Behavioral economics informed message content in text message reminders to improve cervical screening participation: Two pragmatic randomized controlled trials

ABSTRACT

The objective of the reported research was to assess the impact of text message (SMS) reminders and their content on cervical screening rates. Women invited for cervical screening in Northwest London from February-October 2015 were eligible. 3133 women aged 24-29 (Study 1) were randomized (1:1) to 'no SMS' (control), or a primary care physician (PCP) endorsed SMS (SMS-PCP). 11405 women aged 30-64 (Study 2), were randomized (1:1:1:1:1:1:1) to either: no SMS, an SMS without manipulation (SMS), the SMS-PCP, an SMS with a total or proportionate social norm (SMS-SNT or SMS-SNP), or an SMS with a gain-framed or loss-framed message (SMS-GF and SMS-LF). The primary outcome was participation at 18 weeks. In Study 1 participation was significantly higher in the SMS-PCP arm (31.4%) compared to control (26.4%, aOR: 1.29, 95%CI: 1.09-1·51; p=0.002). In Study 2 participation was highest in the SMS-PCP (38.4%) and SMS (38.1%) arms compared to control (34.4%), (aOR: 1.19, 95%CI: 1.03-1.38; p=0.02 and aOR: 1.18, 95%CI: 1.02-1.37; p=0.03, respectively). The results demonstrate that behavioral SMSs improve cervical screening participation. The message content plays an important role in the impact of SMS. The results from this trial have already been used to designing effective policy for cervical cancer screening. The NHS Cervical Screening Programme started running a London-wide screening campaign which was based on the cervical screening trial described here. According to figures published by Public Health England, after six months attendance increased by 4.8%, which is the equivalent of 13,400 more women being screened at 18 weeks.

KEYWORDS: Cervical Screening; Behavior Change; Behavioral Economics; Nudge; Text-Message Reminders; Health Message Content; SMS Reminders.

Trial registration: clinicaltrials.gov (identifier: NCT02363088)

BACKGROUND

Cervical screening (CS) saves lives by detecting pre-cancerous and cancerous cervical lesions earlier, when medical intervention can reduce the potential morbidity and mortality.(Peto et al., 2004) As a result, many countries, including the United Kingdom, have implemented organized CS programs.(Anttila et al., 2004) As with most screening, the benefits of CS are limited to individuals who are tested regularly.(Landy et al., 2016) Despite evidence that 90% of the British public support participation in cancer screening(Waller et al., 2015), coverage has fallen over recent years, from 75.7% in 2011, to 72.0% in 2017.(Digital, 2011, 2017)

Simply 'forgetting' and 'procrastinating' are frequently cited barriers to CS.(Bosgraaf et al., 2014; Ekechi et al., 2014) An English study found that 28% of non-attenders reported that they did not 'get around' to having a smear test,(Ekechi et al., 2014) while a Dutch study reported that 32% 'forgot to schedule' a smear.(Bosgraaf et al., 2014) It follows that reminders improve participation. Eaker *et. al* (2004) found that letter and telephone reminders improved CS participation among non-attenders by 9.2 percentage points (i.e. from 6.3% to 15.5%), and 31.4 percentage points (i.e. from 10% to 41.4%), respectively.(Eaker et al., 2004) While highly effective, these communication channels can be expensive and difficult to scale.(Duffy et al., 2016) As a result, researchers have begun focusing on alternatives, such as text message reminders, also known as short message service (SMS) reminders, which cost relatively little.(Uy et al., 2017)

Within breast screening, SMS has already provided a successful method to improve attendance.(Kerrison et al., 2015) For CS, however, there is little evidence to support their use. A recent systematic review identified just one randomized controlled trial (RCT) exploring the use of SMS in relation to CS. In that study, Rashid et al (2013) compared the effectiveness of

mailed reminders, SMS reminders and telephone reminders as CS recall strategies.[13] Their results indicated that, while SMS reminders were the second most effective recall strategy after telephone reminders, they did not significantly improve uptake over and above mailed reminders.(Abdul Rashid et al., 2013) It is likely that the study's small sample size contributed to this finding, however, as there was evidence of a nine percentage point increase in participation.(Abdul Rashid et al., 2013)

Given that health decisions can also be affected by personal biases,(Kahneman D, 1979; Paul Dolan, 2010; Weinstein et al., 2005) recent studies have begun to explore how behavioral economics can be used to enhance the effectiveness of text-message reminders (i.e. by acting on certain heuristics). For example, in one trial aimed at reducing non-attendance at out-patient appointments, Hallsworth and colleagues tested the effect of incorporating the appointment cost into the text-message, and found that this resulted in a 2.7 percentage point reduction in missed appointments, over and above the 'standard' SMS reminder.(Hallsworth et al., 2015)

Objectives

This study set out to assess the impact of SMS reminders and different SMS message content (informed by behavioral economics) on CS participation.

METHODS

Study design and setting

We performed two RCTs within the Northwest London Borough of Hillingdon (LBH). The trial location was selected due to its low screening coverage and previous experience delivering text-messaging research.(Digital, 2014-15)

Participants

Participants were women, aged 24–64 years, who were invited for CS during the study period (February-October, 2015), and registered with a participating PCP practice.

PCP recruitment

Consent to send participants an SMS was obtained from their PCP. All LBH PCP practices (n=48) were invited to participate. Consent was obtained from 83% (n=40).

Procedures

During the study period, women who were potentially eligible for CS were identified by the LBH call/recall team on a weekly basis. Prior notification lists containing unique identifiers for women to be invited for screening were then sent to PCPs for review. As per standard practice, PCPs excluded ineligible women, such as those undergoing medical treatment, using data stored on the clinical system. Cleansed lists were then returned to the call/recall team, who delivered the invitations to eligible women, along with a trial information leaflet, which provided several ways to opt-out of the trials (see Appendix 1).[19]

On the basis that participation in CS is declining,[5, 6] particularly among women receiving their first invitation,[5,6] we decided to stratify participants by age, with women aged 24-29 ('Study 1') representing those receiving their first CS invitation (i.e. the 'prevalent' population), and women aged 30-64 ('Study 2') representing those receiving a subsequent invitation (i.e. the 'incident' population). Each week, Study 1 participants were randomized to one of two trial arms, while Study 2 participants were randomized to one of seven trial arms. The principal reason for randomizing Study 1 participants to one of two trial arms, as opposed to one of seven, was to ensure adequate numbers were present within each trial arm to test whether a

SMS reminder is an effective intervention to increase CS participation within the prevalent population (the prevalent population is considerably smaller than the incident population, due to the narrower age range of the population i.e. 24-29 vs. 30-64). The principal reason for randomizing Study 2 participants into one of seven trial arms, as opposed to one of two, was to test whether the message content affects the effectiveness of the SMS.

Participants allocated to one of the intervention arms were sent an SMS three weeks after the invitation letter. To control for any effect the timing of the intervention might have, all SMS were sent at same day/time (i.e. 2pm GMT on Wednesdays) via iPlato patient care messaging.(iPlato, (2014))

Randomization

Participants were randomized using a pseudorandom number generator. Participants in Study 1 were randomized (1:1 ratio) to receive either: no SMS (control), or an SMS containing a message from their PCP (SMS-PCP), while participants in Study 2 were randomized (1:1:1:1:1:1:1 ratio) to receive either: 1) no SMS (control), 2) an SMS with no manipulation (SMS), 3) an SMS containing a message from their PCP (SMS-PCP), 4) an SMS with a 'total' social norms message (SMS-SNT), 5) an SMS with a 'proportional' social norms message (SMS-SNP), 6) an SMS with a gain-framed message (SMS-GF), or 7) an SMS with a loss-framed message (SMS-LF).

Blinding

Researchers randomised participants, and so were not blinded to the treatment that subjects received. As individuals were sent an SMS, or no SMS, it was not possible to blind them to the treatment they received.

Intervention design

The SMS content was guided by the MINDSPACE framework(Paul Dolan, 2010) and agreed upon by a panel of experts (see Table 1 for message content). The same panel agreed that just one text-message would be sent, so as not overburden patients with excessive healthcare communication. The information used for the messages was based on information from the Health and Social Care Information Centre (HSCIC; now 'NHS Digital') and the NHSCSP 'informed choices' leaflet.((HSCIC), 2013)

SMS

This SMS contained no manipulation, but: 1) informed recipients their CS is due, 2) provided the PCP phone number, and 3) prompted them to book an appointment. This message provided the core message contained within the other SMS interventions (Table 1).

SMS-PCP

Women, in particular younger women, are more likely to attend screening if invited by their PCP.(de Nooijer et al., 2005) For this reason, we selected the PCP message (SMS-PCP) to be the message tested in Studies 1 and 2. All other manipulations were tested in Study 2 only.

SMS-SNT and SMS-SNP

Humans have a tendency to conform to how they believe others will behave in a given situation. Using social norms to inform individuals of others behavior can consequently evoke behavior change.(Hallsworth et al., 2016; Perkins et al., 2010) We therefore tested messages that informed recipients of the total number of women (SMS-SNT) and the proportion of women (SMS-SNP) in the trial area who were up to date with CS.

SMS-GF and SMS-LF

How health messages are framed in terms of the potential benefits (gains) and costs (losses) can also influence decision-making.(Kahneman D, 1979; Rothman and Salovey, 1997) A gain-framed (SMS-GF) and a loss-framed (SMS-LF) message was consequently designed to assess their effect in the context of the potential number of lives saved or lost through the decision to take part in CS.

Outcome measures

The primary outcome of the study was participation within each arm, 18 weeks after the delivery of the invitation. Age and index of multiple deprivation (IMD) decile were measured as co-variates.

Sample size

Separate sample size calculations were performed for Studies 1 and 2, using standard tests of difference between two proportions. The sample size calculation for Study 1 assumed that uptake for the control arm would be 35.3% (based on uptake for this age group in the LBH for 2013-2014), and that uptake in the SMS-PCP arm would be five percentage points higher (i.e. 40.3%). The sample size calculation for Study 2 assumed that uptake for the control arm would be 51.2% (based on uptake for this age group in the LBH for 2013-2014), and that uptake would similarly be five or more percentage points higher in the SMS arms (i.e. 56.2%). The sample size calculation for Study 1 gave a sample size requirement of 1500 per trial arm, while the sample size calculation for Study 2 gave a sample size requirement of 1600 per trial arm.

The sample size calculations were designed to detect differences at the two-sided 5% alpha level, with a 20% margin for type II error.[a]

Data analysis

Descriptive statistics were used to describe sample characteristics. Unadjusted and adjusted logistic regression were used to assess associations between trial arms and uptake, before and after adjusting for baseline characteristics, on an intention-to-treat (ITT) and per-protocol (PP) basis. Analyses were performed using SPSS (version 22).

RESULTS

Sample characteristics

The study took place between February and October 2015, with follow-up until February 2016. A total of 3139 and 11458 women were randomized in Studies 1 and 2, respectively (Table 2). The mean age of Study 1 and 2 was 26.1 and 42.8 years, respectively. The mean IMD decile for each study was 5.7 and 5.9.

Study 1 – ITT analysis

[a] The uptake reported here differs from the 'coverage' figures reported above, as coverage refers to women who received CS during the age-appropriate interval (i.e. within the previous 3.5 years for women aged 24-49, within the previous 5 years for women aged 50-64Digital, N., 2017. NHS Cervical Screening Programme, England - 2016-17 NHS Digital.), whereas uptake includes women screened within given screening round since receiving an invitation.

Six participants opted out of the study and were excluded. Primary outcome data were missing for an additional 198. The total randomized and analyzed as allocated was 2935 (control n=1453, SMS-PCP n=1482; Figure 1).

In the univariate analysis, uptake was significantly higher in the SMS-PCP arm than the control (31.4% vs. 26.4%; $X^2(1)=8.972$, p=0.003; Table 3). The same was true for the multivariate analysis (adjusted odds ratio [aOR]: 1.29, 95% Confidence Intervals [CI]: 1.09–1.51, p=0.002; Table 3). Women who were older and less deprived were also significantly more likely to participate (aOR: 1.19, 95%CI: 1.09–1.31, p<0.001 and aOR: 1.04, 95%CI: 1.01–1.08, p=0.02; Table 3).

Study 1 – PP analysis

After excluding 908 participants who did not receive an intervention SMS (due to an inactive mobile number or no mobile phone number recorded at their practice), and a further 128 for whom SMS delivery status data was missing, 1388 (control) and 511 (SMS-PCP) women were eligible for inclusion in the PP analysis (Figure 1). Uptake in the SMS-PCP arm was significantly higher than in the control arm, both before and after adjusting for covariates (26.4% vs. 40.9%; $X^2(1)=37.359$, p<0.001; and OR: 1.9, 95%CI: 1.53-2.35, p<0.001; Table 3).

Study 2 – ITT analysis

Fifty-three women opted out and were excluded from the study. Primary outcome data were missing for an additional 753. The total randomized and analyzed as allocated was 10,652 (Figure 2).

In the univariate analysis, uptake was significantly higher in the SMS-PCP and SMS trial arms, compared to the control (uptake was 38.4%, 38.1% and 34.4%, respectively; unadjusted OR: 1.19, 95% CI: 1.02-1.37, p=0.02 and unadjusted OR: 1.17, 95% CI: 1.01-1.36, p=0.03, respectively; Table 4). The same was true for the multivariate analysis (aOR: 1.19, 95% CI: 1.03-1.38, p=0.02 and aOR: 1.18, 95% CI 1.02-1.37, p=0.03, respectively; Table 4). There were no significant differences between the other SMS arms and control (all other *p-values* >0.05; Table 4). Women who were older and less deprived were also more likely to participate (aOR 1.02, 95% CI 1.01-1.02, p<0.001 and aOR 1.03, 95% CI 1.02-1.05, p<0.001, respectively; Table 4).

Study 2 – PP analysis

After excluding 4625 participants who had not receive any intervention SMS (due to an inactive mobile number or no mobile number stored on the PCP clinical system), and a further 1953 for whom SMS delivery status data was missing (Figure 2), 1268, 437, 465, 471, 481, 497 and 485 women were analyzed in the control, SMS, SMS-PCP, SMS-SNP, SMS-SNT, SMS-GF and SMS-LF trial arms, respectively. Unlike the ITT analysis, the PP analysis found that uptake was significantly higher for each of the SMS arms, compared with the control, both in the univariate and multivariate analyses (all *p-value*s <0.05; Table 4).

Mobile phone number availability

In Study 1, 52.6% of women had no mobile phone number recorded on the PCP clinical system, 11.2% had an incorrect or inactive number recorded, and 36.4% had an up to date number recorded (Figure 1). In Study 2, 51.2% of women had no mobile phone number recorded, 10.8% had an incorrect or inactive number recorded, and 38% had an up to date number recorded (Figure 2).

In Study 2, there were significant differences in SMS delivery rates between age-subgroups ($X^2(2)=48.344$, $p<0.001$). Only 31.5% of women aged 50-65 years successfully received an SMS, compared with 41.2% and 38.7% of women aged 30-39 and 40-49 years. There was also a significant difference in SMS delivery by IMD subgroups, with 33.1% and 41.1% of SMS delivered in the most and least deprived tertiles ($X^2(2)=31.399$, $p<0.001$).

DISCUSSION

The results of this study show that SMS reminders significantly improve CS attendance among non-responders living in London. The results are consistent with findings from a recent service evaluation, which similarly found that an SMS, sent six months after the initial invitation, facilitated appointment requests in 5% of CS non-responders.[27]

Our results also show that SMS reminders from the PCP, specifically, yield the largest improvements in uptake. This is consistent with previous research exploring the role of the 'messenger', which similarly demonstrate that healthcare communications are more effective when administered by the PCP.(de Nooijer et al., 2005; Duffy et al., 2016; Rivers et al., 2005)

The SMS with no manipulation yielded second-largest improvements in uptake. One possible explanation for this, is that a shorter, simpler message may require less cognitive effort for the recipient to process, making it easier for more them to make a decision about CS. With the data collected in the study, it is not currently possible to test this hypothesis.

Neither of the SN messages increased attendance in the ITT analysis, and only small differences were observed in the PP analysis. The most likely explanation as to why the SN messages used were not particularly effective, is that participants expected uptake to be higher than what was presented to them (the study was conducted in a low uptake area). Similar results were found in a recent RCT conducted in colorectal screening, in which screening-eligible men who were informed of the low 'true uptake' of screening were actually less likely to participate than those who were not informed.(Sieverding et al., 2010)

As with the SN messages, the gain- and loss-framed messages resulted in small, non-significant increases in participation in the ITT analysis. Unlike the SN messages, however, the gain- and loss-framed messages were found to be much more effective in the PP analysis, with the loss-framed SMS resulting in the highest overall attendance. Loss-framed messages are generally more effective in diagnostic settings, while gain-framed messages are more effective in preventative settings.(Rothman and Salovey, 1997) One explanation as to why the loss-frame message was more effective for CS in this study, is that CS is often misunderstood by patients to be a predominantly diagnostic test.(Hoque, 2013) Another possible explanation is that low frequency behaviors are more susceptible to loss-framing, as indicated in a recent study exploring vaccination behaviours.(Gallagher et al., 2011; Gerend et al., 2008)

It is possible that the messages would have been more effective if they were more personalized. There is RCT evidence demonstrating that communications, which include name of recipient's PCP, are more effective than those which include a more explicit endorsement from their personal PCP.[33] Similarly, there is strong evidence demonstrating that reminders are more effective when they include the recipient's name.[10] Due to the character limit of the SMS (140 characters), we made a pragmatic decision not to include the PCP or recipient's name.

Screening rates in the control and intervention arms of both Study 1 and 2 did not reach the estimates based on LBH baseline rates. This is likely to be in-part because the baseline rates reflect screening at the end of screening rounds, i.e. 32 weeks for invitation. The 18-week outcome time point was selected, because at this point the call/recall team generates a list of women who have not yet been screened and sends these a reminder letter, which would likely

have affected the results. However, national screening coverage also saw a decline over the same period and may have contributed to the lower screening rate seen.(Digital, 2017-18)

Mobile phone number accuracy

The results of the PP analysis demonstrate that the real-world effectiveness of SMS reminders is highly reliant on PCPs having up-to-date mobile numbers for their patients stored on the clinical system. Considering measures to improve the availability and accuracy of patient mobile numbers will subsequently be key to maximizing the potential benefits of SMS reminders. One potential way of achieving this would be to include the 'mobile telephone number' as part of the PCPs' patient registration forms and ensuring they are rourtinely checked at any contact points between the patient and the practice.

Missing data

Primary outcome data (i.e. 'screening status') routinely collected by the call/recall team, was not transferred to the research team for two of the weekly recruitment rounds at the 18-week outcome time point, affecting 951 participants across all randomised arms in both studies. This data was not able to be retrieved from the call/recall team retrospectively as it was updated in real-time and would therefore not reflect the screening status at 18 weeks.

Secondary data (i.e. 'SMS delivery status') collected by the iPlato platform was not transferred to the research team for the final six weekly recruitment rounds (2,081 participants). This data was stored on the iPlato server for a limited time period only and therefore was not able to be retrieved retrospectively. As a result, it was not possible to include these individuals in the analysis. There is no reason to believe that the results would have been affected by the exclusion of these adults as women were recruited and randomized on a weekly basis. For the affected weeks, the data for the entire week was not included in the analysis.

Limitations

This study had several important limitations. First, the face validity of the SMS content was not verified. As such, it not known whether the SMS content communicated concepts (such as social norms) as intended. In addition, the SMS content was selected using MINDSPACE, which does not include the full range of 'behavior change techniques' described in the extant literature.(Michie et al., 2013) As a result, it is possible that more effective SMS content were not considered / tested.

Another important limitation of the study is that we used age as a proxy for 'invitation history', and may have erroneously defined some 'incident invitees' as 'first-time invitees' as a result. It is also important to note that we relied on GP data to determine the eligibility of participants, which may have resulted in some ineligible women being included in the trial (for example, because they have been diagnosed with cervical cancer privately).

In addition to the above limitations, SMS reminders were sent three weeks following the delivery of the invitation letter, so as to allow participants time to opt out of the trial. The delay may have resulted in some women being sent a reminder after they had scheduled or attended a CS appointment. As discussed above, perhaps a more important issue with the delivery of the SMS, however, is that data for 6 weeks of the study were missing. A similar issue exists for the ITT analysis, where two weeks of data could not be included, as the data file containing screening status for these weeks was not transferred to the research team, and could not be retrieved retrospectively.

Finally, it is important to acknowledge that it was not possible to obtain characteristics, such as the proportion of CS invitees who have a mobile telephone number stored on their PCP's clinical system, from PCPs who did not consent to participate in the study. As such, we cannot exclude the possibility that there was some selection bias in terms of the PCPs who participated in our study. In addition, we did not have access to certain individual characteristics which are known to influence CS participation (e.g. education, employment status, etc.), and so could not adjust for these in the multivariate analysis. We were also unable to collect data on whether participants read the text message and, as a result, could not perform a per protocol analysis at this level.

PUBLIC HEALTH IMPLICATIONS

The results of this trial have already been used to design effective policy for CS. The NHS implemented SMS reminders, based on the results of this trial, across all London boroughs between September 2018 and March 2019. According to figures published by Public Health England, attendance increased by 4.8%, which was the equivalent of 13,400 additional screenings. (Ruwende, 2019)

The cost of implementing SMS for CS is difficult to assess. SMS themselves are relatively inexpensive (~£0.03 per message), but there are considerable costs attached to setting-up the infrastructure required to deliver SMS. For example, there are costs attached to the installation and set-up of the SMS software (i.e. iPlato Patient Care Messaging) at PCP practices. Once installed, however, patient care messaging can be used to deliver SMS for a host of healthcare services for which there is sufficient evidence to support their use (e.g. medication adherence, screening attendance, etc.). Based on the current literature, we would advocate conducting cost-effectiveness analysis based on the implementation of SMS

reminders for all three cancer screening programmes. (Hirst et al., 2017) (Kerrison et al., 2015)

ADDITIONAL INFORMATION

Ethics approval and consent to participate

The study was approved by a regional Research Ethics Service and was registered with ClinicalTrials.gov (identifier: NCT02363088). This study was conducted in accordance with the Declaration of Helsinki.

Consent for publication

N/A

Availability of data and material

The authors of this manuscript are happy to share the full dataset upon request.

Conflict of interest

To be submitted in the unblinded version if accepted for next stage review, as funding reveals author identity.

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Figures and Tables

Figure 1. CONSORT flow diagram for Study 1 (age 24-29)

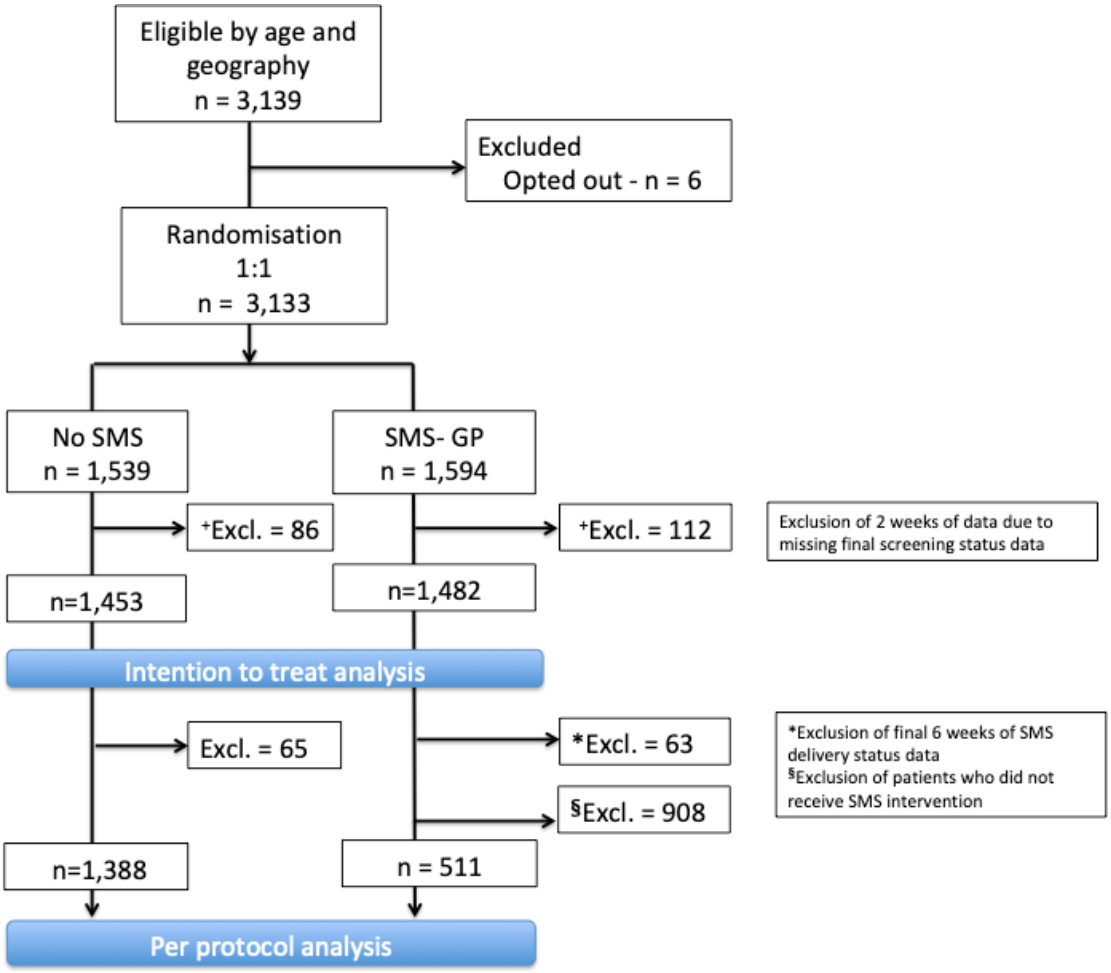

Table 1. SMS intervention by trial arm

Trial arm	SMS type	SMS content
Arm 1 Study 1 & 2	Control / No SMS	No text message reminder
Arm 2 Study 1 & 2	SMS-PCP	**"<PCP NAME>:** Your cervical smear test is due. To book please call <GP phone number>"
Arm 3 Study 2	SMS	"Your cervical smear test is due. To book please call <GP phone number>."
Arm 4 Study 2	SMS-SNP	**Last year in Hillingdon 7 out of 10 women took part in cervical screening.** Your cervical smear test is due. To book please call <GP phone number>"
Arm 5 Study 2	SMS-SNT	**"Last year 12000 women in Hillingdon took part in cervical screening.** Your cervical smear test is due. To book please call <GP phone number>**""**
Arm 6 Study 2	SMS-GF	**"Cervical cancer screening saves 4500 lives in England every year.** Your cervical smear test is due. To book please call <GP phone number>"
Arm 7 Study 2	SMS-LF	**"Failing to attend cervical screening could lead to 4500 avoidable deaths in England each year.** Your cervical smear test is due. To book please call <GP phone number>"

Table 2. Sample characteristics by trial arm

Study 1 - Women aged 24-29 years							
	Control (n=1,453)	**SMS** (n = 0)	**SMS –PCP** (n=1,482)	**SMS -SNP** (n=0)	**SMS -SNT** (n=0)	**SMS -GF** (n=0)	**SMS -LS** (n=0)
Age (y)							
mean	26.1	-	26.1	-	-	-	-
(SD)	(1.9)		(1.9)				
IMD decile*							
Mean	5.7	-	5.6	-	-	-	-
(SD)	(2.4)		(2.3)				
Study 2 - Women aged 30-64 years							
	No SMS (n=1,568)	**SMS** (n=1,522)	**SMS-PCP** (n=1,493)	**SMS -SNP** (n=1,514)	**SMS -SNT** (n=1,488)	**SMS -GF** (n=1,560)	**SMS -LF** (n=1,507)
Age (y)							
mean	42.9	42.8	42.7	42.7	42.5	42.9	42.9
(SD)	(9.3)	(9.3)	(9.2)	(9.2)	(9.2)	(9.3)	(9.3)
IMD decile							
mean	5.97	5.91	5.96	5.99	5.95	5.80	5.94
(SD)	(2.5)	(2.5)	(2.6)	(2.6)	(2.6)	(2.5)	(2.6)

* IMD decile of 1 = most deprived, IMD decile of 10 = least deprived

Note. Summary of trial sample statistics including mean age and Index of Multiple deprivation for Study 1 and Study 2 by trial arm. Abbreviations: IMD - Index of Multiple Deprivation

Table 3. Study 1 (women aged 24-29) – Participation rate, Intention to treat and per protocol analysis by trial arm

	Intention to treat (ITT) analysis				Per Protocol analysis (PPA)		
	Uptake n (%)	**OR (95%CI)**	**aOR (95%CI)**		**Uptake n (%)**	**OR (95%CI)**	**aOR (95%CI)**
Trial arm				**Trial arm**			
Control (n=1,453)	384 (26.4)	-	-	Control (n=1388)	366 (26.4)	-	-
SMS - PCP (n=1,482)	466 (31.4)	1.28** (1.09 –1.50)	1.29** (1.09 – 1.51)	SMS-GP (n=511)	209 (40.9)	1.93*** (1.56-2.39)	1.90*** (1.53 - 2.35)
Covariates							
Age	-		1.19*** (1.09 – 1.31)	Age	-		1.20** (1.07 - 1.35)
IMD Decile	-		1.04* (1.01 – 1.08)	IMD Decile	-		1.05* (1.01 - 1.09)

Note. Unadjusted and adjusted logistic regression analysis for cervical screening participation by trial arm using the control arm as the indicator.
Abbreviations: ITT: Intention to treat; PPA: Per protocol analysis; OR: Odds Ratio; aOR: Adjusted Odds Ration; CI: Confidence Intervals; IMD: Index of Multiple Deprivation.
aOR and 95% CIs are adjusted for trial arm and all other covariates in the table. *p<0.05; **p<0.01; ***p<0.001

Figure 2. CONSORT flow diagram for Study 2 (age 30-64)

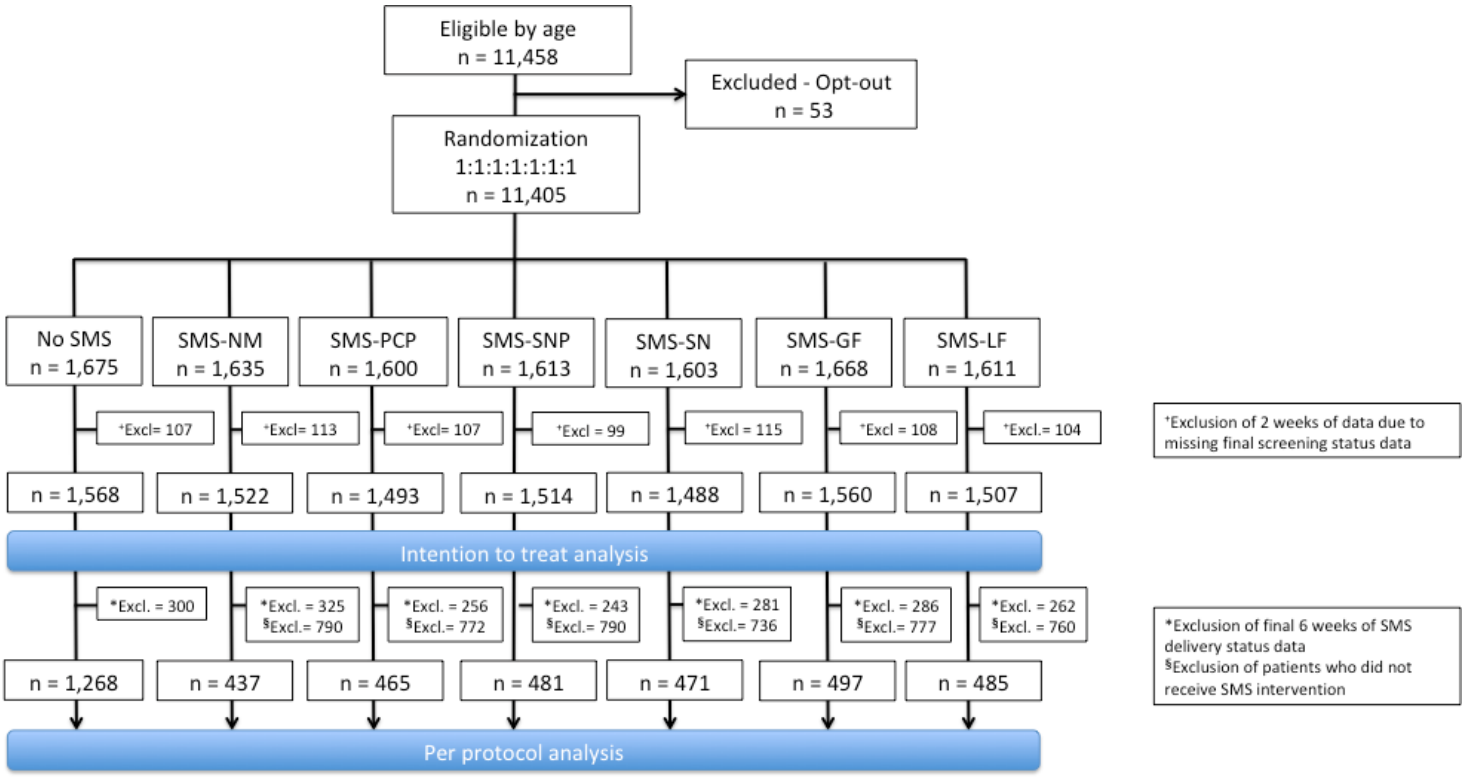

Table 4. Study 2 (women aged 30-64) – Participation rate, Intention to treat and per protocol analysis by trial arm

Intention to treat (ITT) analysis				Per Protocol analysis (PPA)			
	Uptake n (%)	**OR (95%CI)**	**aOR (95%CI)**		**Uptake n (%)**	**OR (95%CI)**	**aOR (95% CI)**
Trial arm				**Trial arm**			
Control (n=1,568)	540 (34.4)	-	-	**Control** (n=1268)	432 (34.1)	-	-
SMS (n=1,522)	580 (38.1)	1.17* (1.01 – 1.36)	1.18* (1.02 – 1.37)	**SMS** (n=437)	187 (42.8)	1.45** (1.16-1.80)	1.48*** (1.18 - 1.85)
SMS-PCP (n=1,493)	575 (38.4)	1.19* (1.02-1.37)	1.19* (1.03 – 1.38)	**SMS-PCP** (n=465)	196 (42.2)	1.41** (1.13-1.75)	1.42** (1.15 - 1.77)
SMS-SNP (n=1,514)	526 (34.7)	1.01 (0.87-1.18)	1.02 (0.88 – 1.18)	**SMS-SNP** (n=481)	196 (40.7)	1.33** (1.07-1.65)	1.35** (1.09 - 1.67)
SMS-SNT (n=1,488)	518 (34.8)	1.02 (0.88 –1.18)	1.02 (0.88 – 1.19)	**SMS-SNT** (n=471)	188 (39.9)	1.29* (1.03-1.60)	1.32* (1.06 - 1.65)
SMS-GF (n=1,560)	579 (37.1)	1.12 (0.97-1.30)	1.13 (0.98 – 1.31)	**SMS-GF** (n=497)	206 (41.4)	1.37** (1.11-1.70)	1.39** (1.12 - 1.72)
SMS-LF (n=1,507)	557 (37.0)	1.12 (0.96-1.29)	1.12 (0.96 – 1.30)	**SMS-LF** (n=485)	230 (47.4)	1.75*** (1.41-2.16)	1.76*** (1.42 - 2.19)
Covariates				**Age**			
Age	-	-	1.02*** (1.01 – 1.02)	Age	-		1.04** (1.01 - 1.07)
IMD decile	-	-	1.03*** (1.02 – 1.05)	IMD decile	-		1.02*** (1.01 - 1.02)

Note. Unadjusted and adjusted logistic regression analysis for cervical screening participation by trial arm using the control arm as the indicator.
Abbreviations: ITT: Intention to treat; PPA: Per protocol analysis; OR: Odds Ratio; aOR: Adjusted Odds Ration; CI: Confidence Intervals; IMD: Index of Multiple Deprivation.
aOR and 95% CIs are adjusted for trial arm and all other covariates in the table. *p<0.05; **p<0.01; ***p<0.001

Appendix 1

Invitation from your general practice to join a study on cervical screening text message reminders.

Every year thousands of women in the UK don't attend cervical screening. This is because many women simply forget to book an appointment. To help more women attend cervical screening, many doctors' surgeries across XXXXXXXXXX have agreed to take part in a study using text messages. If you chose to join this study, you might receive a text message from your GP. This text will remind you to book a cervical screening appointment, if you have not already done so.

As part of the study, some GPs have been given software by the mobile health company XXXXX. This will allow the doctors to send text messages. For this purpose, they will allow XXXXXX to know your NHS number. To help us to understand the results of this study, we will also provide the research team access to certain details. These are limited to your NHS number, age and first half of your postcode. No other details will be accessed. NHS regulations concerning confidentiality of your personal details will be followed at all times

To make sure that you can receive a text, please check that you have given your GP the correct mobile number. You can do this by calling them or telling reception when you next visit. If your contact details are not correct, there is a risk that the text message will not be delivered to you.

If you **do not** want to be part of this study, you can opt out. This means you will not be included in the research and will not receive a text message reminder. You do not have to participate. If you choose to opt out, your standard care will not be affected in any way.

You can opt out by:

1. Emailing the research co-ordinator at xxxxxx
2. Calling 0207 88 66 XXX Monday to Friday 9:00am to 5:00pm.
3. Texting "OPT OUT" with your 10 digit NHS number to 0797 516 XXXX
4. Completing the cut off slip below and mailing it to the address provided.

When opting out, please be sure to include your **10 digit NHS Number which can be found at the bottom of your screening invitation**, which accompanies this letter.

Many thanks.

Sent on behalf of XXXXXXXX General Practitioners and Public Health Research Team.

-OPT OUT REQUEST-

Mail to: xxxxxxx

Opt out statement: *I do not wish to take part in this research or receive a text message from my GP reminding me to book a cervical screening appointment.*

Name_____ ***NHS number*** ☐☐☐ – ☐☐☐ – ☐☐☐☐

If you would like to provide a reason for opting out, please write any comments on the back of this slip.