Community-Level Text Messaging for 2009 H1N1 Prevention in China

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Background: Although patients worldwide increasingly are using mobile phone text messaging (SMS) for clinical care, quality data are sparse on the community-level effectiveness of SMS to prevent and control disease.

Purpose: To determine SMS effectiveness in improving 2009 H1N1 knowledge, attitudes, behaviors, and self-reported outcomes and to assess community SMS acceptability.

Methods: A program evaluation of Shanghai, China's SMS system using a single-blinded, randomized-controlled method was conducted in 2010 and results were analyzed in 2010–2011. Randomly selected community residents who agreed to participate were assigned to receive 3 weeks of either 2009 H1N1 prevention and control or tobacco-cessation messages. Assessments were made of 2009 H1N1 knowledge, attitudes, behaviors, and self-reported influenza-like illness before and after sending messages to participants. Acceptability of SMS also was assessed.

Results: Of 1992 respondents, those receiving 2009 H1N1 messages had higher scores measuring 2009 H1N1 knowledge (4.2% higher) and desired attitudes (9.4% higher) ($p<0.001$); 1.77 times greater odds of new 2009 H1N1 vaccination ($p<0.001$); and 0.12 times smaller odds of reporting influenza-like illness ($p<0.001$) than those receiving tobacco messages. More than 95% of participants found the SMS program useful and trustworthy; nearly 90% would use it again.

Conclusions: SMS can improve self-reported uptake of short-term behaviors, such as vaccination, that can result in long-term prevention and control of disease. SMS can improve knowledge and influence attitudes about infection prevention and control and self-reported health outcomes. In Shanghai, health-based SMS is acceptable to users.
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Background

In 2011, an estimated 5.9 billion mobile phones were in use worldwide.[1] Short message service (SMS), which allows users to send short text messages between mobile phones, has become equally widespread; an estimated 7 trillion SMS messages were sent in 2011.[2] Sending and receiving SMS messages is cheap, even when used frequently.[3]

Messaging of this type has been used to manage specific health conditions, such as diabetes or tobacco use, in high- and low-income settings.[4–6] Studies of SMS messaging effectiveness have therefore focused on selected subpopulations,[7–12] leading to results that can be difficult to generalize to the community. The few studies that have examined community cohorts have focused on clinical efficiency outcomes, such as improving clinical appointment attendance.[13–15]

Short message service messaging is well suited for delivering disease prevention messages and communicating critical information to the community during health emergencies. Messages can be sent instantly to many individuals, and can be received at any time, even when a phone is turned off. Systematic reviews of health-based SMS messaging have found that data supporting its use for disease prevention and control among healthy

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populations are sparse[16–19] and call for large, rigorous studies to demonstrate its effectiveness.

In China, use of mobile phones surpassed 869 million (more than 65% of the population) in 2011,[20] and SMS is used commonly.[20] In May 2009, the Shanghai Municipal Health Bureau (SMHB) began providing health-based SMS messages as part of China's national health hotline service, dubbed 12320. By August 2009, more than 250,000 people had subscribed to this service, and more than 754,000 health-based SMS messages had been sent (Y. Ji, 12320 National Hotline, personal communication, 2010).

In late 2009, in response to the 2009 H1N1 pandemic, the Chinese public health system sought to rapidly disseminate 2009 H1N1 prevention messages while evaluating the effectiveness and acceptability of the 12320 health-based SMS program. The evaluation results were needed to determine if health-based SMS messaging should be expanded to additional sites across China. A program evaluation was conducted to (1) determine SMS effectiveness in improving knowledge, attitudes, behaviors, and self-reported outcomes in 2009 H1N1 prevention and control among Shanghai community residents; and (2) assess SMS program acceptability.

Methods

Shanghai, China's 12320 health-based SMS program (hereafter called SMS program) was evaluated in 2010, and results were analyzed in 2010–2011. The 12320 National Hotline and SMHB staff (hereafter called stakeholders) helped set the level of rigor for data collection (single-blinded, randomized controlled method) and a priori metrics for an effective (≥5% difference in knowledge, attitudes, and behaviors between intervention and control groups) and acceptable (>70% positive response to acceptability questions) program. The magnitude of behavioral change sought (≥5%) was consistent with expected effect sizes from mass media health campaigns.[21]

In January 2010, community participants in Shanghai's SMS program were sampled using a randomized clustered method based on city district and physical address. Eligibility criteria included the following: permanent residence in Shanghai, aged 18–65 years, ownership of a mobile phone, able to send and receive SMS messages, willingness to continue to receive messages sent by the SMS program, and willingness to participate in surveys. Assuming a 15-point scoring system for knowledge, attitudes, and behaviors and population SD of 3 points, 252 respondents in each assignment group were needed to detect a 5% difference with 80% power and $\alpha=0.05$. To account for low participation rates, departures from estimates, and stakeholders' requests, interviewers approached 2000 community residents for enrollment.

From January 21–30, 2010, interviewers conducted door-to-door pre-SMS messaging surveys, collecting data on demographic characteristics and knowledge (30 items); attitudes (four items); behaviors (five items); and outcomes (one item) related to 2009 H1N1 prevention and control. Knowledge measures for 2009 H1N1—a novel pathogen at the time—were based on the most recent 2009 H1N1 prevention and control messages published by SMHB that agreed with U.S. Centers for Disease Control and Prevention (CDC) messages.[22,23] Attitude and behavior measures were based on attitudes toward and active implementation of the most recent SHMB- and CDC-recommended interventions to prevent illness and transmission.

Community dwellers who agreed to participate were randomly assigned electronically by enrollment order to receive SMS messages on either 2009 H1N1 prevention and control (H1N1 group) or tobacco cessation (tobacco group). The measures from the pre-SMS survey were converted into 2009 H1N1 prevention and control SMS messages; tobacco-cessation messages were crafted in consultation with stakeholders and the WHO's tobacco control program in China. Tobacco-cessation messages were chosen as they did not overlap with 2009 H1N1 prevention and control measures. SMS messages were consistent in format and type of content with messages sent by the ongoing SMS program. Interviewers were SMHB staff and students. Interviewers were blinded to respondents' group assignments.

Of 2000 respondents approached for enrollment in Shanghai, 1998 (99.9%) qualified and gave consent for participation. Of these participants, 999 were randomized to the H1N1 group and 999 were randomized to the tobacco group. Of the 999 H1N1 group participants, 995 (99.6%) responded to the post-SMS messaging survey; of the 999 tobacco group participants, 997 (99.8%) responded to the post-SMS messaging survey.

During February 1–10, 2010, one SMS message was sent to each participant each morning for a total of ten different messages on 10 days (see Sidebar). During the subsequent 10 days, the same ten messages were sent again to each participant, one daily, to reinforce the messages. Beginning on February 26, 2010, following the SMS messaging, interviewers conducted door-to-door post–SMS messaging surveys of the same respondents using the same 2009 H1N1 knowledge, attitudes, and behaviors pre–SMS messaging survey. Post-SMS surveys contained additional questions regarding acceptability of the SMS program. IRB review was deemed to be unnecessary by the Chinese Ministry of Health's National and Shanghai 12320 hotline; CDC's human subject review determined this activity to be nonresearch as it met the criteria for a program evaluation, including examining an ongoing program, accessing participants already enrolled in the program, and employing usual program activities.

Demographic factors were compared between H1N1 and tobacco groups using chi-squared tests. For "choose all that apply" knowledge questions, each answer choice was treated as a *true/false* question. Correctly answered knowledge questions were summed to obtain a "knowledge score" (30-point scale). Attitude and behavior questions were based on a 5-point Likert-type scale; answers consistent with 2009 H1N1 prevention and control recommendations were given positive scores and vice versa. Attitudes inconsistent with recommendations received negative scores; neutral attitudes received a score of zero. Scores were summed to obtain an overall desired "attitudes score" (8-point scale) and "behaviors score" (17-point scale). Clinical outcome was assessed by self-reported influenza-like illness in the preceding 2 weeks.

The effect of SMS messages on change in scores between pre-SMS and post-SMS surveys was assessed by (1) the magnitude of the average individual score change within each assignment

SIDEBAR

Text messages on 2009 H1N1 prevention and control and tobacco cessation, Shanghai 12320 Hotline short messaging service program evaluation, 2010

Message number	2009 H1N1 prevention and control messages	Tobacco-cessation messages
1	H1N1 flu is spread by contact with an infected person's cough or sneeze, direct contact such as shaking hands with an infected person, and sometimes by unclean surfaces. Don't forget to cover your cough or sneeze!	Every cigarette you smoke is doing you damage. Smoking creates blood clots which can cause strokes. Some strokes kill, blind, or paralyze.
2	After infection with H1N1 flu, symptoms appear after 1 to 7 days and most people get better within 1 week. Some people can become very ill, including lung infections and even death in a few people. Wash your hands often, people around you might be sick but not have symptoms yet!	Every time you smoke, you draw cancer-producing tar deep into your lungs. The more you smoke, the more tar goes in and the higher your risk of diseases like lung cancer.
3	H1N1 flu symptoms are like those of seasonal flu, including: fever, cough, sore throat. Some people might have diarrhea. Don't go to work or school if you feel ill with any of these symptoms!	Cigarette smoke contains more than 4,000 chemicals, including over 60 chemicals that cause cancer. Research shows smoking and second-hand smoke causes cancer and cardiovascular disease.
4	To prevent transmitting H1N1 flu, cover your mouth and nose with a tissue or your shirt sleeve when coughing or sneezing. If you use a tissue, throw it into the trash can and wash your hands with soap and water or hand sanitizer immediately. Keep others from getting sick!	Smoking causes heart disease. Smoking clogs arteries and causes heart attacks, strokes, and even death. Smoking doubles the risk of heart attack.
5	To prevent becoming infected with H1N1 flu, wash hands frequently with soap and clean water. If you do not have soap and water, use an alcohol hand sanitizer. Clean hands help fight H1N1!	Smoking kills! According to research 1 out of every 2 smokers dies from a smoking-related disease.
6	To prevent becoming infected with H1N1 flu, avoid touching your eyes, nose, or mouth with unclean hands. Germs are spread that way. Find ways to reduce stress and ensure adequate sleep and nutrition. Stay healthy and fight H1N1!	Cigarette smoke contains harmful chemicals such as cyanide and carbon monoxide that can cause severe health problems in children, like ear infections, asthma, and deadly pneumonia. Protect children from secondhand smoke.
7	If you get sick with symptoms of H1N1 flu, stay at home for 7 days or until 24 hours after symptoms disappear to keep from spreading H1N1 flu. Avoid going to work or school and limit contact with others to keep from infecting them. Keep others from getting sick!	Secondhand smoke thickens the blood, damages arteries, and causes strokes and heart attacks. Inhaling even a small amount of secondhand smoke causes great harm.
8	If you get sick with symptoms of H1N1 flu, seek medical care if you have severe symptoms or have other underlying medical conditions. Do not take any antibiotic or antiviral medications, unless they are prescribed by your doctor. When the vaccine is available for you, get vaccinated!	Secondhand smoke attacks the vital organs, increasing the chance of heart disease by 25%. 85% of secondhand smoke can't be seen. Secondhand smoke is an invisible killer.
9	Mild reactions to H1N1 flu vaccination usually need no treatment, including soreness, redness, or swelling at the shot site. Mild headache, muscle aches, fever, or nausea can also occur. Any unusual condition should be seen immediately by a doctor, including high fever, difficulty breathing, or other serious condition. If you or someone you know has a severe reaction, report it by calling 12320.	Secondhand smoke harms the next generation, leading to sudden infant death syndrome, chronic and respiratory diseases, ear infections, and causes or worsens asthma, affecting development of lung function.
10	H1N1 flu is not known to be spread through pork or by the H1N1 vaccine shot.	Secondhand smoke endangers the health of your family. Secondhand smoke increases the risk of stroke by 62%.

group (paired t-test) and (2) the difference in the magnitudes of average individual score change between assignment groups (two-group t-test). Skewness and kurtosis of score distributions were examined for meaningful departures from normality.

Reported 2009 H1N1 vaccination and self-reported influenza-like illness were regressed separately on assignment group (H1N1 versus tobacco) using bivariate conditional logistic regression. Presence of effect modification was assessed by age and gender. List-wise deletion was used for missing data; however, few data were missing (<0.5%). Statistical analyses were conducted using Stata, version 10.

Results

Participants in the H1N1 versus tobacco groups did not differ by demographic characteristics (Table 1). Between the pre-SMS and post-SMS survey, the average individual knowledge score increased significantly within the H1N1 group (by 24.3%, $p<0.001$; Table 2) and within the tobacco group (by 20.1%, $p<0.001$). The 4.2% greater change in average individual knowledge score in the H1N1 group versus the tobacco group also was significant (95% CI=2.9%, 5.6%).

The average individual attitudes score increased significantly within each group between the pre-SMS and post-SMS survey (within the H1N1 group, by 27.3%, $p<0.001$; within the tobacco group, by 17.8%, $p<0.001$). The 9.4% greater change in average individual attitudes score in the H1N1 group versus the tobacco group also was significant (95% CI=6.5%, 12.3%). Although the average individual behaviors score increased significantly within each group between the pre- and post-SMS survey (within the H1N1 group, by 12.1%, $p<0.001$; within the tobacco group, by 11.4%, $p<0.001$), the average individual score changes did not differ between the H1N1 group and the tobacco group (95% CI=−0.8%, 2.2%).

The percentage of participants reporting receipt of 2009 H1N1 vaccination among the H1N1 and tobacco groups was similar in the pre-SMS survey (Table 3). However, compared with the pre-SMS survey, respondents in the H1N1 group had 1.77 times higher odds (95% CI=1.39, 2.26) of reporting receipt of a 2009 H1N1 vaccination than respondents in the tobacco group on the post-SMS survey. No effect modification by age or gender was noted.

The percentage of participants self-reporting influenza-like illness in the preceding 2 weeks among the H1N1 and the tobacco groups was similar in the pre-SMS survey (Table 3). However, after controlling for the difference in knowledge of 2009 H1N1 symptoms between the groups and compared with the pre-SMS survey, respondents in the H1N1 group had 0.12 times lower odds (95% CI=0.06, 0.25) of reporting influenza-like illness than those in the tobacco group on the post-SMS survey. Reports of 2009 H1N1 vaccination receipt were not associated with self-reported influenza-like illness. No effect modification by age or gender was noted.

The knowledge change (4.2%) and attitude change (9.4%) results met or were close to meeting their program effectiveness thresholds (≥5%); the behavior change metric did not. Acceptability thresholds (>70%) were all met. More than 95% of respondents felt the SMS messages were useful and trustworthy, and close to 90% reported they would use the program again.

Table 1. Participant demographics, Shanghai 12320 Hotline Short Messaging Service program evaluation, 2010, n (%) unless otherwise noted

Characteristic	H1N1 group (n=995)	Tobacco group (n=997)	Total (N=1992)	p-value[a]
Age (years)				0.35
18–30	181 (18)	170 (17)	351 (18)	
31–40	213 (21)	193 (19)	406 (20)	
41–50	261 (26)	297 (30)	558 (28)	
51–60	261 (26)	249 (25)	510 (26)	
>60	79 (8)	88 (9)	167 (8)	
Gender				0.82
Male	479 (48)	485 (49)	964 (48)	
Female	516 (52)	512 (51)	1028 (52)	
Educational level				0.89
Primary school or below	19 (2)	23 (2)	42 (2)	
Junior high	151 (15)	137 (14)	288 (14)	
Senior high or secondary school	392 (39)	396 (40)	788 (40)	
Junior or full college degree	417 (42)	425 (43)	842 (42)	
Graduate degree and above	16 (2)	16 (2)	32 (2)	

[a]Chi-squared

Table 2. Participant outcome scores before and after text messages and between assignment groups, Shanghai, 2010

Category	H1N1 group	Tobacco group	Between-group difference	95% CI
Knowledge, average number (%) of correct questions				
Pre-SMS survey	21.25 (70.8)	21.13 (70.4)		
Post-SMS survey	28.53 (95.1)	27.14 (90.5)		
Between-survey difference	**7.29 (24.3)**[*]	**6.02 (20.1)**[*]	1.27 (4.2)	0.86, 1.68 [2.9%, 5.6%][a]
Attitudes, average number (%) of desired attitudes				
Pre-SMS survey	4.90 (61.3)	4.98 (62.3)		
Post-SMS survey	7.08 (88.5)	6.41 (80.1)		
Between-survey difference	**2.18 (27.3)**[*]	**1.42 (17.8)**[*]	0.75 (9.4)	0.52, 0.98 (6.5%, 12.3%)[a]
Behaviors, average number (%) of desired behaviors				
Pre-SMS survey	9.53 (56.1)	9.43 (55.5)		
Post-SMS survey	11.58 (68.1)	11.37 (66.9)		
Between-survey difference	**2.05 (12.1)**[*]	**1.93 (11.4)**[*]	0.12 (0.7)	−0.13, 0.37 (−0.8%, 2.2%)[a]

Note: Boldface indicates significance.
[a]Two-sample *t*-test
*$p<0.001$, paired *t*-test
SMS, short message service

Discussion

Short message service messaging increased respondents' self-reported uptake of 2009 H1N1 vaccination, reduced reports of influenza-like illness, and improved knowledge and attitudes about 2009 H1N1 prevention and control. To our knowledge, this is the first community-based study using a randomized controlled method to demonstrate that SMS disease prevention and control messages can influence both respondents' self-reported health behaviors and outcomes.

The SMS messaging regarding 2009 H1N1 increased self-reported vaccination uptake, suggesting that focused SMS messages can initiate important short-term behaviors that lead to longer-term prevention of illness. The results of the current study are consistent with the only other large randomized controlled study of SMS effectiveness in improving disease prevention behavior, by Stockwell et al.,[12] although the prior study found a smaller magnitude of effect on vaccination behavior and did not report a clinical outcome measure. Because SMS messaging effects extinguish with time,[21] improving vaccination substantially decreases the need to rely on adherence to long-term changes in prevention behaviors.

Interventions that prevent spread of illness, such as hand-washing and wearing personal protective equipment,[24,25] are further limited by variable compliance.[26] Importantly, in pandemic situations such as the 2009 H1N1 pandemic, vaccination has been shown to be more than 70% effective at reducing confirmed disease in multiple countries.[27,28] Vaccination rates likely were underestimated in this study. The 2009 H1N1 vaccine was only provided to select occupational groups in China during February 2010,[23] and a week-long holiday occurred during the study period. If vaccine availability had been greater, uptake of vaccination also might have been greater.

Table 3. Reported vaccination and influenza-like illness before and after text messages, Shanghai, 2010, *n* (%) unless otherwise indicated

Category	H1N1 group (*n*=995)	Tobacco group (*n*=997)	Adjusted matched OR[a] (95% CI)
Reported 2009 H1N1 vaccination			
Pre-SMS survey	155 (15.6)	150 (15.0)	**1.77 (1.39, 2.26)**[*]
Post-SMS survey	234 (23.5)	181 (18.2)	
Reported influenza-like illness			
Pre-SMS survey	67 (6.7)	55 (5.5)	**0.12 (0.06, 0.25)**[*,b]
Post-SMS survey	9 (0.9)	48 (4.8)	

Note: Boldface indicates significance.
[a]Conditional logistic regression, matched on the individual participant
[b]Adjusted for change in knowledge about 2009 H1N1 symptoms
*$p<0.001$

The SMS messaging regarding 2009 H1N1 also was associated with eight times lower odds of self-reported influenza-like illness, even after controlling for knowledge about 2009 H1N1 symptoms, suggesting that SMS messages have the potential to improve clinical outcomes in community dwellers. Behaviors leading to this change might have been prompted, in part, by the increase in 2009 H1N1 knowledge and desired attitudes in the H1N1 group. This study could not assess all potential behaviors; improvements in unmeasured 2009 H1N1 prevention behaviors prompted by SMS messages, such as avoiding sick contacts, could have contributed to the decrease in reported illnesses.

Not surprisingly, the difference in reported vaccination between assignment groups was not associated with the difference in self-reported influenza-like illness. More participants in the H1N1 group reported receiving vaccinations during the SMS messaging in February, but immunity was unlikely to have developed by the time of the post-SMS survey in late February. A decrease in self-reported influenza-like illness from vaccination would have been more pronounced if measured in March.

Between the pre-SMS and post-SMS surveys, knowledge, attitude, and behavior scores increased to an unexpected degree within each group. One plausible explanation is measurement effect, as participants in both groups knew their performance would be observed using a post-SMS survey. In addition, Chinese officials conducted a mass media campaign about the 2009 H1N1 pandemic during the study period,[29] likely enhancing survey performance in both groups.

Self-reported influenza-like illness could have been caused by other etiologies, as laboratory confirmation of 2009 H1N1 infection was not conducted among respondents, potentially introducing misclassification bias. The nature of SMS messaging prevented blinding of respondents; H1N1 group respondents could have been less likely to report influenza-like illness or more likely to report vaccination than tobacco group respondents, leading to a differential bias away from the null. However, bias was likely minimal because overall desired behavior scores did not differ between the groups.

Based on these results, stakeholders considered the SMS program in Shanghai an effective and acceptable program and expanded the program to additional sites across China. National health policy in China was changed as a direct result. China's Ministry of Health and subnational governments now have special permission to disseminate routine and emergency health information via SMS messaging.

Important questions remain for optimizing SMS messaging for community disease prevention and control. The 2009 H1N1 information was novel and needed to be deployed rapidly. Although the SMS program sought to change behaviors regarding 2009 H1N1, specific validated measures of behavior change models were not used, such as understanding which subjects changed behaviors under what circumstances, influences, or cues, and at what stage of change. Behavior change theories should be used to enhance evaluations of how SMS messaging can serve as a "nudge" in a larger context to shift health behaviors.[30] For example, factors that led recipients to adhere to suggestions and pass messages on to others (the diffusion of innovations) could be examined in follow-up studies.

Rigorous studies examining optimal messaging intensity, timing, and repetition can help clarify the most-effective implementation methods for SMS messaging. The average Shanghai resident has excellent access to SMS messaging, and therefore disease prevention and control messaging should be evaluated in other community settings.[31–33] Although further studies are needed, SMS messaging holds the promise of being an effective and acceptable medium for providing disease prevention and control messages to communities, and potentially improving the health of populations.

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