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SMS reminders for monitoring tuberculosis treatment among women in Greater Accra region, Ghana

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Abstract

Tuberculosis (TB) disease has been of public health interest for decades. Its effect on women is more pronounced in their reproductive years. Nonadherence to treatment among people with TB undermines treatment outcomes and worsens the disease. Directly observed therapy for TB requires patients to take their medicine under observation. Mobile phones present the most potential in providing privacy. This study examined the use of short message service (SMS) reminders for monitoring TB treatment adherence among women in the Greater Accra Region, Ghana. A quasi-experimental approach was used to assess the effect of SMS reminder intervention in two phases. Ten facilities were divided into two groups of five, with 105 and 125 for intervention and control groups, respectively. Adherence was assessed using the Medication Adherence Rating Scale for both groups before and after implementing the intervention and thereafter compared. STATA 15 was used to analyze data. Bivariate analyses were performed to assess medication uptake and factors associated with medication nonadherence between the intervention and control groups. p Values < .05 were considered significant. The SMS reminder messages had positive effect on adherence (odds ratio = 4.45, 95% confidence interval = 1.64, 12.11, p < .01). Educational level was the only variable significantly associated with TB treatments adherence. The findings suggest that a one-way SMS is feasible for supporting adherence to TB treatment in Ghana and other similar contexts.

Keywords

SMS, tuberculosis, treatment, adherence, technology, mobile phones, women, Ghana

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Introduction

It is well over a century since the discovery of the bacillus causing tuberculosis (TB), and more than 60 years since the first anti-TB medicine was introduced. The World Health Organization (WHO) has also, over the years, been involved in the control of TB, outlining and recommending standardized treatment regimens for member countries.[1] Despite these measures and available treatments,[2] TB remains a major global health challenge.[3] According to WHO's reports, approximately 10.6 million new cases of TB were diagnosed in 2022, with 30.1% of cases affecting women.[4] The incidence rate of TB in 2021 increased by 3.6%, with an estimated 1.6 million deaths.[5] Unfortunately, more than 90% of TB cases and related mortalities were recorded in low- and middle-income countries (LMICs), despite TB being both preventable and treatable.[6] African countries continue to suffer a disproportionate burden of TB even in the face of advancements in screening and treatment technologies.[7] In Ghana, for instance, 44,000 new cases of TB were

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recorded in 2021, with 43% of cases affecting women.[8] TB does not only affect the health of women but also has significant implications on the life span of pregnancies and outcomes, including the risk of transmission from mother to child,[9] with adverse consequences such as premature birth, growth retardation, and mortality.[10]

TB detected at an early stage is usually easier to treat with appropriate medications and counseling. In most advanced countries, the burden of TB has been reduced due to robust screening, early detection, and digital interventions for treatment.[11] However, in many African countries, TB screening and treatment adherence remain exceedingly low. Studies have established that 40% of TB patients in resource-constrained countries do not follow prescribed treatment plans.[12] In Ghana, the success rate of TB screening and adherence to treatment remains below the 90% set target toward the 2030 END TB goal.[6]

Several factors have been highlighted for the nonadherence to medications among TB patients. The notable ones are stigma, forgetfulness, depression, long duration of regimens, dearth of information, and lack of transport to clinics to pick up drugs.[9,12–14] According to a recent study in Ghana by Appiah et al.,[15] when TB patients in the Ashanti region were surveyed on barriers to treatment adherence, the majority indicated that the lack of family support, long distance to treatment centers, and forgetfulness were their main challenges. The same study also highlighted that most patients had insufficient knowledge about TB and were uncertain about the side effects of drugs.[15] The existence of these factors particularly among vulnerable groups like women cannot provide the necessary support to improve treatment adherence in LMICs.[16]

The WHO has long recommended directly observed therapy (DOT) for TB management among member countries including Ghana.[1] The DOT requires TB patients to take medication under the supervision of a health worker or trained treatment supporter with available community-based interventions.[1,17,18] This intervention has improved TB treatment. However, DOT implementation has been limited in many settings for numerous reasons such as the infringement of patient privacy and significant time commitment by both TB patients and medication supervisors.[19] Thus, treatment adherence has been a major challenge in many countries with a greater burden among women.[14,20] Poor adherence to TB medication increases the risk of disease transmission, drug resistance, relapse, and treatment failure, which contribute to a high mortality rate.[21]

In developing countries, such as Ghana, adherence to treatment in females is negatively influenced by gender roles and expectations. Women from these contexts mostly provide care for all members of their immediate families, in addition to other socioeconomic roles. The role of women in LMICs requires regular interaction with family and other relations, making them susceptible to TB infection. Multidrug-resistant TB, which results in part from non-adherence to treatment, is also known to increase among women in high human immunodeficiency virus-prevalent areas, making it imperative to consider women in TB control. The significance of TB control among women calls for strengthening existing TB interventions to improve treatment adherence among them since they are most at risk of complications.[22–24]

The lack of established pathways to address nonadherence to TB treatment in Ghana may worsen the public health concerns associated with the TB burden.[15] Text messaging and other mobile health (mHealth) technologies have been used to improve the adoption of cross-examination tests for several health concerns, through education and information sharing.[25–27] Studies have shown that mHealth technologies have been recognized as a critical tool for increasing cervical screening with positive treatment outcomes in sub-Saharan Africa.[28–30]

In Ghana, the use of mHealth technologies, particularly SMS has augmented vastly over the last decade, especially for outcomes related to maternity, reproductive health, and noncommunicable diseases.[31–33] Due to limitations associated with sending video and voice messages, alternative message dissemination methods for mHealth messages, such as short message services (SMS) could be considered. We carried out a quasi-experimental trial to determine whether sending one-way SMS reminders to women with TB about medication uptake would boost TB treatment adherence in the Greater Accra Region, Ghana.

Materials and methods

Study design

This was a quasi-experimental study conducted from March 2019 to April 2020 in 10 facilities across the Greater Accra Region of Ghana. Women aged 15 years or older receiving TB treatment in the selected health facilities were recruited into the study. The study was conducted in two phases: the formative phase and the intervention phase.

In the formative phase, a qualitative approach with in-depth interviews and thematic content analysis were used to derive the content of the SMS reminders (Table 1).

The intervention phase involved baseline data collection on TB treatment adherence followed by the implementation of the intervention and end-line data collection on TB treatment adherence. A baseline survey was conducted among study participants in both the intervention and control groups, and then the intervention (daily SMS reminders) was implemented among the intervention group. Data on TB treatment adherence were collected at the end line. Adherence for both baseline and end line was assessed using the Medication Adherence Report Scale (MARS-5).

The MARS-5 scale contains five items describing a range of nonadherent characteristics devoid of threatening

Table 1. Reminder messages for women with Tuberculosis, Greater Accra region, Ghana.

1. Good morning! Have you taken your drugs today?
2. Remember to take your drugs today
3. Time up for your medicine. Good morning
4. Take your drugs everyday
5. Forgetting to take your drugs can prolong healing
6. Good morning. It is important to take your medicine
7. Taking your drugs daily improves healing
8. It's a new day and you need to take your drugs
9. Remember to take your medicine on time
10. You need to take your drugs 1 h before breakfast.

and judgmental questions and provides responses ranging from 1 to 5.[34,35]

The scores for each of the five questions were then summed up to get the total score ranging from 5 to 25 points. The higher the total scores, the higher the individual was regarded to have adhered. Those who scored 25 in this study were regarded as adherent and below 25 as nonadherent (Appendix 1). This method was used to compare the adherence of all participants at baseline and end line and also among the control and intervention groups. The research proposal was reviewed and approved by the Ghana Health Service Ethics Review Committee (GHS-ERC005/11/18).

Participants and setting

The study was conducted in 10 health facilities dotted in three municipalities and four districts in the Greater Accra Region. All the study facilities were public institutions providing TB treatment services. Personnel from the Greater Accra Region of the National TB Control Programme assisted with randomly selecting the 10 health facilities from their database of all facilities providing TB treatment in the region. All 163 facilities providing TB treatment in the region at the time of the study were listed from 1 to 163. An Excel random generator was used to randomly select 10 of the listed numbers for the study. Thereafter, these 10 facilities were mapped by geographic experts. Based on their proximity to each other, they were grouped into two clusters with five facilities in each. A coin was tossed to assign these clusters to either the intervention or the control groups. Ashaiman Polyclinic, Tema General Hospital, Madina Polyclinic, Achimota Hospital, and Ga West Municipal Hospital, Amasaman were grouped as the intervention facilities. The control group consisted of the Greater Accra Regional Hospital, Ridge, La General Hospital, Maamobi Polyclinic, Kaneshie Polyclinic, and Ga South Weija Municipal Hospital, Weija.

Patients with TB between 2 and 6 weeks of treatment with personal mobile phones or regular access to one were recruited concurrently from all facilities between June and December 2019 and followed until April 2020. Patients 15 years or older capable of reading SMS on their mobile phones or willing to be sent voice SMS were recruited. In addition, participants without a mobile phone who had regular access to someone's own were included after seeking the consent of the owner. After daily recruitment, their numbers were dialed by the research assistants for validation.

The aim and details of the study were explained to the participants, and ample time was given for them to seek clarification before providing consent. Participants who did not understand the English language had the study explained to them in their preferred language. Literate participants signed the consent form, while those who could not sign thumb printed it. Participants below age 18 responded to the assent form, and the parent/guardian provided consent. In total, 230 women participated in the baseline, and 190 completed the end-line survey. All study facilities were public institutions providing general healthcare services including TB management. TB is managed in these facilities using the recommended DOT by the WHO.

Sample size for the study

Although all eligible patients who enrolled for TB treatment within the period were used for the study, the minimum sample size used to carry out the required subanalysis was calculated using the formula for determining the sample size for two proportions. The adherence rate for TB treatment among women in Greater Accra Region was not available at the time of the study and was assumed to be 50%. The study hypothesized a 20% improvement in those receiving the daily reminders based on a similar study in Cameroun.[36] Therefore, assuming an adherence rate of 70% for the intervention group, sample size was calculated using sample size formula for testing proportion with fixed value-binary outcome[37]

$$n = \frac{Z_{\alpha/2}\sqrt{2pq} + Z\beta\sqrt{(p_1q_1 + p_2q_2)^2}}{\Delta^2}$$

n: sample size; $z_{\alpha/2}$: z value for a two-sided test corresponding to the chosen α; z_{β}: z value for a one-sided test for the chosen β; p_1: Treatment success rate in the control group; p_2: Treatment success rate in the intervention group; P: mean estimated proportion $(p_1+p_2)/2$; q_1: Treatment failure in the control; q_2: treatment failure in the intervention q: Mean estimated proportion (p_1+p_2); Δ: difference being measured (p_2-p_1).

With a TB treatment adherence rate of 50% for the controls and 70% for those on the SMS intervention at 95% confidence interval with a 5% margin of error and a study power of 80% for the intervention, the sample size for the study is as follows. The 15% nonresponse rate was based on the outcome of the formative research.

$$n = \frac{[1.96\sqrt{2(0.56\times0.44)} + 0.8\sqrt{(0.5\times0.63 + 0.63\times0.37)}]^2}{0.25^2}$$

$n = 93 + 15\%$ nonresponse rate adjustment $= 105$.

Hence, 105 women receiving treatment for TB in five of the 10 selected study facilities were sampled for the intervention and 125 for the remaining five facilities for the control (Table 2).

The study intervention

The SMS reminder messages were developed and sent to participants in the intervention group. The SMS intervention involved sending daily SMS reminders to study participants receiving TB treatment. Using a bulk messaging platform, the daily reminder messages were delivered to participants in the intervention arm. A global communication company for businesses and omnichannel engagement provided the global cloud communication platform for delivering reminder messages. This platform was used to deliver messages for the entire research team for two weeks as a test to ensure the consistency of the platform. The messages for the SMS were one-way directional ones for women with TB who were in the intervention arm of the study. The platform could indicate the time of message delivery. However, it could not indicate when the messages were read. The reading of the messages was self-reported. In addition, network challenges also delayed the delivery of some of the messages. This was always resolved by resending them. Except for two participants in the intervention group who received voice SMS in a local dialect (Twi), all SMS messages were in English.

Data analysis

The completed questionnaires for the survey were compiled from the various study facilities weekly and entered in an excel template. Questionnaire data entered in excel were exported into STATA 15 for analysis. The data were first summarized to describe the study participants using univariate analysis. Each of the components under the five sections of the questionnaire was summarized and described. This was done using frequencies and proportions.

Table 2. Sample size allocation for the intervention and control.

Disease	Intervention	SMS	Control	Total
TB	SMS	105	125	230
Total				230

Note. TB: tuberculosis; SMS: short message services.

The outcome of the study was adherence to TB treatment. Adherence was measured for both the intervention and control groups using the MARS-5. This standard tool was used for both the baseline (during treatment) and end-line (after) treatment, and the results were compared. The comparison was done using multivariate analysis to adjust for confounders that might influence adherence between the groups.

After the univariate analysis, bivariate analysis was done to determine the relationship between the treatment outcomes and the determining variables that had been chosen for the study. Multivariate analysis was then used to adjust for confounding variables to determine the relationship between the determinants and the outcome. For this analysis, p value less than .05 was considered significant at a 95% confidence interval. The difference-in-difference (DID) analysis was used to examine the effects of the SMS reminder messages for participants in the intervention and control groups. The DID was estimated by calculating the difference between the adherence rate at the baseline and the end of the study for the intervention and the control groups separately, using two sample tests for categorical data. To control for other possible factors that might account for the increase in adherence rate in the intervention group between baseline and end line, the logistic model was used. A p value of .05 or less was considered significant.

Results

General characteristics of study respondents

A total of 230 patients with TB participated in the baseline survey: 105 for the intervention and 125 for the control group. The mean age of all study respondents was 40.4 years (SD = 15.0). The majority of the respondents had access to personal mobile phones 196 (86%), were within their reproductive years 169 (74%), and single 149 (65%). Regarding educational status, 85 (37%) had attained the junior secondary level, with 39 (17%) having no formal education. In total, 150 (65%) lived in houses where basic facilities such as lavatories were shared with other tenants. Bivariate analysis was used to compare the characteristics of the study participants in the intervention and control groups at baseline. This was to determine if there were any significant differences between the two groups. A p value of .05 or less was considered significant for all comparisons. The majority of the women in both the intervention (n = 79, 75%) and control groups (n = 90, 72%) were within their reproductive years. The differences in

Table 3. Sociodemographic characteristics of participants in intervention and control groups.

Variable	Total, *N* (%)	Intervention, *n* (%)	Control, *n* (%)	$p\text{-}value^{a}$
Age (years)				
15–49	169 (73.5)	79 (75.2)	90 (72.0)	
>50	61 (26.5)	26 (24.8)	35 (28.0)	.58
Total	230 (100%)	105 (100)	125 (100)	
Marital status				
Not married	149 (64.8)	65 (61.9)	84 (67.2)	
Married/cohabiting	81 (35.2)	40 (38.1)	41 (32.8)	.40
Total	230 (100)	105 (100)	125 (100)	
Housing				
Separate housing	80 (34.8)	39 (37.1)	41 (32.8)	
Shared facility	150 (65.2)	66 (62.9)	84 (67.2)	.49
Total	230 (100)	105 (100)	125 (100)	
Highest level of education attained				
None	39 (17.0)	27 (25.7)	12 (9.6)	
Primary	48 (20.9)	13 (12.4)	35 (28.0)	
O'Level/JHS	85 (37.0)	37 (35.2)	48 (38.4)	
A'Level/SHS	37 (16.1)	14 (13.3)	23 (18.4)	
Tertiary	21 (9.1)	14 (13.3)	7 (5.6)	<.01
Total	**230 (100)**	**105 (100)**	**125 (100)**	
Monthly income (GHS)[b]				
<200	33 (18.0)	17 (19.8)	16 (16.5)	
200–499	100 (54.6)	45 (52.3)	55 (56.7)	
500–699	29 (15.8)	12 (14.0)	17 (17.5)	
700+	21 (11.5)	12 (14.0)	9 (9.3)	.65
Total	**183 (100)**	**86 (100)**	**97 (100)**	
Access to mobile phones[c]				
Owns a mobile	196 (85.6)	96 (91.4)	100 (80.7)	
Access to other's mobile	33 (14.4)	9 (8.6)	24 (19.4)	.02

(continued)

Table 3. Continued.

Variable	Total, *N* (%)	Intervention, *n* (%)	Control, *n* (%)	$p\text{-}^{a}_{value}$
Total	**230 (100)**	**105 (100)**	**124 (100)**	

[a]Fisher's exact *p* value reported.
[b]Monthly income (in Ghana Cedis) was only for participants working and had 19 missing values for intervention and 28 for control.
[c]Access to mobile phones had one missing value for control.
O'Level/JHS: ordinary level/junior high school; A'Level/SHS: advanced level/senior high school; GHS: Ghana Cedis.

the age proportions and the type of housing for participants in the two groups were not statistically significant (Table 3).

About two-thirds of the women in both the intervention (n = 65, 62%) and control (n = 84, 67%) groups were single. Regarding respondent's housing facilities, more than two-thirds of both the intervention (n = 66, 63%) and control (n = 84, 67%) groups lived in houses where basic facilities were shared with others; a system popularly referred to as "compound housing." Access to mobile phones and level of education showed statistical significance in their comparisons, $p = .02$ and $p > .01$, respectively (Table 3).

General background characteristics of participants at end line

A total of 190 women receiving treatment for TB from the 10 study facilities in the region were available for the end-line survey. Most of the women (n = 136, 72%) were within their reproductive years, had attained junior secondary-level education (n = 68 36%), and had access to personal mobile phones (n = 161, 85%). Sixty eight (36%) of the women were married and lived in separate housing (n = 60, 32%), where they had basic facilities to themselves (Table 4).

Comparing intervention and control group at end line

The end-line survey had responses from 89 participants from the intervention and 101 from the control. Sixteen (15%) respondents from the intervention and 24 (19%) from the control were missing at the end-line phase (Figure 1). Deaths, loss to follow-ups (LTFU), and being transferred to other facilities were cited as reasons for the missing participants at the end line.

The influence of SMS on adherence to TB treatment among study participants

Adherence was measured for all participants and separately for both groups at baseline and end line. The results on adherence at baseline among all study participants revealed that 133 (58%) adhered to their TB treatment. However, adherence to TB treatment among all participants at end line increased to 124 (65%). Although there was no significant difference in adherence rate between the intervention and control groups at baseline, the result showed a significant increase at end line. The control group had a similar adherence rate (n = 73, 58%) as the intervention group (n

Table 4. General background characteristics of all study participants at end-line.

Characteristic	Frequency (*n*)	Percent (%)
Age		
15–49	136	71.6
>50	54	28.4
Marital status		
Married	68	35.7
Not Married	122	64.2
Education		
None	36	19.0
Primary	33	17.4
JHS/O'Level	68	35.8
SHS/A'Level	33	17.4
Tertiary	20	10.5
Housing		
Separate housing	60	31.6
Shared facilities	130	68.4
Access to phones		
Yes	161	85.2
No	28	14.8

Note. JHS: junior high school/ordinary level; SHS: senior high school/advanced level.

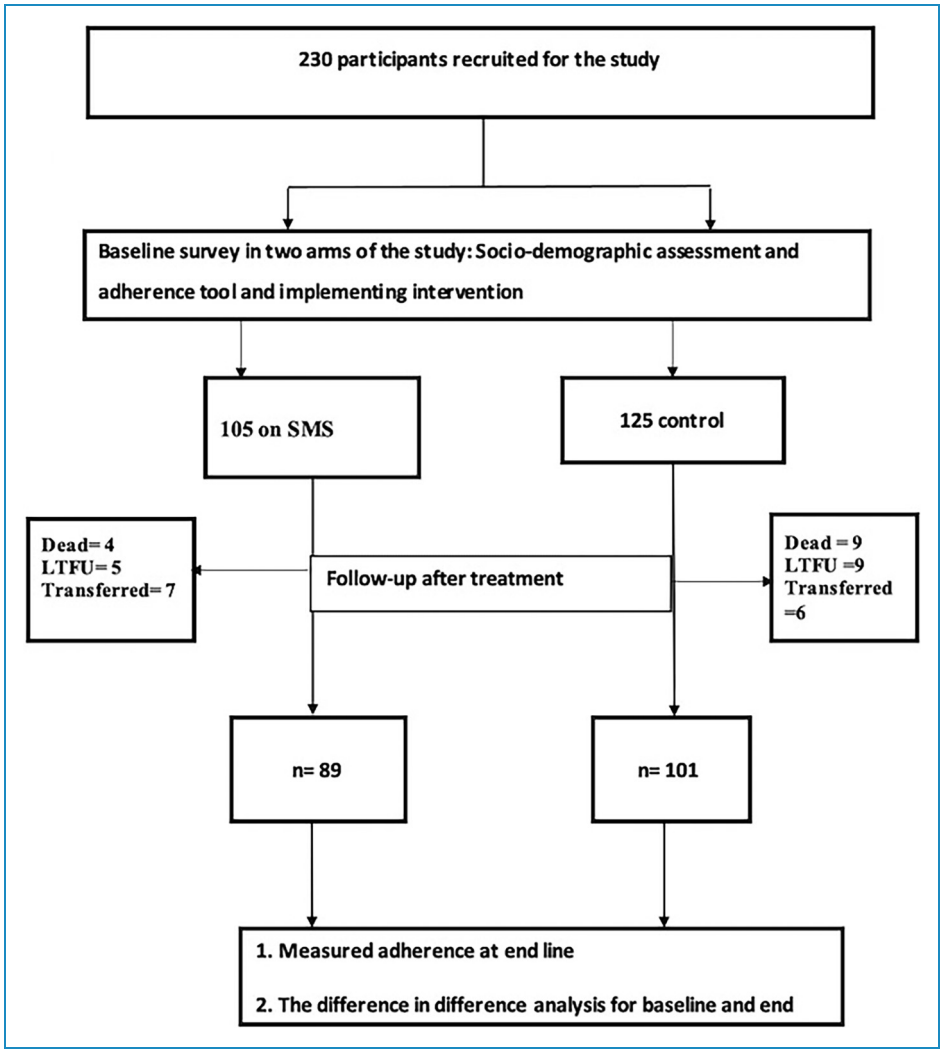

Figure 1. Comparing intervention and control groups at baseline and end-line.

= 60, 57%) at the baseline. Adherence among the intervention group increased from 60 (57%) at the baseline to 72 (81%) at end the line, whereas the control group decreased from 73 (58%) at baseline to 49 (49%) at end line (Table 5).

The DID analysis of adherence at baseline and end line

Further analysis was done to assess the effect of the reminders on the adherence rate among participants using the DID. The difference between adherence rates within the two time points (baseline and end line) for the intervention group was 23.8%. The control group's adherence rate reduced from 58.4% at baseline to 51.5% at end line. The difference between the adherence rate in the control group at baseline and end line was −6.9%. The DID between the intervention (23.8%) and the control (−6.9%) groups was 30.7%. The DID obtained for the adherence rate of TB treatment for participants showed that the SMS reminder messages had a greater positive effect on participants in the intervention group than those in the control group (30.7%; $p \leq 0.001$; Table 6).

Effect of SMS on TB adherence using the logistic model

The logistic regression model was conducted to adjust for factors that had significant differences between the two groups at baseline (educational level and access to mobile phones in (Table 3). The findings revealed a significantly positive impact of the intervention on the odds of participants' adherence to TB treatment (Table 7). The findings from the analysis comparing the exposure to the SMS intervention within the study period revealed an odds ratio of 4.45 (Table 6).

Table 5. Adherence to TB treatment among the intervention and control groups at baseline and end line.

	Adherence to TB treatment					
	Baseline, *n* (%)			End line, *n* (%)		
	Adherent	Nonadherent	*p*	Adherent	Nonadherent	*p*
Intervention	60 (57.1)	45 (42.9)		72 (80.9)	17 (19.1)	
Control	73 (58.4)	52 (41.6)	.85	52 (51.5)	49 (48.5)	**<.01**
Total	133 (57.8)	97 (42.2)		124 (65.3)	66 (34.7)	

Note. TB: tuberculosis.

Table 6. Logistic regression controlling for education and access to mobile phones.

Outcome: adherence	OR	CI	*p-Value*
Exposure to SMS			
Control (Ref)	–	–	–
Intervention	1.24	[0.64, 2.41]	.53
Timeline			
Baseline (Ref)	–	–	–
End line	0.83	[0.44, 1.57]	.57
Change in odds of being adherent difference in difference	4.45	[1.64, 12.11]	<.01

Note. OR: odds ratio; CI: confidence interval; SMS: short message services.

Discussion

This study used a one-way SMS reminder to assess treatment adherence among women with TB in the Greater Accra region. Our findings show that the use of SMS reminders can boost medication adherence among TB patients. The outcome of this study revealed a higher median medication adherence in the daily SMS intervention arm compared to the control arm.

According to the health belief model, variations in perceived threat may be based on susceptibility risk and supposed efficacy; therefore, women's demographics, resources, and time availability can influence their health-seeking behaviors.[33,38] In this study, both the intervention and control arm shared similar characteristics in terms of age, educational level, marital status, monthly income, and access to mobile phones. . Previous studies have emphasized the acceptability of SMS reminders as a medium for effective health promotion against diseases in the general population.[25–27] However, to the best of our knowledge, this is the first study in Ghana where SMS has been used to assess treatment adherence among women with TB.

Effect of SMS reminders on TB adherence among women with TB

After completing SMS reminders for each participant in the intervention group, the adherence rate increased from 57% (60) to 81% (72), while those in the control group had a reduced rate from 58% (73) to 52% (52). The end-line result was statistically significant (DID[2]; 30.7%, $p \leq .001$), thus indicating that when women receive SMS reminders to take their TB drugs, they are more likely to adhere to treatment. This finding is consistent with other studies that recorded an increased adherence rate with similar interventions.[39,40] Another study in Kenya where SMS messages were combined with Video Directly Observed Therapy (VDOT) also identified better compliance among participants.[41] The findings contradict other ones that

Table 7. Effect of SMS on TB adherence using the difference in difference analysis.

	Adherence to TB Treatment, *N* (%)				
	Baseline, *n* (%)	End Line, *n* (%)	Difference,[a] *n* (%)	DID[b] (%)	*p*
Intervention [*N* = 105]	60 (57.1)	72 (80.9)	12 (23.8)	30.7	<.001
Control [*N* = 125]	73 (58.4)	52 (51.5)	−21 (−6.9)		

Note. SMS: short message services; TB: tuberculosis DID: difference-in-differences.
[a]Difference (absolute) in pre- and postintervention proportions of participants who were part of either the treated or control group obtained from a two-sample test for binomial proportions (normal theory test).
[b]Two-tailed *p* value for the DID. Sample sizes are in squared brackets.

found no significant increase in adherence rate after using SMS reminders.[42–44] In Cameroun, Bediang et al.[42] found no difference in the treatment success rate among participants who benefited from a similar intervention. Notwithstanding controlling for possible factors such as access to mobile phones and level of education, which could influence the effect, the SMS reminders remained effective in improving adherence among women with TB in the five intervention facilities.

Although educational level was significant in the bivariate analysis of our study, the SMS reminders were effective even among participants with low educational levels. This contrasts with a major challenge about education status faced in a similar study on TB treatment adherence in Indonesia (52) and Ethiopia's diabetic counselling-based intervention (55). In our study, approximately 28% of the women were technologically or educationally semiliterate, but they all benefited from the intervention by showing comprehensive medication adherence. This suggests that SMS reminders could be used to enhance TB treatment adherence in patients across all literacy levels. These findings agree and fills the gap of other TB and diabetes treatment adherence research, which reported positive outcomes but were not able to close the prime learning gap between patients of low and high literacy. Outcome of this study highlighted the feasibility of SMS reminders for persons of varied educational backgrounds.[45,46] Our study also reveals the possibility of implementing the SMS reminder intervention in low-income countries for TB and other similar infectious diseases. According to Musiimenta et al. (2020), SMS intervention has proven to be effective in Uganda, especially in settings where DOT has been abandoned due to the financial burden on TB patients.[47]

The use of SMS prompts for TB patients in this research was acceptable for supporting medication adherence in the various study settings. Study participants in the intervention arm perceived this technology to be useful in assisting TB treatments. These SMS reminded TB patients to take medication on time, hence addressing the challenges of forgetfulness, especially among patients with busy schedules. This outcome aligns with the response from TB patients in a randomized controlled study by Musiimenta et al.,[48] in southwestern Uganda, where some TB patients perceived this intervention as being "cared for." Such perceptions can motivate TB patients to comply with medication and cooperate with their healthcare providers while taking care of their own lives as well as minimizing the challenge of social isolation.[47,49]

Despite the feasibility of the SMS intervention in this study, mobile network challenges were detected, which required some messages to be resent to study participants to achieve our objective. Similar challenges were reported in studies on TB and antiretroviral therapy experimental research which were resolved.[42,47] With mobile broadband networks (3G/4G) covering more than 75% of the country,[50] poor networks will not be a significant challenge in the implementation of this intervention.

The current practice of DOT that requires a person with TB to be monitored by health workers as well as other relations makes them vulnerable to stigma. The use of reminders could safely be used by health workers to interact with patients without involving others.[51] This will greatly promote privacy for persons affected. Contextual gender norms that disadvantage women in receiving and completing treatment could also be minimized. Women can combine their gender roles with accessing care when reminded to take their TB medications.[52] The bulk messaging platform could reduce the cost of transportation to facilities for affected individuals who are already overburdened by other financial demands. The study further underlines the importance of SMS reminders among women on TB treatment and could be considered for integration into national policies and strategies to improve adherence among patients with TB. To ensure the smooth implementation of similar interventions, network challenges need to be resolved to ensure messages are delivered on scheduled time.

Limitations

The use of standard objective methods to complement the MARS-5 adherence scale was limited by logistical

constraints. The use of MARS-5 adherence scale was self-reliant and hence could be influenced by misreporting. Self-report of adherence at end line could also be affected by recall bias among participants. Moreover, periodic assessment of adherence between baseline and end line by regular follow-up of participants between both periods could not be sustained, owing to time and other resource constraints. Although the bulk messaging platform for sending daily reminders could indicate when the messages were delivered, it was not possible to determine whether or not the messages were read by participants. Self-reports of participants at the end line on their frequency of reading the message could therefore be misreported.

Conclusion

Our findings suggest that medication adherence linked with daily SMS reminders is generally feasible. The outcome of the study shows that sending one-way SMS prompts to women will urge them to adhere to treatment. Therefore, it should be a priority goal to incorporate this intervention into TB treatment protocols to boost medication adherence.

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Appendix 1. MARS-5 questionnaire

People have general concerns about taking their medicines. We would be grateful to have you share your experiences with us. Nothing you share with us will be linked to you. There is no right or wrong answer. Please answer each question based on your personal experience with your TB medication.

	Scores				
Question	Never 5	Rarely 4	Sometimes 3	Often 2	Always 1
I forget to take my medicine					
I alter the dose of my medicines to minimize side effects					
I stop my medicine for a while					
Did you ever miss taking your TB drugs?					
I take less medicines than prescribed					