An assessment of impact of maternal education through text messaging: results from a cluster randomized trial in rural China

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Abstract

Background
Attempts to use mobile phone text messaging to achieve positive results for a range of health issues have been made in recent years. Reports on the impact of maternal education program based on this widely available, inexpensive, and instant communication tool are sparse.

Objective
To explore the impact of maternal education program through text messaging.

Methods
We carried out a cluster randomized trial in a remote region in the Chinese province of Hunan between October 1, 2011 and December 31, 2012. We used county as the unit of cluster (a total of 10 counties), with half of the counties randomly allocated to the intervention arm (with maternal education material adapted from the World Health Organization being delivered by text messaging to village health workers and pregnant women alike) and the other half to the placebo arm (normal care without text messaging). Data on maternal and infant health outcomes and health behaviors were collected and compared between the two arms.

Results
A total of 13,937 pregnant women completed the follow up and were included in the final analysis. The results showed no difference between the intervention arm and the placebo arm in maternal and infant health outcomes or health behaviors after taking cluster effect into consideration.

Conclusions
Adequate resources should be secured to launch larger scale cluster randomized trials with a smaller unit of cluster and more intensive implementing to confirm the benefits of the text messaging based maternal education program suggested by the present trial.
Introduction

Although maternal and infant death rates in China were not as high as in some developing countries (1), the rates in remote areas were still very high, about 300 per 100,000 deliveries for maternal mortality and 40 per 1,000 births for infant mortality. Many of these maternal and infant deaths may be avoidable if mothers/local health workers can learn how to better detect and manage pregnancy complications. The World Health Organization (WHO)’s Promotion of Perinatal Care Program (2) contains teaching aids and texts for maternity care education. These WHO materials have been validated and widely implemented in many regions worldwide, with various levels of successes.

In recent years, attempts have been made to use mobile phone text messaging to achieve positive results for a range of health issues including treatment management and adherence (3-5), quality of life and well-being assessment (6), weight management (7, 8), suicide prevention (9), smoking cessation (10), and other public health issues (11, 12). Attempts have also been made to use mobile phone text messaging to address issues related to maternal and child health including interventions to support post-abortion contraception (13), infertility treatment (14), lactation management (15), and infant feeding (16). While the overarching goal of mobile phone text messaging seeks to promote behavioural changes in both health care providers and the target population of interest, text messaging intervention evaluated to date have met with varying degrees of success (11, 12).

Reports on the impact of maternal education program based on this widely available, inexpensive, and instant communication tool in low and middle-income countries are sparse. To our knowledge, no-one has yet tried to integrate WHO’s maternity care education material with text messaging as a local maternal and infant health promotion tool in remote rural areas in
China. Mobile phones are popular in China (over 50% of the population has a mobile phone) and accessible (with wireless networks spanning most remote areas) and mobile phone text messaging was affordable (<5 cents per message), making China an opportune place to implement a large scale maternal education program using this text messaging based health communication tool. To obtain the empirical data needed to explore this cost-effective novel health promotion opportunity, we designed a cluster randomized trial to evaluate the potential benefits of implementing the WHO maternal education program using text messaging in a remote area in China. We chose cluster randomized trial because it could be implemented in large scale at lower cost and it may help to reduce contamination (17).

Materials and Methods

Ethical approval, trial registration, and reporting

We obtained approval from the Ottawa Hospital Research Ethics and Confidentiality Committee before commencing the proposed study (REB # 2011467-01H). We registered this trial in ClinicalTrials.gov Protocol Registration System (registration number: NCT01775150; https://register.clinicaltrials.gov). We followed the Consort (Consolidated Standards of Reporting Trials (CONSORT) 2010 statement: extension to cluster randomized trials (18) in the reporting of the trial.

Study region

This study was carried out in the Northwestern region of Chinese province of Hunan, a mountainous area comprising about 5 million residents. Basic maternity care in this area is provided by village health workers. Several unique features made the Northwestern region of Hunan province the ideal location for a cluster randomized trial to evaluate the impact of a
maternal health education program. First, the authority governing the whole region agreed to participation in this study, so that no further negotiation with local authorities was needed. As a result, possible bias introduced by selective participation was reduced (17). Second, the region is quite homogeneous, thereby increasing the chance of obtaining a balanced randomization result. Third, half of the village birth attendants in the region had no formal training, and the other half had inadequate or outdated training (19). As a result, there was room for improvement by the proposed maternal education program. Fourth, although the region was not well developed, penetration of mobile phone was high (>70%), rendering an education program relying on health communications by mobile phone feasible.

Development of the health education tool

We developed a health education tool for village health workers and pregnant women alike, the WHO education materials with mobile phone text messaging. We first translated the WHO education material into Mandarin, and then adapted this material into a locally acceptable tool. Although the WHO education material was a well-founded and validated tool, it was developed in English. To make it a user-friendly tool for village health workers and pregnant women in the study region, it required modification in order to become acceptable by village health workers and pregnant women in the region. With respect to nutrition items, for example, modifications to the tool were required because local people in the region had limited consumption of dairy products.

Sample size

In the original design, we planned to use village as the unit of cluster, and sample size estimation was thus based on 1,130 villages (565 villages for each arm) and 10 births for the 12 months of trial per village (11,300 births), and based on the primary outcome (maternal and perinatal death
Given the above-mentioned sample size and baseline death rate, and given $\alpha = 0.05$, we should have a power of 90% to detect a reduction of 30% maternal and perinatal mortality in the intervention arm as compared to the placebo arm (17). These calculations were based on an assumed intra-class correlation of 0.02 for the villages. If a reduction of 30% as the acceptable magnitude of effect for consideration by researchers and/or policy-makers, the available study sample was sufficient to answer the study question.

Recruitment of study participants and randomization

Because of the logistic difficulties and budget constraints, we could not use village as the unit for the cluster trial and had to use county as the unit of trial. We have therefore selected 10 counties in the region and randomly allocated half of the counties to the intervention arm (with text messaging instructions to be sent by county maternal and child health bureaus) and the other half to the placebo arm (routine care with no text messaging). An independent statistician unrelated to this trial generated the random number and the investigator in charge (RHX) allocated the 10 participating counties to intervention arm and placebo arm accordingly. Village health workers in the 10 participating counties were requested to monitor women at reproductive age who planned to have a baby soon and recruit women during the study period once pregnant was diagnosed. Recruitment was started on October 1, 2011 and ended on August 31, 2012.

Delivery of educational material

We worked with local mobile phone carriers and maternal and child health bureaus of the intervention counties to install the adapted WHO education material into their wireless telecommunication systems. Text messages containing education material were packaged based on time periods of pregnancy (first trimester, second trimester, third trimester, labor and delivery, and postpartum; see Table 1 for details), and delivered to village health workers and pregnant
women of the 5 intervention counties according to the pregnancy period recorded by staff at county maternal and child health bureaus. To ensure that the education material could be made available to village health workers and pregnant women in a timely fashion, we asked and obtained a phone number of the husband or a family member if the pregnant woman did not have one.

Data collection

Data on mother’s residence (rural versus urban), gravidity, parity, pregnancy risk status (according to the Chinese national guideline), prenatal visit, prenatal screening, syphilis test, hepatitis B test, folic acid supplementation, mode of delivery, obstetric hemorrhage, maternal death, infant sex, birth weight, perinatal death, thyroid test, phenylketonuria test, and hearing test were collected from study participants by village health workers, using the data collection form developed by the research team.

Statistical analysis

We first compared the distribution of baseline characteristics and we then compared maternal and infant outcomes of the two arms. To adjust for the small number of clusters, the Kendward-Roger method was used. Specifically, to account for clustering by county, the county was specified as a random effect. Cluster level analyses were proceeded after comparing means and medians of maternal and infant outcomes as proportions for each cluster to ensure that they were approximately normally distributed. We then compared mean differences of the maternal and infant outcomes between the two arms using a standard unweighted t-test. Supplementary analysis at individual level was also performed. In the analysis at individual level, odds ratio (OR) and 95% confidence intervals (CI) were expressed as the effect measures, using the placebo arm (no text messaging) as the reference. Multiple logistic regression models were used.
adjusting for the following baseline characteristics: gravidity, parity, rural residence, household income, high risk pregnancy status, and infant gender.

Results

Between October 2011 and August 2012, a total of 25,236 pregnant women were recruited into the study (13,332 in the intervention arm and 11,904 in the placebo arm). Of these, 13,937 (55.2%) completed the follow up and included in the final analysis. Among them, 6,771 were in the intervention arm and 6,966 in the placebo arm. Most of the 11,299 pregnant women excluded from the final analysis did not complete pregnancy prior to the study closing date (December 31, 2012), rather than being lost to follow-up (Figure 1).

Table 2 shows the baseline characteristics of the study population. The study region is a typical rural area of China, with the majority (>90%) of the residents were rural. Maternal and infant baseline characteristics between the two arms were generally comparable (Table 2).

Since means and medians of county-specific outcome measures were very similar (data available upon request), we did not make log transfer of the data and used t-test to compare outcomes between the two arms at county level. The results showed that there was no difference in primary or secondary outcomes between the two arms at county level (Table 3).

At individual level, no difference was observed in the primary outcome (maternal and perinatal mortality rates) (Table 4). For secondary outcomes, cesarean delivery and obstetric hemorrhage were lower in the intervention arm than in the placebo arm, both statistically and clinically (Table 4). No important difference between the two arms for other outcomes was observed (Table 4).
Discussion

Our cluster randomized trial in a rural area in Hunan, China suggested that it was feasible to deliver maternal education material by text messaging through mobile phone to village health workers and pregnant women simultaneously. However, the observed association between maternal education and maternal and infant outcomes was weak and not demonstrable after taking the cluster effect into consideration.

To our knowledge, this is the first study evaluated the impact of WHO’s maternity care education material for local maternity care education in the remote rural area in China with text messaging. Through mobile phone-based text messaging, we were able to deliver the education material to a large number of village health workers and pregnancy women instantly. The cluster randomized trial was the appropriate design to assess the effect of a maternal education program, as it could be implemented with high efficiency and reduced chance of contamination (17).

There are several reasons that may explain why our study failed to find an impact of a promising education tool delivered by an efficient method. First, because of implementation difficulties and budgetary constraint, we had to use the county as the unit of randomization. Originally, we planned to use a smaller unit such as village for randomization. We realized later that because of the cost (with limited funding, we had to negotiate with local carriers for free text messaging service for this project, which the carriers agreed to only at the county level) and logistical (villages lacked the manpower and expertise to deliver education material through text messaging) considerations, it was not feasible to use smaller unit for randomization purpose. Since there were only 10 clusters (counties), it was difficult for us to perform more efficient statistical analysis integrating individual level data with cluster level data. Considerable information was lost with data aggregated at the county level. Second, only about half of the
recruited women were included in the final analysis. Most of the women were excluded not because they were lost in the follow up, but because they had not yet deliver at the time of study termination (again because of budgetary constraints). The loss of sample is unlikely to introduce bias because both intervention and placebo arms terminated at the same time. However, the substantial loss of study subjects resulted in lower power. Third, due to limited funding, we were not able to vigorously promote, implement, and monitor the maternal education program. As a result, the program may have not been implemented to the maximum extent possible, thus limiting its impact. Previous studies have suggested that to ensure the success of text messaging-based interventions, efforts should be made to intensively engage with targeted population (15, 16). Fourth, we have based power calculation on maternal and perinatal mortality rates that were published more than 10 years ago (1). Maternal and infant health has been improved impressively in the past decade in China, including rural China (20), which further limited the study power of this trial.

Much of the mortality and morbidity in developing countries may be attributable to avoidable risk factors such as unhealthy diets, poor personal hygiene, unsafe delivery by birth attendants, and unintentional injuries: almost all these factors are modifiable (21-23). For example, postpartum hemorrhage has been identified as one of the most important causes of maternal deaths in developing countries (21). On the other hand, evidence generated from clinical investigations, mostly from the industrialized countries, has demonstrated that active management of third stage of labour can substantially reduce the incidence of severe postpartum hemorrhage (24). It is therefore reasonable to infer that if deliveries in developing countries were managed in the same manner as in industrialized countries, maternal deaths related to postpartum hemorrhage in these countries could be largely prevented. As another example, higher perinatal
mortality in developing countries can be attributed in part to the lack of access to high quality perinatal care for at-risk mothers, fetuses, and newborns (25-27). Because of the emergent nature of the management of obstetric and neonatal complications, and because of the difficulties in transferring at-risk mothers to nearby medical center in a timely fashion in remote rural areas, instantly accessible information by mobile phone text messaging could provide a helpful tool for village health workers in managing obstetric and neonatal complications locally. Mobile phone text messaging-based health education tool has been advocated by researchers and health organizations alike (11, 12). The scope and extent of use of this tool with respect to important population health issues has expanded rapidly, with various trials being designed or launched on repeat suicidal episodes prevention (28), type II diabetes prevention (29), detection and management of hypertension in indigenous people (30), diabetes self-management in low or middle-income countries (31), secondary prevention of coronary heart disease and diabetes (32), and increasing acceptability and use of effective contraception among young women (33). The impact of such a tool in reducing maternal and infant mortality and severe morbidity in low and middle-income countries such as China has not been well documented. The lack of rigorous evaluation by randomized trials may be the main reason for this. There are currently several international collaborative projects with the goal of reducing mortality and severe morbidity in developing countries (34, 35). These projects were multi-dimensional interventions engaging many provinces and countries and millions of women. Education and training have been included as core interventions, and accurate outcome measurement and adequate program evaluation have been considered as the key for success in these projects. In these projects, however, the evaluation was based an observational or quasi-experimental design. For multi-dimensional interventions with voluntary participation by local governments and residents as the
main method of implementation, randomized trials are difficult to design and conduct. It is more practical to carry out a cluster randomized trial to evaluate the impact of a single intervention such as mobile phone text messaging. Concerns have been raised that a single intervention may not produce a detectable benefit. On the other hand, randomized trials remain the best method of rigorously evaluating the effects of an intervention. If mobile phone text messaging is considered as the core intervention for programs in developing countries aimed at reducing mortality and severe morbidity in mothers and newborns, it is critical to evaluate its beneficial effects using cluster randomized trials. The challenge presented by smaller impact of a single intervention can be overcome by increasing the study sample size.

Although our cluster randomized trial failed to find a significant impact of the maternal education program delivered by text messaging through mobile phone on improved maternal and infant health and health behaviors, the advantages of text messaging in the field of maternal education should not be overlooked. It was able to deliver precisely packaged material by to massive population at low cost. The use of text messaging is generally considered safe.

According to the most recent statement from Food and Drug Administration of the United States, there is no evidence of association between mobile phone uses and adverse health outcomes (36). Although WHO’s most recent assessment stated that there was a possible increased risk of certain types of brain tumors with mobile phone use, this potential risk could be prevented by reduced exposure to radiofrequency fields through a remote device such as a wired earphone or text messaging, as used in the present study, instead of using the phone for direct conversation (37). To send text messages to massive population through mobile phone, the senders need to work with local carriers. Therefore, this type of text messages was usually created and distributed by authoritative sources. On the other hand, messages delivered through social media
platforms such as Facebook or WeChat that could be distributed by anyone in the self-established social groups without scrutiny by experts, were often incorrect or even misleading. Smart phones are needed to use social media platforms, which are often not affordable by people in remote areas.

In summary, a cluster randomized trial in a rural area in Hunan, China suggests that it is possible to deliver maternal education material through text messaging to massive population at low cost. Although this exploration trial failed to demonstrate the benefits of maternal education through text messaging, couple of lessons learned from this exercise could help in the design and execution of future cluster randomized trials evaluating this intervention on maternal and infant health and other health issues. First, the choice of cluster unit for randomization requires a balanced consideration. On one hand, using smaller unit such as village is more efficient in terms of statistical analysis and therefore study power. On the other hand, using larger unit such as county is much easier in the implementation of the trial at much lower cost. However, using a larger unit of cluster will sacrifice the statistical efficiency and study power. Second, to ensure the success of this type of intervention, vigorous promotion, implementation, and monitoring are needed.
Authors contributions

RHX, HT, and SWW conceptualized and designed the study; RHX, HT, MT, JD, DK, YL and SWW made major contribution in the acquisition of data and analysis and interpretation of the data; RHX drafted the article; SWW, HT, MT, DK critically reviewed and revised the paper; all authors approved the final version of the manuscript. Each author certified that he or she had participated sufficiently in the work to believe in its overall validity and to take public responsibility for appropriate portions of its content.
Acknowledgement

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Conflict of interest

The authors have no conflict of interest related to this work to disclose
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20. New publications on maternal and perinatal mortality in China


Table 1. The main contents of text messages sent to health care providers and pregnant women, Hunan, China

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>First trimester</td>
<td>Healthy lifestyle &amp; environment</td>
<td>Food and nutrition</td>
<td>Folic acid intake</td>
<td>Calculating due date</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second trimester</td>
<td>Antenatal exam (every 4 wks)</td>
<td>Rest and exercise</td>
<td>Food &amp; nutrition</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third trimester</td>
<td>Antenatal exam (every 2wks)(once a week)</td>
<td>Counting fetal movement</td>
<td>Food &amp; nutrition</td>
<td>Rest and exercise</td>
<td>Personal hygiene</td>
<td>Sex</td>
<td>Childbirth preparation</td>
</tr>
<tr>
<td>Postpartum</td>
<td>Food and nutrition</td>
<td>Activity &amp; exercises</td>
<td>Sex &amp; family planning</td>
<td>Personal hygiene and environment</td>
<td>Breast care</td>
<td>Check-up</td>
<td>*</td>
</tr>
<tr>
<td>Baby’s care</td>
<td>Breastfeeding</td>
<td>Umbilical cord care</td>
<td>Skin care</td>
<td>Diaper changing</td>
<td>Bathing</td>
<td>SIDS prevention</td>
<td>*</td>
</tr>
</tbody>
</table>

- Monitoring abnormal signs and symptoms for pregnancy complications
Table 2. Comparison of maternal and infant characteristics between the intervention and placebo arms at individual level, Hunan, China

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Intervention (n = 6,771)</th>
<th>Placebo arm (n = 6,966)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravidity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;1 (%)</td>
<td>3285 (48.52)</td>
<td>3478 (49.93)</td>
</tr>
<tr>
<td>1 (%)</td>
<td>3486 (51.48)</td>
<td>3488 (50.07)</td>
</tr>
<tr>
<td>Parity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;1 (%)</td>
<td>3883 (57.35)</td>
<td>4316 (61.96)</td>
</tr>
<tr>
<td>1 (%)</td>
<td>2253 (33.27)</td>
<td>2039 (29.27)</td>
</tr>
<tr>
<td>Rural resident (%)</td>
<td>6388 (94.34)</td>
<td>6389 (91.72)</td>
</tr>
<tr>
<td>High risk pregnancy (%)</td>
<td>2488 (36.75)</td>
<td>2841 (40.78)</td>
</tr>
<tr>
<td>Fetal gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female (%)</td>
<td>3057 (45.15)</td>
<td>3639 (52.24)</td>
</tr>
<tr>
<td>Male (%)</td>
<td>3684 (54.41)</td>
<td>3304 (47.43)</td>
</tr>
</tbody>
</table>
Table 3. Comparison of maternal and infant outcomes between intervention and placebo arms at county level, Hunan, China

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Mean (SD) intervention arm</th>
<th>Mean (SD) placebo arm</th>
<th>Mean difference (95% CI)</th>
<th>P value (based on t-test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early pregnancy visit</td>
<td>94.8% (2.3)</td>
<td>95.0% (1.1)</td>
<td>0.2% (-5.8- 6.2%)</td>
<td>0.94</td>
</tr>
<tr>
<td>Prenatal screening</td>
<td>52.5% (12.7)</td>
<td>41.3% (14.3)</td>
<td>-11.2% (-30.9 to 8.5%)</td>
<td>0.23</td>
</tr>
<tr>
<td>Syphilis test</td>
<td>93.2% (7.1)</td>
<td>96.8% (3.3)</td>
<td>3.6% (-4.5 to 11.6%)</td>
<td>0.34</td>
</tr>
<tr>
<td>Hepatitis B test</td>
<td>94.9% (5.4)</td>
<td>98.3% (1.8)</td>
<td>3.4% (-2.4 to 9.3%)</td>
<td>0.21</td>
</tr>
<tr>
<td>Folic acid supplementation</td>
<td>75.6% (13.6)</td>
<td>78.4% (6.3)</td>
<td>2.7% (-12.8 to 18.2%)</td>
<td>0.69</td>
</tr>
<tr>
<td>Cesarean delivery</td>
<td>37.4% (6.8)</td>
<td>42.8% (16.0)</td>
<td>5.4% (-12.5 to 23.3%)</td>
<td>0.50</td>
</tr>
<tr>
<td>Obstetric hemorrhage</td>
<td>0.7% (0.5)</td>
<td>1.2% (0.8)</td>
<td>0.5% (-0.5 to 1.4%)</td>
<td>0.32</td>
</tr>
<tr>
<td>Maternal death</td>
<td>0.0% (0.1)</td>
<td>0.1% (0.2)</td>
<td>0.1% (-0.1 to 0.3%)</td>
<td>0.47</td>
</tr>
<tr>
<td>Perinatal death</td>
<td>1.3% (0.6)</td>
<td>1.5% (0.4)</td>
<td>0.1% (-0.6 to 0.9%)</td>
<td>0.66</td>
</tr>
<tr>
<td>Birth Weight &lt;2,500 g</td>
<td>3.0% (0.5)</td>
<td>3.7% (2.1)</td>
<td>0.6% (-1.6 to 2.9%)</td>
<td>0.54</td>
</tr>
<tr>
<td>Birth Weight &gt;4,000 g</td>
<td>1.5% (0.6)</td>
<td>1.6% (0.6)</td>
<td>0.1% (-0.8 to 1%)</td>
<td>0.80</td>
</tr>
<tr>
<td>Thyroid test</td>
<td>86.5% (10.2)</td>
<td>88.1% (5.0)</td>
<td>1.7% (-10.1 to 13.4%)</td>
<td>0.75</td>
</tr>
<tr>
<td>Phenylketonuria test</td>
<td>86.4% (10.2)</td>
<td>88.2% (4.9)</td>
<td>1.8% (-9.9 to 13.5%)</td>
<td>0.73</td>
</tr>
<tr>
<td>Hearing tests</td>
<td>2.3% (0.9)</td>
<td>2.1% (0.9)</td>
<td>-0.2% (-1.5 to 1.1%)</td>
<td>0.69</td>
</tr>
</tbody>
</table>
Table 4. Comparison of maternal and infant outcomes between intervention and placebo arms at individual level, Hunan, China

<table>
<thead>
<tr>
<th>Outcomes (% yes)</th>
<th>Intervention (N=6,771)</th>
<th>Placebo (N= 6,966)</th>
<th>Crude RR (95% CI)</th>
<th>Adjust RR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early pregnancy visit</td>
<td>6308 (93.16)</td>
<td>6644 (95.38)</td>
<td>0.99 (0.98-1.00)</td>
<td>0.99 (0.99-1.00)</td>
</tr>
<tr>
<td>Prenatal screening</td>
<td>3291 (48.6)</td>
<td>2381 (34.18)</td>
<td>1.34 (1.28-1.39)</td>
<td>1.25 (1.21-1.31)</td>
</tr>
<tr>
<td>Syphilis test</td>
<td>6121 (90.4)</td>
<td>6625 (95.11)</td>
<td>0.98 (0.97-0.98)</td>
<td>0.98 (0.97-0.99)</td>
</tr>
<tr>
<td>Hepatitis B test</td>
<td>6229 (92)</td>
<td>6767 (97.14)</td>
<td>0.97 (0.96-0.98)</td>
<td>0.98 (0.97-0.99)</td>
</tr>
<tr>
<td>Folic acid supplementation</td>
<td>4733 (69.9)</td>
<td>5431 (77.96)</td>
<td>0.93 (0.91-0.95)</td>
<td>0.92 (0.90-0.93)</td>
</tr>
<tr>
<td>Cesarean delivery</td>
<td>2488 (36.75)</td>
<td>2927 (42.02)</td>
<td>0.88 (0.84-0.92)</td>
<td>0.95 (0.91-0.98)</td>
</tr>
<tr>
<td>Obstetric hemorrhage</td>
<td>47 (0.69)</td>
<td>77 (1.11)</td>
<td>0.64 (0.45-0.92)</td>
<td>0.42 (0.22-0.80)</td>
</tr>
<tr>
<td>Maternal death</td>
<td>3 (0.04)</td>
<td>6 (0.09)</td>
<td>0.52 (0.13-2.10)</td>
<td>*</td>
</tr>
<tr>
<td>Perinatal death</td>
<td>84 (1.24)</td>
<td>101 (1.45)</td>
<td>0.96 (0.72-1.27)</td>
<td>0.73 (0.50-1.06)</td>
</tr>
<tr>
<td>Birth Weight &lt;2,500 g</td>
<td>196 (2.9)</td>
<td>210 (3.02)</td>
<td>0.98 (0.81-1.19)</td>
<td>1.20 (0.97-1.47)</td>
</tr>
<tr>
<td>Birth Weight &gt;4,000 g</td>
<td>97 (1.43)</td>
<td>105 (1.51)</td>
<td>0.97 (0.74-1.28)</td>
<td>1.01 (0.76-1.36)</td>
</tr>
<tr>
<td>Thyroid test</td>
<td>3977 (58.74)</td>
<td>4156 (59.66)</td>
<td>0.96 (0.95-0.98)</td>
<td>0.96 (0.95-0.98)</td>
</tr>
<tr>
<td>Phenylketonuria test</td>
<td>3911 (57.76)</td>
<td>4162 (59.75)</td>
<td>0.96 (0.95-0.98)</td>
<td>0.96 (0.95-0.98)</td>
</tr>
<tr>
<td>Hearing test</td>
<td>3935 (58.12)</td>
<td>3989 (57.26)</td>
<td>0.97 (0.95-0.98)</td>
<td>1.97 (0.95-0.99)</td>
</tr>
</tbody>
</table>

*Not estimable
Adjusted for gravidity, parity, residence, household income, high risk pregnancy status, and gender of infant
Figure 1. Flow chat of study participants of the text messaging trial, Hunan, China

Number of eligible participants at randomization (N=25,236)

Number of participants allocated to experiment arm (N=13,332) (N=13,332)

Number of participants who did not deliver at the time of study close date (N=4,603)

Number of participants lost to follow up (N=1,958)

Number of participants included in the final analysis (N=6,771)

Number of participants allocated to placebo arm (N=11,904)

Number of participants who did not deliver at the time of study close date (N=3,223)

Number of participants lost to follow up (N=1,715)

Number of participants included in the final analysis (N=6,966)