms when needed, use a condom correctly, be faithful to his/her regular partner, always use a condom with his/her sexual partners (adapted from [27]). The response options were very unsure, unsure, sure and very sure, with a high score indicative of greater self-efficacy to prevent HIV. The Cronbach's Alpha for the scale is 0.7. The final measure was perceived risk for contracting HIV—a high score on this variable indicated that respondents did not see themselves at risk of contracting HIV.

Statistical analysis

Cross-tabulations were run for socio-demographic characteristics by randomisation arm. To assess the statistical significance of differences by randomisation arms, we used Pearson's Chi square tests for categorical variables and Mann–Whitney U tests and *t* tests for numeric variables where appropriate. HIV risk behaviours were compared using the baseline and follow-up data. Logistic Regression and Ordinary Least Squares Regression were used to assess the impact the SMSs had on HIV risk behaviours, HIV testing behaviour, knowledge relating to HIV, self-efficacy to practice safe sex and perceptions of their risk of contracting HIV while controlling for socio-demographic characteristics, sexual partnership type, study site and the corresponding baseline measure for the dependent variable. The same types of analyses were used for the SMS dosage analysis. All statistical tests were two sided at alpha = 0.05 and conducted using SPSS version 25.

Results

Description of the Sample

Between July 2016 and September 2017, 2079 participants were assessed for eligibility. 1783 participants were enrolled in the study (see Fig. 1). 492 respondents (49% were lost to follow-up) were analysed in the SMS arm and 457 (44% were lost to follow-up) were analysed in the control arm. Participants who could not be contacted after five attempts within a period of 2 weeks at the date that the follow-up interview should have occurred were regarded as lost to follow-up.

The majority of the sample were male (76.7%) and the largest proportion of respondents were aged between 36 and 49 years old (40.8%) with more than half married or cohabiting (51.4%). More than half the sample had incomplete secondary (high) schooling (61.0%). Most of the respondents were truck drivers or truck driver's assistants (74.8%) and respondents had on average, 8 years (SD: 7 years) experience in their profession. Baseline data indicated that respondents had spent on average 83 (SD 60) days away from home (nearly 3 months) in the past 6 months, although this varied by occupational category of the individual. The majority (79%) of respondents had sex after consuming alcohol, 68.7% used condoms inconsistently in the previous 6 months, 44.4% did not use a condom at last sex and 48.1% engaged in transactional sex. The majority (91.8%) of respondents had previously tested for HIV.

Table 1 indicates the difference in baseline characteristics of the respondents by study arm. Only statistically significant differences by study arm are reported here. Respondents in the control arm were more likely not to have completed secondary schooling (57.1% vs. 65.6%, $\chi^2(1) = 13.31$; $p < 0.01$) than respondents in the SMS arm. Individuals in the SMS arm were more likely to spend time away from home in the previous 6 months than individuals in the control arm (mean 89 vs. 77 days respectively, $t(813) = 2.86$; $p < 0.01$). Respondents in the SMS arm were slightly more likely to have never engaged in transactional sex than respondents in the control arm (54.4% vs. 49.0% respectively; $\chi^2(1) = 4.93$, $p = 0.03$).

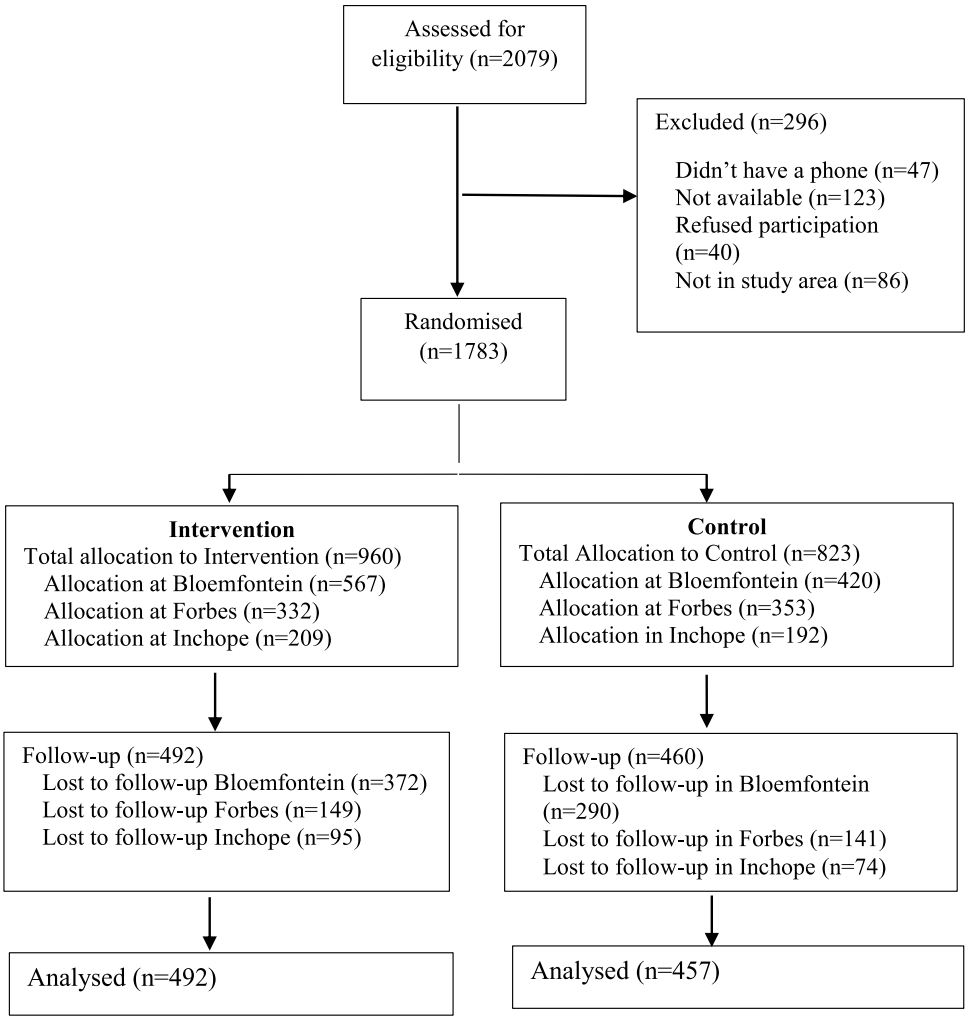

Fig. 1 Retention rates by study arms

Impact of Intervention

In the intention to treat analysis there were no significant differences by study arm with regards to inconsistent condom use in the previous 6 months (67.6% vs. 68.0%; AOR 0.95, 95% CI 0.67–1.33, $p=0.60$), not using a condom at last sex (57.4% vs. 59.8%; AOR 0.77, 95% CI 0.56–1.05, $p=0.08$) and engaging in transactional sex (40.4% vs. 45.0%; AOR 1.30, 95% CI 0.89–1.91, $p=0.15$).

Respondents in the SMS arm had higher odds of having ever tested for HIV at follow up (95.6% vs. 88.6%; AOR 5.17, 95% CI 1.44–18.54, $p=0.01$), were more likely to have tested for HIV in the previous 6 months (86.1% vs. 77.7%; AOR 1.72, 95% CI 1.11–2.66, $p=0.02$) and had better HIV prevention knowledge at the follow-up interview (mean 2.83 vs. 2.75; B 0.07, 95% CI < 0.01–0.14, $p=0.04$). There were no statistically differences by study arm in relation to self-efficacy and HIV risk perceptions (Table 2).

A SMS dosage analysis in terms of HIV prevention knowledge, self-efficacy to practice safe sex, HIV risk perceptions, HIV testing behaviours and HIV risk behaviours was undertaken. We divided the sample up into those that received fewer than 18 messages and those that received 18 or more messages as this was half the number of messages that individuals should have received. SMS dosage ($0 \leq 18$ messages, $n=720$; $1=$ received ≥ 18 messages received, $n=243$) revealed no impact on HIV risk behaviours. However, receiving more than 18 messages did increase the likelihood of an individual undergoing an HIV test in the previous 6 months (AOR 13.13, 95% CI 1.74–99.94, $p=0.01$). This is a similar result to the intention to treat analysis above (Table 3).

Discussion

The RCT revealed that the SMS intervention had no effect on reducing risky sexual behaviour. The lack of efficacy of the SMS intervention on reducing sexual risk behaviours affirms previous research [20, 23, 28]. The reasons for poor outcomes on sexual risk behaviour, as documented in previous studies, include: inability to give participants options either

Table 1 Socio-demographic characteristics at baseline

	SMS		Control		Total		Statistic
	N	%	N	%	N	%	
Age							
18–24 years	83	9.4	96	12.3	179	10.7	χ^2 (3) = 4.63;
25–35 years	335	37.8	293	37.5	628	37.6	$p = 0.20$
36–49 years	375	42.3	305	39.0	680	40.8	
50–69 years	93	10.5	88	11.3	181	10.9	
Sex							
Male	752	78.5	611	74.7	1363	76.7	χ^2 (1) = 3.58;
Female	206	21.5	207	25.3	413	23.3	$p = 0.06$
Single	431	46.2	387	48.4	818	47.2	
Marital							
Married/cohabiting	491	52.6	400	50.0	891	51.4	$\chi^2(2) = 1.63$;
Other	11	1.2	13	1.6	24	1.4	$p = 0.44$
Occupation							
Truck driver/assist	720	76.5	586	72.8	1306	74.8	$\chi^2(2) = 5.69$;
Sex worker	167	17.7	179	22.2	346	19.8	$p = 0.06$
Community members	54	5.7	40	5.0	94	5.4	
Schooling							
Incomplete school	545	57.1	533	65.6	1078	61.0	χ^2 (1) = 13.31;
Complete school	410	42.9	280	34.4	690	39.0	$p < 0.01$
Years in occupation							
Mean (SD)	471	8(7)	424	8(7)	895	8(7)	t(893) = 1.31; $p = 0.19$
Median (IQR)	471	6(3–12)	424	6(3–10)	895	6(3–11)	$U = 92870$; $p = 0.07$
Average number days away from home over 6 months							
Mean (SD)	430	89(60)	385	77(60)	815	83(61)	t(813) = 2.86; $p < 0.01$
Median (IQR)	430	91(28–145)	385	84(14–132)	815	90(18–138)	$U = 72792$; $p < 0.01$
Nationality of participant							
Zimbabwean	238	31.9	259	44.8	497	37.5	Too few observations in some categories
South African	319	42.7	168	29.1	487	36.8	
Mozambican	173	23.2	138	23.9	311	23.5	
Malawian	7	0.9	8	1.4	15	1.1	
Zambian	3	0.4	2	0.3	5	0.4	
Mosotho	4	0.5	1	0.2	5	0.4	
Nigerian	2	0.3	1	0.2	3	0.2	
Namibian	1	0.1	0	0.0	1	0.1	
Motswana	0	0.0	1	0.2	1	0.1	
Condom use in the last 6 mo.							
Consistent	281	29.9	265	33.0	546	31.3	χ^2 (1) = 1.94; $p = 0.16$
Inconsistent	659	70.1	538	67.0	1197	68.7	
Condom use at last sex							
No	410	43.9	362	45.1	772	44.4	χ^2 (1) = 0.29; $p = 0.59$
Yes	525	56.1	440	54.9	965	55.6	
Engaged in transactional sex							
Never	506	54.4	390	49.0	896	51.9	χ^2 (1) = 4.93; $p = 0.03$
Always/sometimes	425	45.6	406	51.0	831	48.1	

Table 1 (continued)

	SMS		Control		Total		Statistic
	N	%	N	%	N	%	
Ever tested for HIV							
Yes	878	92.0	748	91.6	1626	91.8	χ^2 (1) = 0.19; p = 0.67
No	74	7.8	68	8.3	142	8.0	
HIV positive self-report							
Yes	80	9.8	67	9.5	147	9.7	χ^2 (1) = 0.02; p = 0.88
No	739	90.2	636	90.5	1375	90.3	
STI infection in previous 6 mo.							
Yes	53	5.6	38	4.7	91	5.2	χ^2 (1) = 0.67; p = 0.41
No	901	94.4	772	95.3	1673	94.8	

Table 2 HIV risk behaviour, HIV testing behaviours, knowledge and attitude outcomes by intervention status under intention-to-treat (i.e., by randomisation assignment) at baseline and follow-up

	Baseline		Follow-up		Adjusted effect estimate		
	SMS	Con	SMS	Con	OR/B	95% CI	Sig.
HIV risk behaviours							
Inconsist. condom use last 6 mo. N(%)	345/479 (72.0%)	299/447 (66.9%)	325/481 (67.6%)	302/444 (68.0%)	0.91	0.63–1.31	0.60
Didn't use condom at last sex N(%)	299/475 (62.9%)	245/445 (55.1%)	276/481 (57.4%)	265/443 (59.8%)	0.74	0.53–1.03	0.08
Transact. sex sometimes/always N(%)	191/471 (40.6%)	203/439 (46.2%)	195/483 (40.4%)	201/447 (45.0%)	1.35	0.89–2.03	0.15
HIV testing behaviours							
Ever tested for HIV N(%)	96/114 (84.2%)	101/115 (87.8%)	108/113 (95.6%)	101/114 (88.6%)	5.17	1.44–18.54	0.01
Testing for HIV previous 6 mo. N(%)[3]	n/a	n/a	323/375 (86.1%)	265/341 (77.7%)	1.72	1.11–2.66	0.02
Knowledge, attitudes and perceptions							
Risk perceptions Mean (SD)[a]	3.0 (0.9)	2.9 (1.0)	3.2 (0.8)	3.0 (0.9)	0.02	− 0.05 to 0.12	0.37
Self-efficacy Mean (SD)[a]	19.3 (3.3)	19.0 (3.2)	14.7 (6.8)	13.3 (6.7)	− 0.02	− 0.28 to 0.23	0.85
HIV knowledge Mean (SD)[a]	2.6 (0.8)	2.6 (0.8)	2.8 (0.6)	2.7 (0.4)	0.07	<0.01–0.14	0.04

Full adjusted multiple logistic or OLS regression models with controls see Online Appendix 2 Tables S1–S8. Control variables include the baseline measure for the corresponding outcome variable, age of the respondent, sex of the respondent, type of occupation, level of schooling achieved, study site and type of sexual partner

[a]The sample size varies between 348 and 372 for each category in the continuous variables

to have text messages or voice messages as the medium of communication [29]; inconvenient times when messages are administered, inadequate or poor content, short-term follow-up period of less than 12 months and inadequate feedback from the participants, and lack of linkage to services [9, 10, 30–32]. In our study, SMS messages pertaining to sexual risk behaviours were generic and non-interactive. Higher message specificity and interactive (personalized) messaging on increasing self-efficacy for negotiating condom use may have produced better outcomes.

The SMS intervention however increased self-reported HIV testing in the previous 6 months, a finding supported by previous research [9, 10, 13, 18, 19, 33]. Given the high rates of testing in this sample at baseline, SMS reminders may have served more as a form of behavioural optimization of HIV testing. These results are important given that

Table 3 HIV risk behaviours, HIV testing uptake, HIV knowledge, perceptions and self-efficacy outcomes by SMS dosage

	Inconsist. condom use last 6 mo. (AOR, 95% CI)	Didn't use condom at last sex (AOR, 95% CI)	Transact. sex sometimes/always (AOR, 95% CI)
≥18 messages received (vs. < 18 messages)	1.58 (0.86–2.91)	0.84 (0.47–1.52)	0.12 (0.02–1.02)
Controls	Yes	Yes	Yes
N	433	429	426
	Tested in previous 6 mo. (AOR, 95% CI)	Risk perceptions (B, 95% CI)	Self-efficacy (B, 95% CI)
≥18 messages received (vs. < 18 messages)	13.13* (1.74–99.40)	0.03 (−0.11 to 0.22)	0.01 (−0.03 to 0.08)
Controls	Yes	Yes	Yes
N	340	390	437
			HIV knowledge (B, 95% CI)
≥18 messages received (vs. < 18 messages)			0.01 (−0.11 to 0.13)
Controls			Yes
N			398

Full adjusted multiple logistic and OLS regression models with controls see Online Appendix 2 Tables S9–S15. Control variables include the baseline measure for the corresponding outcome variable, age of the respondent, sex of the respondent, type of occupation, level of schooling achieved, study site and type of sexual partner

regular HIV testing reduces HIV risk behaviours and HIV incidence, reduces HIV-related stigma and promptly links HIV positive individuals to available services [34–36]. Also, it has been argued that those individuals who are aware that they are HIV positive are more likely to use a condom than those who are unaware of their HIV status [37]. HIV testing amongst high-risk populations (trucker drivers and sex workers) is vital [38] and this study shows that bulk health promotional SMS reminders can be a cheap and cost effective way to increase these behaviours amongst these hard-to-access and vulnerable populations.

The general text messages with little adaption to context demonstrates the viability of the medium regarding its ability to educate and inform groups of people on certain aspects of sexual health. In view of the current international and regional health agenda to increase HIV treatment rates among key and vulnerable populations [38], these findings add weight to the 'scaling-up of SMS technologies' for basic HIV prevention.

Limitations

There are a number of limitations concerning this RCT. First, the ability to retain study respondents was hampered by their mobility, hence the low response rate at follow-up. Second, it was difficult to discern whether the respondents read and understood the messages or they just deleted the messages. Third, the HIV risk behaviour outcomes are all subject to social-desirability bias due to the self-reported nature of these items. Forth, the dosage analysis was underpowered, making it difficult to demonstrate statistically significant differences between the control and SMS arm. Fifth, in certain instances there was insufficient variation to include all the control variables, therefore certain controls were excluded from the analysis. Sixth, there was no disaggregation of results by population i.e. truckers, sex workers and community members and whether there was geographical variations within the results, due to the small sample size. Finally, the recruitment of participants within a 5-kilometer radius from the NSA clinic may have biased the sample, which may be one reason for the very high rates of HIV testing seen at baseline.

Conclusion

Results from this RCT show that a generic SMS intervention, which provides health-promoting information can optimize current behaviours (HIV testing) amongst high-risk populations in southern Africa. However, as regards it promotional effects for reducing risky sexual behaviours in high HIV risk populations, more contextually based research is required.

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Compliance with Ethical Standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Study procedures were approved by the University of KwaZulu-Natal Institutional Review Board (BFC483/14) and by national ethical committees (Medical Research Council of Zimbabwe and National Health Bioethics Committee for Mozambique) in each of the three countries.

Informed Consent Informed consent was obtained from all individual participants included in the study.

References

1. Kharsany ABM, Karim QA. HIV infection and AIDS in Sub-Saharan Africa: current status, challenges and opportunities. Open AIDS J. 2016;10:34–48.
2. The Joint United Nations Programme on HIV/AIDS. UNAIDS Data 2017. 2017. http://www.unaids.org/en/resources/documents/2017/2017_data_book. Accessed 1 Feb 2019.
3. The Joint United Nations Programme on HIV/AIDS. The Gap Report 2014: Sex Workers. 2014. http://www.unaids.org/en/resources/documents/2014/Sexworkers. Accessed 1 Feb 2019.
4. Delany-Moretlwe S, Bello B, Kinross P, Oliff M, Chersich M, Kleinschmidt I, et al. HIV prevalence and risk in long-distance truck drivers in South Africa: a national cross-sectional survey. Int J STD AIDS. 2014;25(6):428–38.
5. Lafort Y, Geelhoed D, Cumba L, Lázaro CDDM, Delva W, Luchters S, et al. Reproductive health services for populations at high risk of HIV: performance of a night clinic in Tete province, Mozambique. BMC Health Serv Res. 2010;10(1):144.
6. Botão C, Horth RZ, Frank H, Cummings B, Inguane C, Sathane I, et al. Prevalence of HIV and associated risk factors among long distance truck drivers in Inchope, Mozambique, 2012. AIDS Behav. 2016;20(4):811–20.
7. Catalani C, Philbrick W, Fraser H, Mechael P, Israelski DM. mHealth for HIV treatment & prevention: a systematic review of the literature. Open AIDS J. 2013;7:17.
8. Mbuagbaw L, Mursleen S, Lytvyn L, Smieja M, Dolovich L, Thabane L. Mobile phone text messaging interventions for HIV and other chronic diseases: an overview of systematic reviews and framework for evidence transfer. BMC Health Serv Res. 2015;15(1):33.
9. Kelvin EA, George G, Mwai E, Nyaga E, Mantell JE, Romo ML, et al. Offering self-administered oral HIV testing to truck drivers in Kenya to increase testing: a randomized controlled trial. AIDS Care. 2018;30(1):47–55.
10. Kelvin E, George G, Mwai E, Kinyanjui S, Romo M, Odhiambo J, et al. A randomized controlled trial to increase HIV testing demand among female sex workers in kenya through announcing the availability of HIV self-testing via text message. AIDs Behav. 2018;1–10
11. Tomlinson M, Rotheram-Borus MJ, Swartz L, Tsai AC. Scaling up mHealth: where is the evidence? PLoS Med. 2013;10(2):e1001382.
12. Cornelius JB, Dmochowski J, Boyer C, Lawrence JS, Lightfoot M, Moore M. Text-messaging-enhanced HIV intervention for African American adolescents: a feasibility study. J Assoc Nurses AIDS Care. 2013;24(3):256–67.
13. Agarwal A, Hamdallah M, Swain SN, Mukherjee S, Singh N, Mahapatra S, et al. Implementation of a confidential helpline for men having sex with men in India. JMIR mHealth and uHealth. 2015;3(1).
14. Goedel WC, Mitchell JW, Krebs P, Duncan DT. Willingness to use mobile phone apps for HIV prevention among men who have sex with men in London: web-based survey. JMIR mHealth uHealth. 2017;5(10).
15. Hammett TM, Des Jarlais D, Johnston P, Kling R, Ngu D, Liu W, et al. HIV prevention for injection drug users in China and Vietnam: policy and research considerations. Global Public Health. 2007;2(2):125–39.
16. Prem Kumar S, Kumar GA, Poluru R, Schneider JA, Dandona L, Vemu L, et al. Contact with HIV prevention programmes & willingness for new interventions among truckers in India. Indian J Med Res. 2013;137(6):1061–71.
17. Bourne C, Knight V, Guy R, Wand H, Lu H, McNulty A. Short message service reminder intervention doubles sexually transmitted infection/HIV re-testing rates among men who have sex with men. Sex Transm Infect. 2011;87(3):229–31.
18. de Tolly K, Skinner D, Nembaware V, Benjamin P. Investigation into the use of short message services to expand uptake of human immunodeficiency virus testing, and whether content and dosage have impact. Telemed e-Health. 2012;18(1):18–23.
19. Njuguna N, Ngure K, Mugo N, Sambu C, Sianyo C, Gakuo S, et al. The effect of human immunodeficiency Virus prevention and reproductive health text messages on human immunodeficiency virus testing among young women in rural Kenya: a pilot study. Sex Transm Dis. 2016;43(6):353.
20. Burns K, Keating P, Free C. A systematic review of randomised control trials of sexual health interventions delivered by mobile technologies. BMC Public Health. 2016;16(1):778.
21. Deng L, Geng W, editors. Effects of short message service on HIV prevention among young college students. In: IEEE 8th international conference on information technology in medicine and education (ITME) 2016.
22. Reback CJ, Grant DL, Fletcher JB, Branson CM, Shoptaw S, Bowers JR, et al. Text messaging reduces HIV risk behaviors among methamphetamine-using men who have sex with men. AIDS Behav. 2012;16(7):1993–2002.
23. Chib A, Wilkin H, Ling LX, Hoefman B, Van Biejma H. You have an important message! Evaluating the effectiveness of a text message HIV/AIDS campaign in Northwest Uganda. J Health Commun. 2012;17(sup1):146–57.
24. Crush J, Williams B, Gouws E, Lurie M. Migration and HIV/AIDS in South Africa. Dev S Afr. 2005;22(3):293–318.
25. North Star Alliance. Key figures 2016. http://www.northstar-alliance.org/key-figures/ Accessed 1 Feb 2019.
26. Jewkes R, Dunkle K, Nduna M, Shai NJ. Transactional sex and HIV incidence in a cohort of young women in the stepping stones trial. J AIDS Clin Res. 2012;3(5).

27. Smith KW, McGraw SA, Costa LA, McKinley JB. A self-efficacy scale for HIV risk behaviors: development and evaluation. AIDS Educ Prev. 1996.
28. Cole-Lewis H, Kershaw T. Text messaging as a tool for behavior change in disease prevention and management. Epidemiol Rev. 2010;32(1):56–69.
29. Brody C, Tuot S, Chhoun P, Swendenman D, Kaplan KC, Yi S. Mobile Link–a theory-based messaging intervention for improving sexual and reproductive health of female entertainment workers in Cambodia: study protocol of a randomized controlled trial. Trials. 2018;19(1):235.
30. De Leon E, Fuentes LW, Cohen JE. Characterizing periodic messaging interventions across health behaviors and media: systematic review. J Med Internet Res. 2014;16(3).
31. Siedner MJ, Lankowski AJ, Kanyesigye M, Bwana MB, Haberer JE, Bangsberg DR. A combination SMS and transportation reimbursement intervention to improve HIV care following abnormal CD4 test results in rural Uganda: a prospective observational cohort study. BMC Med. 2015;13(1):160.
32. Sullivan PS, Jones J, Kishore N, Stephenson R. The roles of technology in primary HIV prevention for men who have sex with men. Curr HIV/AIDS Rep. 2015;12(4):481–8.
33. Ybarra ML, Prescott TL, Phillips GL, Bull SS, Parsons JT, Mustanski B. Pilot RCT results of an mHealth HIV prevention program for sexual minority male adolescents. Pediatrics. 2017;140(1):e20162999.
34. Coates TJ, Kulich M, Celentano DD, Zelaya CE, Chariyalertsak S, Chingono A, et al. Effect of community-based voluntary counselling and testing on HIV incidence and social and behavioural outcomes (NIMH Project Accept; HPTN 043): a cluster-randomised trial. Lancet Global Health. 2014;2(5):e267–77.
35. Young SD, Hlavka Z, Modiba P, Gray G, Van Rooyen H, Richter L, et al. HIV-related stigma, social norms and HIV testing in Soweto and Vulindlela, South Africa: NIMH Project Accept (HPTN 043). J Acquir Immune Defic Syndr. 2010;55(5):620.
36. Van Rooyen H, Barnabas RV, Baeten JM, Phakathi Z, Joseph P, Krows M, et al. High HIV testing uptake and linkage to care in a novel program of home_based HIV counseling and testing with facilitated referral in KwaZulu-Natal, South Africa. J Acquir Immune Defic Syndr. 2013;64(1):e1.
37. Rosenberg NE, Westreich D, Bärnighausen T, Miller WC, Behets F, Maman S, et al. Assessing the effect of HIV counseling and testing on HIV acquisition among South African youth. AIDS (London, England). 2013;27(17):2765.
38. WHO. Consolidated guidelines on HIV prevention, diagnosis, treatment and care for key populations–2016 update: World Health Organization. 2016.