

EFFECTIVENESS OF HEALTH EDUCATION MODULE DELIVERED THROUGH WHATSAPP TO ENHANCE TREATMENT ADHERENCE AND SUCCESSFUL OUTCOME OF TUBERCULOSIS IN SEREMBAN DISTRICT, NEGERI SEMBILAN, MALAYSIA

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<https://doi.org/10.32827/ijphcs.6.4.145>

ABSTRACT

Introduction: Health education and awareness program have shown to be the factor that promote adherence behaviour and successful outcome of tuberculosis (TB). Mobile health (mHealth) initiative that utilize WhatsApp may help in achieving health objectives.

Aims: This study aimed to determine the effectiveness of Health Education Module named TB@Clicks delivered through WhatsApp to enhance treatment adherence and successful outcome among pulmonary tuberculosis (PTB) patients.

Methodology: A randomized controlled trial was done among all newly diagnosed TB cases registered in Seremban District between 1st of July 2017 until 9th of April 2018. The patients who fulfils the eligibility criteria were systematically selected and randomly assigned to receive TB@Clicks module through WhatsApp or continue with the existing conventional health education. The respondents were followed-up until treatment was completed. The estimated total sample size was 110. Adherence rate and treatment outcome were gathered from the record book in Health Clinics. Multivariate statistical analysis was conducted to determine the effectiveness of intervention on both outcomes.

Result: A total of 110 PTB patients were recruited and 93 patients retained in the study (84.5%). Among them, 50 (90.9%) was from intervention group and 43 (78.2%) was from control group. There were 81.8% of respondents who received intervention adhered to TB treatment and 85.5% has the successful treatment outcome as compared to only 69.1% adherence and 70.9% with treatment success in control group but both were not statistically significant ($p=0.121$ & $p=0.065$). In multivariate analyses performed using generalized linear mixed models, PTB patients who had received intervention was 4.1 (95% CI = 1.16-14.87) times as likely to had successful treatment outcome as patients who had not received intervention.

Conclusion: The TB@Clicks intervention module delivered through WhatsApp was effectively enhanced the treatment success rate but no significant effects on the adherence rate among PTB patients.

Keywords: Pulmonary tuberculosis, mHealth, medication adherence

1. Introduction

Adherence to medication is the leading key to successful outcome of tuberculosis (TB) management. The successful treatment of infectious cases is essential to break the chain of the infection transmission (WHO, 2018a). Good knowledge obtained from health education and awareness program has proven to be the factor that promote adherence behaviour. For example, patients with inadequate knowledge of the duration of the treatment is found to be associated with non-adherent to the medication due to the feelings of cure after taking the treatment for one- or two- months only (Ibrahim et al, 2014; Tesfahuneygn, Medhin, & Legesse, 2015). Therefore, it is very important to educate patients on the importance of completing their treatment although they do not feel the need for it. Many studies also supported that the more the patients were educated about the nature of TB disease, the more likely they would adhere to anti-TB medications (Yao, et al, 2011; Tachfouti, et al, 2012; Sariem, et al, 2013, Rondags, et al, 2014, Tesfahuneygn, et al, 2015; Peltzer & Pengpid, 2015; Theron, et al, 2015). Meanwhile, in the Malaysia National Strategic Plan for TB Control 2016-2020, stated that one of the key strategies to control TB is health education activities (Ministry of Health (MOH) Malaysia, 2016b). Health education to the newly diagnosed PTB patient upon the treatment initiation was also recommended in the Malaysia Clinical Practice Guidelines of Tuberculosis (MOH Malaysia, 2012).

Conventionally, health education is given to the patients by healthcare provider via face to face approach, where patients must come to the clinic for counselling session. However, in the era of the new technology and the availability of the internet that is conveniently accessible and affordable, the channel used to educate patients has not been restricted at the clinic setting only. WhatsApp is an example of the tool that can be utilized to achieve this health objective. This initiative is called mHealth (WHO, 2011). The mHealth has the potential to transform the face of health services delivery across the globe (WHO, 2011). It also may improve health system efficiency in regions where resources and trained medical professionals are very scarce. In Malaysia, the population has increasingly utilized WhatsApp instant messaging as a tool of communicating and interacting with other people (Statista, 2016).

TB in Malaysia has been existed for decades and yet still among the top five most common communicable diseases in the country (MOH, 2016b). Apart of that, the incidence rate is still relatively high ranges from 78 to 82 per 100,000 population between 2013 to 2016 (MOH, 2014; MOH, 2015; MOH, 2016a; MOH, 2017). There are also slow declining rates of the disease at less than 2% per year between 2014 and 2015 (MOH, 2016b). Seremban is a district out of 7 districts in Negeri Sembilan state of Malaysia. The number of TB cases in Negeri Sembilan ranges from 631 to 680 within these 5 years, 2013 to 2017 and the incidence

rate in 2015 is 60.7 per 100,000 population (MOH, 2016; State Government of Negeri Sembilan, 2019). Out of 7 districts, Seremban has the highest number of reported TB cases (340 cases in 2017) which constituted more than half from the total of TB cases in the state (MOH Malaysia, 2019). Apart of that, the TB treatment success rate in Seremban district also has been low for many years, 74.8%, 86.2%, 83.3% in 2016, 2017 and 2018 respectively (Seremban District Health Office, 2019). The targeted treatment success rate is more than 85%. This indicator of performance is one of national TB control program. The defaulter rate in Seremban also has not achieved the target, for example the defaulter rate in 2017 was 5.6% which the highest in the state (Seremban District Health Office, 2018). This was the reason why Seremban District has been chosen for the study location.

Based on the TB situation in Malaysia and Seremban District particularly, the importance of knowledge to promote adherence behaviour and the progressive dissemination of mHealth globally and considering particularly its potential to enhance medication adherence and treatment success, an intervention using WhatsApp was carried out. The aim of the study was to determine the effectiveness of health education module delivered via WhatsApp to enhance and promote adherence to treatment and successful outcome among newly diagnosed TB patients.

2. Methodology

2.1. Study designs and participants

Participants were recruited into randomized controlled trial through registered new TB cases in Seremban District between 1st of July 2017 until 31st of March 2018. The eligibility criteria for inclusions are newly diagnosed with smear or bacteriologically positive or negative pulmonary tuberculosis (PTB), age between 18 to 65 years, Malaysian citizen, have access to WhatsApp for personal used and who were prescribed the 6-month of Directly Observed Therapy, Short Course regime (DOT) of TB treatment and continued follow-up at government facilities during the study period. The participants had to be on treatment for less than a month to allow the intervention to help establish the adherent behaviour early. Enrolment continued until the pre-determined sample size was met. The estimated total sample size calculated was 110. Eligible participants were consented using written consent taken by the Assistant Medical Officer in-charged of TB program in health facilities. The trial was approved by Malaysia Research and Ethics Committee (MREC) (NMRR-17-132-34290) and registered under Australian New Zealand Clinical Trials Registry (ANZCTR) (ACTRN12619000329167)

2.2. Randomization and blinding

Once a patient consented to participate, a study representative at Seremban District Health Office randomly assigned the participant using blocked randomization technique to receive either health education module through WhatsApp or continue with current conventional method (face-to-face) health education. To avoid contamination of the intervention information, all the respondents were asked not to share any content of the WhatsApp they received with other people. The healthcare provider was not known which group patients

were assigned. An officer at District Health Office was responsible to deliver the pre-set WhatsApp messages to the intervention group using a dedicated phone number allocated for this study purpose.

2.3. The implementation procedures

The module was named as TB@Clicks as the information pertaining TB is just in one click from the mobile phone or any device that support WhatsApp application. This module was developed during this study and adopted based on the constructs in the Information, Motivation and Behavioral-skills (IMB) theoretical approach (Table 1).

The implementation was done in two phases. The educational phase, the respondent in intervention group received health education messages through WhatsApp. A set of messages from TB@Clicks module was sent to individual respondents within one-day period during intensive phase. The respondents could ask any questions related to TB and its treatment through WhatsApp only. While, for control group, no WhatsApp messages was sent during intensive phase. For the maintenance or sustainability phase, each respondent in both intervention and control groups received reminder messages through WhatsApp at 1-, 2-, 3-month after received the intervention module.

2.4. Determination of outcome

The main or primary outcome of the study is the adherence rate to TB treatment and treatment success rate. Both outcomes were determined from the respondents record in Health Clinic (TBIS 10-I) at the end of 6-month of prescribed treatment duration for DOTS as recommended by WHO for newly diagnosed PTB patients and Malaysia Clinical Practice Guideline for TB (WHO, 2002; MOH, 2012). The treatment success was based on WHO definition, the sum of cured and treatment completed whereby the treatment is cured if “*a PTB patient with bacteriologically confirmed TB at the beginning of treatment who was smear- or culture-negative in the last month of treatment and on at least one previous occasion and the treatment is completed if a patient without evidence of failure but with no record to show that sputum smear or culture results in the last month of treatment and on at least one previous occasion were negative, either because tests were not done or because results are unavailable*” (WHO, 2014).

2.5. Statistical analysis

The data analysis was done using a SPSS version 22.0 statistical software for Windows. Descriptive analysis was carried out to examine the sociodemographic distribution of respondents in this study. Generalized Linear Mixed Model (GLMM) statistical analysis was used to determine the effects of TB@Clicks health education intervention module on adherence rate to TB medication and treatment success rate. There were 10 independent variables included in the multivariate model which were the trial status, sociodemographic variables (age, gender, marital status, employment status, income status, educational status, ethnicity, smoking status), and type of PTB (smear positive or smear negative). The target variable was binomial whether the respondents had adhered or non-adhered to the TB medication and treatment success or treatment unsuccessful. The working unstructured covariance was used in the SPSS as it resulted in the best possible model fit, evidenced by the

lowest Akaike corrected information criterion (ACIC) and Bayesian information criterion (BIC). A significant difference was set at $p < 0.05$.

3. Results

3.1. Response rate

The recruitment process was started among all newly diagnosed TB patients in Seremban District registered in MyTB system from 1st July 2017 and continued until the sample size was achieved on 9th of April 2018. There was a total of 316 newly diagnosed TB patients were registered between the period and 158 TB patients were assessed for eligibility. Among them, 48 patients did not meet study inclusion criteria includes age status ($n=9$), non-citizen ($n=5$), no smartphone/WhatsApp application ($n=3$), extra-PTB case ($n=7$), taking DOT from other facility or DOT outside Seremban District ($n=15$) and another 9 respondents refused to participate due to lack of interest and other reason not known. The final sample size was 110 respondents enrolled in the study; 55 respondents randomized into intervention group and another 55 were into the control group within the recruitment period. Each respondent was followed-up for at least 6 months. The ranges of followed-up duration were between 2 to 10 months with average of 6 months duration.

At the end of the study, 5 patients from the intervention group and 12 patients from the control group were lost during follow up (Table 2). It meant the response rate for the intervention group was 90.9% and for the control group was 78.2% (84.5% combined response rate). The reason for lost during follow up were due to mortality (7.3%), defaulted TB treatment (7.3%) and changed diagnosis to bronchiectasis after 1 month on TB treatment (0.9%). Chi-square test was performed to see there was any significant difference between intervention and control groups for respondents who were loss to followed-up. The result revealed that there was no significant difference between intervention and control groups regarding loss to follow-up ($p=0.065$).

Table 2 Response rate of the study (N=110)

Variables	Intervention Frequency (%) n=55	Control Frequency (%) n=55	Total Frequency (%)	Test statistic (df)	p- value
Retained in the study	50 (90.9%)	43 (78.2%)	93 (84.5%)		
Causes of loss to follow-up (n=17)	n=5	n=12	17 (15.5%)	3.409(1)	0.065
Mortality	5 (9.1%)	3 (5.5%)	8 (7.3%)		
Loss to follow-up/defaulted treatment	0	8 (14.5%)	8 (7.3%)		
Changed diagnosis	0	1 (1.8%)	1 (0.9%)		

Note: χ^2 (Chi-square) test, df = degree of freedom, significant $p < 0.05$

3.2. Sociodemographic characteristics of respondents according to group

Table 3 tabulates respondents' sociodemographic characteristics at baseline. There was not statistically significant between the two groups of study across most of the variables except for the age variable ($p=0.029$).

Table 3 Comparison of respondents' sociodemographic characteristics between the intervention and control group (N=110)

Variables	Intervention		Control		Test statistics (df)	p-value
	Frequency (n=55)	%	Frequency (n=55)	%		
Mean age \pm SD (year)	38.29 \pm 13.73		43.91 \pm 12.88		-2.21 (108) ^b	0.029
Gender						
Male	31	56.4	34	61.8	0.34 (1) ^a	0.561
Female	24	43.6	21	38.2		
Ethnicity						
Malay	31	56.4	32	58.2	0.82 (3) ^a	0.844
Chinese	11	20.0	12	21.8		
Indian	12	21.8	9	16.4		
Others	1	1.8	2	3.6		
Educational level						
University/ Diploma	4	7.3	5	9.1	2.03 (3) ^a	0.566
Secondary	43	78.2	46	83.6		
Primary/No formal education	8	14.5	4	7.3		
Marital status						
Married	31	56.4	40	72.7	3.22 (1) ^a	0.073
Unmarried	24	43.6	15	27.3		
Income						
<RM1,000	27	49.1	20	36.4	2.61 (2) ^a	0.271
RM1,001-Rm3,000	26	47.3	30	54.5		
>RM3,001	2	3.6	5	9.1		
Employment Status						
Employed	29	52.7	38	69.1	3.09 (1) ^a	0.079
Unemployed	26	47.3	17	30.9		
Smoking status						
Yes	18	32.7	20	36.4	0.16 (1) ^a	0.688
No	37	67.3	35	63.6		

Note: a= χ^2 (Chi-square) test, b = Independent t-test, df = degree of freedom, significant $p<0.05$

Apart of sociodemographic, the other characteristics obtained are presented in Table 4. The variables include the type of PTB, type of regime of treatment the patients received, and HIV status of the patients compared between the intervention and control group. These variables were showed not statistically different between the groups.

Table 4 Comparison of respondents' other characteristics between the intervention and control group (N=110)

Variables	Intervention		Control		Test statistics (df)	p-value
	Frequency (n=55)	%	Frequency (n=55)	%		
Type of PTB						
PTB Positive smear	41	74.5	46	83.6	1.37 (1)	0.241
PTB Negative smear	14	25.5	9	16.4		
Type of treatment regime						
FDCs	45	81.8	47	85.5	0.27 (1)	0.797
EHRZ/SHRZ regime	10	18.2	8	14.5		
HIV status						
Negative	54	98.2	55	100	1.01 (1)	0.315
Positive	1	0.8	0	0		

Note: $a=\chi^2$ (Chi-square) test, df = degree of freedom, significant $p<0.05$

3.3. Comparisons of TB medication adherence rate among respondents between intervention and control group

Table 5 shows the comparison of adherence rate towards TB medication among the respondents in both groups. The number of respondents who adhered to medication was higher in the group that received intervention (81.8%) compared to control group (69.1%). However, no significant difference between the groups.

Table 5 Comparison of TB medication adherence rate among respondents between intervention and control group (N=110)

Variables	Intervention		Control		Test statistics (df)	p-value
	Frequency (n=55)	%	Frequency (n=55)	%		
Adherence rate						
Adhered	45	81.8	38	69.1	2.405 (1)	0.121
Non-adhered	10	18.2	17	30.9		

Note: $a=\chi^2$ (Chi-square) test, df = degree of freedom, significant $p<0.05$

3.4. Comparison of tuberculosis treatment success rate among respondents between intervention and control group

The total treatment success rate among the respondents in both groups was 78.2%. The intervention group showed a better treatment success rate (85.5%) as compared to the control group (70.9%). However, it showed no significant difference of treatment success rate between the intervention and control group (Table 6).

Table 6 Comparison of tuberculosis treatment success rate among respondents between intervention and control group (N=110)

Variables	Intervention		Control		Test statistics (df)	p-value
	Frequency (n=55)	%	Frequency (n=55)	%		
Treatment success	47	85.5	39	70.9	3.411	0.065
Treatment unsuccessful	n=8	14.5	n=16	29.1		
Died	5	9.1	3	5.4		
Treatment failure	3	5.4	4	7.3		
Defaulted	0	0	8	14.5		
Others	0	0	1	1.8		

Note: a= χ^2 (Chi-square) test, b = Independent t-test, df = degree of freedom, significant $p < 0.05$

3.5. The effects of TB@Clicks Module delivered using WhatsApp on medication adherence rate

Table 7 shows the results derived from multivariate analysis. The results revealed that none of the variables were significant. Therefore, the intervention module using WhatsApp has no significant effects to the adherence rate among PTB patients.

Table 7 Fixed coefficients for logit adherence

Variable	Coefficient	Std Error	t	p value	Odds ratio	95% CI for Odds ratio	
						Lower	Upper
Intercept	13.91	882.75	0.02	0.987	1,095,423	0.000	
Age	-0.001	0.022	-0.06	0.951	0.1	0.1	1.04
Trial group							
Intervention	0.77	0.56	1.37	0.174	2.16	0.708	6.574
Control	0						
Employment status							
Unemployed	-0.08	0.58	-0.14	0.89	0.922	0.29	2.94
Employed	0						
Gender							
Female	0.08	0.72	0.1	0.92	1.077	0.26	4.47
Male	0						
Marital status							
Unmarried	0.27	0.57	0.48	0.63	1.316	0.43	4.06
Married	0						
Educational status							
Lower educational	-0.38	0.96	-0.4	0.69	0.681	0.1	4.61
Higher educational	0						
Ethnicity							
Non-Malay	-0.27	0.54	-0.5	0.62	0.761	0.26	2.24

Variable	Coefficient	Std Error	t	p value	Odds ratio	95% CI for Odds ratio	
						Lower	Upper
Malay	0						
Smoking status							
Non-smoker/ ex-smoker	-0.23	0.69	-0.33	0.74	0.797	0.2	3.15
Smoker	0						
Income							
≥RM3,000	0.41	0.95	0.44	0.66	1.51	0.23	9.89
<RM3,000	0						
Type of PTB							
Smear negative	-1.38	0.85	-1.64	0.11	0.25	0.05	1.34
Smear positive	0						

Note: significant *p*-value <0.05

3.6. The effects of TB@Clicks Module using WhatsApp on the treatment success rate

Table 8 shows the fixed coefficient effect of the outcome variable studied. The positive estimates of group intervention and control imply that patients in the intervention group are 4.1 (95% CI = 1.16-14.87, *p*=0.03) times more likely to have successful treatment than that of patient who was not received any intervention. In other words, the intervention group has positive effects on the successful outcome of a PTB patient compared to those who did not receive the intervention. In addition, the negative and significant estimates for marital status mean that unmarried patients are not more likely to get successful treatment than married patients (*p*=0.034). Being single resulted in unsuccessful treatment outcome among PTB patient who received DOT treatment regime.

Table 8 Fixed coefficient for logit treatment success

Variable	Coefficient	Std error	t	p value	Odds ratio	95% CI for odds ratio	
						Lower	Upper
Intercept	-14.114	1455.4	-0.01	0.992	0.000	0.000	
Age	-0.002	0.023	-0.104	0.917	0.998	0.953	1.044
Trial group							
Intervention	1.422	0.644	2.208	0.03	4.144	1.155	14.873
Control	0						
Employment status							
Unemployed	-0.817	0.644	-1.269	0.208	0.442	0.123	1.586
Employed	0						
Gender							
Female	0.433	0.8	0.542	0.589	1.542	0.315	7.542
Male	0						
Marital status							
Unmarried	-1.345	0.626	-2.146	0.034	0.261	0.075	0.904
Married	0						
Educational							
Lower education	0.04	0.952	0.042	0.967	1.041	0.157	6.886

Variable	Coefficient	Std error	t	p value	Odds ratio	95% CI for odds ratio	
						Lower	Upper
Higher education	0						
Ethnicity							
Non-malay	-0.159	0.586	-0.271	0.787	0.853	0.267	2.728
Malay	0						
Smoking status							
Non-smoker/ ex-smoker	0.508	0.737	0.688	0.493	1.661	0.385	7.176
Smoker	0						
Income							
≥RM3,000	-0.101	1.076	-0.094	0.925	0.904	0.107	7.655
<RM3,000	0						
Type of PTB							
Smear negative	0.946	0.881	1.074	0.286	2.577	0.448	14.814
Smear positive	0						

Note: significant p -value <0.05

4. Discussion

It has been reported that intervention to enhance good adherence behaviour to medication will lead to the successful treatment outcome of TB (Alipanah, Jarlsberg, Miller, et al, 2018). Education is a strategy recommended by Centers for Disease Control and Prevention (CDC) to address barriers in adhering to TB medications (CDC, 2014). Moreover, the presence of health promotion information, motivation, and behavioral skills elements in the intervention module appears to be associated with health promotion intervention impact (Fisher, et al, 2003). For example, the TB@Clicks module provides information that TB is curable and the treatment regimens are effective to kill bacteria may motivate an individual to maintain with the positive self-care practice which is to continue taking the medication until completed although they already feeling better after only few months of taking the regime.

Apart of that, the strategy used in this study to tackle barriers to completing TB treatment by addressing knowledge gaps, attitudes, and behaviours surrounding adherence to TB treatment. Using mHealth module intervention by utilizing the usage of WhatsApp application to improve the knowledge on TB and its treatment may improve one perception and the way in which something is regarded, understood, or interpreted and thus promote the good self-care practice on TB and adherence behaviour towards TB medication. A local study was revealed that low in knowledge, traditional believes and negative perception towards TB treatment were found to be significantly associated with the non-adherence among TB patients (Shariff, et al, 2017).

Nevertheless, the mHealth intervention using WhatsApp was not significantly promote the adherence rate among PTB patients after adjustment in multivariable analysis. This is in contrast with a study done among PTB patients to assess the feasibility of Video Directly

Observed Therapy (VDOT) found that the interventional strategy using mobile health technology was effective to support adherence with TB treatment, even in resource-limited settings which is in contrast with the result from this study (Nguyen, Pham, Nguyen, et al, 2017). The study found that after 2 months of followed-up, the majority of respondent had 0 daily doses missed (83.5%) and only 7 respondents had missed dose for 1, 2 and 4 days respectively (Nguyen, et al, 2017). Despite education given through WhatsApp, some patients might ignore the messages or did not follow through and understand the module due to different reason unknown as it is beyond the scope of this study.

Globally, the treatment success rate was reported to be 82% in 2016 (WHO, 2018b). In Malaysia, the TB success rate was 79.6% in 2015 and 74.8% for Seremban District which far below the national target performance indicator set at 85% and above (MOH, 2016b; Seremban District Health Office, 2019). The challenge to the successful outcome of TB is to ensure the patient to comply and continue to adhere with the medication for long period (Bloom, et al, 2017). Patient with incomplete treatment may become the potential source of spreading TB to others unknowingly.

Results of the study showed that there were more patients with outcome of successful treatment in the intervention group compared to the control group. Multivariate analysis after adjustment revealed that the TB@Clicks intervention module using WhatsApp was effective to enhance and promote the treatment success among PTB patients attending Health Clinics in Seremban District. At present, there are no study that utilized WhatsApp as a tool to deliver health education among TB patients was found elsewhere. A systematic review done by Lee, et al (2019) to evaluate the outcome measures reported in TB mHealth literature in low- and middle- income countries revealed a total of 12 studies adopted short message service (SMS), 5 studies used SMS in combination with additional technologies such as VDOT or mobile apps and none was utilized WhatsApp for intervention yet (Lee, Lee, Lee, et al, 2019).

In contrast to a study by Bediang, Stoll, Elia, et al (2018) found that mHealth intervention using SMS reminders among TB patients in Cameroon did not increase the successful outcome of TB treatment. However, the dropout rate was high during the follow-up at fifth and sixth month of treatment (Bediang, et al, 2018). Apart of that, an interventional study using SMS reminder among newly diagnosed PTB patients in Karachi to evaluate the impact of intervention on treatment success also found that there was no significant difference between groups with treatment success outcome ($p=0.782$) (Mohammed, Glennerster & Khan, 2016).

5. Conclusion and recommendation

The treatment success was significantly enhanced by the intervention that utilized WhatsApp to deliver health education module but no significant effects on the adherence rate among PTB patients in Seremban District. Both adherence rate and treatment success rate in the intervention group and control group among PTB patients who received DOTS in government health clinic were still unsatisfactory. However, the use of digital health applications using mobile health devices to improve treatment support for active TB patients

is warranted further research as it holds considerable promise to transform adherence support and good outcome among TB patients.

Acknowledgements

This manuscript was prepared as part of the requirement for the degree of Doctor of Public Health from Universiti Putra Malaysia. The authors would like to thank the Director General of Health Malaysia for permission to publish this manuscript.

Authors contribution

Author 1: information gathering, preparation and editing of manuscript

Author 2: final review of the manuscript

References

- Alipanah, N., Jarlsberg, L., Miller, C., Linh, N.N, Falzon, D., Jaramillo, E & Nahid, P. (2018). Adherence interventions and outcomes of tuberculosis treatment: A systematic review and meta-analysis of trials and observational studies. *PLoS Medicine*, 15(7), 1-44.
- Bediang, G., Stoll, B., Elia, N., Abena, J. L., & Geissbuhler, A. (2018). SMS reminders to improve adherence and cure of tuberculosis patients in Cameroon (TB-SMS Cameroon): a randomised controlled trial. *BMC public health*, 18(1), 583.
- Centers for Disease Control and Prevention (CDC) (2014). *Module 6: managing tuberculosis patients and improving adherence*. Atlanta, Georgia: U.S. Department of Health and Human Services. Retrieved from <https://www.cdc.gov/tb/education/ssmodules/pdfs/Module6.pdf> on 3rd March 2019.
- Fisher, W.A., Fisher, J.D. & Harman, J. (2003). *The information-motivation-behavioral skills model: A general social psychological approach to understanding and promoting health behavior. Chapter 4. Social Psychological Foundations of Health and Illness*. Edited by Jerry Suls, Kenneth A. Wallston. Copyright © 2003 by Blackwell Publishing Ltd. Page 82-106.
- Ibrahim, L.M., Hadejia, I.S., Nguku, P., Dankoli, R., Waziri, N.E., Akhimien, M.O., ... & Nsubuga, P. (2014). Factors associated with interruption of treatment among pulmonary tuberculosis patients in Plateau State, Nigeria. 2011. *Pan African Medical Journal*, 17(78), 1-6.
- Lee, S., Lee, Y., Lee, S., Islam, S., & Kim, S. Y. (2019). Toward developing a standardized core set of outcome measures in mobile health interventions for tuberculosis management: systematic review. *JMIR mHealth and uHealth*, 7(2), e12385.

- Ministry of Health Malaysia (MOH) (2012). *Clinical practice guidelines: Management of Tuberculosis*. Third edition. Putrajaya: Malaysia Health Technology Assessment Section (MaHTAS) publication.
- Ministry of Health Malaysia (2014). *Health facts 2014*. Planning Division, Health Informatics Centre. MOH/S/RAN/73.14(AR), June 2014.
- Ministry of Health Malaysia (2015). *Health facts 2015*. Planning Division, Health Informatics Centre. MOH/S/RAN/93.15(AR), August 2015.
- Ministry of Health Malaysia (2016a). *Health facts 2016*. Planning Division, Health Informatics Centre. MOH/S/RAN/17.16(AR), August 2016.
- Ministry of Health Malaysia (2016b). *National strategic plan for tuberculosis control (2016-2020)*. Putrajaya, Malaysia: Disease Control Division (TB/Leprosy Sector).
- Ministry of Health Malaysia (2017). *Health facts 2017 (Reference data for 2016)*. Planning Division, Health Informatics Centre. MOH/S/RAN/47.17(AR), November 2017.
- Ministry of Health Malaysia (2019). *Sistem Maklumat Tibi (MyTB)*. Retrieved from <http://mytb.moh.gov.my/> on 10th April 2019.
- Mohammed, S., Glennerster, R. & Khan, A.J. (2016). Impact of a daily sms medication reminder system on tuberculosis treatment outcomes: a randomized controlled trial. *PLoS ONE*, 11(11), 1-13.
- Nguyen, T.A., Pham, M.T., Nguyen, T.L., Nguyen, V.N., Pham, D.C., Nguyen, B.H. & Fox, G.J. (2017). Video directly observed therapy to support adherence with treatment for tuberculosis in vietnam: A prospective cohort study. *International Journal of Infectious Diseases*, 65, 85-89.
- Peltzer, K. & Pengpid, S. (2015). Predictors of non-adherence to anti-tuberculosis patients in Thailand. *Journal of Human Ecology*, 52(1,2), 26-31.
- Rondags, A., Himawan, A.B., Metsemakers, J.F.M. & Kristina, T.N. (2014). Factors influencing non-adherence to tuberculosis treatment in Jepara, Central Java, Indonesia. *Southeast Asian Journal of Tropical Medicine & Public Health*, 45(4), 859-868.
- Sariem, C.N., Gyang, S.S., Tayo, F., Auta, A., Omale, S. and Ndukwe, H.C. (2013). Factors influencing tuberculosis medication adherence in a tertiary health institution in Nigeria. *West African Journal of Pharmacy*, 24 (2), 66-75.
- Seremban District Health Office (2019). *Pencapaian KPI Pengarah Kesihatan Negeri*. Presented on January 2019.
- Seremban District Health Office (2018). *Pencapaian program Tibi di Pejabat Kesihatan Daerah Seremban Kohort Oktober 2017 hingga Mac 2018*.
- Shariff, N.M., Shah, S.A., Kamaludin, F. (2017). Barriers and motivation factors towards treatment compliance from the perspective of defaulted tuberculosis patients in Kuala Lumpur. *Jurnal Sains Kesihatan Malaysia* 15(1), 75-87.

- State Government of Negeri Sembilan (2019). Official portal. *Data sosioekonomi Negeri Sembilan 2015*. <http://www.ns.gov.my/> retrieved on 10th April 2019.
- Statista (2016). *The Statistic Portal*. Share of mobile internet users in selected countries who are active WhatsApp users as of 4th quarter 2014. Retrieved on 5 December 2016 from <https://www.statista.com/statistics/291540/mobile-internet-user-whatsapp/>.
- Tesfahuneygn, G., Medhin, G., Legesse, M. (2015). Adherence to anti-tuberculosis treatment and treatment outcomes among tuberculosis patients in Alamata District, northeast Ethiopia. *BMC Research Notes*, 8(503), 1-11.
- Theron, G., Peter, J., Zijenah, L., Chanda, D., Mangu, C., Clowes, P.,.... & Dheda, K. (2015). Psychological distress and its relationship with non-adherence to TB treatment: a multicentre study. *BioMed Central Infectious Diseases*, 15(253). 12 pages.
- World Health Organization (WHO) (2002). *An expanded DOTS framework for effective tuberculosis control*. Geneva: World Health Organization. Retrieved on 30 November 2016 from http://apps.who.int/iris/bitstream/10665/67232/1/WHO_CDS_TB_2002.297.pdf.
- World Health Organization (WHO) (2011). *mHealth: New horizons for health through mobile technologies: second global survey on eHealth*. Geneva, Switzerland: WHO Press.
- World Health Organization (WHO) (2014). *Definitions and reporting framework for tuberculosis – 2013 revision*. Geneva: World Health Organization. Retrieved on 30 November 2016 from http://apps.who.int/iris/bitstream/10665/79199/1/9789241505345_eng.pdf.
- World Health Organization (WHO) (2018a). *Compendium of WHO guidelines and associated standards: ensuring optimum delivery of the cascade of care for patients with tuberculosis, second edition*. Geneva, Switzerland: WHO. Licence: CC BY-NC-SA 3.0 IGO. Retrieved on 2 October 2018 from <http://apps.who.int/iris/bitstream/handle/10665/272644/9789241514101-eng.pdf?ua=1>.
- World Health Organization (WHO) (2018b). *Global Tuberculosis Report 2018*. Geneva, Switzerland: WHO Press. Retrieved on 2 October 2018 from www.who.int/.
- Yao, S., Huang WH., Hof, S.V.D., Yang, SM., Wang, XL., Chen, W., Fang, XH., Pan, HF. (2011). Treatment adherence among sputum smear positive pulmonary tuberculosis patients in mountainous areas in China. *BMC Health Services Research*, 11(341), 1-8.
- Tachfouti, N., Slama, K., Berraho, M. & Nejari, C. (2012). The impact of knowledge and attitudes on adherence to tuberculosis treatment: a case-control study in a Moroccan region. *Pan African Medical Journal*, 12(52), 1-8.

Table 1 Core components and contents of TB@Clicks health education module adapted from IMB model

Module	Objective	Content	Module construct (IMB model)
Section A: TB@Info	<ol style="list-style-type: none"> To create awareness towards TB and adherence behaviour To improve knowledge on TB. To emphasize that TB is curable To increase individuals' capacities to use health information to make appropriate health decisions and maintain basic health. 	<ol style="list-style-type: none"> Why TB is still a problem in Malaysia? What you should know about TB? <ul style="list-style-type: none"> - What causes TB - How does TB spread - Who is more likely to develop TB disease - What are the signs and symptoms of TB - How is TB diagnosed and managed - Can TB be treated - What are the complications of TB disease - Does TB causes death How can I protect others from TB 	Information, motivation and behavioural skill component
Section B: TB@Treatment	<ol style="list-style-type: none"> To improve knowledge on TB and its treatment To increase individuals' capacities to use health information to make appropriate health decisions and maintain basic health. To motivate and increase an individual's confidence to take action to improve health To develop skills that enhance the action of an individual's towards adherence to medication. 	<ol style="list-style-type: none"> What medication should I take when I have TB disease DOTS and DOT; what is it What are the side effects of TB treatment What to do to reduce and manage side effects Why do I need to take TB medicines regularly What are the implications of not completing treatment 	Information, motivation and behavioural-skill component
Section C: TB@Glance	<ol style="list-style-type: none"> To summarize the information on tuberculosis for better understanding To emphasize the adherence to treatment is very important 	<ol style="list-style-type: none"> The difference between TB disease and TB infection Untreated TB can spread the disease to other people Why should I take medicine if I don't feel sick Ways to better recovery in TB 	Information, motivation and behavioural-skill component