Background Factors Associated with Willingness to Use *Mhealth* for Tuberculosis Treatment Adherence in Kisumu, Siaya and Homa-Bay Counties of Kenya

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Background and Purpose: Poor adherence to the antimicrobial regimen has been cited as one of the most challenging problems for TB treatment as this provides favourable conditions for the maintenance of disease transmission, high mortality and the development of resistant strains. *mHealth* has been advocated as an innovative tool for improving both access to and quality of health care in underserved and remote locations. However, there remains limited evidence on patients' willingness to adopt it for TB treatment adherence.

Methods: A semi-structured questionnaire was used to collect data from 522 eligible patients seeking TB care at study sites.

Results: The predictors of willingness to use *mHealth* include residing in rural settings, earning monthly income of at least Ksh 10,000, travelling more than 5KM to access a health facility, using a text function sometimes/oftenly and preference for *mHealth* intervention at night-time/evening. The others are Turn-around-Time of 21 –30 days from the time they first reported to the public facility till first diagnosis as TB case, believing that stopping treatment before completing the full course was harmful to one's health and taking the medication in the afternoon.

Conclusion: There are several factors influencing patients' willingness to use *mHealth,* which should be considered when rolling out *mHealth* interventions for medication adherence and other desired health outcome

Keywords: *mHealth*, TB, Willingness

1   Introduction

TB is ranked alongside HIV as the leading cause of death from infectious diseases worldwide (WHO, 2015). A major barrier to better results is the high number of new smear-positive cases that voluntarily interrupt treatment. Low cure rates and a high treatment default rate provide favourable conditions for the maintenance of disease transmission, high mortality and the development of resistant strains (Volmink and Garner, 2006). However, widespread progress at controlling TB is restricted by poor infrastructure and increasing health-system costs. mHealth has been advocated as an innovative tool for improving both access to and quality of health care in underserved and remote locations in low and middle-income countries. mHealth is defined by the WHO (2011) as the "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistances and other wireless devices". Mobile phone access has risen dramatically, creating significant opportunities for creative and cost-effective implementation of mHealth interventions. However, despite the growing interest in mHealth, there remains limited evidence on TB patients' willingness to use the technology. Absence of such information hampers efforts to capitalize on expanding successful mHealth pilot projects and hence the need for this study. The objective of the study was to determine the level of willingness to use mHealth

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intervention on Tuberculosis treatment adherence and related factors in Kisumu, Siaya and Homa-Bay Counties of Kenya.

2   Methodology

This cross-sectional study was conducted in selected hospitals in the Nyanza North TB control region which covers, Siaya, Kisumu and Homa-Bay Counties. The study population was the newly diagnosed TB patients and those beginning re-treatment phases. A total of 522 participants were recruited for the study as they initiated TB treatment until the desired sample size was attained. All study participants were required to provide a written informed consent at enrolment. A semi-structured questionnaire was used to obtain participant demographic, socio-economic and willingness to use mHealth data which was then analyzed using Statistical Package for Social Sciences (SPSS) software. Both descriptive and inferential statistics were utilized.

3   Results

3.1   Willingness to use *mHealth* in relation to selected socio-demographic characteristics

There was a significantly increased proportion of willingness to use mHealth among patients from Siaya County (57.3%) (OR=2.34; 95% CI: 1.52 – 3.60; p<0.001) when compared to those patients from Homa Bay (36.5%) (Table 1). The proportion of those willing to use mHealth was significantly higher among patients from rural settings (54.0%) (OR=1.96; 95% CI: 1.38 – 2.78; p<0.001) than those who reside in urban areas (31.8%). In addition, the level of willingness to use mHealth, was significantly higher among the participants from the age category of 33-37 years (51.8%) (OR=1.85; 95% CI: 1.04 – 3.31; p=0.037) and 28-32 years 51.8%) (OR=1.85; 95% CI: 1.04 – 3.31; p=0.037) compared to those who were above 42 years (36.7%). The proportion of willingness to use mHealth was significantly less among those who didn't have a specific main occupation (36.5%) (OR=0.49; 95%CI: 0.28 - 0.87; p=0.014) compared to those who were employed/ Salaried workers (53.8%).Willingness to use of mobile phones for health was significantly higher among patients whose income were less than KSh10,000 (47.8%) (OR=1.55; 95% CI: 1.03 – 2.33; p=0.037) and with income of KSh10,000-20,000 (OR=1.92; 95% CI: 1.11 – 3.35; p=0.020) than those who were without any income or dependent (37.2%). Respondents who indicated that they didn't know the distance from place of residence to the public health facility were significantly less likely to accept using mobile phone (16.7%) (OR=0.27; 95% CI: 0.08 – 0.95; p=0.041) compared to those patients with less than 2 KM (40.0%).

3.2   Willingness to use *mHealth* in relation to mobile phone Access and usage

TB patients who indicated that they own mobile phones were significantly more willing to use mHealth (52.9%) (OR=2.37; 95% CI: 1.56 – 3.61; p<0.001) compared to those patients sharing mobile phones (32.1%) (Table 2). Also, the willingness to use mHealth was significantly higher among respondents who rarely used mobile phone, rarely used text function and those who considered night-time or Evening to be the ideal time for mHealth intervention (56.4%) (OR=3.19; 95%CI: 2.14- 4.75; p<0.001) and at any time (61.8%) (OR=3.98; 95%CI: 1.87- 8.50; p<0.001) compared to those who indicated in the morning time (28.9%) respectively.

3.3   Willingness to use *mHealth* in relation to TB Treatment and Turn-Around-Time (TAT) Among the Study Participants

Greater willingness to use mHealth was noted among patients who took 21 –30 days from the time first reported to the public facility till first diagnosed as TB cases (60.8%) (OR=2.39; 95% CI: 1.55 – 3.68; p<0.001) than to those who took 1 - 10 days (39.4%) (Table 3). The type of TB, treatment outcomes and any experience of side effects did not have any association with willingness to use mHealth intervention for TB treatment adherence.

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3.4   Willingness to use *mHealth* in relation to TB treatment Adherence

Respondents who believed that stopping treatment before completing the full regimen will be harmful to health had significantly increased proportion of willingness to use mHealth intervention (51.4%) (OR=9.68; 95% CI: 4.08 – 22.93; $p<0.001$) than to those who had contrary view (9.8%) (Table 4). This was also reported by TB patients who reported taking the medication in the afternoon.

3.5   Multivariate Analysis of Factors Associated with willingness to use *mHealth*

After Multivariable analysis, eight out of fifteen factors were independently associated with willingness to use mHealth (Table 5). Respondents from rural setting were 2 times more willing to use mHealth (AOR=2.02; 95% CI: 1.23 – 3.32; $p=0.005$) when compared to those respondents from urban setting. Willingness to use mHealth was 1.7 times more among patients whose monthly income were less than KSh10,000 (47.8%) (AOR=1.68; 95% CI: 1.00 – 2.83; $p=0.049$), about 2 times among those with monthly income of KSh10,000-20,000 (AOR=2.22; 95% CI: 1.11 – 3.35; $p=0.020$) and 10.8 times among those with monthly income of KSh 40,0000-50,000 (AOR=10.81; 95% CI: 1.53 – 76.55; $p=0.017$) than those who were without monthly income. Other factors are as shown in table 5.

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Table 1. Willingness to use *mHealth* in relation to Socio-demographic characteristics

Variables	Full Willingness, N=235		Partial Willingness (N=287)		OR Ψ	95% CI φ		χ2 test
	n	%	n	%		Lower	Upper	P value*
County								
Siaya	82	57.3	61	42.7	2.34	1.52	3.60	**<0.001**
Kisumu	72	45.9	85	54.1	1.48	0.97	2.24	0.067
Homa Bay	81	36.5	141	63.5	Reference			
Residence								
Rural	129	54.0	110	46.0	1.96	1.38	2.78	**<0.001**
Urban	106	37.5	177	62.5	Reference			
Age in years								
18-22	29	44.6	36	55.4	1.39	0.74	2.60	0.302
23-27	43	51.8	40	48.2	1.85	1.04	3.31	**0.037**
28-32	43	51.8	40	48.2	1.85	1.04	3.31	**0.037**
33-37	52	45.6	62	54.4	1.45	0.85	2.47	0.177
38-42	28	41.2	40	58.8	1.21	0.65	2.25	0.551
> 42	40	36.7	69	63.3	Reference			
Main Occupation								
Employed	56	53.8	48	46.2	Ref.			
Farmer	40	41.7	56	58.3	0.61	0.35	1.07	0.086
Business	67	43.8	86	56.2	0.67	0.41	1.10	0.114
None	35	36.5	61	63.5	0.49	0.28	0.87	**0.014**
Others	37	50.7	36	49.3	0.88	0.48	1.60	0.678
Monthly income								
>10,000	118	47.8	129	52.2	1.55	1.03	2.33	**0.037**
10,000-20,000	41	53.2	36	46.8	1.92	1.11	3.35	**0.020**
20,000-30,000	10	35.7	18	64.3	0.94	0.41	2.17	0.882
30,000-40,000	0	0.0	2	100.0	UD	UN	UN	0.999
40,000-50,000	4	66.7	2	33.3	3.38	0.60	19.03	0.167
Over 50,000	4	66.7	2	33.3	3.38	0.60	19.03	0.167
None	58	37.2	98	62.8	Ref.			
Distance from place of residence to the public health facility								
Less than 2KM	107	42.8	143	57.2	Reference			
2-5KM	86	47.8	94	52.2	1.22	0.83	1.80	0.306
> 5+ KM	39	52.7	35	47.3	1.49	0.89	2.51	0.134
Don't know	3	16.7	15	83.3	0.27	0.08	0.95	**0.041**
Ψ Odds ratio; φ95% Confidence Interval; UN= Undefined; Ref= Reference								

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Table 2. Willingness to use *mHealth* in relation to Mobile Phone Access and usage

Variables	Full Willingness N=235		Partial Willingness (N=287)		OR Ψ	95% CI φ		χ2 test
	n	%	n	%		Lower	Upper	P value*
Mobile phone Access								
Owns	184	52.9	164	47.1	2.37	1.56	3.61	**<0.001**
Shares								
without Household	8	27.6	31	72.4	0.81	0.33	1.97	0.636
within Household	43	32.1	91	67.9	Ref.			
Mobile phone Usage								
Seldom	44	41.1	63	58.9	5.89	2.46	14.09	**<0.001**
Daily	184	52.7	165	47.3	9.40	4.18	21.15	**<0.001**
Unreported	7	10.6	59	89.4	Ref.			
Frequency of using text function								
Rare	67	44.4	84	55.6	2.93	1.59	5.39	**<0.001**
Sometimes	83	55.3	67	44.7	4.54	2.46	8.38	**<0.001**
Often	67	48.9	70	51.1	3.51	1.89	6.52	**<0.001**
Always	18	21.4	66	78.6	Ref.			
When would you consider as the ideal timing of the SMS or phone call?								
Morning	56	28.9	138	71.1	Ref.			
Noon	17	38.6	27	61.4	1.55	0.79	3.07	0.207
Night / Evening	141	56.4	109	43.6	3.19	2.14	4.75	**<0.001**
Any time	21	61.8	13	38.2	3.98	1.87	8.50	**<0.001**

* Significant at p<0.05 bolded; Ψ Odds ratio; φ95% Confidence Interval; Ref.=Reference

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Table 3. Willingness to use *mHealth* in relation to TB Treatment and Turn-Around-Time

Variables	Full Willingness N=235		Partial Willingness (N=287)		OR Ψ	95% CI φ		χ2 test
	n	%	n	%		Lower	Upper	P value*
Turn-Around-Time from first visit to the public facility till TB diagnosis								
1 - 10 days	80	39.4	123	60.6	Ref.			
11 - 20 days	33	37.9	54	62.1	0.94	0.56	1.58	0.813
21 - 30 days	90	60.8	58	39.2	2.39	1.55	3.68	**<0.001**
Over 30 days	32	38.1	52	61.9	0.95	0.56	1.60	0.836
Turn-Around-Time during sputum examination								
1 day	36	45.6	43	54.4	Ref.			
2 days	90	45.9	106	54.1	1.01	0.60	1.71	0.958
3 days	52	35.4	95	64.6	0.65	0.38	1.14	0.135
Over 3 days	57	57.0	43	43.0	1.58	0.87	2.87	0.129
Treatment Outcome								
Cured	213	45.9	251	54.1	1.39	0.79	2.43	0.250
Relapse	22	37.9	36	62.1	Ref.			
Type of TB								
Pulmonary TB	188	43.9	240	56.1	Ref.			
Extra pulmonary TB-EPTB	47	50.0	47	50.0	1.28	0.82	2.00	0.284
Are you currently experiencing any side effects?								
Yes	46	45.5	55	54.5	1.03	0.66	1.59	0.906
No	189	44.9	232	55.1	Ref.			

* Significant at p<0.05 bolded; Ψ Odds ratio; φ95% Confidence Interval

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Table 5. Willingness to use *mHealth* in relation to TB treatment Adherence

Variables	Full Willingness, N=235		Partial Willingness (N=287)		OR ψ	95% CI φ		χ2 test
	n	%	n	%		Lower	Upper	*P value
Are you confident you will finish the entire treatment?								
Agree	230	45.7	273	54.3	2.36	0.84	6.65	0.104
Not sure	5	26.3	14	73.7	Ref.			
Do you believe stopping treatment before full course will harm your health?								
Agree	228	51.4	216	48.6	9.68	4.08	22.93	**<0.001**
Not sure	1	5.9	16	94.1	0.57	0.06	5.11	0.618
Disagree	6	9.8	55	90.2	Ref.			
Where do you keep your medications?								
HandBag	45	42.9	60	57.1	1.11	0.63	1.98	0.713
cupboard	60	46.2	70	53.8	1.27	0.74	2.21	0.389
container at home	55	44.7	68	55.3	1.20	0.69	2.10	0.518
bedside table	30	54.5	25	45.5	1.78	0.90	3.53	0.097
Under the pillow	10	45.5	12	54.5	1.24	0.48	3.18	0.657
Elsewhere	35	40.2	52	59.8	Ref.			
When do you take your medications?								
Morning	63	51.2	60	48.8	1.56	0.98	2.49	0.061
Afternoon	41	69.5	18	30.5	3.38	1.80	6.36	**<0.001**
Evening	61	36.7	105	63.3	0.86	0.56	1.34	0.510
At bed time	70	40.2	104	59.8	Ref.			
How do you take your medications?								
With food	87	51.2	83	48.8	Ref.			
Without food	104	45.0	127	55.0	0.78	0.53	1.16	0.223
Other	44	36.4	77	63.6	0.55	0.34	0.88	**0.013**
How do you remember to take your medications?								
By Family member	47	45.2	57	54.8	0.92	0.44	1.93	0.818
visible medications	64	47.4	71	52.6	1.00	0.49	2.06	0.997
Tie to a daily routine	66	44.0	84	56.0	0.87	0.43	1.78	0.709
Wait for *mHealth*	40	42.1	55	57.9	0.81	0.38	1.72	0.581
Other	18	47.4	20	52.6	Ref.			
In the last 7 days, did you miss any of your TB medications?								
Yes	22	43.1	29	56.9	0.92	0.51	1.65	0.776
No	213	45.2	258	54.8	Ref			
Have you ever missed your clinic appointments?								
Yes	15	36.6	26	63.4	Ref			
No	220	45.7	261	54.3	1.46	0.76	2.83	0.260
Adherence to TB treatment								
Non-Adherent	95	42.4	129	57.6	Ref			
Adherent	140	47.0	158	53.0	1.20	0.85	1.71	0.299

* Significant at p<0.05 bolded; ψ Odds ratio; φ95% Confidence Interval; Ref=Reference

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Table 6. Factors Associated with Willingness to Use *mHealth*

Predictors	AOR$^\psi$	95% CI φ Lower	Upper	p value*
Reduced model				
Residence				
Rural	2.02	1.23	3.32	**0.005**
Urban	Reference			
Monthly income				
Less than 10,000	1.68	1.00	2.83	**0.049**
10,000-20,000	2.22	1.11	4.46	**0.024**
20,000-30,000	0.85	0.31	2.33	0.757
30,000-40,000	UD	UD	UD	0.999
40,000-50,000	10.81	1.53	76.55	**0.017**
Over 50,000	2.79	0.43	18.12	0.282
None/Dependent	Reference			
Distance from place of residence to the public health facility				
Less than 2KM	Reference			
Between 2-5KM	1.00	0.62	1.60	0.989
More than 5+ KM	2.29	1.16	4.53	**0.017**
Don't know	0.23	0.06	0.93	**0.039**
Frequency of using text function				
Unreported/Very Rare	1.78	0.80	3.96	0.159
Sometimes	3.20	1.40	7.32	**0.006**
Often	2.44	1.04	5.70	**0.040**
Always	Reference			
When would you consider as the ideal timing of the SMS or phone call?				
Morning	Reference			
Noon	0.98	0.45	2.16	0.968
Night time/ Evening	2.39	1.45	3.93	**0.001**
Any time	3.53	1.38	9.00	**0.008**
Turn-Around-Time from first visit to health facility till TB diagnosis				
1 - 10 days	Reference			
11 - 20 days	1.04	0.56	1.93	0.893
21 - 30 days	2.77	1.62	4.74	**<0.001**
Over 30 days	1.73	0.88	3.41	0.112
Do you believe stopping treatment full course will harm your health?				
Agree	6.23	2.03	19.13	**0.001**
Not sure	0.25	0.02	2.66	0.250
Disagree	Reference			
When do you take your medications?				
Morning	1.27	0.72	2.26	0.412
Afternoon	2.77	1.30	5.92	**0.008**
Evening	0.62	0.36	1.05	0.077
At bed time	Reference			
* Significance at p<0.05 bolded; ψ Adjusted odds ratio; φ 95% Confidence Interval				

4 Discussion, conclusion and recommendations

The willingness to use mHealth for medical intervention has been increasing in a similar pace as its accessibility possibly due to perceived benefits. In a systematic review, Hamine and others (2015) found that the acceptability of mHealth tools for chronic disease management adherence were reported to be generally high among both patients and providers. However, previous studies have documented a number of concerns key among them being the dependence on professional supervision, unnecessary medicalization, and undue anxiety if technology failed (Faridi et al., 2008, Ryan et al., 2012). Among providers, concerns include the amount of time and effort required to review data and provide responses in

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time (Halkoaho et al.; 2007). Most of these concerns are reported by studies conducted in developed countries. Perhaps the main barrier to widespread use of mHealth interventions in developing countries may be issues related to cost of implementing the system. Further research is needed to unravel this. A systematic review by Kannisto and others (2014), demonstrated that text message reminders were easy to use, and patients were willing to receive text messages, and satisfied with the text message reminders. This knowledge is essential because patients' views influence the acceptance of the text message intervention and its integration into patients' daily lives (Vervloet et al., 2012). The World Health Organization promotes services similar to those mHealth, since they contribute to a more equitable delivery of care among patients living in low-income countries or in rural areas (Ryu, 2012). In addition, mHealth facilitates more frequent communication with patients and provides the opportunity to deliver health-related messages when they may have the greatest impact (Anglada-Martinez, 2015). At bivariate analysis, the age of the participant was associated with the willingness to use mHealth.. MHealth has been reported to be very feasible and usable among the young people for obvious reasons. For example, in a study on how patients with type 1 diabetes interact with an mHealth tool called "Sweet Talk system" both adolescent patients with diabetes mellitus and their parents perceived that using an mAdherence system increased the adolescent's independence and confidence in disease management (Franklin et al., 2008). In another study, the willingness to accept mHealth in form of text messages was positively associated with being young (Xiao et al., 2014). Among elderly populations, mAdherence was accepted and considered especially useful among older patients living alone and/or with memory issues (Durso et al., 2003). Notably, Burner and others (2013) reported that the use of the mHealth in diabetes self-management was conditioned by gender. Physician providers also favored an mAdherence system that provided patient data and supported clinical decision-making (Worringham et al., 2011). There were county variations in the levels of willingness to use mHealth intervention. TB patients from Siaya County reported significantly higher levels of willingness to use mHealth (57.3%) when compared to those patients from Homa Bay (36.5%). Regional differences in the willingness to use any new intervention are expected due to the varying characteristics of the populations, health facilities and the service provision. In China, living in the middle or north region was a predictor of acceptance of text messages targeted at improving antiretroviral therapy adherence (Xiao et al., 2014).

The proportion of willingness to use mHealth was significantly higher among patients from rural settings (54.0%) than those who reside in urban areas (31.8%). Indeed, research has shown that the ability to improve care and reduce strain on rural healthcare practices will depend on the effective use of technology (Effken & Abbott, 2009). In another study, the willingness to receive short messages for improving antiretroviral therapy adherence in China was positively associated with being a rural resident (Xiao et al., 2014). On the other hand, those who lived within 2 KM had higher levels of willingness to use (40.0%) compared with those who could not estimate the distance (16.7%). This may be linked to the participants' level of interaction with their environment which encompasses social, educational and individual patient characteristics among others. Also, the willingness to use mHealth was significantly higher among respondents who rarely used mobile phone (41.1%) and those who used mobile phone daily (52.7%) compared to those whose mobile phone usage was unknown (10.6%). Similarly, the willingness to use mHealth was significantly higher among respondents who very rarely used text function (44.4%) sometimes used text function (55.3%) and oftenly used text function (48.9%) than those who used the text function always (21.4%). This finding is however contrary to the expectation that those who interact with mobile phones always would have no problem accepting their use for health related purposes. This observation may imply that frequent usage of mobile phones as a tool of communication may not necessarily reflect equal acceptance for health purposes. However this behaviour could be modified gradually through patient education. Further research is needed to fully understand this observation. In addition, the proportion of mHealth acceptance was significantly high among respondents who considered night-time or evening to be the ideal time for mHealth intervention (56.4%) and at any time (61.8%) compared to those who indicated in the morning time (28.9%) respectively. Morning hours are considered "rush" hours when most people are headed for work and might not want to overload the already burdened hours with the tasks of reading text messages or phone call reminders and this may explain the observed phenomenon. On the other hand evening or night-times are considered relaxed and many people may be willing to spare some time for mHealth intervention. Hence the implementation of any mHealth intervention may need to consider the patients' preffered timings in order to increase the effectiveness of the intervention as targeted. Greater

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willingness to use mHealth was noted among patients who took 21–30 days from the time they first reported to the public facility till first diagnoses as TB cases. In a similar study, having serious disease condition or disease stage was associated with willingness to accept mHealth (Xiao et al., 2014). Other factors include, taking the medication in the afternoon, pairing medication with substances other than with food or activities not associated with food.

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