

# Effect of WhatsApp-based periodical interactive SLMs teaching and communication on TB diagnosis completion among TB contacts of TB cases in Faridabad, Haryana



Original article

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**Abstract:** **Objective:** An Impact assessment of WhatsApp-based self-learning materials (SLMs) teaching and interactive communication on Tuberculosis (TB) diagnosis completion among TB contacts.

**Methods:** A quasi-experimental one-group pre-post-test study involving 86 TB contacts selected through cluster simple random sampling across 5 TB units in Faridabad from February to April 2023. Data were collected telephonically (5–6 min) at 3 time points: 6–7 d, 27–28 d, and 55–56 d and analyzed at a  $P < 0.05$  significance level. Paired samples  $t$ -tests and one-way repeated measures analysis of variance (ANOVA) were used in this study.

**Results:** The study results showed that compared to first pre-intervention (5% [4]) the TB diagnosis completion rate increased (11% [9]/45% [33]), respectively after the first and second interventions; however, no significant difference was observed between first pre- and post-intervention ( $t [84] = 1.39, P = 0.166$ ) during (6–7/27–28 d); whereas a significant difference ( $t [84] = 4.02, P < 0.001$ ) was observed after the second post intervention (55–56 d) compared to second pre-intervention (27–28 d). Moreover, overall, over 3 time points (6–7, 27–28, 55–56 d), a significant difference ( $F [2170] = 18.94, P < 0.00001$ ) was observed pre-post intervention upon TB diagnosis completion among TB contacts.

**Conclusions:** WhatsApp-based SLMs teaching and interactive communication have proven effective in increasing TB diagnosis completion among TB contacts; hence, policymakers should promote m-health literacy, especially for TB-affected underserved populations living in remote areas, encouraging them to seek timely diagnosis and follow-up care.

**Keywords:** m-health • SLMs • TB contacts • TB diagnosis completion • WhatsApp

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## 1. Introduction

Tuberculosis (TB) continues to be a profound global health challenge, causing 1.25 million deaths and 10.8 million new cases.<sup>1</sup>

Despite ongoing efforts, TB-burdened developing countries, including India, are still not able to reach all affected individuals, and only 2 out of 5 TB cases are

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seeking diagnosis and care, leading to nearly 40 million missed cases and ongoing transmission in the millions, all of which pose significant challenges to TB elimination worldwide.<sup>2</sup>

Additionally, the rise of TB and drug-resistant cases remains alarming worldwide (including India).<sup>3</sup> Contributing key challenges include a lack of TB awareness, stigma, inadequate resources and infrastructure, TB drug non-adherence, continuous resistant-TB strains transmission, missed cases (pre- and during TB care), delayed case identification (ID), and overall TB care negligence.<sup>4</sup>

To control TB incidence and drug resistance, it is equally important to take care of the TB cascade (from early ID to TB cure) of TB contacts along with active TB cases.<sup>5</sup> Moreover, interactive communication is key to building trust, motivating, improving education, promoting health, and engaging people.<sup>6</sup> Hence, there is a pressing need to explore more ways of effective awareness campaigns to educate more TB-affected people along with the general public, and prompt urgent action to combat the disease.<sup>7</sup>

In the digital age globally (regardless of socioeconomic, gender, and area), due to ubiquitous access to the internet and low-cost smartphones, as a first screen it has become an integral part of people's daily lives compared to traditional PCs<sup>8</sup>; for getting information, interactive communication, entertainment, shopping, education, health consultation, and so forth<sup>9</sup>; despite that smartphone – feature's maximum utilization to identify, educate, engage and motivate TB contacts for their timely diagnosis still under exploration stage.<sup>10</sup>

Smartphone-based health interventions are being well explored for health care providers and even for TB patients to some extent (like for TB drug adherence and monitoring, etc.); but in the case of TB close contacts (who are the primary source from whom TB incidences are coming up regularly and who are still not seeking TB care on time and remain the most neglected potential recipients of TB care services),<sup>10</sup> these applications' and features' utilization for digital literacy, continuous motivation, and engagement for them are largely unexplored.

Research hypothesis: There will be a statistically significant difference in pre- and post-intervention TB diagnostics completion after participating in smartphone-based teaching.

Inclusion Criteria: Individuals who were willing to participate in the study and had close contact with indexed active TB cases, regardless of age or gender, and who had access to at least one smartphone with an active internet connection in their household, were eligible.

Exclusion Criteria: Individuals who did not have at least one smartphone in their family and those unwilling to participate in the study were excluded.

## 2. Methods

### 2.1. Research design and settings

A quasi-experimental one-group pre-post-test design was used to select 86 TB contacts of 20 indexed TB cases using cluster simple random sampling from 5 TB units (clusters) in Faridabad, Haryana, from 1 February to 30 April 2023.

### 2.2. Population and sample

TB contacts were the targeted sample, and individuals affected by TB constituted the population. A G\*power (Heinrich Heine University Düsseldorf, Düsseldorf, Germany) analysis was done, indicating that a minimum of 54 samples were required to detect a significant difference (at  $P < 0.05$ ) with 0.9 power in pre/post-intervention scores, so for larger generalization, a total of 86 samples were enrolled as per eligibility criteria, keeping in mind the attrition rate.

### 2.3. Instrument

#### 2.3.1. Structured interview schedule (scoring, validity, and reliability)

The Structured Interview Schedule includes two sections (A & B) with 18 total closed-ended questions, was initially developed in English and subsequently translated into Hindi. Where, section A (Q. 1 to 8): incorporated demographic details like ID and TB unit, age, age groups, gender, education level, previous h/o TB in family, exposed to microbiologically confirmed/clinically diagnosed (MC/CD) TB case, and residential area. And, section B (Q. 9 to 19): contains questions related to the interview to get answers and answers scored as Yes (1)/No (0)/Not diagnosed (0)/tuberculin skin test (TST) (1)/Interferon Gamma Release Assay (IGRA) (2)/another way (3), Not tested (0)/Negative (1)/Positive (2)/Waited for result (3)/Normal (1)/Abnormal (2)/Mycobacterium Tuberculosis (MTB) not detected (1)/MTB detected (2)/not eligible for TB preventive treatment/anti tubercle treatment (NE-TPT/ATT) (1)/Advised TPT (2)/Advised ATT (4), for observation pre-post intervention – 0–7/28/56 d; so, the total score lies between 0 and 1 for each observation.

The Structured Interview Schedule was provided to 10 clinical experts to ensure content validity. And to assess the internal consistency of the study tool, a test-retest reliability analysis was conducted by administering the tool to the same participants under similar conditions at two different time points, with a minimum gap of 10 weeks between the two assessments. The calculated Cronbach's alpha was  $r = 0.85$ , indicating

that the tool is reliable for collecting and statistically analyzing data.

## 2.4. Ethical consideration

This is a sub-study of the main study, so after receiving ethical and administrative permissions from all concerned authorities [IEC-AIB/AUH/2021-3, dated 23 August 2021; CTD and STO, Haryana, dated 22 April 2021], the enrollment of samples was done as per the inclusion criteria.

## 2.5. Intervention

Anonymity and confidentiality of participants were maintained; And from each family of TB case one family TB supporter (FTBS) was selected by taking Verbal and written consent; along with a prior information was also given to all enrolled TB contacts through FTBS of family at the time of first medication registration at TB units of indexed TB case by TBHVs that a call would come to them between 1 PM and 4 PM. from the researcher for a telephonic interview (pre/post intervention - a smartphone based - teaching session by self-learning materials [SLMs]).

Along with a broadcast - WhatsApp group of participants was developed with the given WhatsApp numbers (to maintain confidentiality and anonymity of participants) and a word file was sent through this individually (includes the study purpose, participation related risks and benefits, FTBS role, etc.) for their prior understanding about study and their exact role under study; Then, SLMs - files with voice messages were WhatsApped periodically for booster teaching during 8th days and 29th days after enrollment in the study, to educate and motivate TB contacts through FTBS for their TB diagnosis completion, while maintaining interactive bidirectional communication. On average, the researcher spent half an hour conducting interviews with 5–8 participants each day; additionally, a pilot study was conducted with 22 participants to test and refine the research instruments and interventions.

## 2.6. Data collection

The data was collected 3 times by telephonic interview [(time took 5–6 min/FTBS related contacts)], and total calls were done (106) as per convenient time of participants: after enrollment, first interview was done within 6–7 d (first pre-intervention), second interview within 27–28 d (first post intervention as per 0–7 d, and first pre-intervention as per 0–28 d), third interview within 55–56 d (second post intervention as per 0–28 d).

## 2.7. Statistical data analysis

The pre- and post-intervention data from 86 participants were included in the final analysis using statistics and data at the  $P < 0.05$  (two-tailed) significance level. We conducted a paired samples *t*-test to compare the pre- and post-intervention impacts within 6–7, 27–28, and 55–56 d, additionally, an analysis of variance (ANOVA) (*F*-statistic) test was also performed to evaluate the overall differences in the effect of the interventions on the completion of TB diagnosis among TB contacts.

# 3. Results

## 3.1. Demographic details of TB contacts

Under study, the majority of participants were in the mean age of  $27.5 \pm 16.9$  (ranged 6–68 months) years; 93% (80) were above 6 years; 52% (45) females were outnumbered, then 48% (41) males; 19% (16) at primary (1–5), 24% (21) at middle (6–8), whereas 35% (30) were at secondary educational level (9–12); 57% (49) don't have previous history of TB in the family; and 66% (57) were exposed to microbiologically confirmed TB cases; and 64% (55) were urban residents; as shown in Table 1.

## 3.2. Descriptive comparison of pre- and post-intervention TB diagnosis completion

Table 2 - data shows that TB symptoms were not found among contacts during the first and second pre-post intervention (0–56 d).

### 3.2.1. During first pre/post intervention (6–7/27–28 d)

During pre – intervention 71% (61) were approached for TB testing; 5% (4) were evaluated; 5% (4) were diagnosed another way without TST/IGRA/chest X-ray/MTB testing, and found eligible for TPT; in this way, finally 95% (82) not diagnosed and only 5% (4) were diagnosed.

Whereas during Post intervention - 89% (73) were approached for TB testing; 11% (9) were evaluated; 11% (9) were diagnosed with TST; out of 11, 10% (8) found negative and 1% (1) found positive with TST and further tested for (1) chest X-ray and found normal (1); in this way finally 89% (73) not diagnosed and 11% (9) were diagnosed where 10% (8) diagnosed not found eligible for TPT or ATT, only 1% (1) found eligible for TPT.

| Characteristics                                              | <i>n</i> | Percentage (%) |
|--------------------------------------------------------------|----------|----------------|
| <i>Age (mean ± SD [min.–max.]),</i><br>27.5 ± 16.9 (0.6– 68) |          |                |
| <i>Age groups, years old</i>                                 |          |                |
| >6                                                           | 80       | 93             |
| ≤6                                                           | 6        | 7              |
| <i>Gender</i>                                                |          |                |
| Male                                                         | 41       | 48             |
| Female                                                       | 45       | 52             |
| <i>Educational level</i>                                     |          |                |
| Illiterate                                                   | 14       | 16             |
| Primary (1–5)                                                | 16       | 19             |
| Middle (6–8)                                                 | 21       | 24             |
| Secondary (9–12)                                             | 30       | 35             |
| Graduation or above                                          | 5        | 6              |
| <i>Previous h/o TB in family</i>                             |          |                |
| No                                                           | 49       | 57             |
| Yes                                                          | 37       | 43             |
| <i>Exposed to MC/CD TB case</i>                              |          |                |
| CD                                                           | 29       | 34             |
| MC                                                           | 57       | 66             |
| <i>Residential area</i>                                      |          |                |
| Rural                                                        | 31       | 36             |
| Urban                                                        | 55       | 64             |

Note: MC/CD, microbiologically confirmed/clinically diagnosed; TB, tuberculosis.

**Table 1.** Demographic characteristics of TB contacts (*n* = 86).

| Items                                             | 6–7 d    | 27–28 d  | 55–56 d  |
|---------------------------------------------------|----------|----------|----------|
| <i>TB symptoms present</i>                        |          |          |          |
| No                                                | 86 (100) | 86 (100) | 86 (100) |
| Yes                                               | -        | -        | -        |
| <i>Approached for TB evaluation &amp; testing</i> |          |          |          |
| No                                                | 25 (29)  | 9 (11)   | 11 (15)  |
| Yes                                               | 61 (71)  | 73 (89)  | 62 (85)  |
| <i>Evaluated or tested for TB diagnosis</i>       |          |          |          |
| No                                                | 82 (95)  | 73 (89)  | 40 (55)  |
| Yes                                               | 4 (5)    | 9 (11)   | 33 (45)  |
| <i>Diagnosis done through</i>                     |          |          |          |
| Not diagnosed                                     | 82 (95)  | 73 (89)  | 40 (55)  |
| TST                                               | -        | 9 (11)   | 33 (45)  |
| IGRA                                              | -        | -        | -        |
| Another way                                       | 4 (5)    | -        | -        |
| <i>Result of TST/IGRA</i>                         |          |          |          |
| Not tested                                        | 86 (100) | 73 (89)  | 40 (55)  |

(Continued)

**Table 2.** Continued

| Items                                   | 6–7 d    | 27–28 d  | 55–56 d  |
|-----------------------------------------|----------|----------|----------|
| Negative                                | -        | 8 (10)   | 20 (27)  |
| Positive                                | -        | 1 (1)    | 13 (18)  |
| Waited for result                       | -        | -        | -        |
| <i>Chest X-ray done</i>                 |          |          |          |
| No                                      | 86 (100) | 81 (99)  | 60 (82)  |
| Yes                                     | -        | 1 (1)    | 13 (18)  |
| <i>Result of Chest X-ray</i>            |          |          |          |
| Not tested                              | 86 (100) | 81 (99)  | 60 (82)  |
| Normal                                  | -        | 1 (1)    | 13 (18)  |
| Abnormal                                | -        | -        | -        |
| Waited for result                       | -        | -        | -        |
| <i>Tested for ATT-TB</i>                |          |          |          |
| No                                      | 86 (100) | 86 (100) | 86 (100) |
| Yes                                     | -        | -        | -        |
| <i>Result of ATT-TB</i>                 |          |          |          |
| Not tested                              | 86 (100) | 86 (100) | 86 (100) |
| MTB not detected                        | -        | -        | -        |
| MTB detected                            | -        | -        | -        |
| Waited for result                       | -        | -        | -        |
| <i>TB diagnosis outcome</i>             |          |          |          |
| Not - diagnosed                         | 82 (95)  | 73 (89)  | 40 (55)  |
| NE-TPT/ATT                              | -        | 8 (10)   | 20 (27)  |
| Advised TPT                             | 4 (5)    | 1 (1)    | 13 (18)  |
| Waited for result                       | -        | -        | -        |
| Advised ATT                             | -        | -        | -        |
| <i>Overall -TB diagnosis completion</i> |          |          |          |
| No                                      | 82 (95)  | 73 (89)  | 40 (55)  |
| Yes                                     | 4 (5)    | 9 (11)   | 33 (45)  |

Note: IGRA, Interferon Gamma Release Assay; MTB, *Mycobacterium Tuberculosis*; NE-TPT/ATT, not eligible for TB preventive treatment/anti-tubercle treatment; TB, tuberculosis; TST, tuberculin skin test

**Table 2.** Descriptive comparison of pre- post-intervention TB diagnosis completion of TB contacts during intervals: 6–7, 27–28, and 55–56 d [*n* (%)].

### 3.2.2. During second pre-post intervention (27–28 to 55–56 d)

During pre – intervention 89% (73) were approached for TB testing; 11% (9) were evaluated; 11% (9) were diagnosed with TST; out of 11, 10% (8) found negative and 1% (1) found positive with TST and further tested for (1) chest X ray and found normal (1); In this way, finally 89% (73) contacts were not diagnosed, and 11% (9) were diagnosed; out of which 1% (1) diagnosed were found eligible for TPT, but 10% (8) were not found eligible either for TPT or ATT. Whereas during post intervention

-85% (62) were approached for TB testing; but 45% (33) were evaluated and tested with TST, where 27% (20) found negative means not eligible for TPT but 18% (13) were found positive and further tested for chest X-ray and found normal, means found eligible for TPT; in this way overall 45% (33) were diagnosed and 55% (40) not diagnosed (Table 2).

### 3.3. Inferential comparison of pre- and post-intervention TB diagnosis completion

#### 3.3.1. During first pre/post intervention (6–7/27–28 d)

The paired samples *t*-test result in Table 3 indicated that the first post-intervention TB diagnosis completion mean (0.11) were higher than the first pre-intervention means (0.05) of TB contacts, with a mean difference of 0.06, but not found statistically significant at 0.05 level of significance with a “*t*” value of 1.39, (df) 84,  $P = 0.166$ ; so here accept the  $H_0a$  and reject the  $H_1a$ .

#### 3.3.2. During second pre/post intervention (27–28/55–56 d)

The second post-intervention TB diagnosis completion mean (0.38) were higher than the second pre-intervention means (0.11) of TB contacts, with a Mean difference of 0.27, and found statistically significant with a “*t*” value of 4.02, (df) 84, at  $P < 0.001$  level of significance; so here accept the  $H_1b$  and reject the  $H_0b$ . Hence, a significant mean difference of 0.27 post-interventionally established the effectiveness of smartphone

features-based continuous teaching (through first and second SLMS) in increasing TB diagnosis completion among TB contacts.

A repeated measure ANOVA was conducted to evaluate the impact of smartphone-based teaching on the completion of TB diagnosis over 3 time points: 6–7 d, 27–28 d, and 55–56 d after enrollment in the study. The results revealed a significant effect of the intervention, with  $F(2,170) = 18.94$ ,  $P < 0.00001$ . This indicates that smartphone-based teaching significantly increased the completion rates for TB diagnosis (Table 4).

## 4. Discussion

The lack of knowledge about TB and communication gaps contribute to delays in the early ID, diagnosis, and treatment initiation of TB cases.<sup>11</sup> This issue affects not only those suspected of having TB but also their close contacts, whether or not they display symptoms<sup>11</sup>; to address these challenges, available smartphone features (WhatsApp) have been used to impart information for educating further for the early diagnosis of TB contacts under study.<sup>12</sup>

Data were collected and analyzed from 86 TB contacts of 20 active TB patients enrolled in the study. The majority of participants were female, above 6 years old, with a mean age of  $27.5 \pm 16.9$ , educated between the 9th and 12th standard, did not have a previous history of TB in the family, were exposed to microbiologically confirmed TB cases, and were urban dwellers (Table 1).<sup>13</sup>

| Variable and Pre/post-test days | Mean | SD   | Mean diff. | Std. Err. Mean diff | <i>t</i> | <i>P</i>      |
|---------------------------------|------|------|------------|---------------------|----------|---------------|
| TB diagnosis completion         |      |      | 0.06       | 0.04                | 1.39     | 0.166*** (NS) |
| 6–7 (pre first)                 | 0.05 | 0.21 |            |                     |          |               |
| 27–28 (post first)              | 0.11 | 0.31 |            |                     |          |               |
| TB diagnosis completion         |      |      | 0.27       | 0.07                | 4.02     | <0.001*       |
| 27–28 (pre second)              | 0.11 | 0.31 |            |                     |          |               |
| 55–56 (post second)             | 0.38 | 0.49 |            |                     |          |               |

Note: TB, tuberculosis; df (84); \*significantly differed at  $P < 0.01$  level of significance.

**Table 3.** Mean, mean difference, standard error of mean difference, and *t* value of TB diagnosis completion among TB contacts during different time intervals.

| Items              | SS    | df  | MS   | <i>F</i> | <i>P</i>  |
|--------------------|-------|-----|------|----------|-----------|
| Between-treatments | 5.59  | 2   | 2.79 | 18.94    | <0.00001* |
| Within-treatments  | 32.21 | 255 | 0.13 |          |           |
| Error              | 25.08 | 170 | 0.15 |          |           |

Note: ANOVA, analysis of variance; TB, tuberculosis; df (2170); \*significantly differed at  $P < 0.01$  level of significance.

**Table 4.** A repeated measures ANOVA test result of pre-post interventions (6–7, 27–28, 55–56 d) TB diagnosis completion.

Moreover, before the interventions, during the initial 0–7 d, only 5% (4) of contacts were diagnosed without testing and advised to initiate TPT for LTBI; however, after the first and second interventions, the diagnosis completion rates increased: during the 8–28 d, 11% (9) non-significantly ( $t(84) = 1.39$ ,  $P = 0.166$ ), but during the 29–56 d, 45% (33) significantly ( $t(84) = 4.02$ ,  $P < 0.001$ ) TB contacts completed their diagnosis; although after first - 1% (1) and second intervention - 18% (13) TST-positive with normal Chest X-ray (among diagnosed contacts) were found latently infected and advised to start TPT, although, none were diagnosed with active TB (as detailed in Table 2); moreover, overall, over 3 time points (6–7, 27–28, 55–56 d), a significant difference [ $F(2170) = 18.94$ ,  $P < 0.00001$ ] was also observed pre-post first and second intervention upon TB diagnosis completion among TB contacts; and these findings were also found consistent with the recent research findings.<sup>14–16</sup>

Therefore, the significant study results in post-first and second intervention indicated that communication through WhatsApp and sending SLMs through WhatsApp is effective in increasing healthcare-seeking behavior of TB contacts by educating, engaging, and motivating them for their early TB diagnosis completion and treatment initiation appropriately under study.<sup>17</sup> We should enhance m-health literacy, particularly through smartphone-based teaching and learning, for all healthcare providers, healthcare workers, TB patients, TB contacts, and the general public, to escalate and support all ongoing efforts toward TB prevention and control digitally. By utilizing the widespread access of smartphone-based features (WhatsApp), TB healthcare providers can reach more people affected by TB to impart targeted information for enhancing TB diagnosis completion by establishing interactive communication to deliver more effective TB care.

Additionally, the small sample size and absence of a control group for comparison restrict the ability to generalize the study results beyond the specific population examined. We recommend conducting further research that utilizes various smartphone features and research designs to enhance the completion of TB diagnosis and TB care outcomes.

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## 5. Conclusions

The study concluded that WhatsApp-based SLMs teaching and interactive communication for early TB diagnosis completion are effective and found to be feasible. They can be further conducted using various research methodologies with a larger sample size. Along with the policymakers and developers of m-health infrastructure, ensure more ubiquitous availability of internet services and low-priced smartphones with low-cost data packs to lower-income TB-affected populations, for improving early ID, diagnosis, treatment, and follow-up care; and ultimately, more access to TB healthcare quality services to underserved TB-affected people of remote areas.

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## Abbreviations and acronyms

AUH, Amity University Haryana; CTD, Central Tuberculosis Division; CTIR, Clinical Trials Registry- India; FTBS, Family TB Supporter; ICMR, Indian Council of Medical Research; ID, Identification; IEC, Institutional Ethical Committee; IGRA, Interferon Gamma Release Assay; MC/CD, Microbiologically Confirmed/Clinically Diagnosed; MTB, *Mycobacterium Tuberculosis*; NE-TPT/ATT, Not Eligible for TB Preventive Treatment/Anti Tubercle Treatment; PCs, personal computers; SLMs, Self Learning Materials; STO, State TB Officer; TB, Tuberculosis; TBHVs, TB Health Visitors; TST, Tuberculin Skin Test.

## Ethical approval

Ethical issues are not involved in this paper.

## Conflicts of interest

All contributing authors declare no conflicts of interest.

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