UCD GEARY INSTITUTE FOR PUBLIC POLICY
DISCUSSION PAPER SERIES

Impact of a text messaging program on adolescent reproductive health: a cluster-randomized trial in Ghana

Slawa Rokicki
Interfaculty Initiative in Health Policy, Harvard University
Geary Institute for Public Policy, University College Dublin

Jessica Cohen
Department of Global Health and Population, Harvard T.H. Chan School of Public Health

Joshua A. Salomon
Department of Global Health and Population, Harvard T.H. Chan School of Public Health

Günther Fink
Department of Global Health and Population, Harvard T.H. Chan School of Public Health

Geary WP2017/02
January 12, 2017

Impact of a Text Messaging Program on Adolescent Reproductive Health: A Cluster–Randomized Trial in Ghana*

Slawa Rokicki[1], PhD, Jessica Cohen[2], PhD, Joshua A. Salomon[2], PhD, and Günther Fink[2], PhD

Abstract

Objectives. To evaluate whether text-messaging programs can improve reproductive health among adolescent girls in low- and middle-income countries.

Methods. We conducted a cluster–randomized controlled trial among 756 female students aged 14 to 24 years in Accra, Ghana, in 2014. We randomized 38 schools to unidirectional intervention (n=12), interactive intervention (n=12), and control (n=14). The unidirectional intervention sent participants text messages with reproductive health information. The interactive intervention engaged adolescents in text-messaging reproductive health quiz games. The primary study outcome was reproductive health knowledge at 3 and 15 months. Additional outcomes included self-reported pregnancy and sexual behavior. Analysis was by intent-to-treat.

Results. From baseline to 3 months, the unidirectional intervention increased knowledge by 11 percentage points (95% confidence interval [CI]=7, 15) and the interactive intervention by 24 percentage points (95% CI=19, 28), from a control baseline of 26%. Although we found no changes in reproductive health outcomes overall, both unidirectional (odds ratio [OR]=0.14; 95% CI=0.03, 0.71) and interactive interventions (OR=0.15; 95% CI=0.03, 0.86) lowered odds of self-reported pregnancy for sexually active participants.

---

* Published online at: http://ajph.aphapublications.org/doi/abs/10.2105/AJPH.2016.303562

[1] Interfaculty Initiative in Health Policy, Harvard University
Geary Institute for Public Policy, University College Dublin. Email: slawa.rokicki@ucd.ie

[2] Department of Global Health and Population, Harvard T.H. Chan School of Public Health

Conclusions. Text-messaging programs can lead to large improvements in reproductive health knowledge and have the potential to lower pregnancy risk for sexually active adolescent girls.

Keywords: reproductive health, sexual education, adolescent health, mobile health, text messaging, global health

INTRODUCTION

More than 13 million adolescent girls give birth each year, and over 95% of these births occur in low- and middle-income countries (LMICs).[1] Adolescent pregnancies are associated with an increased risk of unsafe abortion[2], low birth weight and preterm delivery[3], birth complications[4], child stunting[5], and early school exit and social stigmatization for adolescent mothers.[6] Despite the large number of risk factors associated with teenage pregnancies, reproductive health knowledge and the adoption of modern contraception remain low in many developing countries.[7,8] In many countries in sub-Saharan Africa, more than 50% of unmarried, sexually active 15- to 19-year-old adolescents have an unmet need for modern contraception.[2,9]

Over the past 10 years, mobile phone access has skyrocketed in LMICs, from 22 subscriptions per 100 people in 2005 to 90 in 2014.[10] Text-messaging programs offer a promising new platform to improve sexual and reproductive health, in particular among adolescents, by providing information in a private and confidential way. The past decade has seen a rapid rise in text-messaging programs that aim to improve health[11–13]; however, systematic reviews have consistently found a dearth of high-quality peer-reviewed studies examining outcomes of these programs in LMICs.[14–17] Despite a large number of recent projects leveraging mobile technology among adolescent populations in LMICs, none of these employs a randomized trial design to provide evidence of effectiveness.[18–23]

To examine the potential of text-messaging sexual-education programs to improve adolescent reproductive health, we conducted a randomized controlled trial in Ghana, investigating the effectiveness of both 1-way and 2-way text-messaging programs on knowledge and sexual behavior. Ghana provides an ideal setting for this study both because of the high rates of cell phone access (115 mobile phone subscriptions per 100 people in 2014)[10] and because of the large gaps in adolescents' reproductive health knowledge.

METHODS

We conducted this cluster–randomized trial in Accra, Ghana. According to the most recent estimates, half of Ghanaian women have sexual intercourse before the age of 18 years, but less than a third of sexually active unmarried girls aged 15 to 19 years use any form of modern contraception.[24] The prevalence of adolescent pregnancy remains high:

42% of sexually experienced 15–19-year-old girls report previous pregnancies, with 3 in 5 births classified as unintended.[25] Reproductive health knowledge is low: 56% of Ghanaian female adolescents consider washing after sexual intercourse an option to prevent pregnancy and 62% are not aware that a girl can get pregnant if she has sex while standing up.[26]

The sampling frame for the study was provided by the 2012–2013 Ghana Education Service Register of Secondary Schools in Greater Accra. The primary sampling unit for the study was secondary schools. We restricted sampling to day schools (we excluded boarding schools). Within schools, we restricted sampling to girls aged 14 to 24 years. Participants gave written consent, with those aged younger than 18 years obtaining parental consent, and were informed that they could exit the study at any time.

We randomized 38 schools to unidirectional intervention (n=12), interactive intervention (n=12), and the control group (n=14). Randomization was based on a computer-generated random number draw by the principal investigator. We stratified randomization by school category (a measure of quality designated by the Ghana Education Service) and by whether the school had a home economics class. Study participants and data collection staff could not be masked because the intervention required overt participation. We used a cluster design to encourage communication about the intervention among participants in the same school, with the objective of reducing social stigma and increasing social support for discussing sexual health issues.

Recruitment

We recruited participants between January 15 and February 28, 2014. We visited schools to secure agreement of the headmaster or headmistress and to select a specific class within the school. All chosen classes were in their second year of senior secondary school (similar to grade 11 in the United States). We chose classes with the objective of maximizing the number of girls with the following process. If a home economics class was offered at the school, we chose the home economics class for the study because most students studying home economics in Ghana are female; if a home economics class was not

offered, the investigators worked with the school head to choose a class that had a large number of female students.

We invited female students in the chosen class of each school to participate in the study. Girls who refused consent and all boys were asked to step outside for the duration of the study visit. Participants in all groups were told they would receive "health messages" on their phones, including such topics as reproductive health or malaria. Participants used their own mobile phones or could use a family member's phone. Participants without phones were eligible to be enrolled in the trial; however, phones were not provided. After enrollment, participants in the interactive intervention group received a brief training on how to respond to the quiz questions.

Interventions

We designed the study to evaluate the effectiveness of 2 interventions. As part of the unidirectional intervention, participants were sent 1 reproductive health message via text message once a week. These messages focused on pregnancy prevention and contained information on topics of reproductive anatomy, pregnancy, sexually transmitted infections (STIs), and contraception including male condoms, female condoms, birth control pills, and emergency contraception (see Appendix Table A for complete content). Message content was generated after extensive focus groups with young adults before the launch of the study, with the goal of understanding the most popular sexual health topics of interest, as well as guidance from the Ghana Health Service Health Promotion Unit, who edited wording and approved appropriateness of the content for this age group.

As part of the interactive intervention, participants were not sent any information initially, but were instead sent 1 multiple-choice quiz question via text message each week to which they were invited to respond free of charge. Upon responding, participants immediately received a confirmatory text message informing them whether they answered correctly along with the correct answer and additional information, which corresponded to the information provided in the unidirectional intervention. During the course of the week, participants were sent up to 2 reminder messages encouraging them to respond if they had not yet responded. Participants who never responded were sent a text message with the correct answer and the additional information at the end of the week. For every 2 correct

responses, participants were sent an airtime credit reward of 1 GHS (US$0.38). Airtime credit rewards were sent at the end of the week, along with a message informing participants of how many questions they had correctly answered and encouraging them to continue participating.

The control group participants were sent placebo messages once a week with information about malaria. All programs ran for 12 weeks.

As part of the intervention, the unidirectional and interactive groups also received 4 extra tips about the effectiveness of condoms, the benefits of talking with their boyfriend about reproductive health, and the existence of a free public hotline number that they could call for reproductive health information (sent twice). This was done as a means of increasing access and communication of reproductive health information. After the 3-month follow-up, participants in both intervention and control arms were offered a 30- to 45-minute lecture about reproductive health by a nurse recruited by the Alliance for Reproductive Health Rights, a Ghanaian nongovernmental organization.

All messages were in English, the language of secondary school instruction in Ghana, and automatically sent to participants through a computerized system. If a message was not delivered, it was resent. Study staff maintained a record of all incoming and outgoing text messages with participants.

Procedures and Outcomes

Participants completed a written baseline questionnaire, a follow-up questionnaire 3 months later, and a second follow-up questionnaire 15 months after baseline. Study staff proctored the questionnaires under test-taking conditions. Participants provided demographic information at baseline. Reproductive health knowledge was recorded at baseline and at both the 3-month and 15-month follow-ups. Information on sexual behavior and pregnancies was collected only at the 15-month follow-up. Participants completed self-administered questionnaires at baseline and the 3-month follow-up on paper; at the 15-month follow-up, they self-administered the questionnaire on tablet computers to maximize privacy for individual responses about sexual behavior.

The primary outcome was reproductive health knowledge. Participants completed a quiz with 24 true-or-false questions at both the 3-month and 15-month follow-ups (see

Appendix Table B for details). At 15 months, we additionally evaluated the impact of the interventions on self-reported pregnancy, sexual activity, and contraceptive use (see Appendix Table C for definitions of all outcome variables).

Statistical analysis

The study was powered to detect an improvement of 15 percentage points in the knowledge score with power equal to 0.9 and an α of 0.05 in pairwise comparisons between the control arm and each of the 2 intervention arms. This calculation was based on an average of 30 participants in 12 schools in each arm, and an intraclass correlation coefficient of 0.05 (a design effect DEFF of 2.5).

We used linear regression models (ordinary least squares) to estimate intent-to-treat effects on knowledge and multilevel logistic regression models for self-reported pregnancy and sexual behavior outcomes. For age at sexual debut, we used a linear regression model. We estimated two multivariable regression models for each outcome: the first adjusting only for stratification variables, and the second additionally adjusting for baseline individual- and school-level characteristics, including age, ethnicity, religion, mother's education, father's education, school size, and baseline knowledge.

For linear regression models, standard errors were clustered at the school level to correct for within-school correlation of outcomes. Logistic regression models included school random effects. We used R (version 3.1.1; R Foundation, Vienna, Austria) for all analyses. The study design was registered on ClinicalTrials.gov (NCT02031575).

RESULTS

A total of 38 schools were eligible for randomization (Figure 1). After randomization, we found 3 schools to be ineligible (they were boarding schools) and 1 refused on the basis of time constraints. The final sample included 34 schools with 12 schools assigned to the unidirectional intervention, 10 schools assigned to the interactive intervention, and 12 schools assigned to control group. A total of 756 participants enrolled in the study, of which 716 (95%) were successfully followed up at 3 months and 721 (95%) were successfully followed up at 15 months. Of those participants followed up at 3 months, 99% had provided a phone number at baseline and 83% claimed to have received at least 1

text message. Participants who used a family member's phone were less likely to report receiving messages than those who owned a phone (71% compared with 86%, respectively). In the interactive group, weekly response rates to the quiz questions remained relatively stable, ranging from 64% to 70% over the 12-week intervention duration. Table 1 shows baseline demographic characteristics and knowledge scores, which were evenly distributed among the groups.

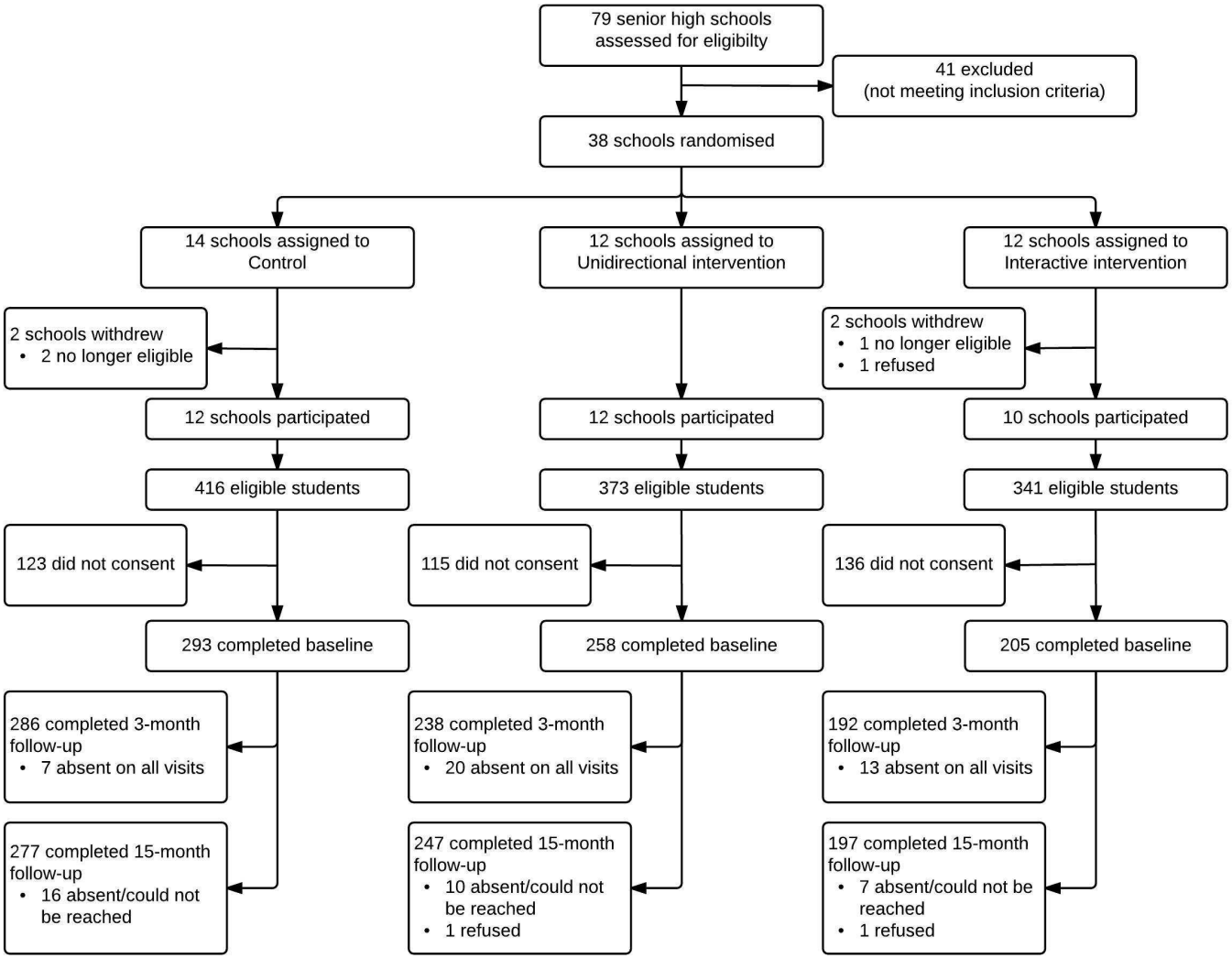


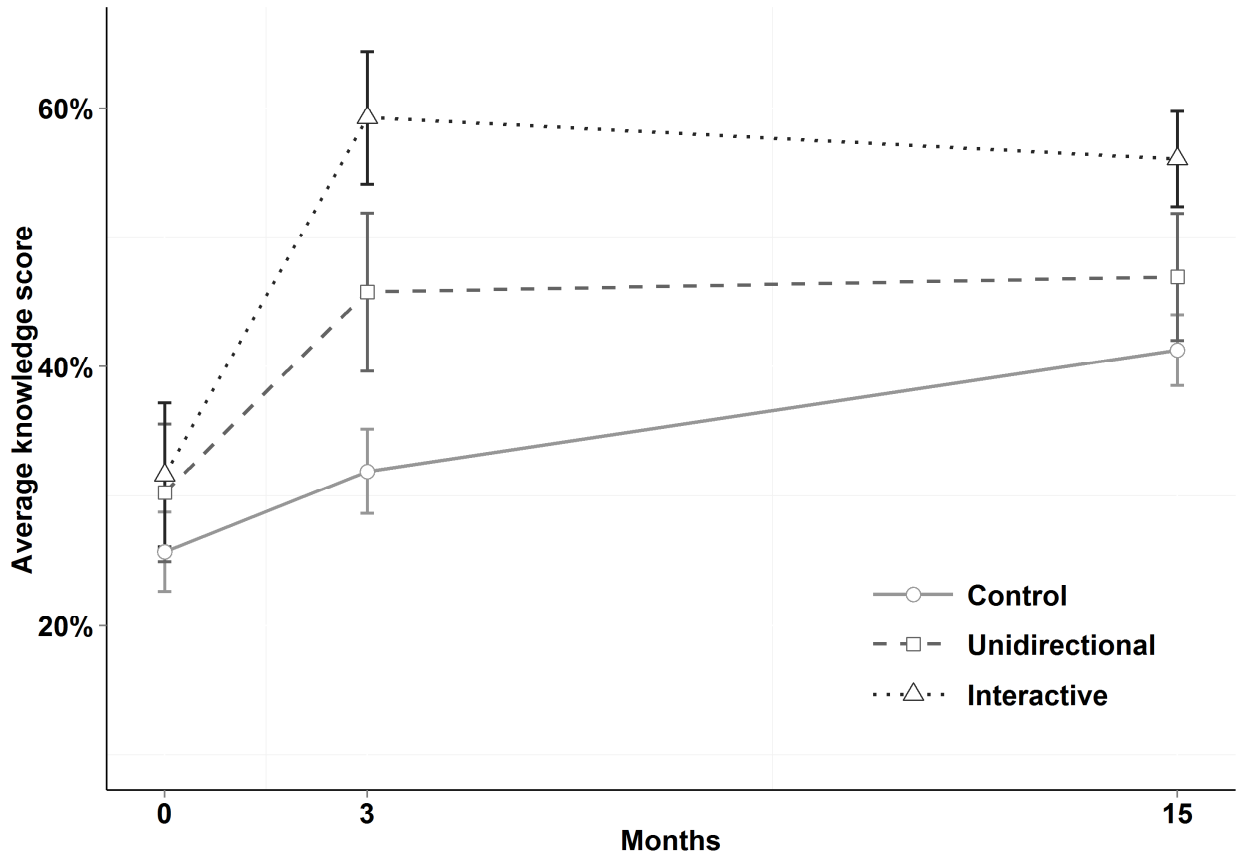
Figure 1. Profile of Cluster-Randomized Controlled Trial of Text-Messaging Programs and Reproductive Health Among Adolescent Girls in Ghana, 2014

Table 1. Baseline Characteristics of the Intent-to-Treat Population

	Control	Unidirectional	Interactive
Number of clusters	12	12	10
Number of total participants	293	258	205
Median participants per cluster	22.5 (7–48)	20.5 (3–46)	19.5 (4–39)
Participated at 3 mo. Follow-up	286 (98%)	238 (92%)	192 (94%)
Participated at 15 mo. Follow-up	277 (95%)	247 (96%)	197 (96%)
Age (years)	17.8 (1.2)	17.6 (1.4)	17.6 (1.5)
Religion[a]:			
Muslim	52 (18%)	37 (14%)	24 (12%)
Catholic	21 (7%)	21 (8%)	18 (9%)
Spiritual/Pentecostal/Charismatic	128 (44%)	120 (47%)	93 (45%)
Protestant	61 (21%)	61 (24%)	54 (26%)
Other	26 (9%)	14 (5%)	12 (6%)
Mother's Education[b]:			
Don't know	72 (25%)	56 (22%)	47 (23%)
Less than Secondary	47 (16%)	46 (18%)	22 (11%)
At least Secondary	170 (58%)	154 (60%)	135 (66%)
Father's Education[c]:			
Don't know	65 (22%)	42 (16%)	41 (20%)
Less than Secondary	119 (41%)	109 (42%)	77 (38%)
At least Secondary	105 (36%)	106 (41%)	86 (42%)
Ethnicity[d]:			
Akan	112 (38%)	113 (44%)	70 (34%)
Ga	86 (29%)	61 (24%)	68 (33%)
Ewe	42 (14%)	49 (19%)	39 (19%)
Other	41 (14%)	23 (9%)	25 (12%)
Own phone[e]:			
Yes	247 (84%)	219 (85%)	177 (86%)
No, but have access	38 (13%)	29 (11%)	24 (12%)
No, no access	2 (1%)	5 (2%)	3 (1%)
Baseline knowledge score	0.26 (0.16)	0.30 (0.17)	0.31 (0.18)

[a]Data missing for 5 control, 5 unidirectional, and 4 interactive participants.
[b]Data missing for 4 control, 2 unidirectional, and 1 interactive participants.
[c]Data missing for 4 control, 1 unidirectional, and 1 interactive participants.
[d]Data missing for 12 control, 12 unidirectional, and 3 interactive participants.
[e]Data missing (although phone number was provided by all) for 6 control, 5 unidirectional, and 1 interactive participants.

Figure 2 shows the adjusted means of the knowledge score for the interactive, unidirectional, and control groups at 0 (baseline), 3, and 15 months (estimates are reported in Appendix Table D and Appendix Figure A). From baseline to the 3-month follow-up, average knowledge scores increased from 26% to 32% in the control, 30% to 45% in the unidirectional, and 31% to 60% in the interactive groups. After we adjusted for covariates, average knowledge in the unidirectional and interactive groups was 11 percentage points (95% confidence interval [CI]=7, 15) and 24 percentage points (95% CI=19, 28) greater than in the control group, respectively. The interactive intervention was significantly more effective than the unidirectional intervention, with an additional knowledge score increase of 13 percentage points (95% CI=8, 18). At 15 months, these gains were largely sustained, although the control group caught up over time to the unidirectional group; average knowledge in the interactive group was 11 percentage points (95% CI=8, 15) greater than in the control group, and the unidirectional intervention was no longer significantly different from the control group (3; 95% CI=–1, 7). We conducted an additional analysis that included only participants who owned a phone; results are similar to those with the full sample (data not shown).



Notes: Estimates are predicted scores obtained from a linear regression of knowledge score on intervention group, and adjusted for presence of home economics class, school category, age, religion, ethnicity, mother's education, father's education, school size, and baseline knowledge.

Figure 2. Adjusted Mean and 95% Confidence Intervals of Knowledge Score at 0 (Baseline), 3 Months, and 15 Months for Interactive, Unidirectional, and Control Groups

Table 2 shows the results for self-reported pregnancy and sexual behavior from both unadjusted and adjusted models. Although the direction of the effects found in both models stays the same, the point estimates vary and standard errors in the adjusted models are generally narrower as a result of the additional control variables. There was no significant impact of either intervention on ever having sexual intercourse, on having sexual intercourse in the past year, or on pregnancy in the past year for the full sample of participants (Table 2).

Conditional on having sexual intercourse in the past year, the unidirectional and the interactive programs significantly lowered the odds of self-reported pregnancy by 86% in the adjusted models (odds ratio [OR]=0.14; 95% CI=0.03, 0.71) and 85% (OR=0.15; 95% CI=0.03, 0.86), respectively, compared with the control group (Table 2). The interactive intervention increased the odds of using the birth control pill in the past year (OR=13.23; 95% CI=1.08, 161.80) although small sample sizes resulted in large confidence intervals. The interactive intervention also decreased the odds of using emergency contraception (OR=0.22; 95% CI=0.06, 0.88). The interactive intervention appeared to increase risk of sex without a condom in the past year (OR=3.47; 95% CI=1.12, 10.74). There was no impact on age of sexual debut for those who have ever had sexual intercourse (Appendix Table E).

Table 2. Estimated Intervention Effects for Self-Reported Pregnancy and Sexual Behavior

				Unidirectional—Control		Interactive—Control	
Variable	**Control, No. (%)**	**Unidirectional, No. (%)**	**Interactive, No. (%)**	**Crude OR (95% CI)**	**AOR (95% CI)**	**Crude OR (95% CI)**	**AOR (95% CI)**
Full sample							
Ever had sexual intercourse	88/273 (32)	83/239 (35)	64/196 (33)	1.04 (0.71, 1.52)	1.06 (0.71, 1.58)	1.29 (0.85, 1.95)	1.24 (0.80, 1.93)
Sexual intercourse in past year	58/273 (21)	64/243 (26)	51/196 (26)	1.21 (0.80, 1.84)	1.22 (0.79, 1.87)	1.54 (0.97, 2.44)	1.55 (0.96, 2.50)
Pregnant in past year	10/276 (4)	5/243 (2)	6/193 (3)	0.51 (0.17, 1.54)	0.39 (0.12, 1.29)	0.85 (0.27, 2.69)	0.59 (0.17, 2.00)
Sexually active sample							
Pregnant in past year	9/58 (16)	5/63 (8)	4/51 (8)	0.40 (0.12, 1.38)	0.14 (0.03, 0.71)	0.42 (0.10, 1.7)	0.15 (0.03, 0.86)
Used any contraception past year	26/56 (46)	35/60 (58)	25/46 (54)	1.77 (0.83, 3.79)	1.52 (0.68, 3.43)	1.27 (0.56, 2.90)	1.18 (0.48, 2.90)
Used contraception at last sexual intercourse	27/54 (50)	36/59 (61)	27/50 (54)	1.61 (0.75, 3.49)	1.40 (0.61, 3.22)	1.28 (0.57, 2.91)	1.17 (0.48, 2.85)
Used condom at sexual debut	30/54 (56)	34/62 (55)	27/49 (55)	0.99 (0.46, 2.11)	0.83 (0.36, 1.89)	1.14 (0.50, 2.63)	0.97 (0.39, 2.40)
Had sexual intercourse without condom past year	38/57 (67)	48/62 (77)	42/49 (86)	1.50 (0.65, 3.48)	1.85 (0.73, 4.70)	2.80 (1.02, 7.70)	3.47 (1.12, 10.74)
Used condom in past year	15/58 (26)	17/64 (27)	16/51 (31)	1.17 (0.51, 2.69)	1.14 (0.47, 2.79)	1.29 (0.53, 3.13)	1.25 (0.48, 3.23)
Used birth control pill in past year	1/58 (2)	5/64 (8)	5/51 (10)	4.91 (0.55, 43.40)	5.04 (0.50, 50.49)	6.88 (0.73, 64.72)	13.23 (1.08, 161.80)
Used emergency contraception past year	10/58 (17)	11/64 (17)	4/51 (8)	1.07 (0.36, 3.13)	0.81 (0.28, 2.34)	0.31 (0.08, 1.25)	0.22 (0.05, 0.88)

Notes. AOR=adjusted odds ratio; CI=confidence interval; OR|=|odds ratio. Odds ratios from multilevel logistic regression model with school random effects. Crude model adjusted for stratification variables—that is, presence of home economics class and school category. Adjusted model additionally adjusted for age, religion, ethnicity, mother's education, father's education, school size, and baseline knowledge. One participant in the control group and 2 in the interactive group reported being pregnant in the past year but not having sexual intercourse in the past year. We did not recode them; analysis including those participants in the sexually active sample does not change the direction or the significance of the results.

DISCUSSION

The results presented in this study suggest that text-messaging programs can be effective tools to improve reproductive health knowledge among adolescents. We observed large improvements in knowledge at 3 months that were sustained after 15 months for both 1-way and 2-way programs. However, the 2-way interactive program was significantly more effective at increasing knowledge than the 1-way program. For the sexual behavior outcomes, results were mixed. Among sexually active adolescents, we found both programs to be protective against self-reported pregnancies; however, we found no significant impact on pregnancy in the full sample. Larger impacts on reproductive health outcomes seem plausible once a majority of treated women become sexually active.

Somewhat surprisingly, we found that the interactive intervention was positively associated with having sex without a condom among sexually active adolescents in the interactive group. The main focus of the intervention content was on pregnancy prevention rather than on STIs, which appears to have resulted in a move away from condoms as a primary method of contraception with a shift toward birth control pills. Other studies have found that fear of pregnancy, not of STIs, motivates Ghanaian adolescents to use contraceptives.[25] However, in settings where HIV and other STI rates are high, these messages may not be appropriate. This study highlights the importance of carefully adjusting content and framing of mobile phone programs to local public health needs.

Interestingly, control-group participants increased their knowledge over time. We speculate that this may have been attributable to a combination of learning about reproductive health from other sources such as the media, from the nurse's lecture at the 3-month follow-up, or because of repeated questionnaires about these issues at baseline and 3 months.

Limitations

This study had several limitations. First, for reproductive health outcomes, the study exclusively relied on self-reported measures. It is possible that respondents in intervention groups may have felt more pressure to misreport their sexual behavior. Because they received messages that encouraged use of contraception to prevent unintended pregnancy,

they may have consequently underreported pregnancy. The direction of this bias is not obvious, however, as the exposure to the programs may have increased familiarity and openness to sexual health questions, so that program participants may have been more likely to report undesired outcomes than the control participants (such as sex without a condom). To mitigate misreporting concerns, all questions at the 15-month follow-ups were asked via self-administered tablet computers, which have been shown to increase honesty in adolescent responses of sexual behavior.[27] Nevertheless, self-reported sexual behavioral data among adolescents has been found in other contexts to suffer from recall error, misunderstanding, and social desirability bias; biological markers of pregnancy and sexual health are needed to better understand the health impact of the programs.[28] In addition, the 15-month questionnaire elicited respondents' primary use of contraception; if some women used multiple methods, we could have underestimated the impact of the intervention on use of condoms, birth control, and emergency contraception.

Second, the interactive program was a multicomponent intervention that included interactive quizzes, financial incentives, and reminder messages; we are not able to discern which components made the biggest impact on knowledge. Third, we included only adolescent girls in secondary school in Accra; program impact may be different among high-risk girls, boys, and adolescents in rural areas or other countries. Evidence from a review of 83 sexual-education programs across the world evaluating the impact of sexual education on knowledge, attitudes, and behaviors found that programs that had positive effects were equally effective in both rural and urban areas, among girls and boys, and among low- and middle-income youths, and that replication of effective studies in other settings yielded consistent results.[29] Finally, neither the participants nor the study staff could be masked to assignment. However, staff were trained to provide the same description of the messages to all groups to prevent differential uptake. Similarity of baseline characteristics across groups indicates that the participants were comparable.

An important consideration is that of selective attrition. We believe that this risk is minimal in our study; we followed up more than 94% of participants in all 3 arms and confirmed pregnancy status for 28 of the 35 lost participants by asking classmates and school administrations about their status.

Intention-to-treat estimates may be conservative estimates of the true causal effects of the intervention as 17% of girls did not receive any messages because of technical challenges as well as decreased phone access among girls who did not own their own phone. However, these are common problems in text-messaging programs and future research or program scale-up should keep these challenges in mind.[17]

Public Health Implications

School-based comprehensive sexual education in a study context has been found to be largely effective at increasing knowledge; behavioral impacts have been observed for some programs, though less consistently.[29–32] However, poor implementation of school-based programs at scale, including problems of curricula lacking basic information on condoms and contraception, poor teaching, and short program durations, have often resulted in a lack of fidelity to the designed intervention, reducing program effectiveness.[33] Our study supports the idea that text-messaging programs may be effective ways to fill this gap, by providing accurate and complete information via a medium with which adolescents are comfortable. Moreover, text-messaging programs can be tailored to the audience both in terms of cultural and individual characteristics[34], and they can inexpensively reach a large and diverse population—the marginal costs of the interactive and unidirectional programs per participant were US$1.91 and US$0.30, respectively.

The past decade's rapid rise in mobile phone access provides an opportunity to harness this technology to improve health, particularly in LMICs.[10] Young people are the most likely age group to use their phone to send text messages in LMICs[35], yet very few mobile health interventions have been developed for and evaluated on adolescents in LMICs.[15,16,34] The results of this trial suggest that mobile platforms are indeed a feasible platform for improving adolescent health knowledge and, ultimately, health outcomes. More research is needed to examine the impact of adolescent text-messaging programs on objective measures of reproductive health and over the long term in LMICs.

Contributor Statement

SR designed the trial, intervention, and instrument; managed and monitored the trial and data collection, analyzed and interpreted the data, and drafted and edited the manuscript. JS contributed to the instrument design and edited the manuscript. JC contributed to the study design and instrument design, and edited the manuscript. GF contributed to the study design and instrument design, and edited the manuscript.

Acknowledgments

This research was funded by the Weiss Family Fund for Research in Development Economics, the Harvard Lab for Economic Applications and Policy, and the Harvard Institute for Quantitative Social Science. Study sponsors had no role in study design, data collection, analysis, interpretation, writing of the report, or decision for publication.

We thank Mary Beth Landrum and Mark McGovern for their feedback and support. We are grateful to the participants and the administrations of the schools that participated in the trial. We thank Comfort Bonney Arku, Grace Gletsu, Maham Farhat, Christine Papai, Richard Adanu, Philip Amara, and the IPA staff who contributed to this study for their hard work and support. We thank Grace Kafui Annan and staff at the Ghana Health Service Health Promotion Unit for their guidance and support.

Human Participant Protection

IRB approval was granted by the Committee on the Use of Human Subjects in Research at Harvard University (IRB13-1647) as well as the Ghana Health Service Ethical Review Committee (GHS-ERC:05/09/13).

References

1. United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects, the 2015 Revision: Birth by Age of Mother Downloadable File. https://esa.un.org/unpd/wpp/Download/Standard/Fertility/. Published 2015.
2. Woog V, Singh S, Browne A, Philbin J. *Adolescent Women's Need for and Use of Sexual and Reproductive Health Services in Developing Countries*. New York: Guttmacher Institute; 2015. https://www.guttmacher.org/sites/default/files/report_pdf/adolescent-srhs-need-developing-countries.pdf.
3. Chen X-K, Wen SW, Fleming N, Demissie K, Rhoads GG, Walker M. Teenage pregnancy and adverse birth outcomes: a large population based retrospective cohort study. *Int J Epidemiol*. 2007;36(2):368-373. doi:10.1093/ije/dyl284.
4. Mayor S. Pregnancy and childbirth are leading causes of death in teenage girls in developing countries. *BMJ*. 2004;328(7449):1152. doi:10.1136/bmj.328.7449.1152-a.
5. Fink G, Sudfeld CR, Danaei G, Ezzati M, Fawzi WW. Scaling-Up Access to Family Planning May Improve Linear Growth and Child Development in Low and Middle Income Countries. *PLoS ONE*. 2014;9(7):e102391. doi:10.1371/journal.pone.0102391.
6. Hindin MJ, Fatusi AO. Adolescent sexual and reproductive health in developing countries: an overview of trends and interventions. *Int Perspect Sex Reprod Health*. 2009:58–62.
7. Singh S, Bankole A, Woog V. Evaluating the need for sex education in developing countries: sexual behaviour, knowledge of preventing sexually transmitted infections/HIV and unplanned pregnancy. *Sex Educ*. 2005;5(4):307-331. doi:10.1080/14681810500278089.
8. Biddlecom A, Hessburg, Laura, Singh S, Bankole A, Darabi, Leila. *Protecting the Next Generation In Sub-Saharan Africa: Learning from Adolescents to Prevent HIV and Unintended Pregnancy*. New York: Guttmacher Institute; 2007.
9. MacQuarrie KLD. *Unmet Need for Family Planning among Young Women: Levels and Trends.* Rockville, Maryland, USA: ICF International; 2014. http://www.dhsprogram.com/pubs/pdf/CR34/CR34.pdf.

10. World Bank. *The Little Data Book on Information and Communication Technology 2015*. Washington D.C.: World Bank; 2016. doi:10.1596/978-1-4648-0558-5.
11. Lester RT, Ritvo P, Mills EJ, et al. Effects of a mobile phone short message service on antiretroviral treatment adherence in Kenya (WelTel Kenya1): a randomised trial. *The Lancet*. 2010;376(9755):1838–1845.
12. Raifman JRG, Lanthorn HE, Rokicki S, Fink G. The Impact of Text Message Reminders on Adherence to Antimalarial Treatment in Northern Ghana: A Randomized Trial. *PLoS ONE*. 2014;9(10):e109032. doi:10.1371/journal.pone.0109032.
13. Jamison JC, Karlan D, Raffler P. *Mixed Method Evaluation of a Passive mHealth Sexual Information Texting Service in Uganda*. National Bureau of Economic Research; 2013. http://www.nber.org/papers/w19107. Accessed July 1, 2014.
14. Kruk ME, Nigenda G, Knaul FM. Redesigning Primary Care to Tackle the Global Epidemic of Noncommunicable Disease. *Am J Public Health*. 2015;105(3):431-437. doi:10.2105/AJPH.2014.302392.
15. Gurman TA, Rubin SE, Roess AA. Effectiveness of mHealth Behavior Change Communication Interventions in Developing Countries: A Systematic Review of the Literature. *J Health Commun*. 2012;17(sup1):82-104. doi:10.1080/10810730.2011.649160.
16. Déglise C, Suggs LS, Odermatt P. Short Message Service (SMS) Applications for Disease Prevention in Developing Countries. *J Med Internet Res*. 2012;14(1):e3. doi:10.2196/jmir.1823.
17. Aranda-Jan CB, Mohutsiwa-Dibe N, Loukanova S. Systematic review on what works, what does not work and why of implementation of mobile health (mHealth) projects in Africa. *BMC Public Health*. 2014;14(1):188. doi:10.1186/1471-2458-14-188.
18. Gonsalves L, L'Engle KL, Tamrat T, et al. Adolescent/Youth Reproductive Mobile Access and Delivery Initiative for Love and Life Outcomes (ARMADILLO) Study: formative protocol for mHealth platform development and piloting. *Reprod Health*. 2015;12:67. doi:10.1186/s12978-015-0059-y.
19. Vahdat HL, L'Engle KL, Plourde KF, Magaria L, Olawo A. There are some questions you may not ask in a clinic: Providing contraception information to young people in Kenya using SMS. *Int J Gynecol Obstet*. 2013;123:e2–e6.

20. 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):146-157. doi:10.1080/10810730.2011.649104.
21. Mitchell KJ, Bull S, Kiwanuka J, Ybarra ML. Cell phone usage among adolescents in Uganda: acceptability for relaying health information. *Health Educ Res*. 2011;26(5):770-781. doi:10.1093/her/cyr022.
22. Akinfaderin-Agarau F, Chirtau M, Ekponimo S, Power S. Opportunities and limitations for using new media and mobile phones to expand access to sexual and reproductive health information and services for adolescent girls and young women in six Nigerian states. *Afr J Reprod Health*. 2012;16(2):219-230.
23. L'Engle KL, Vahdat HL, Ndakidemi E, Lasway C, Zan T. Evaluating feasibility, reach and potential impact of a text message family planning information service in Tanzania. *Contraception*. 2013;87(2):251-256. doi:10.1016/j.contraception.2012.07.009.
24. Ghana Statistical Service (GSS), Ghana Health Service (GHS), and ICF International. *Ghana Demographic and Health Survey 2014*. Rockville, Maryland, USA: GSS, GHS, and ICF International; 2015. http://dhsprogram.com/pubs/pdf/FR307/FR307.pdf.
25. Hessburg L et al. *Protecting the Next Generation in Ghana: New Evidence on Adolescent Sexual and Reproductive Health Needs*. New York: Guttmacher Institute; 2007.
26. Awusabo-Asare K, Biddlecom A, Kumi-Kyereme A, Patterson K. *Adolescent Sexual and Reproductive Health in Ghana: Results from the 2004 National Survey of Adolescents*. New York: Guttmacher Institute; 2006.
27. Kelly CA, Soler-Hampejsek E, Mensch BS, Hewett PC. Social Desirability Bias in Sexual Behavior Reporting: Evidence from an Interview Mode Experiment in Rural Malawi [. *Int Perspect Sex Reprod Health*. 2013;39(1):014-021. doi:10.1363/3901413.
28. Plummer ML, Ross DA, Wight D, et al. "A bit more truthful": the validity of adolescent sexual behaviour data collected in rural northern Tanzania using five methods. *Sex Transm Infect*. 2004;80(suppl 2):ii49-ii56. doi:10.1136/sti.2004.011924.
29. Kirby DB, Laris BA, Rolleri LA. Sex and HIV Education Programs: Their Impact on Sexual Behaviors of Young People Throughout the World. *J Adolesc Health*. 2007;40(3):206-217. doi:10.1016/j.jadohealth.2006.11.143.

30. Fonner VA, Armstrong KS, Kennedy CE, O'Reilly KR, Sweat MD. School Based Sex Education and HIV Prevention in Low- and Middle-Income Countries: A Systematic Review and Meta-Analysis. *PLoS ONE*. 2014;9(3):e89692. doi:10.1371/journal.pone.0089692.
31. Napierala Mavedzenge SM, Doyle AM, Ross DA. HIV Prevention in Young People in Sub-Saharan Africa: A Systematic Review. *J Adolesc Health*. 2011;49(6):568-586. doi:10.1016/j.jadohealth.2011.02.007.
32. Haberland N, Rogow D. Sexuality Education: Emerging Trends in Evidence and Practice. *J Adolesc Health*. 2015;56(1):S15-S21. doi:10.1016/j.jadohealth.2014.08.013.
33. Chandra-Mouli V, Lane C, Wong S. What Does Not Work in Adolescent Sexual and Reproductive Health: A Review of Evidence on Interventions Commonly Accepted as Best Practices. *Glob Health Sci Pract*. 2015;3(3):333-340. doi:10.9745/GHSP-D-15-00126.
34. Guse K, Levine D, Martins S, et al. Interventions Using New Digital Media to Improve Adolescent Sexual Health: A Systematic Review. *J Adolesc Health*. 2012;51(6):535-543. doi:10.1016/j.jadohealth.2012.03.014.
35. Pew Research Center. Cell Phones in Africa: Communication Lifeline. Pew Research Center's Global Attitudes Project. http://www.pewglobal.org/2015/04/15/cell-phones-in-africa-communication-lifeline/. Published April 15, 2015. Accessed March 4, 2016.

Supporting Information

Appendix

Table A. Content of SMS for Interactive, Unidirectional, and Control groups

Week	Interactive Group			Unidirectional Group	Control Group
	Quiz Question/Tip text	Correct Answer	Response from SMART	Fact/Tip text	Fact text
1	SMART quiz:How many ovaries does a woman have? Reply SMT1 for 1 ovary or SMT2 for 2 ovaries. Reply to this number for free. Reply until you receive confirmation	SMT2	SMART:Right! A woman has 2 ovaries. This is where eggs are stored. She has a womb (uterus) where a fertilized egg implants and a pregnancy grows.Two fallopian tubes connect ovaries to the womb.The cervix connects the womb to the vagina. The vagina is a tube of muscle connecting cervix to outside of body	SMART fact: A woman has 2 ovaries. This is where eggs are stored. She has a womb (uterus) where a fertilized egg implants and a pregnancy grows.Two fallopian tubes connect ovaries to the womb.The cervix connects the womb to the vagina. The vagina is a tube of muscle connecting cervix to outside of body	SMART fact: In 2012, malaria killed over 483000 children under 5 years, or about 1 child every minute. Malaria kills over 45000 adolescents per year in Africa.
2	SMART quiz:When is the most likely time that a girl can get pregnant? Reply SMT1 for days 1-7 of her menses, reply SMT2 for days 8-19, or SMT3 for days 20-28.	SMT2	SMART answer: Correct! The menstrual cycle is usually 28 days. If day 1 is the first day of your menses, then days 8-19 are the most likely time that you can get pregnant. The egg is released from the ovaries between days 8-19. If sperms are present, then the egg may be fertilized, causing pregnancy.	SMART fact: The menstrual cycle is usually 28 days. If day 1 is the first day of your menses, then days 8-19 are the most likely time that you can get pregnant. The egg is released from the ovaries between days 8-19. If sperms are present, then the egg may be fertilized, causing pregnancy.	SMART fact:Malaria is caused by Plasmodium falciparum parasites.The only way the parasites are spread to people are thru bites of infected Anopheles mosquitoes.
3	SMART quiz: True or False: Standing up during sex can prevent a girl from getting pregnant. Reply SMT1 for true or SMT2 for false.	SMT2	SMART answer: Correct! Standing up during sex does NOT prevent pregnancy. When a man ejaculates (releases sperm), the sperms are deposited deep into the	SMART fact: Standing up during sex does NOT prevent pregnancy. When a man ejaculates (releases sperm), the sperms are deposited deep into the vagina immediately after	SMART fact:Getting malaria while pregnant is very serious. About 9% of pregnant women in Ghana die of malaria. It can also

			vagina immediately after ejaculation, allowing fertilization to take place. Bathing/washing will NOT prevent pregnancy either.	ejaculation, allowing fertilization to take place. Bathing/washing will NOT prevent pregnancy either.	result in low birth weight babies.
Tip 1: End of week 3	SMART tip: If you have any questions about your health, you can call 0302208585 or 080028585 (Toll free- Voda only) to speak to a nurse. It is confidential.			SMART tip: If you have any questions about your health, you can call 0302208585 or 080028585 (Toll free- Voda only) to speak to a nurse. It is confidential.	
4	SMART:Can you be a carrier of a Sexually Transmitted Infection (STI) and NOT be aware that you have it? Reply SMT1 for yes or SMT2 for no.	SMT1	SMART:Right!You can have STI without having any symptoms or knowing you are a carrier.It can take months to see symptoms like sores, itches and problems urinating.A partner may have a STI and it may be impossible for him or you to know that he has it.Condoms or abstinence are effective ways to prevent STI	SMART fact:You can be a carrier of a sexually transmitted infection (STI) without having any symptoms or knowing you are a carrier. It can take months to see symptoms like sores, itches and problems urinating. A partner may have a STI and it may be impossible for him or you to know that he has it.	SMART fact:The first symptoms of malaria are fever, headache, and chills. These occur 2-3 days after the mosquito bite.Other symptoms are body pain and nausea.
5	SMART quiz: True or False: A woman with an untreated gonorrhea may have severe lower abdominal pains. Reply SMT1 for true or SMT2 for false.	SMT1	SMART:Right! Untreated gonorrhea may lead to severe pains in lower abdomen called pelvic inflammatory disease. It can cause infertility.It also makes it easier to get HIV. It may take months to see signs of gonorrhea in females. In males it takes days. Its important to seek treatment from a health center.	SMART fact: Untreated gonorrhea may lead to severe pains in lower abdomen called pelvic inflammatory disease. It can cause infertility.It also makes it easier to get HIV. It may take months to see signs of gonorrhea in females. In males it takes days. Its important to seek treatment from a health center.	SMART:Malaria symptoms resemble diseases like pneumonia or typhoid.At health centers you can get rapid diagnostic test (just a few min) to identify the disease.

Tip 2: End of week 5	SMART Tip: Talking about reproductive health with friends, family, and a boyfriend/future boyfriend is smart. It can help you to be healthier and make good choices that are right for you. Be sure to talk to your friends about the SMART messages, and encourage them to participate! Win together!			SMART Tip: Talking about reproductive health with friends, family, and a boyfriend/future boyfriend is smart. It can help you to be healthier and make good choices that are right for you. Be sure to talk to your friends about the SMART messages and ask them about their opinions!	
6	SMART quiz: True or false: A woman can wear the female condom for up to 8 hours before she has sex. Reply SMT1 for true or SMT2 for false.	SMT1	SMART:Right! The female condom is made of a thin transparent and soft plastic that looks like a tube that is closed at one end.It is designed to fit into a woman's vagina. It can be worn up to 8 hours before a woman has sex.It protects against both STIs and pregnancy.It is 95% effective if worn correctly.	SMART fact: The female condom is made of a thin transparent and soft plastic that looks like a tube that is closed at one end.It is designed to fit into a woman's vagina. It can be worn up to 8 hours before a woman has sex.It protects against both STIs and pregnancy.It is 95% effective if worn correctly.	SMART fact: You can cure malaria with drugs called ACTs like Artesunate-Amodiaquine. ACTs combine two drugs together into each pill. They are 97% effective.
Tip 3: End of week 6	SMART Tip: Great job! Remember, if you don't want to have sex, it's ok to say no. Call 0302208585 or 080028585 (Toll free-Vodafone only) to speak to a nurse about strategies for saying no. It is completely confidential. You could also call this			SMART Tip: Great job! Remember, if you don't want to have sex, it's ok to say no. Call 0302208585 or 080028585 (Toll free- Vodafone only) to speak to a nurse about strategies for saying no. It is completely confidential. You could also call this number if you have any questions bothering you.	

	number if you have any questions bothering you.				
7	SMART:When putting on a condom, should a man unroll it all the way first before putting it on the penis? Reply SMT1 for yes or SMT2 for no.	SMT2	SMART: Right! When putting on a condom, do NOT unroll the entire condom first. Open the package, hold the tip of the condom with one hand and roll it down the penis with the other hand. Leave space at the tip to collect semen. If there is no space at the tip the condom will burst open during ejaculation.	SMART: When putting on a condom, a man should NOT unroll the entire condom first.Open the package, hold the tip of the condom with one hand and roll it down the penis with the other hand. Leave space at the tip to collect semen.If there is no space at the tip the condom will burst open during ejaculation.	SMART fact:The malaria parasite has developed resistance to previous drugs like chloroquine. This means the drug no longer works to cure malaria.Only ACTs cure.
8	SMART:When using a condom, when should a man pull out of the vagina after ejaculation? Reply SMT1 for while penis is still stiff or SMT2 for when penis is soft.	SMT1	SMART answer: Right! When using a condom, it is important for the man to pull his penis out right after ejaculation, while it is still stiff. If the penis gets soft then the condom could fall off inside the woman's vagina. If this happens then it is possible that the woman will get pregnant.	SMART fact: When using a condom, it is important for the man to pull his penis out right after ejaculation, while it is still stiff. If the penis gets soft then the condom could fall off inside the woman's vagina. If this happens then it is possible that the woman will get pregnant.	SMART fact: If you take an ACT and don't finish all the pills, the malaria parasite will survive. This builds resistance to the medicine. Always finish ACTs.
Tip 4: End of Week 8	SMART Tip: Contraception means a method to prevent pregnancy.Birth control pills and condoms are types of contraception.Condoms are only effective if you	NA	SMART Tip: Contraception means a method to prevent pregnancy.Birth control pills and condoms are types of contraception.Condoms are only effective if you use them correctly and use them every time you have sex.	SMART Tip: Contraception means a method to prevent pregnancy.Birth control pills and condoms are types of contraception.Condoms are only effective if you use them correctly and use them every time you have sex. Then they are	

	use them correctly and use them every time you have sex. Then they are 98% effective against STDs and pregnancy.Condoms do NOT cause infertility in men.		Then they are 98% effective against STDs and pregnancy.Condoms do NOT cause infertility in men.	98% effective against STDs and pregnancy.Condoms do NOT cause infertility in men.	
9	SMART quiz:How often is the Pill taken (the birth control Pill)? Reply SMT1 for only after a woman has sex or reply SMT2 for once a day, everyday.	SMT2	SMART answer: Right! The Pill is taken once a day whether or not a woman has sex.If you choose to use the Pill as your contraceptive method then you must take it everyday or it is NOT effective. You can't just take it whenever you please! It contains low and safe doses of hormones and prevents pregnancy.	SMART: The birth control Pill is taken once a day whether or not a woman has sex.If you choose to use the Pill as your contraceptive method then you must take it everyday or it is NOT effective. You can't just take it whenever you please! It contains low and safe doses of hormones and prevents pregnancy.	SMART fact: There are no vaccines against malaria. You can prevent malaria with treated mosquito nets.Traditional medicines are not effective in curing malaria.
10	SMART quiz: True or False: Birth control pills are effective even if a woman misses taking them for 2-3 days in a row. Reply SMT1 for true or SMT2 for false.	SMT2	SMART answer: Right! The Pill is NOT effective if a woman misses it for 2 or 3 days in a row. The Pill must be taken everyday and if a woman stops taking it then she may get pregnant after 2-3 days. It does NOT take 6 months to become pregnant after stopping birth control.	SMART fact:The Pill is NOT effective if a woman misses it for 2 or 3 days in a row. The Pill must be taken everyday and if a woman stops taking it then she may get pregnant after 2-3 days. It does NOT take 6 months to become pregnant after stopping birth control.	SMART fact:Children who survive episodes of severe malaria may develop learning problems, brain damage, or anemia (low iron in body which affects their growth).
11	SMART:True or False:A woman should take a rest from the Pill every year because the pills build up in the body over time.Reply SMT1 for true	SMT2	SMART answer: Right! The Pill does NOT build up in the body so women do NOT need to take a rest from the Pill. If a woman has side effects like nausea,	SMART fact: The Pill does NOT build up in the body over time so women do NOT need to take a rest from the Pill. If a woman has side effects like nausea, switching to another type or	SMART fact: Common myths about how malaria is spread are that you can get infected from working too much in the sun or

	or SMT2 for false.		switching to another type or brand might help. The Pill protects against pregnancy but not STIs. The Pill does not cause infertility later in life.	brand might help. The Pill protects against pregnancy but not STIs. The Pill does not cause infertility later in life.	eating hot foods. These are NOT true.
12	SMART quiz: True or False. Emergency contraception must be taken within 1 hour of unprotected sex. Reply SMT1 for true, and SMT2 for false.	SMT2	SMART: Right! Emergency contraception (like Postinor-2) is a method to reduce chance of pregnancy after unprotected sex or when a condom breaks. The 2 pills must be taken within 5 DAYS of unprotected sex (that's 120 hours). It should only be used for emergencies, not as a regular method of contraception.	SMART fact: Emergency contraception (like Postinor-2) is a method to reduce chance of pregnancy after unprotected sex or when a condom breaks. The 2 pills must be taken within 5 DAYS of unprotected sex. It should only be used for emergencies, not as a regular method of contraception.	SMART fact:Increased prevention of malaria with nets and treatment with ACTs have led to more than 3million lives saved since 2010, mostly children under 5 yrs.

Table B. Knowledge Quiz and percent of participants responding correctly at baseline

Item	% responding correctly at baseline
Standing up during sex can help prevent pregnancy. (FALSE)	29 %
Condoms cause infertility in men. (FALSE)	37 %
To put on a condom, you should first unroll it all the way and then try to put it on the penis. (FALSE)	7 %
When putting on a condom, it is important to leave space at the tip. (TRUE)	28 %
When using a condom, it is important for the man to pull his penis out right after ejaculation, while it is still stiff. (TRUE)	18 %
Birth control pills (known as The Pill) are taken once every day, whether or not you have sex. (TRUE)	21 %
Birth control pills protect against sexually transmitted infections. (FALSE)	46 %
Birth control pills are effective even if a woman misses taking them for two or three days in a row. (FALSE)	17 %
It is important that women should "take a rest" from the pill every year because the pills build up in a woman's body over time. (FALSE)	7 %
If a woman is having side effects with one kind of pill, switching to another type or brand might help. (TRUE)	15 %
After a woman stops taking birth control pills, she is unable to get pregnant for at least six months. (FALSE)	19 %
The female condom can be worn up to 8 hours before having sex. (TRUE)	7 %
Emergency contraception must be taken within 1 hour of having unprotected sex. (FALSE)	8 %
Symptoms of gonorrhea in females will appear the day after becoming infected. (FALSE)	33 %
Gonorrhea infection makes it easier to get HIV and other STIs and pass them to sex partners. (TRUE)	52 %
If left untreated, sexually transmitted infections like gonorrhea can cause infertility in both men and women. (TRUE)	63 %
A woman with an untreated gonorrhea may have severe lower abdominal pains. (TRUE)	50 %
If day 1 is the first day of a woman's period, she has the greatest chance of becoming pregnant during days 8-19. (TRUE)	47 %
You can have a sexually transmitted infection without having any symptoms or knowing you are a carrier. (TRUE)	44 %
Every woman has 1 ovary where her eggs are stored. (FALSE)	30 %
STI symptoms can include sores, itches, and problems urinating. (TRUE)	Only asked at follow-up
Postinor-2 is a type of emergency contraception. (TRUE)	Only asked at follow-up
The female condom protects against both sexually transmitted infections and pregnancy. (TRUE)	Only asked at follow-up
Washing/bathing oneself after sex can prevent pregnancy.(FALSE)	Only asked at follow-up

Note: Response choices for each item were "True", "False", and "Don't know". An incorrect answer, a "don't know", and a missing answer were counted as incorrect.

Table C. List of outcome variables and regression model

Outcome	Time Measured	Model
Full sample		
Knowledge of reproductive health	0, 3, 15 months	Linear
Ever had sexual intercourse	15 months	Logit
Had sexual intercourse in the past year	15 months	Logit
Pregnancy in the past year	15 months	Logit
Subgroup who reported having sex in the past year		
Pregnancy in the past year	15 months	Logit
Used any contraception in past year	15 months	Logit
Used contraception at last sexual intercourse	15 months	Logit
Used condom at sexual debut	15 months	Logit
Had sexual intercourse without a condom in past year	15 months	Logit
Used a condom in the past year as primary contraception	15 months	Logit
Used birth control pill in past year as primary contraception	15 months	Logit
Used emergency contraception in past year as primary contraception	15 months	Logit
Age at sexual debut	15 months	Linear

Table D. Estimated intervention effects for knowledge

				Unidirectional – Control		Interactive – Control		Interactive – Unidirectional	
	Control mean	**Uni-directional** mean	**Interactive** mean	**Crude Difference (95% CI)**	**Adjusted Difference (95% CI)**	**Crude Difference (95% CI)**	**Adjusted Difference (95% CI)**	**Crude Difference (95% CI)**	**Adjusted Difference (95% CI)**
Baseline	26% n=293	30% n=258	31% n=205	5 (-1 to 10)	4 (-0.9 to 10)	6 (-0.3 to 12)	5 (-1 to 11)	1 (-7 to 9)	0.6 (-7 to 8)
Follow-up at 3 months	32% n=286	45% n=238	60% n=192	14 (7 to 21)	11 (7 to 15)	27 (21 to 33)	24 (19 to 28)	13 (5 to 21)	13 (8 to 18)
Follow-up at 15 months	42% n=277	47% n=247	56% n=197	6 (0.1 to 11)	3 (-1 to 7)	15 (10 to 19)	11 (8 to 15)	9 (3 to 15)	8 (4 to 13)

Notes: Knowledge score is percentage correct of a 24-item index at follow-up (20-item index at baseline). Percentages are unadjusted. Missing answer, "don't know' coded as incorrect answer. Crude model is adjusted for school category and presence of home economics class. Adjusted model is additionally adjusted for baseline knowledge, age, religion, ethnicity, mother completed at least secondary school, father completed at least secondary school, and school size. Clustered standard errors at school level in parentheses.

Table E: Estimated intervention effects for age at sexual debut among adolescents who have ever had sex

				Unidirectional - Control		Interactive – Control	
	Control mean	**Unidirec-tional mean**	**Inter-active mean**	**Crude Diff (95% CI)**	**Adj. Diff (95% CI)**	**Crude Diff (95% CI)**	**Adj. Diff (95% CI)**
Age at sexual debut	17.7 n=60	17.4 n=66	17.9 n=40	-0.25 (-0.88 to 0.38)	-0.26 (-0.89 to 0.37)	0.10 (-0.38 to 0.59)	0.17 (-0.40 to 0.74)

Notes: Linear model with clustered standard errors at school level, conditional on ever having sex. Crude model adjusted for presence of home economics class and school category. Adjusted model additionally adjusted for religion, ethnicity, mother's education, father's education, school size, and baseline knowledge.

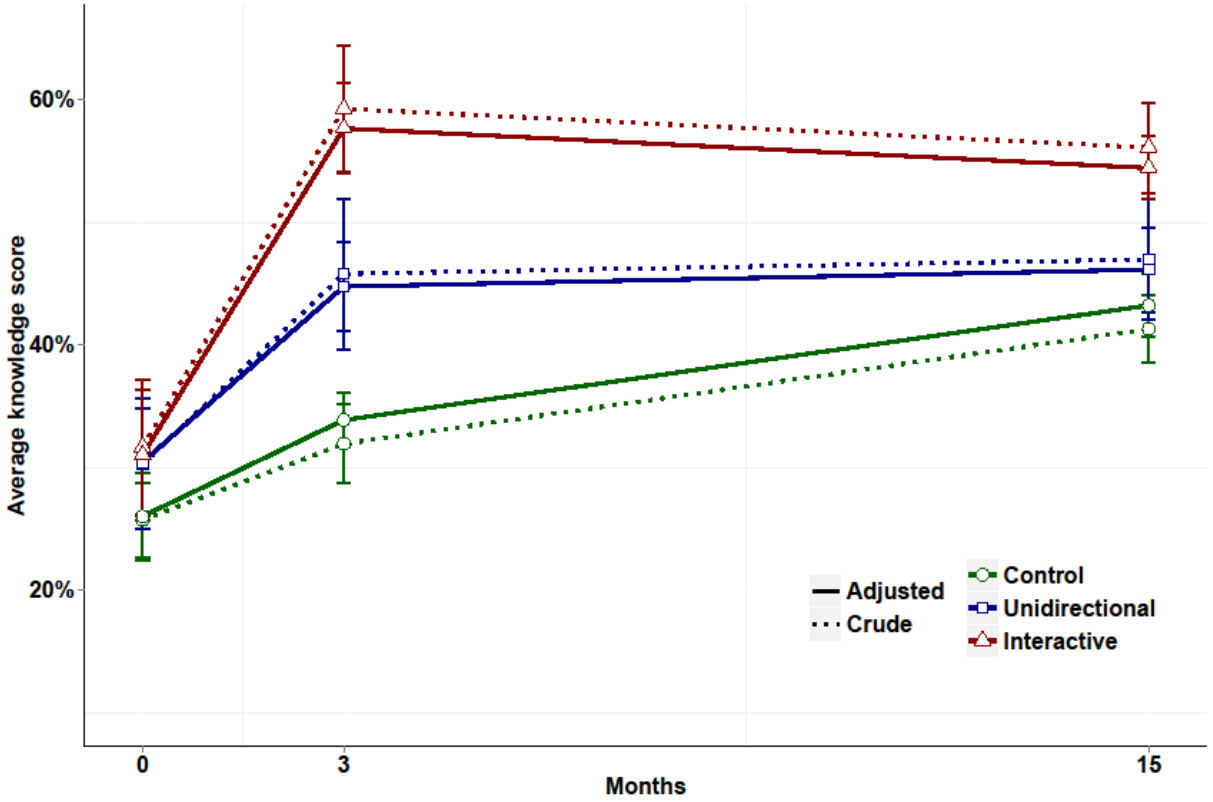


Figure A. Crude and adjusted mean and 95% confidence intervals of knowledge score at 0 (Baseline), 3, and 15 months for Interactive, Unidirectional, and Control groups

Notes: Estimates come from a regression of knowledge score on intervention group. Crude model adjusted for blocking variables, that is, presence of home economics class and school category. Adjusted model additionally adjusted for age, religion, ethnicity, mother's education, father's education, school size, and baseline knowledge.