SMART Statistical Analysis Plan

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Table of Contents

List of Tables and Figures

List of Tables

List of Figures

I. Introduction

Purpose of Statistical Analysis Plan

This analysis plan aims to pre-specify analyses before comparing outcomes for treatment and control groups. By creating this analysis plan, which serves as a record of our *ex ante* planned analysis, we hope to minimize issues of data mining and specification searching.

Abstract

Despite the fact that 76% of females in Ghana have heard of at least one modern contraceptive method and 96% have heard of HIV/AIDS, this awareness has not translated into use of contraception. Recent studies show that use of modern contraception among female adolescents is very low: only about one-third of sexually experienced female adolescents used a condom the first time they had sex. The burden of sexually transmitted infections is high, with up to 20% of sexually active 15-19 year old girls reporting ever having symptoms. The Study on mhealth and Reproductive Health in Teens is a randomized controlled trial that will evaluate the effectiveness of an interactive text-messaging program on improvement in reproductive health knowledge, communication, and attitudes among female adolescents in Accra, Ghana. Research will begin in January 2014 and conclude in June 2014.

Purpose of Research

Background

Despite the fact that 76% of females in Ghana have heard of at least one modern contraceptive method and 96% have heard of AIDS, this awareness has not translated into use of contraception (Awusabo-Asare K et al. 2006). According to the Guttmacher Institute's 2004 National Survey of Adolescents, only about one-third of sexually experienced female adolescents used a condom the first time they had sex. Among 15–19-year-old females who are currently pregnant, more than two-thirds did not want the pregnancy at that time or did not want to become pregnant at all (Awusabo-Asare K et al. 2006). Thus there remains a large gap in translating awareness of contraception into a subsequent preventative behavior.

Extensive focus groups and piloting by the authors, as well as results from other studies, has led to four major barriers that underlie the lack of uptake of modern contraception by women. First, there appears to be a lack of basic biological knowledge about sex and pregnancy. Misconceptions about sexual health appear common, such as whether actions like washing after sex or standing up during sex can prevent pregnancy (Awusabo-Asare K et al. 2006, Rokicki 2013). This confusion leads to uncertainty about whether contraception is necessary. Second, despite having heard of contraception like the male condom or the birth control pill, Ghanaian adolescent girls appear to have very limited knowledge about how to use contraception and how contraception functions in the body, leading to lack of self-efficacy surrounding contraceptive use. They do not feel capable of putting on a condom onto a male partner. They do not generally know how often to take the birth control Pill (Rokicki 2013). Third, there appear to exist many misconceptions about contraception. Many are worried about inaccurate future fertility risks associated with use of contraception. Other worries include side effects such as gaining weight or getting infections (Rokicki 2013). Finally, there is an apparent lack of communication about reproductive health among adolescents with their friends, parents, health workers or teachers, and partners.

New research has demonstrated the importance of communication in sexual health. In one qualitative study, newly infected HIV-positive cases aged 20-25 were matched with HIV-negative controls by gender, marital status, and community (Higgins Working Paper). Compared to HIV-negative participants, respondents who had recently seroconverted described

relationships marked by poorer communication, greater suspicion and mistrust, and larger, more transitory sexual networks. In another study conducted in Accra, communication about HIV/AIDS between students and parents or other family members increased the odds of using a condom at last sexual intercourse (Adu-Mireku 2003). Finally, self-reported ability to communicate with peers was found to be related to more positive condom attitudes, which in turn was associated with greater condom commitment and use (Halpern 2004).

Ghanaian Context

In response to the outbreak of the HIV/AIDS epidemic in 1986, the Ghanaian government initiated a set of educational programs designed to increase awareness of the disease. By 1998, general awareness of HIV among 15–19-year-olds reached 97% of both males and females.

In 1994, the government of Ghana revised the National Population Policy and followed it with an Adolescent Reproductive Health Policy in 1996. One of the strategies in both policy documents was to teach family life education in pre-tertiary educational institutions. As a result, by 2004, 61% of males and 70% of females aged 15-19 years reported that sex education was offered in their schools. Ninety-three percent of female and male adolescents were introduced to sex education before they had their first sexual experience (median age at first intercourse is 17.4 years for women and 19.5 years for men) (Awusabo-Asare K et al. 2006).

According to the students, sex education classes covered topics on how pregnancy happens and how to prevent it, and about STIs. However, in practice the actual learning of sex education has generally been superficial; for example, the Ghana AIDS Commission found that in 2004 only about one in five young men and women could name any specific way by which HIV is transmitted. In 2008, only 28.3% of females and 34.2% of males aged 15 - 24 13 years had comprehensive knowledge of HIV. Thus there remain substantial gaps in knowledge, which may be one of the reasons that actual use of contraception is so low.

Mobile Phone Programs

Worldwide, mobile phone ownership has grown at a remarkable pace, from fewer than 1 billion mobile subscriptions in 2000 to over 6 billion in 2012, of which nearly 5 billion in developing countries (World Bank. Among women ages 15-19 years living in Accra, 89% have access to a household mobile phone (Ghana 2009). In urban settings like Accra, the vast majority of adolescents have their own personal phone (Rokicki 2013). One of the most promising technologies in international development is the increasing popularity and use of short messaging service (SMS), also known as text messaging. SMS is cheap (costing pennies for a message), instantaneous, and convenient. Young people are the greatest users of SMS.

Public health programs have begun to take advantage of mobile phones in many ways, including diagnostics, health education, and drug adherence. Sexual health clinics use SMS for appointment reminders, provision of STI test results, communication of sexual health information and assistance with contact-tracing following STI diagnosis (Lim et al. 2008). In Kenya, One World has launched a service whereby people can text questions regarding HIV/AIDS to a special number and receive a reply. Daily tips are also sent out to subscribers detailing how to prevent and deal with infection (BBC News 2013). In 2011, a team of researchers conducted a study to investigate if health promotion via cell phone could be an acceptable way to relay information among adolescents in Uganda (Mitchell et al. 2011). Self-reported quantitative survey data from 1503 secondary school students suggested about half of all students and 61% of those who owned a cell phone believed that they would access a text messaging-based HIV prevention program if it were available.

However, despite an increase in popularity of mobile health programs in development, there are mixed results as to whether they are actually successful in changing behavior or improving health (Rosenberg 2013). A systematic review conducted by Cole-Lewis and Kershaw in 2010 found that 8 of 9 sufficiently powered studies found evidence to support text messaging as a tool for behavior change. However, only one of the studies was conducted in a developing country and most studies were focused on weight control or smoking behavior.

One recent study in rural China sent weekly health messages and monthly quiz questions about health and nutrition knowledge to caregivers of grade four students (Mo et al. 2013). They found that the messages increased purchases of nutritional supplements and students experienced gains in both physical health and academic performance but only if the weekly messages came with quiz questions that encouraged recipient response.

Almost all reproductive health programs using SMS messages have evaluated only the acceptability of the dissemination of health information using SMS or awareness of the program existing (Lim et al. 2008). One notable exception was a randomized controlled trial in Australia, which used SMS to promote safer sex and sun safety to young people. They found that women (but not men) in the intervention group were more likely to get an STI test or discuss sexual health with a clinician than their control counterparts. However, there was no significant impact on condom use in either men or women. (Lim et al. 2010). Another notable exception was a study in Uganda that sent reliable information about sexual health to adult users who could submit questions via text messages (Jamison et al 2013). The results showed that the system was not successful in reducing risky sexual behavior. However, the target audience of this program was older, most married adults in a setting that has a high AIDS prevalence rate. Thus although these studies provide some empirical evidence on effectiveness of SMS sexual mhealth programs, they are not externally valid for a Ghanaian urban adolescent audience that readily uses text messages to communicate. Thus there remains a gap in understanding of whether SMS messages can improve reproductive health among adolescents in an urban African setting.

Educational Theory and Behavioral Change

The structure of the text messages will be in the form of quizzes that the recipient responds to for a financial reward. Education and marketing theory show that engagement and interaction between senders and recipients of information can increase retention of the material through active processing of the information and mental retrieval (Roediger and Karpicke, 2006). In addition, the interaction may increase the importance of the information that recipients place on the content of the messages (Fjeldsoe et al, 2009, Lee 2005). Finally, rewarding correct answers may increase attention to the text messages, and provide motivation to learn which can make the messages more effective (Sarter et al 2006).

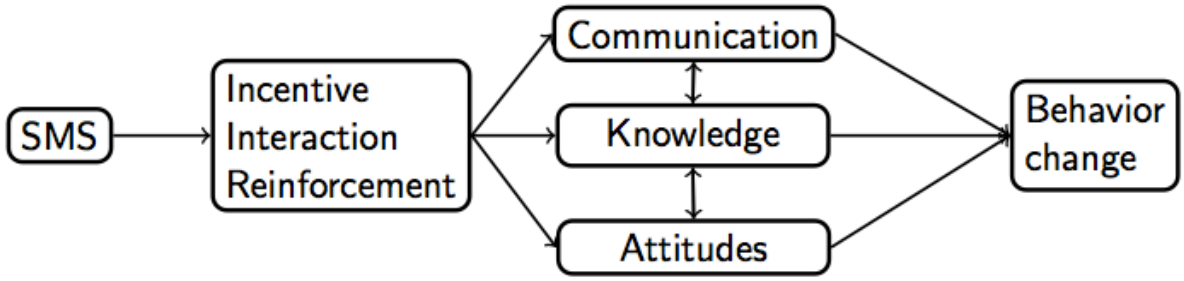
The Health Belief Model of Behavior Change suggests that adoption of a protective health behavior depends on feelings of susceptibility to a disease and on beliefs about the benefits and costs of protective health behavior (Becker, 1974, Rosenstock 1988). Recent additions to the model have included perceptions of self-efficacy about the protective behavior and perceived social support for the behavior (Adih 1999). The model suggests that influencing events can serve as cues to action that impact these beliefs (Janz and Becker, 1984). Text messages may serve as the cue to action that can be used to change a person's feelings on susceptibility and implications for health as long as the information is relevant to the person and easy for the person to understand. In the context of reproductive health, text messages can be used to change perceived susceptibility to sexually transmitted diseases, increase self-efficacy and decrease barriers to usage of condoms and contraception, and increase social support by encouraging communication (Table 1).

Table 1 How SMS messages may act on dimensions of Health Belief Model

Health Belief Model Dimension	Text messaging cue
Perceived susceptibility	Info on types of STD symptoms and time to see symptoms
Perceived self-efficacy	Increase knowledge on how to correctly put on a condom and how contraception is used/functions in the body
Perceived barriers	Debunk misconceptions about side effects, pregnancy preventions that don't work, efficacy of condoms
Perceived social support	Increase communication among friends and family about condoms and reproductive health

We show the full theoretical model in Figure 1. The SMS text message provides incentive to learn, interaction with the user, and reinforcement of the instructional material, which work to affect the communication, knowledge, and attitudes about reproductive health. The change in these outcomes can affect future behavior change.

Figure 1 Theoretical Model within each dimension of Health Belief Model



SMART program

The Study on mhealth and Reproductive Health in Teens (SMART) is a randomized controlled trial designed to evaluate the effect of sending text messages about reproductive health to young women aged 15-19 years on knowledge, attitudes, communication, and behavior.

The goals of the study are to evaluate the following research questions:

(1) Does information provided via text messages to adolescents improve reproductive health knowledge, communication, and attitudes among adolescent girls?

(2) Does a reward incentivized mobile phone operated game quiz improve reproductive health knowledge, communication, and attitudes among adolescent girls?

II. Methods

Study Design and Protocol

Study Overview

The study will be conducted in the following way. There will be two treatment arms and one control arm. The first treatment is designated the "basic treatment"; this arm only sends messages to participants. The second treatment is designated the "interactive treatment"; this arm sends and receives messages from participants, with incentives provided for the participants to reply. The control arm sends placebo messages. There will be a randomized block design with treatment clustered at the school level. The number of schools in the basic and interactive arms will be 12, while for the control we anticipate 14 schools. We anticipate an average of 30 students per school for a total of 1140 students.

Sampling Frame

The study will be conducted in senior high public or private day schools[1] in Greater Accra, Ghana that are either mixed gender or girls schools. The sampling frame was drawn from the 2012 Register of Secondary Schools from the Ghana Education Service. From this list, there were originally 46 public and private day schools in Greater Accra. However, 8 schools from that register had either moved or had been eliminated so they were dropped from the sampling frame. This yielded a total of 38 schools, which we will divide into 12 basic treatment, 12 interactive treatment, and 14 control. According to a power calculation, 36 schools (12 in

[1] Day schools are necessary because boarding school students are not allowed to have their phones at any time during the semester while they are enrolled in a boarding school, while day school students return home to their phones each night.

each treatment arm) will allow us to detect a difference of 15 percentage points in technical reproductive health knowledge as measured by the percentage correct of a 20 item true/false quiz[2].

In each school we will recruit the second year Home Economics class wherever possible. This class is at least 95% female. Any males in the class will not be asked to participate. The typical class size of a Home Economics class ranges from 10-50 students. Of the 38 schools, 9 do not have a Home Economics class. In these schools, we will choose only the girls from another class, mostly likely the General Arts or Business class. In addition, we will recruit one other classroom in each school to be a spillover classroom. We will recruit both males and females from the spillover classes. This class will usually be the Science class. Typical class sizes of Science classes are 15-40 students.

Randomization

The randomization will be at the classroom level. Because the range of abilities of students highly correlate with the category of the school (Categories B, C, D, and Private with B being the better schools[3]), we will block the randomization by school category. In addition, we will block by whether or not the school has a Home Economics class.

Data Collection

The data will be collected via self-administered questionnaires that the students take as a quiz. The questionnaire takes about 20-35 minutes to complete, as determined by pretesting and piloting. Students will be instructed as to how to fill out the questionnaire.

The 2013-2014 school year begins on September 16th. The year is organized into three terms: September 16th – December 19th, January 13th – April 11th and May 6th – August 1st. Thus students will still be in the same class between the January/February baseline and the May/June follow-up.

Additional data collection will take place in June in the form of qualitative phone interviews. SMART researchers will call the numbers of a random selection of students in the interactive and basic treatment arms to find out more information about the students' feelings towards the texting program, and ask more personal questions about changes in sexual behavior due to the texting program. These qualitative interviews will be conducted in local language, recorded and transcribed.

Basic Design

The study design is shown in Figure 1. Students will be recruited from one classroom in each school. In January-February 2014, SMART researchers go to each school to first explain the texting program to students and give students a consent form that they will take home to their parents. If the student is at least 18 years old, they will be able to sign their own consent form. The researchers will then return to the school about a week later to conduct the baseline questionnaire. The baseline questionnaire will consist of about 65 questions that include demographics, knowledge and communication of reproductive health, and attitudes and behavior towards reproductive health.

Classrooms will be randomized to either one of two treatment arms (basic treatment or interactive treatment) or control. The duration of the intervention will be 12 weeks. Students in the same class will all receive the same message and be encouraged to discuss the questions together.

The basic treatment will send one informative message per week about reproductive health, with an additional 3 messages before the start of week 4, 6, and 9, about a hotline number they can call for free if they have questions, the importance of communication, and

[2] Assumptions: power 0.9, alpha 0.05, intraclass correlation of 0.05, 30 students per cluster.

[3] Private schools are usually either very high (A) or very low (D) level as they are either for students of great ability whose parents want to pay for a better education, or they serve to take students who did not pass their middle school examinations and failed to enter any public high school.

encouragement to learn more about reproductive health. The full list of messages for all treatment and control arms is in Appendix A.

The interactive treatment arm will send one multiple choice quiz question about reproductive health per week, with the expectation of a response. Responding will be made free to the participant. The system will then send out a confirmatory message with more information if the response is correct or a corrective message with more information if the response is incorrect. For every two correct answers given, the system will send 1GH¢ airtime credit to the participant. Two reminder messages will be sent to those who had not yet responded. At the end of the week, anyone who has not responded will receive the corrective message. An additional 3 messages will be sent out similar to the basic treatment outlined above, but with wording encouraging the participant to keep responding to get more airtime credit (see Appendix A). These additional messages will be sent before the start of week 4, 6, and 9.

The control arm will send one informative message per week about malaria prevention and treatment.

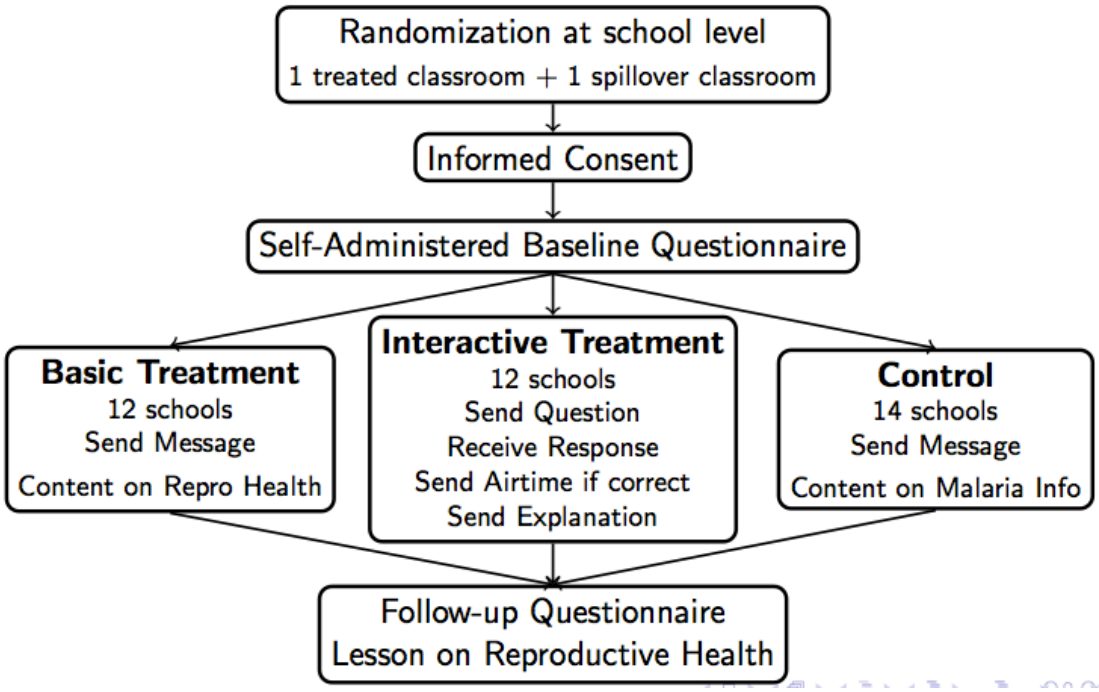
In May and June 2014, the SMART research team will return to each school to conduct the follow-up examination. Another questionnaire will be given out that will assess knowledge, communication, attitudes, and behavior surrounding reproductive health. The follow-up questionnaire will not include demographics, but will include questions evaluating the texting program in its usefulness and likeability.

During the follow-up classroom visit, the classrooms will receive a lesson in reproductive health by a health professional from an NGO with reproductive health experience. All of the answers to the quiz will be explained so that students come away with the correct information.

Spillover

Additionally, one more classroom in each school will be administered the baseline and follow-up questionnaires but will be given no treatment. This classroom will usually be a mixed gender class. This will allow us to analyze the spillover effect of the text messages to other students in the same school that did not receive the messages.

Figure 2 Study Design



Statistical analysis

Descriptive Statistics and Balance

We will generate descriptive statistics by treatment group for all demographic variables to show the balance of covariates in the treatment arms and control arm.

Table 2 Balance of response rates and individual/school characteristics across treatment arms

	Mean for Control	Mean for Basic Treatment	Mean for Interactive Treatment	Pooled F-stat (p-value)
Panel A: Response Rates				
Refused to consent				
Completed baseline				
Number lost to follow-up				
Number of missing values				
Panel B: Individual and school characteristics				
Age				
Muslim				
Catholic				
Spiritual				
Protestant				
No religion				
Other religion				
Year in SHS				
Highest Ed of Father				
Highest Ed of Mother				
Time in community <2 yrs				
Time in community 2-5 yrs				
Time in community 6-10 yrs				
Time in community >10 yrs				
Akan				
Ga/Adange				
Fanti				
Ewe				
Other ethnicity				
Own a mobile phone				
Classroom size				
Distance from Accra central				
Panel C: Basic Sex Health Education at Baseline				
Heard of HIV/AIDS				
Heard of condoms				
Seen a condom				
Learned how to put on condom				
Know how to put on a condom				
Has heard of birth control Pill				
Has heard of emergency contraception				

Hypotheses

The study generates the following predictions, which we wish to test empirically:

> H1: Adolescents in Basic Treatment and Interactive arms will have greater knowledge, greater communication, and more positive attitudes of reproductive health as compared to the control arm.

H2: Adolescents in Interactive Treatment arm will have greater knowledge, greater communication, and more positive attitudes of reproductive health as compared to the Basic Treatment arm.

Main Analysis

Knowledge

Our analytic approach begins with an intent-to-treat model comparing outcomes for those who were randomized to either the basic treatment or the interactive treatment to those who were randomized to control. We evaluate three models: a minimal model only adjusted for those variables on which we blocked our randomization, a model adjusted for all other baseline individual and school-level characteristics, and a model that adjusts for baseline knowledge. For all analyses, standard errors will be clustered at the school level since the randomization occurs at the school level.

The Knowledge Index is a score of the percentage correct of 25 items on the follow up questionnaire. The index is composed of questions that are marked as "True", "False", or "Don't know". A "Don't know" answer is marked as incorrect. Reproductive health includes knowledge of biological aspects of sex and sexually transmitted diseases; technical understanding of contraceptive methods including male and female condoms, birth control pills, and emergency contraception; and rejection of misconceptions about pregnancy and contraception.

The Ordinary Least Squares (OLS) model is therefore specified in Eq 1.

$$(1)\ KnowledgeScore_{is} \sim \alpha_1 + \gamma_1 BasicTrt_s + \gamma_2 InteractiveTrt_s + X'_s\delta_1 + \varepsilon_{is}$$

for student *i* in school *s*. X_s is the vector of blocking variables during the randomization process which include school category and whether or not the school has a Home Economics department. Since we have randomly assigned treatment to the schools, conditional on the blocking variables, we expect $E(\varepsilon_{is}|BasicTrt, InteractiveTrt, X_s)=0$.

The treatment effects are captured by γ_1 and γ_2, which is the causal effect of being in a basic treatment school versus the control and an in an interactive treatment school versus the control, respectively. We test the first hypothesis, $H_{0,1}:\gamma_1=\gamma_2=0$, with an overall F-test and we examine the coefficients and standard errors of the regression. We test the second hypothesis, $H_{0,2}:\gamma_1=\gamma_2$, with a generalized linear hypothesis test of the difference between the two coefficients[4]. The blocking variables, which include category of school and an indicator for whether the school has a Home Economics class, must remain in the otherwise unadjusted model because the randomization was conditional on these variables. An additional model will adjust the minimal model with school-level characteristics such as class size and distance to center of Accra, and individual-level characteristics such as age, ethnicity, and religion. This adjusted model is shown in Eq 2. The adjusted model should not change our parameter estimates, but may reduce standard errors by adding precision.

$$(2)\ KnowledgeScore_{is} \sim \alpha_1 + \gamma_1 BasicTrt_s + \gamma_2 InteractiveTrt_s + X'_s\delta_1 + Z'_s\delta_2 + G'_i\delta_3 + \varepsilon_{is}$$

where X_s is the same vector of blocking variables as before, Z_s is a vector of school-level covariates and G_i is a vector of individual-level covariates. We test the same hypotheses as before.

[4] We are not powered to test the difference between basic and interactive arms based on initial power calculations.

Table 3 Table Shell for Knowledge OLS Regressions

	(1) Minimal model	(2) Adjusted with covariates	(3) Adjusted with baseline score
Basic Treatment			
Interactive Treatment			
Basic*Baseline	-	-	
Interactive*Baseline	-	-	
Controls			
Blocking variables	X	X	X
Individual covariates		X	X
School covariates		X	X
Baseline score			X
Mean Dep Var (Ctl)			
F-statistic			
Basic=Interactive p-value			
N			

Standard errors clustered at school level.

Finally, we will also conduct a third specification that includes the baseline knowledge score as a covariate, in order to assess whether there is a differential effect for those who did really well on the baseline score compared to those who did poorly. The specification is shown in Eq 3.

$$(3)\ KnowledgeScore_{is} \sim \alpha_1 + \gamma_1 BasicTrt_s + \gamma_2 InteractiveTrt_s + \gamma_3 BaselineScore_i + \gamma_4 BasicTrt_s * BaselineScore_i + \gamma_5 InteractiveTrt_s * BaselineScore_i + X'_s\delta_1 + Z'_s\delta_2 + G'_i\delta_3 + \varepsilon_{is}$$

The interactive terms result in parameter estimates for γ_4 and γ_5. We can assess if there was a differential impact of baseline score on the final score by comparing these estimates to the null. The table shell for the three regressions are shown in Table 3.

Communication

Communication will be assessed via 4 questions following the structure, "In the last 3 months, how often have you spoken to [X] about sex or reproductive health issues?" where [X] includes "your parents", "your close friends", "a teacher, nurse, or any professional", and "boyfriend". The responses provided by the student are on a 5-point scale: "Every day or almost every day", "At least once a week", "At least once a month", "Less than once a month", and "Never" with higher points given to more communication on a numeric scale of 0-4. We will conduct linear regression on the ordinal variable for ease of interpretation, and include an ordinal regression model in the appendix. Additionally, we will dichotomize the responses with "At least once a week" or more since the text messages will be sent on a weekly basis. We will use the same covariates as in the knowledge outcome specification for both the minimal model and the adjusted model. The table shell for the communication regression results are shown in Table 4.

Table 4 Table Shell for Communication OLS Regression Results

	Friends		Family		Professional		Boyfriend	
	Minimal	Adj	Minimal	Adj	Minimal	Adj	Minimal	Adj
Linear Score (0-4)								
Basic Trt								
Interactive Trt								
Mean Dep Var (Ctl)								
Binary Indicator (>= At least once a week)								
Basic Trt								
Interactive Trt								
Mean Dep Var (Ctl)								
Controls								
Blocking variables	X	X	X	X	X	X	X	X
Individual covariates		X		X		X		X
School covariates		X		X		X		X
F-statistic								
Basic=Interactive p-value								
N								

Standard errors clustered at school level.

Attitudes

Attitudes will be broken into 6 families for family testing: perceived self-efficacy in STD and pregnancy prevention, barriers to use, benefits of use, partner communication, susceptibility of STDs, and social support. Items for all attitude questions are ranked on a 5-point Likert-type scale, with higher scores indicating attitudes consistent with increased protection against sexual risk-taking behaviors. Table 5 shows the question and corresponding family for the attitudes outcomes. We will report the Cronbach's Alpha for each family.

Table 5 Families of Items of Attitudes about Reproductive Health

Family	Item
Perceived self-efficacy	I know about the signs and symptoms of STDs. I know how to use a condom correctly. I know how to use the birth control Pill correctly. I am confident that I can use a condom every time I have sex. I could insist on using a condom during sex even if my boyfriend/girlfriend (or future boyfriend/girlfriend) does not want to use one. I am confident I could refuse to have sex if my boyfriend/girlfriend (or future boyfriend/girlfriend) does not want to use a condom.
Barriers to use	I would be embarrassed to buy condoms. It is too much of an inconvenience to use a condom every time you have sex. I would feel embarrassed to buy the birth control pill.
Benefits of Use	Condoms are effective against sexually transmitted diseases.
Partner Communication	I would feel comfortable talking about avoiding or delaying sex with a boyfriend/girlfriend (or future boyfriend/girlfriend). I would be embarrassed to talk about using condoms with my boyfriend/girlfriend (or future boyfriend/girlfriend).
Susceptibility	I would be worried about getting an STI if I had sex without a condom at this time in my life.
Social Support	My friends think contraception should be used to prevent unwanted

	pregnancy. My friends think condoms should be used during sex before marriage. I feel comfortable talking to my friends about condoms and contraception. My friends would approve of me using contraception or condoms to avoid pregnancy. I feel comfortable talking to my parents about condoms and contraception.

We will use both linear models and ordinal logistic models on all individual items. Additionally, we may use the standardized treatment effect to summarize the items within one family. The standardized treatment effect is shown in Eq 4.

$$(4)\quad \frac{1}{J}\sum_{j\epsilon J}\frac{\xi_j}{\sigma_j}$$

where σ_j is the standard deviation of y_j in the control group and ξ_j is the coefficient of interest for item *j* in an attitudes family (the γ coefficients from the individual regressions). To account for covariance in the estimates of these standardized effects, we will estimate pooled OLS for all items *j* in J (Finkelstein et al. 2012). This will implicitly weight all items in a family as equal.

Missing Data

We expect there will be some missing data. We will use various methods to overcome these issues and report any differences. We will report only complete case analysis in the main results and include additional missing data analyses in the appendix. The methods include:

- For knowledge, communication, and attitudes, we will impute the missing data using multiple imputation techniques as function of individual and school characteristics
- For the knowledge score, we will mark those missing as incorrect
- For the knowledge score, we will conduct weighted complete case analysis by the inverse weight of the fraction who answered the item

Other analyses

Treatment-on-treated (Local Average Treatment Effect)

We anticipate that over the 6 months of the program, any number of problems may occur with participants actually receiving the messages they were randomized to receive. First, networks compete aggressively for new clients and it is extremely common for Ghanaians to buy a new SIM card for a different network rather than add more credit to an existing card to take advantage of new deals. Second, students may lose or break their phones. Third, students may opt out of the messages if they do not find them acceptable. Fourth, students may provide incorrect phone numbers or they may be entered into the system incorrectly. Thus we expect that not everyone who is randomized to receive a treatment message will actually receive it.

To address this problem, in addition to the Intent-to-Treat analysis, we will estimate treatment-on-treated (TOT) effects with 2-stage least squares instrumental variable analysis. (The local average treatment effect is the same as the TOT when no one in the control group gets treated.) The instrument in this case is randomization and treatment is receiving at least one message.

The first model of the TOT analysis will use random assignment status as an instrument to predict program compliance for the basic and interactive treatment groups, which is measured by an indicator of receiving at least 1 message. The subsequent models will use the predicted compliance variable for the respective group to estimate the program's effects on each outcome. These analyses provide a relatively unbiased estimate of the program's effects among those who received treatment.

Heterogeneous Treatment Effects

We will investigate whether our treatment effects are heterogeneous along a number of dimensions: age (15-17, 18-23), religion (Catholic, Islam, Protestant/Spiritual), category of school, and community connectedness. The model will interact treatment with those variables. Our hypotheses for the heterogeneous treatment effects are as follows:

- We hypothesize that older students may have larger treatment effects because the information is more relevant to them.
- We hypothesize that students of Spiritual religion will have larger treatment effects because Catholic and Muslim students tend to be more conservative and often refuse to even try to answer questions correctly because they do not believe that they should know anything about condoms or contraception (Rokicki 2013).
- We hypothesize that higher category of schools will have larger treatment effects as better students may retain more information.
- We hypothesize that those with greater community connectedness will see greater treatment effects due to other research that has shown that being "connected" with the community has beneficial effects across a range of health and social outcomes (Karim 2003). Community connectedness is a score that is made up of number of close friends that the student reports having and whether the student has lived in the same area for at least 6 years.

Spillover Effects

We will analyze whether the program had any spillover effects by analyzing the data from the classrooms we recruit to fill out the questionnaire but not to receive any treatment. In each school we will hand out the questionnaire to another second year class, usually the Science class. This class will be mixed gender. The analyses will follow the same comparisons as previously outlined but will focus on the spillover classes only as opposed to the main randomized classes.

We will also analyze the spillover effect heterogeneously by gender with a model interaction for treatment and gender. We anticipate that spillover effects may be higher for girls than boys, since the treated are all girls and we have found from qualitative work that speaking about reproductive health across gender is very difficult and uncomfortable for adolescents (Rokicki 2013).

Process Measures

Finally, we will analyze a number of process measures to evaluate whether the program did what it was intended to do. If the program fails to improve the outcomes we measure, the process measures may help us understand why it failed.

First, we ask about the functionality of SMART – that is, did the participants receive the appropriate messages for their treatment group, how many messages did they receive, did they read the messages, and did the participant respond back to the messages. Next we ask about the likeability of the SMART program; that is, whether the participant liked receiving the messages and whether the messages were embarrassing or useful. We ask this in a number of ways to understand whether the program was relevant to the participant's life, and whether it was too complicated. We also ask about whether the participant felt the program was effective in helping the participant make good choices in life and more knowledgeable about their choices about sex and contraception. We also ask about the cost of the program – whether the participant lost or gained money, which may be a deterrent in using it.

Finally, we test whether the program increased communication directly by asking participants how often they spoke to their family, friends, professional, or boyfriend about the

messages they received. We also ask whether the student made use of a free hotline to which we provide the phone number[5].

Table 6 Questions related to Process Measures

Category	Question	Response Format	Analyzed as
Functionality	Did you receive any text messages from SMART?	Yes/No	0/1
	How many messages did you receive from SMART?	Number	0, 1, 2-6, 7-12
	What were the messages about?	Multiple choice	0/1 correct or not
	Did you read the messages?	Yes/No	0/1
	Did you respond back to any of the messages?	Yes/No	0/1
Likeability	Did you enjoy receiving the messages?	Yes/No	0/1
	The messages I received from SMART were embarrassing.	Yes/No	0/1
	The messages I received from SMART were interesting and helpful.	Yes/No	0/1
	The SMART program was complicated.	Yes/No	0/1
	The messages I received from SMART were relevant to me and my life.	Yes/No	0/1
Effectiveness	The messages I received will help me make good choices about sex in the future.	Yes/No	0/1
	The messages I received made me feel more knowledgeable about my choices (or future choices) about sex and contraception.	Yes/No	0/1
	I learned a lot from the SMART messages.		
Cost	The SMART program cost me airtime credit.	Yes/No	0/1
	I gained airtime credit from SMART.	Yes/No	0/1
Communication	How often did you talk about the messages with [X][1]?	3 choices	0/1: Always/Sometimes vs Never
	Did you call the free nurse hotline?	Yes/No	0/1
Interference	Did you receive messages from any other source in the past 6 months that were about reproductive health?	Yes/No	0/1

1 [X] is the same set of four categories of people as in the communication outcome section (family, friends, professional, and boyfriend).

To analyze the process measures, we will first do pairwise t-tests of the percentage in each arm agreeing with the binary measures. We will show the results for each individual measure as well as summarize the results by family with a standardized average.

[5] The hotline number is managed by Marie Stopes International (MSI)

Appendix

Appendix A: Baseline Questionnaire

Name: _____

Mobile Number: [___|___|___|___|___ | ___|___|___|___|___]

Mobile Network:
1. ☐MTN
2. ☐Tigo
3. ☐Airtel
4. ☐Vodafone
5. ☐Glo
6. ☐Expresso

Instructions: Please remember to **answer every single question**! If you don't know, mark, "don't know." **Write legibly** and don't worry about your spelling. Do the best you can. Your answers are confidential.

A1	What is your gender?	1. ☐Male 2. ☐Female
A2	How old are you?	Write in age: [___|___] years
A3	Are you married?	1. ☐Yes 2. ☐No
A4	What is the main religion of your family?	1. ☐Islam 2. ☐Catholic 3. ☐Protestant/Methodist/Presbyterian 4. ☐Spiritual/Pentecostal/Charismatic 5. ☐No religion 6. ☐Other, specify _____
A5	What year in secondary school are you in?	1. ☐SHS 1 2. ☐SHS 2 3. ☐SHS 3
A6a	What's the highest level of education of your father?	1. ☐None 2. ☐Primary 3. ☐Vocational 4. ☐Secondary 5. ☐Tertiary/University 6. ☐Don't know
A6b	What's the highest level of education of your mother?	1. ☐None 2. ☐Primary 3. ☐Vocational 4. ☐Secondary 5. ☐Tertiary/University 6. ☐Don't know
A7	How long have you lived in the community that you now live in?	1. ☐Less than 2 years 2. ☐2-5 years 3. ☐6-10 years 4. ☐More than 10 years
A8	What is your ethnic group/tribe? (Mark the one you identify with most)	1. ☐Akan 2. ☐Ga/Adangbe 3. ☐Fanti 4. ☐Ewe 5. ☐Other, specify: _____
A10	Do you own a mobile phone?	1. ☐Yes, I own a mobile phone 2. ☐No, I do not own a mobile phone but I have access to a family member's phone 3. ☐No, I do not own a mobile phone and I have no access to any phone

	Instructions: The next set of questions have to do with Reproductive Health. "Reproductive health" means anything having to do with the genital organs, sexual health, HIV/AIDS, and having sex.	
B1	Have you ever heard of HIV/AIDS?	1. ☐Yes 2. ☐No
B2	During the time you have attended school, have you ever participated in any class that discussed any reproductive health issues such as sex, pregnancy, and HIV/AIDS?	1. ☐Yes 2. ☐No
B3	Have you heard of any other sexually transmitted diseases besides AIDS?	1. ☐Yes, write the name: :_____ 2. ☐No
B4	Have you ever heard of condoms?	1. ☐Yes 2. ☐No
B5	Have you ever seen a condom?	1. ☐Yes 2. ☐No
B6	During the time you have attended school, did you learn the steps of how to put a condom on your partner or yourself properly?	1. ☐Yes 2. ☐No
B7	Have you ever heard of the birth control Pill?	1. ☐Yes 2. ☐No
B8	Have you ever heard of emergency contraception?	1. ☐Yes 2. ☐No
B9	If you wanted to ask a question about sex, pregnancy, or contraception, who would you ask? (Take your first choice)	1. ☐ I don't know who to ask 2. ☐ Doctor, clinic or hospital 3. ☐ Teacher 4. ☐ Pharmacy/drug shop 5. ☐ Parent or family member 6. ☐ Friend 7. ☐ Other, specify _____
B10	How many close friends do you have? If you don't have any, just write 00.	Write in number: [____ | ____]
B14a	In the last 3 months, how often have you spoken to your close friends about sex or reproductive health issues?	1. ☐ I don't have any close friends. 2. ☐ Every day or almost every day 3. ☐ At least once a week 4. ☐ At least once a month 5. ☐ Less than once a month 6. ☐ Never
B11b	In the last 3 months, how often have you spoken to a teacher, nurse, or any professional about sex or reproductive health issues?	1. ☐ Every day or almost every day 2. ☐ At least once a week 3. ☐ At least once a month 4. ☐ Less than once a month 5. ☐ Never
B12	Do you have a girlfriend/boyfriend?	1. ☐Yes, it's a committed relationship 2. ☐Yes, but it's not very serious 3. ☐No 4. ☐I'm married

B11c	In the last 3 months, how often have you spoken to your girlfriend/boyfriend about sex or reproductive health issues?	1. ☐ I don't have a girlfriend/boyfriend. 2. ☐ Every day or almost every day 3. ☐ At least once a week 4. ☐ At least once a month 5. ☐ Less than once a month 6. ☐ Never
B11d	In the last 3 months, how often have you spoken to your parents about sex or reproductive health issues?	1. ☐ Every day or almost every day 2. ☐ At least once a week 3. ☐ At least once a month 4. ☐ Less than once a month 5. ☐ Never

Instructions: **The next set of questions are true or false. Please do your best!**

C1	Standing up during sex can help prevent pregnancy.	1. ☐True 2. ☐False 3. ☐Don't know
C2	Condoms cause infertility in men.	1. ☐True 2. ☐False 3. ☐Don't know
C3	To put on a condom, you should first unroll it and then try to put it on the penis.	1. ☐True 2. ☐False 3. ☐Don't know
C4	When putting on a condom, it is important to leave space at the tip.	1. ☐True 2. ☐False 3. ☐Don't know
C5	When using a condom, it is important for the man to pull his penis out right after ejaculation, while it is still stiff.	1. ☐True 2. ☐False 3. ☐Don't know
C6	Birth control pills (known as The Pill) are taken once every day, whether or not you have sex.	1. ☐True 2. ☐False 3. ☐Don't know
C7	Birth control pills protect against sexually transmitted diseases.	1. ☐True 2. ☐False 3. ☐Don't know
C8	Birth control pills are effective even if a woman misses taking them for two or three days in a row.	1. ☐True 2. ☐False 3. ☐Don't know
C9	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.	1. ☐True 2. ☐False 3. ☐Don't know
C10	If a woman is having side effects with one kind of pill, switching to another type or brand might help.	1. ☐True 2. ☐False 3. ☐Don't know
C11	After a woman stops taking birth control pills, she is unable to get pregnant for at least six months.	1. ☐True 2. ☐False 3. ☐Don't know
C12	The female condom can be worn up to 8 hours before having sex.	1. ☐True 2. ☐False 3. ☐Don't know

C13	Emergency contraception must be taken within 1 hour of having unprotected sex.	1. ☐True 2. ☐False 3. ☐Don't know
C14	Symptoms of gonorrhea in females will appear the day after becoming infected.	1. ☐True 2. ☐False 3. ☐Don't know
C15	Gonorrhea infection makes it easier to get HIV and other STDs and pass them to sex partners.	1. ☐True 2. ☐False 3. ☐Don't know
C16	If left untreated, sexually transmitted infections like gonorrhea can cause infertility in both men and women.	1. ☐True 2. ☐False 3. ☐Don't know
C17	A woman with an untreated gonorrhea may have severe lower abdominal pains.	1. ☐True 2. ☐False 3. ☐Don't know
C18	If day 1 is the first day of a woman's period, she has the greatest chance of becoming pregnant during days 8-19.	1. ☐True 2. ☐False 3. ☐Don't know
C19	You can have a sexually transmitted infection without having any symptoms or knowing you are a carrier.	1. ☐True 2. ☐False 3. ☐Don't know
C20	Every woman has 1 ovary where her eggs are stored.	1. ☐True 2. ☐False 3. ☐Don't know

Instructions: Please agree or disagree with the following statements.

D1	I know about the signs and symptoms of STDs.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D2	I know how to use a condom correctly.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D3	I know how to use the birth control Pill correctly.	6. ☐Strongly agree 7. ☐Agree a little bit 8. ☐Neither agree nor disagree 9. ☐Disagree a little bit 10. ☐Strongly disagree
D4	Condoms are effective against sexually transmitted diseases.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree

D5	I am confident that I can use a condom every time I have sex.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D6	I would be embarrassed to talk about using condoms with my boyfriend/girlfriend (or future boyfriend/girlfriend).	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D7	I would be worried about getting an STI if I had sex without a condom at this time in my life.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D8	My friends think contraception should be used to prevent unwanted pregnancy.	3. ☐Strongly agree 4. ☐Agree a little bit 5. ☐Neither agree nor disagree 6. ☐Disagree a little bit 7. ☐Strongly disagree
D9	It is too much of an inconvenience to use a condom every time you have sex.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D10	I could insist on using a condom during sex even if my boyfriend/girlfriend (or future boyfriend/girlfriend) does not want to use one.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D11	My friends think condoms should be used during sex before marriage.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D12	I feel comfortable talking to my friends about condoms and contraception.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D13	I would feel embarrassed to buy the birth control pill.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D14	My friends would approve of me using contraception or condoms to avoid pregnancy.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree

D15	I would feel comfortable talking about avoiding or delaying sex with a boyfriend/girlfriend (or future boyfriend/girlfriend).	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D16	I feel comfortable talking to my parents about condoms and contraception.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D17	I am confident I could refuse to have sex if my boyfriend/girlfriend (or future boyfriend/girlfriend) does not want to use a condom.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D18	I would be embarrassed to buy condoms.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D19	What questions do you have about sex, pregnancy, STDs, or reproductive health? Write your comments (if you have them) here:	

Appendix B: Content of SMS Messages for all arms

1. Interactive Treatment Arm: Content of Messages and Responses

	Type	Question Content	Correct Ans	SMART response back to participant, with either "Right!" or "Sorry!" as intro.
1	**Intro**	Hello! Thank you for signing up for SMART, a text message program on health. You will receive 12 questions to which you should please reply. Always reply in capital letters. NB: every 2 correct answers attracts a credit reward.Thanks!	NA	NA
3	**Female body**	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	Every woman has 2 ovaries, where eggs are stored. She has a womb (uterus) where a fertilized egg implants and a pregnancy grows. Two fallopian tubes connect the ovaries to the womb. The cervix connects the womb to the vagina. The vagina is a tube of muscle connecting the cervix to the outside of the body
5	**Female body**	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	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.
4	**Female body**	SMART Health quiz:True or False:Standing up during sex can prevent a girl from getting pregnant. Reply SMT1 for true or SMT2 for false.	SMT2	Standing up during sex does NOT prevent pregnancy. When a man ejaculates, the sperms are deposited deep into the vagina immediately after ejaculation, allowing fertilization to take place. Bathing will not prevent pregnancy either.
6	**Health Tip**	SMART Health Tip: Don't forget to talk to your friends if you don't know the answer to the questions we send! Talking with friends is SMART! Win together!	NA	NA
7	**STD**	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	You can have a STI without having any symptoms or knowing you are a carrier. It can take weeks to see symptoms like sores, itches and problems urinating. A partner might have a STI and it may be impossible for him or you to know that he has it. Condoms and abstinence are effective ways to prevent STIs.
8	**STD**	SMART: Do the signs and symptoms of Gonorrhea appear within 2 days of getting infected among females? Reply SMT1 for yes or SMT2 for no.	SMT2	It can take months to see signs of gonorrhea in females. In males it takes only days. It is important to seek treatment of gonorrhea from a health center. Untreated gonorrhea may lead to severe pains in lower abdomen called pelvic inflammatory disease. It can cause infertility, and makes it easier to get HIV.
9	**Health Tip**	SMART Tip: 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	NA	NA

		a nurse about strategies for saying no. You could also call this number if you have any questions bothering you.		
10	**Contraception**	SMART quiz: True or false: The female condom can be worn up to 8 hours before sex. Reply SMT1 for true or SMT2 for false.	SMT1	The female condom is a sheath of thin, transparent, and soft plastic that is designed to fit into a woman's vagina. It protects against both STIs and pregnancy. It has very safe and can be worn up to 8 hours before sex. It is 95% effective if worn correctly.
11	**Contraception**	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	Do NOT unroll the entire condom first. Hold the tip 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, then the condom will burst open during ejaculation. When used correctly, condoms are 98% effective against STDs and pregnancy
12	**Contraception**	SMART quiz: When using a condom, when should the man pull out of the vagina after ejaculation? Reply SMT1 for while penis is still stiff or SMT2 for when penis is soft.	SMT1	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.
13	**Health Tip**	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 98% effective against STDs and pregnancy. They do not cause infertility in men.	NA	NA
14	**Contraception**	SMART:How often is the Pill taken (the birth control Pill)? Reply SMT1 for only after you have sex or text SMT2 for once a day, everyday.	SMT2	The Pill is taken once a day, whether or not you have 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 very low and safe doses of hormones, which prevent release of eggs from ovaries.
15	**Contraception**	SMART: True or False: It takes only 2-3 days for a woman to get pregnant after she stops taking the Pill. Reply SMT1 for true or SMT2 for false.	SMT1	The Pill is taken everyday and if a woman stops taking it then she may get pregnant after 2-3 days. There is no delay in becoming pregnant after a woman stops taking the pills. A woman's future fertility is not affected by taking the Pill. The Pill is NOT effective if a woman misses it for 2 or 3 days in a row.
16	**Contraception**	SMART Health quiz: Do birth control pills "build up" in a woman's body over time? Reply SMT1 for yes, SMT2 for no.	SMT2	The Pill does NOT build up in the body. After 2-3 days, there is no trace of the Pill left. For this reason, women do NOT need to "take a rest" from the Pill.
17	**Contraception**	SMART: True or False. Emergency contraception must be taken within 1 hour of unprotected sex. Reply SMT1 for	SMT2	Emergency contraception (like Postinor-2) is a method to reduce the chance of pregnancy after unprotected sex or when a condom breaks. The 2 special pills must be taken within 5 days of

		true, and SMT2 for false.		unprotected sex (you have more than 1 hour). It should only be used for emergencies, not as a regular method of contraception.
18	**Health Tip**	SMART tip: Strategies like drinking water, drinking malt and sugar, or bathing will NOT prevent pregnancy. Those are all myths and do not work! Abstinence and contraception can reduce the chance of getting pregnant.		
	End of program message	SMART tip: Great job! The quiz is finished! Remember to call 0302208585 or 080028585 (Toll free- Vodafone only) if you have any questions about your health.		

2. Basic Treatment Arm Messages:

	Message Content
1	Hello! Thank you for signing up for SMART, a text message program on reproductive health. You will receive messages for 12 weeks. You can talk about the messages with anyone you please. Thank you!
2	SMART fact: A woman has 2 ovaries, where eggs are stored. She has a womb (uterus) where a fertilized egg implants and a pregnancy grows. Two fallopian tubes connect the ovaries to the womb. The cervix connects the womb to the vagina. The vagina is a tube of muscle connecting the cervix to the outside of the body
3	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.
4	SMART fact: Standing up during sex does NOT prevent pregnancy. When a man ejaculates, the sperms are deposited deep into the vagina immediately after ejaculation, allowing fertilization to take place. Bathing will not prevent pregnancy either.
5	SMART Health Tip: You can talk to your friends about the messages we send. Talking about reproductive health is SMART!
6	SMART fact: You can have a STI without having any symptoms or knowing you are a carrier. It can take weeks to see symptoms like sores, itches and problems urinating. A partner might have a STI and it may be impossible for him or you to know that he has it. Condoms and abstinence are effective ways to prevent STIs.
7	SMART fact: It can take months to see signs of gonorrhea in females. In males it takes only days. It is important to seek treatment of gonorrhea from a health center. Untreated gonorrhea may lead to severe pains in lower abdomen called pelvic inflammatory disease. It can cause infertility, and makes it easier to get HIV.
8	SMART Tip: 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. You could also call this number if you have any questions bothering you.
9	SMART fact: The female condom is a sheath of thin, transparent, and soft plastic that is designed to fit into a woman's vagina. It protects against both STIs and pregnancy. It has very safe and can be worn up to 8 hours before sex. It is 95% effective if worn correctly.
10	SMART fact: When using a male condom, do NOT unroll the entire condom first. Hold the tip 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, then the condom will burst open during ejaculation. When used correctly, condoms are 98% effective against STDs and pregnancy
11	SMART fact: When using a male 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.
12	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 98% effective against STDs and pregnancy. They do not cause infertility in men.
13	SMART fact: The Pill is taken once a day, whether or not you have 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 very low and safe doses of hormones, which prevent release of eggs from ovaries.
14	SMART fact: The Pill is taken everyday and if a woman stops taking it then she may get pregnant after 2-3 days. There is no delay in becoming pregnant after a woman stops taking the pills. A woman's future fertility is not affected by taking the Pill. The Pill is NOT effective if a woman misses it for 2 or 3 days in a row.
15	SMART fact: The Pill does NOT build up in the body. After 2-3 days, there is no trace of the Pill left. For this reason, women do NOT need to "take a rest" from the Pill.
16	SMART fact: Emergency contraception (like Postinor-2) is a method to reduce the chance of pregnancy after unprotected sex or when a condom breaks. The 2 special pills must be taken within 5 days of unprotected sex. It should only be used for emergencies, not as a regular method of contraception.
17	SMART tip: Strategies like drinking water, drinking malt and sugar, or bathing will NOT prevent pregnancy. Those are all myths and do not work! Abstinence and contraception can reduce the chance of getting pregnant.
18	SMART: Great job! The quiz is finished! Remember to call 0302208585 or 080028585 (Toll free-Vodafone only) if you have any questions about your health.

3. Control Arm: Malaria Messages

	Message Content
1	Hello! Thank you for signing up for SMART, a text message program about health. You will receive messages for 12 weeks. Thank you!
1	SMART fact: In 2013, malaria caused an estimated 627,000 deaths, mostly among African children.
2	SMART fact: Children who survive episodes of severe malaria may develop learning impairments and brain damage. Protect kids w/ mosquito nets.
3	SMART fact: Malaria is transmitted only through the bites of Anopheles mosquitoes, which spread parasites from person to person.
4	SMART fact: Pregnant women and their unborn children are particularly vulnerable to malaria. About 10,000 pregnant women die each year from malaria in Africa.
5	SMART fact: There are currently no licensed vaccines against malaria. You can prevent malaria with treated mosquito nets.
6	SMART fact: Symptoms of malaria appear 7 days or more after the infective mosquito bite. The first symptoms are fever, headache, chills and vomiting.
7	SMART fact: You can cure malaria with ACTs like Lonart which are subsidized by the government– find them at almost any drug shop.
8	SMART fact: If you take an ACT and don't finish all the pills, the parasite will survive. This builds resistance to the medication. Always finish ACTs.
9	SMART fact:Recurrent infections of malaria may result in severe anemia.This occurs especially in young kids with frequent infections that are improperly treated
10	SMART fact: The cost of treating malaria and losing days of work due to illness is much higher than preventing it. Prevent malaria with mosquito nets!
11	SMART fact: In 2012, malaria killed an estimated 483000 children under five years of age, or one child almost every minute.
12	SMART fact: Increased prevention and control measures have led to a reduction in malaria mortality rates by more than one-third. Prevention works!
13	SMART: The mhealth program is finished! Thanks for your participation.

Appendix C: Follow-up Questionnaire

Name: _____

Mobile Number: [____|____|____|____|____ | ____|____|____|____|____]

Mobile Network:
1. ☐MTN
2. ☐Tigo
3. ☐Airtel
4. ☐Vodafone
5. ☐Glo
6. ☐Expresso

Instructions: Please remember to **answer every single question**! If you don't know, mark, "don't know." **Write legibly** and don't worry about your spelling.

B9	If you wanted to ask a question about sex, pregnancy, or contraception, who would you ask? (Take your first choice)	1. ☐ I don't know who to ask 2. ☐ Doctor, clinic or hospital 3. ☐ Teacher 4. ☐ Pharmacy/drug shop 5. ☐ Parent or family member 6. ☐ Friend 7. ☐ Other, specify _____
B10	How many close friends do you have? If you don't have any, just write 00.	Write in number: [____ | ____]
B11a	In the last 3 months, how often have you spoken to your close friends about sex or reproductive health issues?	1. ☐ I don't have any close friends. 2. ☐ Every day or almost every day 3. ☐ At least once a week 4. ☐ At least once a month 5. ☐ Less than once a month 6. ☐ Never
B11b	In the last 3 months, how often have you spoken to a teacher, nurse, or any professional about sex or reproductive health issues?	1. ☐ Every day or almost every day 2. ☐ At least once a week 3. ☐ At least once a month 4. ☐ Less than once a month 5. ☐ Never
B12	Do you have a girlfriend/boyfriend?	1. ☐Yes, it's a committed relationship 2. ☐Yes, but it's not very serious 3. ☐No 4. ☐I'm married
B11c	In the last 3 months, how often have you spoken to your girlfriend/boyfriend about sex or reproductive health issues?	1. ☐ I don't have a girlfriend/boyfriend. 2. ☐ Every day or almost every day 3. ☐ At least once a week 4. ☐ At least once a month 5. ☐ Less than once a month 6. ☐ Never
B11d	In the last 3 months, how often have you spoken to your parents/guardian about sex or reproductive health issues?	1. ☐ Every day or almost every day 2. ☐ At least once a week 3. ☐ At least once a month 4. ☐ Less than once a month 5. ☐ Never

Instructions: **The next set of questions are true or false. Please do your best!**		
C1	Standing up during sex can help prevent pregnancy.	1. ☐True 2. ☐False -888. ☐Don't know
C2	Condoms cause infertility in men.	1. ☐True 2. ☐False -888. ☐Don't know
C3	To put on a condom, you should first unroll it and then try to put it on the penis.	1. ☐True 2. ☐False -888. ☐Don't know
C4	When putting on a condom, it is important to leave space at the tip.	1. ☐True 2. ☐False -888. ☐Don't know
C5	When using a condom, it is important for the man to pull out right after ejaculation, while the penis is still erect.	1. ☐True 2. ☐False -888. ☐Don't know
C6	Birth control pills (known as The Pill) are taken once every day, whether or not you have sex.	1. ☐True 2. ☐False -888. ☐Don't know
C7	Birth control pills protect against sexually transmitted diseases.	1. ☐True 2. ☐False -888. ☐Don't know
C8	Birth control pills are effective even if a woman misses taking them for two or three days in a row.	1. ☐True 2. ☐False -888. ☐Don't know
C9	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.	1. ☐True 2. ☐False -888. ☐Don't know
C10	If a woman is having side effects with one kind of pill, switching to another type or brand might help.	1. ☐True 2. ☐False -888. ☐Don't know
C11	After a woman stops taking birth control pills, she is unable to get pregnant for at least six months.	1. ☐True 2. ☐False -888. ☐Don't know
C12	The female condom can be worn up to 8 hours before having sex.	1. ☐True 2. ☐False -888. ☐Don't know
C13	Emergency contraception must be taken within 1 hour of having unprotected sex.	1. ☐True 2. ☐False -888. ☐Don't know
C14	Symptoms of gonorrhea in females will appear the day after becoming infected.	1. ☐True 2. ☐False -888. ☐Don't know
C15	Gonorrhea infection makes it easier to get HIV and other STDs and pass them to sex partners.	1. ☐True 2. ☐False -888. ☐Don't know
C16	If left untreated, sexually transmitted infections like gonorrhea can cause infertility in both men and women.	1. ☐True 2. ☐False -888. ☐Don't know

C17	A woman with an untreated STI may have severe abdominal pains in her lower abdomen area.	1. ☐True 2. ☐False -888. ☐Don't know
C18	If day 1 is the first day of a woman's period, she has the greatest chance of becoming pregnant during days 8-19.	1. ☐True 2. ☐False -888. ☐Don't know
C19	You can have a sexually transmitted infection without having any symptoms or knowing you are a carrier.	1. ☐True 2. ☐False -888. ☐Don't know
C20	Every woman has 1 ovary where her eggs are stored.	1. ☐True 2. ☐False -888. ☐Don't know
C21	Washing/bathing oneself after sex can prevent pregnancy.	1. ☐True 2. ☐False -888. ☐Don't know
C22	STI symptoms can include pain and problems with urinating.	1. ☐True 2. ☐False -888. ☐Don't know
C23	Gonorrhea can be treated with antibiotics.	1. ☐True 2. ☐False -888. ☐Don't know
C24	Drinking lots of malt and sugar can prevent pregnancy.	1. ☐True 2. ☐False -888. ☐Don't know
C25	98 percent of women relying on male condoms will not get pregnant if they use them correctly every time they have sex.	1. ☐True 2. ☐False -888. ☐Don't know

Instructions: Please either agree or disagree with the following statements.

D1	I know about the signs and symptoms of STDs.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D2	I know how to use a condom correctly.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D3	I know how to use the birth control Pill correctly.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D4	Condoms are effective against sexually transmitted diseases.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree

D5	I am confident that I can use a condom every time I have sex.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D6	I would be embarrassed to talk about using condoms with my boyfriend/girlfriend (or future boyfriend/girlfriend).	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D7	I would be worried about getting an STI if I had sex without a condom at this time in my life.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D8	My friends think contraception should be used to prevent unwanted pregnancy.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D9	It is too much of an inconvenience to use a condom every time you have sex.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D10	I could insist on using a condom during sex even if my boyfriend/girlfriend (or future boyfriend/girlfriend) does not want to use one.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D11	My friends think condoms should be used during sex before marriage.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D12	I feel comfortable talking to my friends about condoms and contraception.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D13	My parents would approve of me using contraception or condoms to avoid pregnancy.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D14	My friends would approve of me using contraception or condoms to avoid pregnancy.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree

D15	I would feel comfortable talking about avoiding or delaying sex with a boyfriend/girlfriend (or future boyfriend/girlfriend).	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D16	I feel comfortable talking to my parents about condoms and contraception.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree
D17	I am confident I could refuse to have sex if my boyfriend/girlfriend (or future boyfriend/girlfriend) does not want to use a condom.	1. ☐Strongly agree 2. ☐Agree a little bit 3. ☐Neither agree nor disagree 4. ☐Disagree a little bit 5. ☐Strongly disagree

Instructions: The next section is about the SMART text messaging program that you were enrolled in.		
E1	Did you receive any text messages from SMART?	1. ☐Yes 2. ☐No -888. ☐Don't know
E2	About how many messages did you receive from SMART? If you're not sure, give a guess.	Write in number of messages received: [____| ____| ____]
E3	What were the messages about?	1. ☐Nutrition 2. ☐Malaria 3. ☐Reproductive health 4. ☐Other, specify _____ -888. ☐Don't know/Don't remember
E4	Did you enjoy receiving the messages?	1. ☐Yes, very much 2. ☐They were just ok. 3. ☐No, I didn't like them. -888. ☐Don't know
E5	Did you read the messages?	1. ☐Yes, I read every one of them. 2. ☐Yes, but I didn't read all of them. 3. ☐No, I just deleted them.
E5	Did you respond to any of the messages?	1. ☐Yes, I responded all the time 2. ☐Yes, but only to a few 3. ☐No, I didn't respond to any of them
E6	Did you call the free hotline number that was provided in the messages?	1. ☐Yes 2. ☐No, I decided not to call it 3. ☐No, there wasn't any hotline provided.
E7	How often did you talk to your friends about the messages?	1. ☐I talked about every new message 2. ☐I talked about some of the messages 3. ☐I never discussed the messages
E8	How often did you talk to a teacher, nurse, or any professional about the messages?	1. ☐I talked about every new message 2. ☐I talked about some of the messages 3. ☐I never discussed the messages
E9	How often did you talk to your parents about the messages?	1. ☐I talked about every new message 2. ☐I talked about some of the messages 3. ☐I never discussed the messages

E10	How often did you talk to your boyfriend about the messages?	1. ☐I don't have a boyfriend. 2. ☐I talked about every new message 3. ☐I talked about some of the messages 4. ☐I never discussed the messages
E11	The messages I received from SMART were embarrassing.	1. ☐Yes, very much 2. ☐Yes, a little bit 3. ☐No -888. ☐Don't know
E12	The messages I received from SMART were relevant to me and my life.	1. ☐Yes, very much 2. ☐Yes, a little bit 3. ☐No -888. ☐Don't know
E13	I gained airtime credit from SMART.	1. ☐Yes, very much 2. ☐Yes, a little bit 3. ☐No -888. ☐Don't know
E14	The messages I received made me feel more knowledgeable about my choices (or future choices) about sex and contraception.	1. ☐Yes, very much 2. ☐Yes, a little bit 3. ☐No -888. ☐Don't know
E15	The messages I received from SMART were interesting and helpful.	1. ☐Yes, very much 2. ☐Yes, a little bit 3. ☐No -888. ☐Don't know
E16	The SMART program cost me airtime credit.	1. ☐Yes, very much 2. ☐Yes, a little bit 3. ☐No -888. ☐Don't know
E17	The messages I received from SMART will help me make good choices about sex in the future.	1. ☐Agree 2. ☐Disagree -888. ☐Don't know
E18	I learned a lot from the SMART messages.	1. ☐Yes, very much 2. ☐Yes, a little bit 3. ☐No -888. ☐Don't know
E18	The SMART program was complicated.	1. ☐Yes, very much 2. ☐Yes, a little bit 3. ☐No -888. ☐Don't know
E19	Did you receive messages from any other source in the past 6 months that were about reproductive health?	1. ☐Yes, specify the source _____ 2. ☐No -888. ☐Don't know
E20	Do you have any comments you would like to tell us about the SMART messages? We appreciate all comments, even if they are criticisms! Write your comments here:	

References

Adanu, Richard MK, et al. "Sexually transmitted infections and health seeking behaviour among Ghanaian women in Accra." *African journal of reproductive health* 12.3 (2008).

Adanu, Richard MK, et al. "Sexual and reproductive health in Accra, Ghana." *Ghana Medical Journal* 46.2 (2012): 58-65.

Adu-Mireku, Samuel. "Family communication about HIV/AIDS and sexual behaviour among senior secondary school students in Accra, Ghana." African Health Sciences 3.1 (2003): 7-14.

Agyei, William K, Richard Biritwum, AG Ashitey, Robert Hill (2000). Sexual Behavior and Contraception Among Unmarried Adolescents and Young Adults in Greater Accra and Eastern Regions of Ghana. Journal of Biosocial Science, 32, pp 495-512.

Awusabo-Asare K et al., Adolescent Sexual and Reproductive Health in Ghana: Results from the 2004 National Survey of Adolescents, Occasional Report, New York: Guttmacher Institute, 2006, No. 22.

BBC News. Texts aim to fight AIDS in Kenya. 1 December 2013. Accessed May 1, 2013. http://news.bbc.co.uk/2/hi/technology/4054475.stm.

Ghana AIDS Commission. UNAIDS. Ghana Country AIDS Progress Report. March 2012.

Ghana, S.S. (2009). Ghana Demographic and Health Survey 2008. Calverton MD, Measure DHS.

Finkelstein, Amy, et al. "The Oregon Health Insurance Experiment: Evidence from the First Year*." *The Quarterly Journal of Economics* 127.3 (2012): 1057-1106.

Fjeldsoe, B. S., Marshall, A. L., & Miller, Y. D. (2009). Behavior change interventions delivered by mobile telephone short-message service.American journal of preventive medicine, 36(2), 165-173.

Halpern-Felsher BL, Kropp RY, Boyer CB, Tschann JM, Ellen JM. Adolescents' self-efficacy to communicate about sex: its role in condom attitudes, commitment, and use. Adolescence. 2004 Fall; 39(155):443-56.

Higgins, JA et al. "The Importance of Relationship Dynamics in HIV Transmission: Results from a Qualitative Case-Control Study in Rakai, Uganda." Working Paper. 2013.

Jamison, Julian et al. "Mixed Method Evaluation of a Passive mHealth Sexual Information Texting Service in Uganda." Innovations for Poverty Action. May 2013.

Janz, Nancy K., and Marshall H. Becker. "The health belief model: A decade later." *Health Education & Behavior* 11.1 (1984): 1-47.

Karim, Ali Mehryar et al. "Reproductive Health Risk and Protective Factors Among Unmarried Youth in Ghana." International Family Planning Perspectives, 2003, 29(1): 14-24.

Lee, T. (2005). The impact of perceptions of interactivity on customer trust and transaction intentions in mobile commerce. Journal of Electronic Commerce Research, 6(3), 165-180.

Lim, Megan SC, et al. "SMS STI: a review of the uses of mobile phone text messaging in sexual health." International journal of STD & AIDS 19.5 (2008): 287-290.

Lim, Megan SC, et al. "Impact of text and email messaging on the sexual health of young people: a randomised controlled trial." Journal of epidemiology and community health 66.1 (2012): 69-74.

Mitchell, Kimberly J., et al. "Cell phone usage among adolescents in Uganda: acceptability for relaying health information." Health Education Research 26.5 (2011): 770-781.

Mo, Di et al. "Text Messaging and Its Impacts on the Health and Education of the Poor:
Evidence from Field Experiments in Rural China." Working Paper 262. Rural Education Access Project. July 2013.

Roediger, H. L., & Karpicke, J. D. (2006). Test-enhanced learning taking memory tests improves long-term retention. Psychological Science, 17(3), 249-255.

Rokicki, Slawa. (2013). Preliminary Research on Study on Mhealth and Reproductive Health in Teens. Study Report.

Rosenberg, Tina. "The Benefits of Mobile Health, On Hold." March 13, 2013. Accessed May 1, 2013. http://opinionator.blogs.nytimes.com/2013/03/13/the-benefits-of-mobile-health-on-hold/

Rosenstock, Irwin M., Victor J. Strecher, and Marshall H. Becker. "Social learning theory and the health belief model." *Health Education & Behavior* 15.2 (1988): 175-183.

Sarter, M., Gehring, W. J., & Kozak, R. (2006). More attention must be paid: the neurobiology of attentional effort. Brain research reviews, 51(2), 145-160.

World Bank. (2012, July 17). *Mobile Phone Access Reaches Three Quarters of Planet's Population.* Retrieved from http://www.worldbank.org/en/news/press-release/2012/07/17/mobile-phone-access-reaches-three-quarters-planets-population