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ORIGINAL RESEARCH

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Short message service usage may improve the public's self-health management: A community-based randomized controlled study

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Abstract

Background and Aims: The last decade has witnessed unprecedented growth in mobile phone use. It links millions of previously unconnected people. The ubiquity of mobile phones, which allows for use of the short message service (SMS), offers new and innovative opportunities for disease prevention and health education. SMS usage appears to be a feasible, popular, and effective way of improving health literacy. This study measured the effect of SMS health education on the improvement of health management in Shenzhen, China.

Methods: This was a community-based randomized controlled study. A total of 32 communities were randomly chosen out of 320, then about 200 participants were randomly sampled from each selected community. The subjects were equally divided into two groups at random. About half of the participants received health intervention messages via Internet-based SMS for almost a year. The data were analyzed by descriptive and inferential statistical methods.

Results: The proportion of participants involved in self-health management increased from 30.92% to 38.68% over the year ($\chi^2 = 42.49$, $p < 0.001$) in the intervention group. People with marginal health literacy reported the highest increase (10.92%), while people with low health literacy reported the smallest (5.25%). The control group showed no difference in baseline and final health management proportions (28.02% and 29.64%, $p > 0.05$). No statistical difference in the prevalence of chronic disease (15.16% and 13.89%, $p > 0.05$) was found before and after the intervention in the intervention group. The prevalence in the intervention group was lower after the intervention than it was in the control group (17.33%, $\chi^2 = 14.45$, $p < 0.001$).

Conclusions: SMS may be a powerful tool for improving the public's health literacy and health management because it is widely available, popular, affordable, and instant.

KEYWORDS

community, health literacy, health management, health promotion, short message service

1 | INTRODUCTION

Unhealthy lifestyle behaviors are the major cause of public health problems. Promoting positive health behavior is a current trend that warrants innovative solutions for the majority of chronic health conditions.[1] The use of new technologies such as mobile phones and the Internet is continually increasing. There is a growing interest in the use of mobile phones in healthcare service delivery.[2] Mobile Health (mHealth) is defined as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices."[3] Current evidence indicates that healthcare interventions via short message service (SMS) are beneficial for medical and public health-related uses and other administrative processes.[4] In 1985, after Green defined self-health management,[5] the study of self-health management increased. Self-health management includes understanding health management concepts and establishing a healthy lifestyle. It involves a health management system, treatment, physical and psychosocial changes, and people's ability to make lifestyle changes in response to the development of chronic diseases.

SMS uses the text message function of mobile phones to send health-related information to specific populations to guide their medication intake and health behaviors and to encourage them by suggesting ways of improving their self-health management. Due to the advantages of convenience, reliability, wide coverage, low cost, pertinence, and retransmission ability, SMS has been easily accepted by the majority[6] of people and has been widely used in medical treatment and public health promotion in both developed and developing countries.[7] SMS could be used to promote a wide range of health behaviors, such as weight loss, physical exercise, smoking cessation, adopting good nutrition, self-managing diabetes mellitus, medication compliance, HIV prevention, and asthma and hypertension management.[8] It has played an important role in health behavior interventions.[9] SMS is a simple and cost-effective tool for sending medication reminders, proving effective in several healthcare services.[10] Research[11] shows that mHealth services are effective even when mHealth participants themselves do not have adequate health knowledge (a point of difficulty that may prevent them receiving eHealth services).

Health literacy is defined as the degree to which people can obtain, process, and understand basic health information and services needed to make appropriate health decisions.[12] The consequences of inadequate health literacy include poor health status, lack of knowledge about medical care and medical conditions, decreased comprehension of medical information, lack of understanding and use of preventive services, poor self-reported health, poor compliance, increased hospitalization, and increased healthcare costs.[13] Physical inactivity is a leading risk for mortality worldwide.[14] Low health literacy (LHL) is associated with high mortality, high hospitalization rates, increased use of emergency care, poor self-management skills for chronic disease,[15] and low frequency of use of available medical/mhealth services.[16]

To improve the level of national health literacy and health behavior, China issued the Chinese Basic Knowledge and Skills of Health Literacy[17] document in 2008, initiating action in national health literacy promotion. Various means have been used to promote health literacy since then, but SMS is not a commonly used intervention. The population of Shenzhen has rapidly increased from 15,000 to 14 million in the past 30 years. In the population pyramid, young people represent the majority of the population. Given that traditional avenues of health education are limited for them, the use of SMS for health education and improving health management in this young population should be explored.

2 | SUBJECTS AND METHODS

2.1 | Study population

The study population was a representative sample of Shenzhen adults who had lived in Shenzhen for more than 6 months at the time of the survey.

Inclusion criteria: ≥18 years; lived in Shenzhen for at least 6 months; voluntary.

Exclusion criteria: Cognitive disorders; seriously ill and cannot cooperate with the investigation.

2.2 | Sampling

According to the calculation of the sample size of the cluster-randomized intervention trial ($N = \text{deff} \times (\mu^2 \times P \times (1\text{-}P)) / \delta^2$), and after reviewing past literature and combining the results of the pre-survey, a conservative value of 13% was determined, with the allowable error of 0.1, $\mu_\alpha = 1.96$. The number of people in each group was at least 2570, and the total number of people in the two groups was at least 5140. Considering the potential loss to follow-up, the population was expanded to 6000.

Sixteen street districts were chosen randomly from all 53 street districts in Shenzhen, then two communities were randomly chosen from 1 street district. Next, 32 communities were randomly allocated to 16 intervention and 16 control groups. The participants were selected by cluster sampling from each community until at least 200 participants (≥18 years) were chosen from one community. The randomization list was created by computer database. Finally, a total of 6500 participants were included in the study (Figure 1). Due to the design of the trial, only the data collectors were blinded (single-blind).

2.3 | Intervention methods

Conventional health education (such as a bulletin board) was given to the participants in the control group, while SMS messages were sent to intervention group participants who were also subjected to conventional health education.

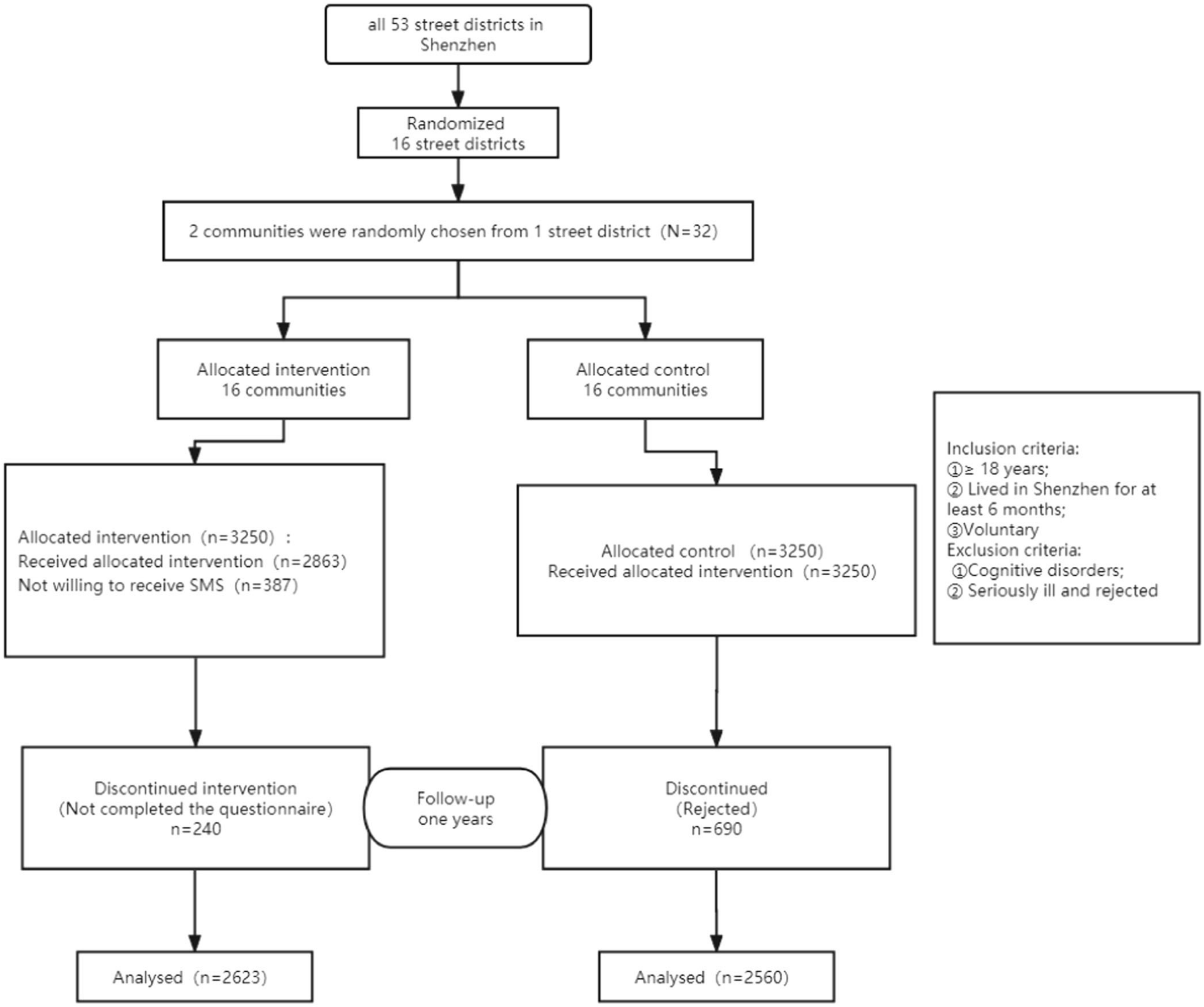

FIGURE 1 The flow diagram

2.3.1 | The content of SMS messages

The first health literacy assessment was conducted in 2012 after which the project team formulated a series of text messages that covered all the LHL issues arising from the assessment. The message content was designed in accordance with both scientific principles and the basic principle of the conditioned reflex. The SMS consisted of three parts: first it displayed the evidence from survey data, designed to interest participants in engaging; it then explained the factors that would prompt them to gain new health knowledge, including the consequences of poor health behaviors and the determinants of their health status; and finally the SMS listed healthy behaviors, encouraging participants to follow good examples. The content was contained to 250–400 words in length. Under the project team's intended scenario, text messages were the trigger tool[18] to induce behavior change in participants. Through regular SMS reminders, the positive psychology of participant behavior change was continually reinforced while interfering with repeated, potentially negative behaviors.

2.3.2 | SMS frequency

The SMS messages were sent via a group-message-sending system designed by an Internet company. This network system was designed to distribute health messages; it could send health messages instantly to the phone numbers entered and recorded in the system. The intervention was maintained for 12 months with a message frequency of one SMS per week. About 60 SMS messages were sent to each participant during the intervention. In view of the cost of SMS delivery and the limits to health information absorption by the intervention subjects, only one message was sent each week, on a Friday.

2.4 | Evaluation criterion

2.4.1 | Health literacy

Based on systems theory, the rapid assessment of health literacy (RAHL) questionnaire was designed to measure 3 dimensions: health knowledge, health behavior, and health skills.[19] The questionnaire used the Chinese language. Cronbach's value was 0.82. The health knowledge section measured the participant's knowledge of basic sanitation, prevention of infectious disease and chronic diseases, nutrition and diet, mental health, and the harm of smoking. The health behavior section examined daily healthy habits, mental health status, smoking behavior, medication compliance, frequency of health check-ups, and exercise training. The health skills section assessed skills in staying safe, emergency treatment, and correctly washing hands. There were 20 items in the questionnaire, with five scores for each item. As with the *Test of Functional Health Literacy in Adults*,[20] the health literacy assessed by RAHL was divided into three levels using the cutoffs 60% and 75%: LHL, high health literacy (HHL), and marginal health literacy (MHL). The scale results were evaluated by professionals.

2.4.2 | Health management

The respondents were required to report their health management behaviors and physical examination results for the assessment of their health status, and were required to be capable of trying to change unhealthy lifestyle behaviors affecting their health that were revealed in the assessment—behaviors related to exercise, balanced diet, and psychological health, for instance. Participants whose medical examination, assessment, and self-management results met self-health management requirements were considered to meet the standards of self-health management.

2.4.3 | Chronic diseases

We designed a questionnaire to investigate participants' chronic diseases in the previous year based on their physicians' medical diagnoses. The classification of diseases was made according to the International Classification of diseases, 10th edition.

2.5 | Statistical analysis

All data analyses were processed with SPSS 21.0 (2012, SPSS Inc.), and analyzed by chi-square test. Categorical data were reported as number (%), with $p < 0.05$ (2-sided) considered statistically significant.

2.6 | Ethical issues

The study protocol and all the procedures were approved by an Ethical Committee (ID: JCZX1201) and conformed to the principles embodied in the Declaration of Helsinki. Informed consent was obtained from each participant before the project began. All participants were voluntary and anonymous, and no incentives were given for participation.

3 | RESULTS

3.1 | Basic information

3.1.1 | Willing to receive SMS health messages

A total of 6413 baseline survey questionnaires were sent and completed (98.66%) before the intervention to 3007 males (46.89%) and 3406 females (53.11%) aged 35 ± 12. After the intervention, 6450 questionnaires were sent to participants. Six thousand and four hundred questionnaires were completed (99.22%), with 2623 (81.84%) from the intervention group and 2560 the control group (79.8%). About 2863 participants (89.33%) in the intervention group were willing to receive health messages from the research team, submitting their mobile phone numbers accordingly. Among them, 89.32% were males and 91.77% were aged between 18 and 24 (Table 1). The intervention and control groups did not differ in age, gender, or couple status (data not shown) ($p > 0.05$).

3.1.2 | Health management

Before the intervention, no statistical differences in chronic disease prevalence or self-health management status were detected between the intervention and control groups (Table 2). The chronic disease

TABLE 1 Characteristics of participants willing and not willing to receive a short message service (SMS) related to health

Variable		Willing to receive SMS		Not willing to receive SMS		Total
		n	%	*n*	%	
Gender	Male	1330	89.32	159	10.68	1489
	Female	1533	89.34	183	10.66	1716
Age group, years	18–24	580	91.77	52	8.23	632
	25–39	1427	89.24	172	10.76	1599
	40–49	494	88.06	67	11.94	561
	50–64	282	86.50	44	13.50	326
	≥65	80	91.95	7	8.05	87
Total		2863	89.33	342	10.67	3205

prevalence was 14.82% and 14.82%, respectively ($p > 0.05$). The self-health management proportions were 30.05% and 28.90%, respectively ($p > 0.05$).

3.2 | Health management change

After the intervention, the proportion of respondents who started health management in the intervention group increased significantly from 30.92% to 38.68% ($\chi^2 = 42.49$, $p < 0.001$) (Table 3). The highest increase was reported by people with MHL (10.92%), rising from 284 to 361, while the lowest was those with LHL (5.25%), rising from 424 to 437. Change in the control group was not reported (28.02% and 29.64%, $\chi^2 = 2.04$, $p > 0.05$).

3.3 | Health status change

The prevalence of chronic disease reported by the intervention group before and after the intervention decreased significantly from 15.16% to 13.89% ($\chi^2 = 2.11$, $p > 0.05$) (Table 4). The prevalence of chronic disease in people with LHL increased from 14.32% to 18.32%, but decreased in both MHL and HHL participants, from 15.76% and 16.02% to 12.39% and 9.49%, respectively.

In the control group, the prevalence of chronic disease increased before and after the intervention from 16.18% to 17.33% ($\chi^2 = 1.53$, $p > 0.05$), but no difference was reported in the health literacy dimension ($p > 0.05$).

Before the intervention, the prevalence of chronic disease was not significantly different between the intervention and control groups ($\chi^2 = 3.51$, $p > 0.05$) but became significant after the intervention ($\chi^2 = 14.45$, $p < 0.001$). The prevalence of chronic disease was lower in the intervention than in the control group (13.89% vs. 17.33%).

TABLE 2 Health status of intervention and control groups before the intervention

Health status	Intervention group *n*	%	Control group *n*	%	χ^2	*p*
Chronic diseases						
Yes	475	14.82	530	16.52	3.51	0.06
No	2730	85.18	2678	83.48		
Self-health management						
Yes	963	30.05	927	28.90	1.02	0.31
No	2242	69.95	2281	71.10		

*$N = 3205$.

4 | DISCUSSION

Research on public health management aimed at strengthening effective interventions is lacking.[21] The number of articles and studies on the effect of SMS usage on health interventions has increased exponentially, but few studies have investigated SMS and health management. This is the first study of an SMS program to promote health management in a community-based population in China.

4.1 | SMS is an effective intervention to improve public health and health management

The ownership rate of mobile phones in Shenzhen is high, with more than 18 million mobile phones in use. This study found that people who accepted the SMS intervention were very willing to receive health messages (89.33%), demonstrating that promotion of health education by SMS is highly acceptable, especially for young people with higher education levels.[22] Public health management is influenced by policy, society, environment, education, culture, economy, and population characteristics, so it is difficult to improve public health management at a rapid speed; however, we found that our SMS intervention could help participants to improve their public health management by 7.76% within a year—not an easy task, but it was achieved.

TABLE 3 Proportion of respondents with self-health management by health literacy for the intervention and control groups before and after the intervention

Health literacy	Intervention group: Before intervention *n*	%	After intervention *n*	%	χ^2	*p*	Control group: Before intervention *n*	%	After intervention *n*	%	χ^2	*p*
LHL	424	28.92	437	34.14			386	26.29	438	29.84		
MHL	284	27.98	361	38.90			273	26.40	278	25.98		
HHL	283	39.09	439	44.34			240	33.99	233	35.09		
Total	991	30.92	1237	38.68	42.49	**0.001**	899	28.02	949	29.64	2.04	0.15

Note: Bold value shows comparison between intervention group, $\chi^2 = 42.49$, $p < 0.001$.
Abbreviations: HHL, high health literacy; LHL, low health literacy; MHL, middle health literacy.

TABLE 4 Prevalence of chronic disease (health status) by health literacy for the intervention and control groups before and after the intervention

	Intervention group						Control group					
	Before intervention		After intervention				Before intervention		After intervention			
Health literacy	*n*	%	*n*	%	χ^2	*p*	*n*	%	*n*	%	χ^2	*p*
LHL	210	14.32	235	18.36	8.2	**0.01**	243	16.55	252	17.17	0.2	0.66
MHL	160	15.76	115	12.39			166	16.05	189	17.66		
HHL	116	16.02	94	9.49			110	15.58	114	17.17		
Total	486	15.16	444	13.89*	2.11	0.15	519	16.18	555	17.33*	1.53	0.22

Note: Bold value shows comparison of LHL, MHL and HHL groups, $\chi^2 = 8.20$, $p = 0.01$.

Abbreviations: HHL, high health literacy; LHL, low health literacy; MHL, middle health literacy.

*Comparison between intervention and control groups, $\chi^2 = 14.45$, $p < 0.001$.

Our findings are similar to other studies' findings that SMS is more easily accepted than other interventions.[23] Text messages have had an obvious effect on promoting health awareness,[24] improving health knowledge,[25] changing unhealthy behavior, and improving therapies.[8,26] SMS messaging has been more effective than pamphlets in improving knowledge, attitudes, and practices, especially in promoting physical activity.[14] SMS can be used successfully for short-term behavior change.[2]

The popularity of mobile phones and the Internet is high. Simple SMS interventions complement current public health policies, especially for people in countries and regions with poor health conditions, but it is undeniable that SMS relies on the construction of SMS platform technology and a basic mobile phone usage rate, both factors closely related to the development of regional populations and their economic status. Relying on doctors or nurses to send text messages is not appropriate as it increases the burden on doctors, but, compared with the traditional health education model (i.e., lectures, publicity materials, and so forth), SMS messages can be sent faster and more widely and are more suitable to areas with limited medical resources. Developing a sustainable messaging platform may already be the most economical public health strategy.

4.2 | Improving health literacy can improve health management

LHL is associated with increased mortality, a high rate of hospitalization, and poor self-management skills of patients with chronic disease.[27] Good health literacy is a protective factor for human health. We found that text messaging had a positive effect on people with MHL and HHL; for example, the proportion of respondents with good self-health management skills increased the most in the MHL group (10.92%), while their rate of chronic diseases (health status) decreased from 15.76% to 12.39% after the intervention. Those with HLH reporting good self-health evaluation increased from 24.98% to 31.16%, while their rate of chronic diseases decreased from 16.02% to 9.49%, whereas those with LHL reported increased prevalence of chronic diseases, from 14.32% to 18.32%. This suggests that SMS intervention has a greater impact on people with MHL than with HLH, but did not produce a better health maintenance effect on people with LHL. People with LHL may have low access to SMS or may lack self-health management consciousness, so may have faced obstacles to active participation in this study. They have a relatively low level of education, suffer poor economic conditions, and have a lack of health awareness, demonstrating low self-health management initiative. For people with HHL, the better the self-health evaluation, the better the self-management of their health because health-conscious people are more active in implementing a health-promoting lifestyle[28] and ensuring health safeguards for themselves.

4.3 | Flexible design of messages can improve health management

SMS interventions need to be considered carefully in terms of their content.[29] Careful attention to message framing and timing of message delivery[14] is helpful. The duration of interventions in many studies ranged from 1 to 24 months. The frequency of text messaging varied from daily to every 2 weeks.[30] The present study was designed to send one message each week for 12 months, which is acceptable.[31] A too-high or too-low release frequency may not be successful in health literacy interventions. If the intervention is too frequent, it may be considered annoying, making it difficult for participants to accept or digest the health information offered. If people do not carefully read the message, it may have the opposite effect, creating extra health issues. If the frequency of intervention is too low, it might be difficult to generate a reinforcing stimulus.

In terms of content, we considered people's need for health knowledge, adopting a scientific and reasonable design for the SMS framework. The analysis of health literacy status found that people with LHL and HHL paid attention to different health intervention messages, so we designed different content according to people's varied situations aimed at changing or reinforcing their health behaviors, actively targeting health literacy.

The intervention stimulated action and provided emotional support at temporally appropriate moments.[32] In terms of designing the length of the message, we limited the text reading time to 2 min, and the message to 250–400 words. Compared to brochures and leaflets, the messages contained less health information, but we considered them to be an appropriate length, fitting people's reading habits. If a message is too long, people may avoid reading it, while people rarely read all messages received.

Text messages can increase participants' self-health management, especially for those with chronic diseases. For certain patients, SMS may enhance chronic disease management and patient-provider communication.[33] When comparing a study on changing behavior among older people,[34] we found that SMS intervention was more effective for younger people with higher education. Learning through receiving SMS messages can be an effective and appealing method of knowledge acquisition among people with higher education.[35]

4.4 | SMS short intervention did not cause significant health improvement

Although it was found that the SMS intervention enhanced levels of health literacy and public health management, it did not significantly improve participants' health conditions or decrease their prevalence of chronic disease. Achieving overall improvement in public health is not a simple matter; it cannot be achieved only by SMS interventions but requires a series of integrated interventions. SMS can be used as a tool for short-term intervention to improve the self-health management of chronic conditions or diseases arising from smoking,[36] obesity,[37] diabetes,[38] and asthma.[39] Our results may also be due to the limited duration of the intervention in this study; 1 year is not long enough to improve the public's health.[40] SMS played a more effective role in participants with HHL who reported greater benefit from the intervention, but SMS messaging was not so effective among participants with LHL who reported limited improvement.

4.5 | SMS is a low-cost intervention with good application prospects

Traditional communication mechanisms, such as pamphlets, publicity campaigns, and lectures, are characterized by complex implementation processes, limited coverage rates, and sizable costs. Mass media, such as television, newspapers, and radio, have good coverage but are also costly. In the previous studies, SMS was found to be more effective than pamphlets in improving health knowledge, attitudes, and practices.[41] SMS messaging has the advantage of being low cost, having wide coverage, and being simple to implement and manage. It offers health promoters an exciting opportunity to involve huge numbers of individuals at a low cost.[42] In our previous study,[19] the cost-effectiveness of SMS intervention per intervener was 0.54 for improving health literacy. In line with the results of other researchers,[43] SMS intervention surpasses traditional health education methods and expands the possibilities of multiple transmission. SMS intervention may have a benefit for people with LHL, providing them with more health education at a lower cost. Not only is it low cost, but the method is also popular, convenient, and applicable to every model of mobile phone.[25]

4.6 | Limitations

Because overestimation or underestimation in responses may have occurred in both the intervention and control group questionnaires, the current study included two groups (intervention and control) that completed pre-tests and post-tests to reduce the effects of reporting bias. Although the use of SMS might have similar potential in developing and developed countries, this health management method is still not applicable globally. It is difficult to calculate the potential overall effect of SMS-based programs. With limited human resources and funding, our study failed to take advantage of text interactivity or to achieve targeted, individualized guidance and intervention. The intervention time was not long enough and could not fully reflect the long-term effect of the intervention on public health literacy. Such an objective demands further research that explores the implementation effect when study participants are supplied with more refined, scientific, and professional personalized service.

In Conclusion, SMS is a potentially powerful tool for conducting health promotion among young people or among those with higher levels of education; it is a tool that may change their behaviors and improve their health management.

AUTHOR CONTRIBUTIONS

Zhuang Runsen: Conceptualization; data curation; formal analysis; methodology; project administration; resources; validation; writing – original draft; writing – review & editing. **Xiang Yueying**: Funding acquisition; methodology; software; supervision. **Han Tieguang**: Data curation; formal analysis; investigation; resources. **Yang Guoan**: Investigation; project administration; Resources. **Zhang Yuan**: Data curation; formal analysis; investigation; Resources. **Cao Li**: Data curation; formal analysis; investigation; Resources. **Cai Minyi**: Data curation; formal analysis; investigation; writing – review & editing.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data are available on reasonable request. The datasets analyzed for the results presented in this article are available from the corresponding author.

TRANSPARENCY STATEMENT

The lead author Zhuang Runsen affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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