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The efficacy of an EMR-enabled text messaging system to the expanded health beliefs, diabetes care profile and HbA1c of diabetes mellitus patients

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Abstract

As diabetes mellitus (DM) becomes a global emergency, there is a need to explore novel interventions to address problems in self – management. Literature agree in the potential of mobile phones to carry-out self-care for a wide-array of disease conditions. Diabetes Self – Management Support and Education Through Text – Messaging (DSMSET) is a low-cost, two-way text messaging system designed to deliver self - help, educational messages based on the nine (9) dimensions of health management. DSMSET serves as a plugin to SHINE OS+, an open – source electronic medical record (EMR) system. The research is also based on the Expanded Health Belief Model and explores the efficacy of SMS in improving Expanded Health Beliefs, Diabetes Care Profile and in decreasing HbA1C of adult patients with DM. A two-arm, randomized controlled trial, a total of 122 eligible subjects from UERM PO Domingo OPD Services Department of Medicine and Sweet Diabetics Club based in CHAMP Wellness Clinic were enrolled. Using simple table random digits, subjects were divided equally to trial arms between SMS and non – SMS. The SMS group received DSMSET intervention for 90 days and were required to reply pre-set codes. Both groups answered two sets of survey questionnaires. Patient profile data including demographics for both groups were collected using SHINE OS+ before and after 90-day period. At follow-up, 110 participants were distributed equally and were subjected to analysis with descriptive and inferential statistics using STATA15 and SPSS23. Results show that Total Expanded Health Belief Scores (8 Constructs), Diabetes Care Profile Score, Likelihood to Take Action Score of the SMS group increased compared to the non-SMS group. Combined Expanded Health Belief Scores also showed modest improvement. However, SMS group posted relatively unchanged HbA1c levels while the non-SMS group had increased HbA1c on average.

Keywords: diabetes mellitus; diabetes self-management support; diabetes education; text-messaging; SMS; glycemic control; expanded health beliefs; diabetes care profile; likelihood to take action

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1. Introduction

The prevalence of diabetes mellitus (DM) has been alarmingly increasing worldwide. It is considered by the International Diabetes Federation as a global emergency, for which every ten seconds, a person dies from diabetes – related causes [1]. The Philippines is one of the world's emerging diabetes hotspots. Ranked in the top 15 in the world for diabetes prevalence, there are 3.4 million Filipinos ages 20 - 79 are affected with the disease, representing a prevalence rate of 7.7 [2].

Many models have been used to modify human behaviors such as the Expanded Health Belief Model (EHBM) and Diabetes Care Profile (DCP), and a score of research studies proved the existence of real - world evidence of algorithms and standards for Diabetes Self - Management Support and Education (DSMSE). However, these standards may be complex and difficult for patients to follow because of several factors. In one study conducted in Minneapolis and Albuquerque by Adams et al. (2013), participants may initially agree to attend DSMSE, but fail to attend the assigned educational sessions or eventually attend sessions sporadically [3]. A similar study conducted by Gucciardi, Demelo, Offenheim, & Stewart (2008) found that the most common reasons given by participants for their absence from the DSMSE programs were conflicts between their work schedules, distance to the DSMSE center, the high cost of DSME among others [4]. As such, it is critical that healthcare systems develop innovative ways to improve diabetes self - management of patients using technology. One of the promising solutions are the use of mobile phones which are integral part of our everyday lives.

SMS - based interventions have been a crucial platform in the field of health in delivering information and promotion of self - management [5]. They also serve as tool towards adherence in treatment [6] and to remind patients to conform with their health regimens [7]. For DM, the mobile phone text messaging across several literature proved the efficacy of SMS for diabetes management [8,9,10,11,12,13,14]. However, there are few researches available that focus on the use of SMS and its effects in the health beliefs, diabetes care profile and HbA1c.

Diabetes Self - Management Support and Education Through Text - Messaging (DSMSET) is a low - cost, two - way text messaging system designed to deliver self - help, educational messages based on the nine (9) dimensions of health management. DSMSET serves as a plugin to SHINE OS+, an open - source EMR system. One of the biggest motivations of this study is to challenge the use of SMS as an adjunct mechanism for diabetes self - management support and education programs, if not an alternative way. It also aims to analyze the efficacy of DSMSET intervention to improve the expanded health beliefs of the patients with DM and their DCPs that would eventually lead to the Likelihood to Take Actions (LTA) towards glycemic control and decreased levels of HbA1c as clinical cue or evidence that DSMSET is indeed effective.

2. Research Design and Methods

2.1. Design

The study was prospective, categorically experimental, analytical and a randomized control trial (RCT). This research also corresponded to the following conditions which satisfies the known standard requirements of an experimental study: (1) There were baseline and post - intervention data collections for both SMS and non - SMS groups, (2) There were two trial arms: treatment group (SMS group) and control group (non - SMS group) and (3) The subjects were randomly assigned to either treatment group or control group.

2.2. Sample Size

Since the study design utilized RCT, the researchers were blinded as to the outcome of the number of participants that were selected for both trial arms. The true sample size was 122 subjects and was computed using the formula:

$$Sample\ Size = \frac{2 \cdot sd^2 \cdot \left(Z\alpha_{/2} + Z_\beta\right)^2}{d^2} = \frac{2 \cdot (2.5)^2 \cdot (1.96 + 0.84)^2}{(1.27)^2} = \frac{98}{1.61} = 60.87 \approx 61 \quad (1)$$

where:

$sd = Standard\ Devision\ from\ the\ previous\ study\ or\ pilot\ study$

$Z\alpha_{/2} = Standard\ Normal\ Z\ value\ at\ type\ 1\ error\ of\ 5\%$

$Z_\beta = refer\ to\ Z\ Table\ at\ 80\%\ power$

$d = difference\ between\ means$

Both the control group and the experimental group had 61 samples or 122 samples in total. Moreover, the largest standard deviation from the previous literature was considered in order to obtain the most conservative sample size.

2.3. Population Selection

Subjects were recruited from the University of the East Ramon Magsaysay Memorial Medical Center, Inc. (UERMMMCI) P. O. Domingo Out - Patient Services and a Remote Station Diabetes Club (Sweet Diabetics Club Inc. based in Champ Wellness Clinic) in the Philippines from December 2016 - February 2017. Eligible participants were enrolled based on the following criteria: (1) 18 years old - above who have been diagnosed of diabetes Type 1 or Type 2 based on the WHO/IDF guidelines; (2) Have his/her own personal any mobile phone (whether QWERTY or smart phone) or have access to one belonging to a relative; (3) Should be able to read; (4) No history of psychiatric diseases and clinically and legally competent based on the MacCarthur Competence Assessment Scale for Clinical Research; (5) Willing to return for follow - up after 3 months (90 days) and (6) Willing to be enrolled in the Secured Health Information Network and Exchange (SHINE OS+) system.

Exclusion criteria on the other hand are the following: (1) Pregnant women; (2) Patients with concomitant conditions such as renal insufficiency with a creatinine level > 1.5 mg/dl, hepatic insufficiency; (3) Patients who had undergone a comprehensive diabetes self - care management training program within the past year and (4) Patients with any form of hemoglobinopathy.

2.4. Data Collection and Ethics Approval

Prior to the intervention, cellphone number, email address, demographic characteristic, HbA1c, Combined Expanded Health Belief Scores (CEHBS), Likelihood to Take Action Scores (LTAS) through the Expanded Health Belief Questionnaire (Tool A) and DCP Scores through Diabetes Care Profile Questionnaire (Tool B) were collected as baseline data. Demographics and contact data in particular were collected and recorded using the SHINE OS+ system by a trained person who was not involved in the research. On the other hand, HbA1c was collected by a medical technologist / physician or intern through high - performance liquid chromatography technique. The biological samples were kept in the BioCross Laboratory that passed the strict standards of the Philippines' Department of Health. All the samples were coded to preserve the anonymity of the subjects. CEHBS, DCP Scores and HbA1c were collected again from the two groups after 3 months (90 days). Baseline and post - intervention data were collected, processed and analyzed using SPSS v.23 and STATA 15. Data gathering procedures lasted for approximately two days, both baseline and post - intervention. Ethical approval for this study was obtained from the Research Institute for the Health Sciences of the UERMMMCI with the code 0291/E/G/16/33.

2.5. DSMSET Development

SHINE OS+ (https://www.shine.ph/) is an open source EMR developed in the Philippines used in rural health facilities. SHINE OS+ v3.0 was used for the DSMSET research for basic patient profiling. It was built using Laravel 5.1 framework, PHP 5.6 and MySQL 5.5 for its database. The DSMSET plug - in was developed to send reminders to enrolled patients and receive replies to confirm receipt of messages via SMS. DSMSET plug – in is an independent application which is built using Rails 4.2.6 and Ruby 2.3.1 using PostgreSQL 9.5.5 for its database. It utilizes Chikka API (https://api.chikka.com) for the SMS functionalities. DSMSET have a dashboard on the number of sent reminders, received reminders and queued reminders to monitor reminders and replies.

As patient data is being encoded using SHINE OS+, the patient can be enrolled in DSMSET. Upon enrollment, SHINE OS+ will push the patient data, specifically the name and mobile number to DSMSET plug - in to create the reminder schedule. The reminder schedule template is an Excel file loaded in the DSMSET plugin. Given this template, reminders are queued on particular dates based on the enrollment date. For example, if the enrollment date is January 1, 2018, Monday, the first reminder message will be sent on the succeeding Monday, January 8, 2018.

DSMSET plug – in uses CRON job to execute sending reminders every Monday, Wednesday, Friday and Saturday at 9 A.M. It retrieves the reminders queued for the day. Afterwards, it tries to send each message via Chikka API. If Chikka API returns an 'Accepted' status, it marks the reminder as 'Sent'; otherwise, it marks the reminder as 'Not Sent'. If the patient, who receives the reminder, decides to reply to the message, DSMSET plug – in receives and records the reply.

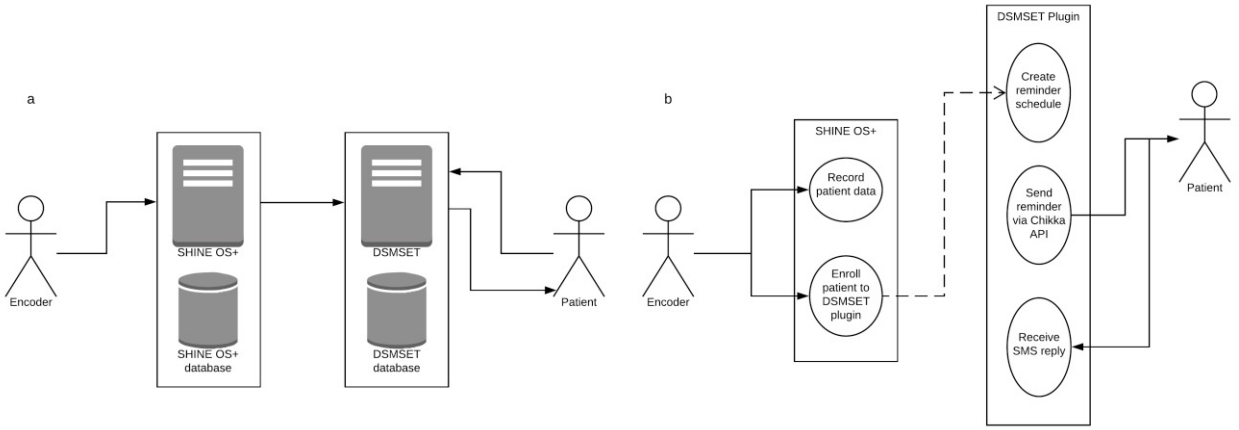

Fig. 1. (a) DSMSET System Architecture; (b) DSMSET Use Case Diagram

2.6. Intervention

The SMS reminder template is based on the nine (9) dimensions of disease management and various literature/resources [15, 16]. The messages, which contained at most 160 characters per message, were translated in Filipino language by "Sentro ng Wikang Filipino" of the University of the Philippines (UP) Manila. The formulated messages were evaluated by the two endocrinologist - consultants from the Department of Medicine, Section of Endocrinology, UERMMMCI. A focus group discussion was facilitated among 11 DM patients who determined that SMS template can be easily understood.

DSMSET was provided to the SMS group for 3 months (90 days). SMS sending started after the data collection and the SMS group received the messages at any place where signal from a network service provider is available. Moreover, the SMS group should have received a total at least eight (8) messages weekly, every 9 A.M. Except Week 12, including one (1) sign - in and one sign - off messages and three (3) core messages based on the EHBM and DCP, five (5) messages were sent every Monday, Wednesday and Friday. There were at least three (3) reinforcement messages were sent every Saturday. As mentioned in earlier sub – sections, the messages were based on the nine (9) dimensions of health management and additional topics on complications of diabetes [17]. The core messages were patterned from the questions in Tools A and B; while, the reinforcement messages were patterned from the nine (9) dimensions of health management. This ensured that all topics were covered and adhered to the variables of the EHBM and DCP. Table 1 summarizes the topics covered by the DSMSET.

Table 1. List of DSMSET topics per week.

Week Number	Topic	Week Number	Topic
1	Knowing Diabetes Mellitus	7	Foot care
2	Healthy Eating	8	Tobacco and Alcohol Control
3	Physical Activity	9 & 10	Complications of Diabetes Mellitus
4	Monitoring	11	Patient – held records
5 & 6	Medication	12 (Part 1 & 2)	Problem Solving by Empowerment of Patients

2.7. Analysis

Chi - square was used to compare the proportion between SMS and non – SMS groups for demographics i.e., sex and scores i.e., high and low. On the other hand, Fisher's exact test and Mann - Whitney's U test were utilized for the educational attainment and age, respectively. Independent sample *t* - test was used in comparing the Expanded Health Belief Score (EHBS), LTAS, CEHBS DCP Scores and HbA1c variables by intervention i.e., SMS and non - SMS; while paired *t* - test was used to compared the baseline and post – intervention values.

3. Results

Figure 2 depicts the study CONSORT diagram. A total of 150 patients were assessed for eligibility while 122 patients were randomized and were distributed equally into the trial arms. At follow – up, a total of 110 patients returned, with 1 mortality from the SMS arm. Total patients were split into equal groups for analysis.

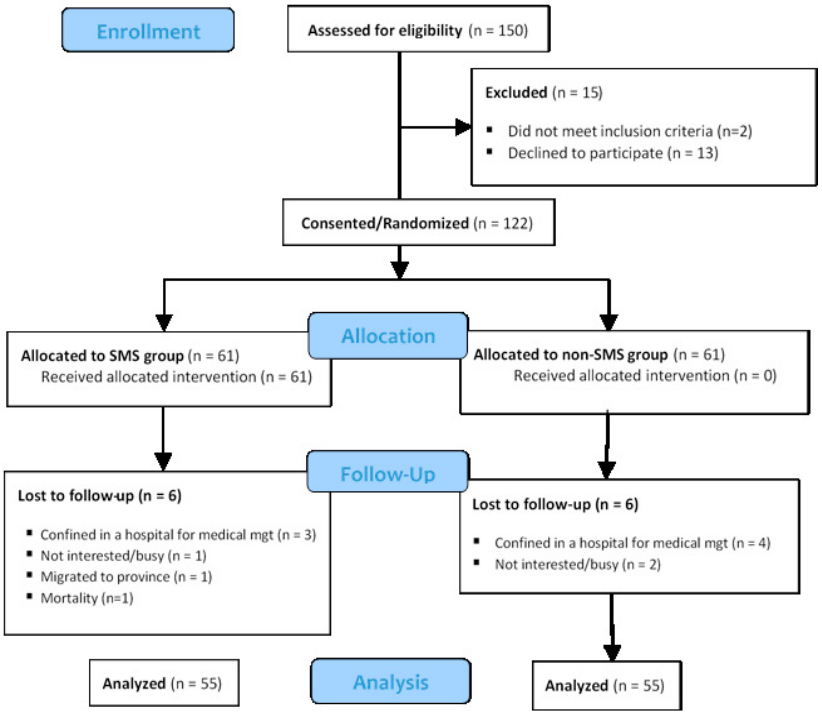

Fig. 2. Study CONSORT diagram.

3.1 Demographics

A total of 110 participants were included in the study per protocol analysis, equally distributed between SMS and non – SMS trial arms. There were no significant differences in baseline demographic characteristics of the two groups. The overall median age was 64 years old, ranging from 32 – 83 years old, with eight out of 10 being female. The majority or 54% had finished secondary schooling. Patients generally had poor glycemic control during the past 3 months, as evidenced by an average HbA1c measurement of 7.98 ± 1.33% as seen in Table 2.

Table 2. Baseline Characteristics of DSMSET Trial Participants.

	All (n = 110)	SMS (n = 55)	Non – SMS (n = 55)	p – value
	Mean ± SD; Median (Range); Frequency (%)			
HbA1c (%)	7.98 ± 1.33	8.11 ± 1.21	7.85 ± 1.45	0.300
Age (in years old)	64 (32 – 83)	65 (35 – 83)	63 (32 – 82)	0.514
Sex				0.467
Male	21 (19.09)	9 (16.36)	12 (21.82)	
Female	89 (80.91)	46 (83.64)	43 (78.18)	
Educational Attainment				0.836
Elementary	23 (20.91)	13 (23.64)	10 (18.18)	
Secondary Education	59 (53.64)	28 (50.91)	31 (56.36)	

Vocational	7 (6.36)	4 (7.27)	3 (5.45)
College	20 (18.18)	9 (6.36)	11(20.00)
Postgraduate	0 (0.00)	0 (0.00)	0 (0.00)
None	1 (0.91)	1 (1.82)	0 (0.00)

3.2 DCP

As shown in Table 3, DCP scores of the two arms were statistically comparable at baseline ($p = 0.109$), but not at post – intervention ($p = 0.0001$). Mean score (± SD) of the SMS arm increased from 84.4 ± 16.69 to 103.13 ± 14.06 at ($p < 0.001$), but the change in the control group, from 89.4 ± 15.73 to 91.24 ± 15.98, was not significant ($p = 0.433$).

Table 3. Overall DCP Scores.

	All ($n = 110$)	SMS ($n = 55$)	Non – SMS ($n = 55$)	p – value
	Mean ± SD; Frequency (%)			
Baseline	86.9 ± 16.33	84.4 ± 16.69	89.4 ± 15.73	0.109
Post – intervention	97.18 ± 16.13	103.13 ± 14.06	91.24 ± 15.98	0.0001
p - value	< 0.001	< 0.001	0.433	
Baseline: Low	14 (12.73)	10 (18.18)	4 (7.27)	0.086
Baseline: High	96 (87.27)	45 (81.82)	51 (92.73)	0.363
Post – intervention: Low	5 (4.55)	1 (1.82)	4 (7.27)	
Post – intervention: High	105 (95.45)	54 (98.18)	51 (92.73)	

Note: Range of overall DCP scores: 52 – 122. Score of > 68 is considered high.

3.3 HbA1c

As shown in Table 4, HbA1c levels of the two study groups, where p – value before ($p = 0.300$) and after ($p = 0.317$), were not significantly different from each other. The SMS arm did not demonstrate a statistically noticeable change in the glycemic marker from baseline with 8.11 ± 1.21% to end with 8.10 ± 1.41% ($p = 0.963$). In contrast, the average HbA1c of the control group was seen to significantly increase, beginning with 7.85 ± 1.45% and ending at 8.38 ± 1.50%, which are significantly different from each other ($p = 0.018$).

Table 4. Changes in HbA1c.

	All ($n = 110$)	SMS ($n = 55$)	Non – SMS ($n = 55$)	p – value
	Mean ± SD			
Baseline	7.98 ± 1.33	8.11 ± 1.21	7.85 ± 1.45	0.300
Post – intervention	8.24 ± 1.46	8.10 ± 1.41	8.38 ± 1.50	0.317
p – value	0.091^{Δ}	0.963^{Δ}	0.018^{Δ}	

3.4 EHBS

The study arms appeared to be comparable in their total EHBS at baseline ($p = 0.100$) as shown in Table 5. After the trial, the mean score of the SMS arm was significantly higher ($p = 0.0001$). A significant increase in mean scores was observed among patients who received DSMSET text messaging, from 377.71 ± 33.33 to 398.65 ± 30.86 ($p = 0.0004$) but not among those without SMS reminders, from 366.93 ± 34.99 to 368.07 ± 44.05 ($p = 0.846$). All patients scored high at evaluations of total EHBS.

Table 5. Total EHBS (8 constructs).

	All (n = 110)	SMS (n = 55)	Non – SMS (n = 55)	p – value
	Mean ± SD; Frequency (%)			
Baseline	372.32 ± 34.44	377.71 ± 33.33	366.93 ± 34.99	0.100
Post – intervention	383.36 ± 40.85	398.65 ± 30.86	368.07 ± 44.05	0.0001
p - value	0.009$^{\Delta}$	0.0004$^{\Delta}$	0.846$^{\Delta}$	
Baseline: Low	0 (0.00)	0 (0.00)	0 (0.00)	1.00
Baseline: High	110 (100)	55 (100)	55 (100)	
Post – intervention: Low	0 (0.00)	0 (0.00)	0 (0.00)	1.00
Post – intervention: High	110 (100)	55 (100)	55 (100)	

Note: Range of total EHBS (8 constructs) is 123 – 486. Score of > 256 is considered high.

3.5 LTAS and CEHBS

Patients in the two study arms were not statistically comparable in their LTAS at baseline (26.44 ± 4.80 and 26.13 ± 5.31, p = 0.749), but a notable difference in scores was detected during the post – trial survey (29.31 ± 3.59 and 26.78 ± 5.05, p = 0.003), as shown in Table 6. Scores of both groups rose significantly from baseline. Only a handful of study participants had low LTAS at any time. Moreover, the combined EHBS of study groups were statistically similar at baseline (p = 0.099) and different at post – trial (p < 0.001) as shown in Table 7. Average score of the SMS arm displayed a significant rise, from 404.15 ± 34.09 to 427.96 ± 32.38 (p = 0.001). The same was not observed in the control group (p = 0.770).

Table 6. Over – all LTAS.

	All (n = 110)	SMS (n = 55)	Non – SMS (n = 55)	p – value
	Mean ± SD; Frequency (%)			
Baseline	26.28 ± 5.04	26.44 ± 4.80	26.13 ± 5.31	0.749
Post – intervention	28.05 ± 4.54	29.31 ± 3.59	26.78 ± 5.05	0.003
p - value	0.001$^{\Delta}$	<0.001$^{\Delta}$	0.376$^{\Delta}$	
Baseline: Low	5 (4.55)	2 (3.64)	3 (5.45)	1.00
Baseline: High	105 (95.45)	53 (96.36)	52 (94.55)	
Post – intervention: Low	4 (3.64	1 (1.82)	3 (5.45)	0.618
Post – intervention: High	106 (96.36)	54 (98.18)	52 (94.55)	

Note: Range of LTAS is 8 - 32. Score of > 16 is considered high.

Table 7. CEHBS (EHBS + LTAS).

	All (n = 110)	SMS (n = 55)	Non – SMS (n = 55)	p – value
	Mean ± SD; Frequency (%)			
Baseline	398.6 ± 35.24	404.15 ± 34.09	393.05 ± 35.81	0.099
Post – intervention	411.41 ± 42.63	427.96 ± 32.38	394.85 ± 45.41	<0.001
p - value	0.003$^{\Delta}$	0.0001$^{\Delta}$	0.770$^{\Delta}$	
Baseline: Low	0 (0.00)	0 (0.00)	0 (0.00)	1.00
Baseline: High	110 (100)	55 (100)	55 (100)	
Post – intervention: Low	0 (0.00)	0 (0.00)	0 (0.00)	1.00
Post – intervention: High	110 (100)	55 (100)	55 (100)	

4. Discussions, Limitations and Conclusions

4.1 Discussions on the Effects of DSMSET to DCP

Overall, the SMS group improved from baseline to post – intervention compared to non – SMS group from 84.4 ± 16.69 to 103.13 ± 14.06 ($p < 0.001$), similar to the results conducted by Fatehi et al. (2010) and Haddad et al. (2014) [18, 19]. Moreover, DCP scores of the two arm were statistically comparable at baseline ($p = 0.109$) but not remarkable at post – intervention. This further affirmed that the DSMSET helped the SMS group to understand concepts on foot care, exercise and meal plan and how the participants take in the information regarding diabetes mellitus, diabetes – related self – management, diabetes – related lifestyle modifications.

Subsequently, support also improved in the same way although not significantly (from 24.07 SD ± 4.82 to 26.85 SD ± 3.02) in a study conducted by Rotheram-Borus (2012) and Nundy et al. (2013) where the amount of social support received overall and received daily improved at 3 months and 6 months, while satisfaction with overall and daily social support improved only at 6 months [20, 21]. Comparatively, this research did not require a buddy – participant to support each other. In terms of methods, the present study is not mixed research and analysis of the the profundity of support systems in improving diabetes management with the aid of technology was not explored. Nevertheless, it can be assumed that the intervention has helped the SMS group to receive reinforcements from family, relatives, friends and health care providers.

4.2 Discussions on the Effects of DSMSET to HbA1C

HbA1c levels before ($p = 0.30$) and after ($p = 0.317$) across the trial arms were not significantly different from each other. Although not proven and not within the scope of this study, some extraneous variables which cannot be controlled might influence these results. Diet, daily physical activities and adherence to medication might also vary from subject to subject. On the average, SMS group did not demonstrate a statistically noticeable change in the glycemic levels from baseline to end (8.11 ± 1.21% to 8.10 ± 1.41%, $p = 0.963$) while the non – SMS group was seen to have increased HbA1c levels, beginning from 7.85 ± 1.45% ending at 8.38 ± 1.50% ($p = 0.018$).

Compared to other studies, a previous work done by Zolfaghari et al. (2012) posed significant decrease in HbA1c with mean change of -1.01% for the SMS intervention yet both studies found that no significant differences were observed between the trial arms ($p = 0.186$) [22]. Similar findings were found in the research conducted by Peters et al. (2017) [23] and Capozza et al. (2015) [24].

Conducted in a larger setting, there was also significant decrease in HbA1c levels when SMS reminders were used in a study piloted at the Philippine General Hospital in 2013 by Tamban, Isip-Tan and Jimeno with SMS= 7.13 + 0.99, control= 7.53 + 0.91, ($p = 0.034$) to SMS=6.99 + 0.86, control = 7.34 + 0.90, ($p = 0.0452$) [15]. Contrary to the present study, the former group used the SMS intervention for 9 months, collected data through time series and other parameters such as diet and exercise, mean change in body weight and body mass index were sought.

4.3 Discussions on the Effects of DSMSET to EHBS, LTAS and CEHBS

Akin to DCP scores, the SMS group improved from baseline to post – intervention when EHBS (8 constructs) is combined, with 377.71 ± 33.33 to 398.65 ± 30.86 ($p = 0.0004$). This is comparable with non – SMS group from 366.93 ± 34.99 to 368.07 ± 44.05 ($p = 0.846$). With a high mean score of greater than 243 to the Total EHBS of the SMS arm, results gauged the effectiveness of DSMSET intervention with most patients of the said group were expected to perform diabetes self - care or engage in diabetes - specific health behaviors.

Moreover, it can be probable that most subjects in the SMS arm responded appropriately to symptoms and modifying factors, such as health messages, DSMSET messages in particular were likely to result in obtaining medical care or encouraging other participants to engage in positive health behaviors. Subjects were also projected to perceive burdens and consequences e.g. pain, death, disability associated with diabetes appropriately and locus of control, social support and understanding of diabetes and treatment regimen through the help of SMS would fairly improve.

Only a handful of researches appeared to link the efficacy of SMS – based self – management to the health beliefs among diabetic patients. Moghadam, Taheri, Zadeh and Parsa (2014) challenged the use of the SMS and its' effects to the health beliefs and found out that at baseline, there was no significant difference to the mean score knowledge, self-care behavior and model parts of Health Belief Model (HBM) between two groups ($p = >0.05$) while after intervention, the mean score variables in the experimental group was significantly increased and significant differences were found between the two groups ($p =<0.01$) [25]. Compared to the present research however, Moghadam and colleagues didn't state in their findings as to which part of the HBM was used and that the expanded

version of the model was applied for this study. The former study was also quasi-experimental with smaller sample size.

Relatively, Nundy, Dick, Solomon and Peek (2013) showed modification of participants' health beliefs and self-management behaviors although the research is qualitative in nature and provided in-depth analysis of the subject's answers [21]. Gatwood et al. (2016) on the other hand found out that the health beliefs and attitudes at baseline posed no significant differences between treatments groups for any of the measured health beliefs and attitudes (all $p = 0.05$) [26].

For LTAS, the SMS group improved compared to the non – SMS group, from baseline to post – intervention with 26.44 ± 4.80 ($p = 0.749$) to 29.31 ± 3.59 ($p = 0.003$), particularly a significant difference on the post – intervention scores. The trend is also noticeable across other parameters such as DCP scores and EHBS (8 constructs). With these results, it can be inferred that most of the subjects of the SMS groups increased their beliefs on the effectiveness of the recommended health behaviors or actions and the probability that the subject may adopt the appropriate behaviors at baseline and post – intervention may improve. Positive changes in LTAS can also gauge the effectiveness of DSMSET similar to the findings of Hanauer et al. (2009). Different to the present study however, Computerized Automated Reminder Diabetes System (CARDS) only focused on Blood Glucose (BG) monitoring to test LTAS. The researchers also used SMS and email applications and did not use questionnaires as instruments to gauge the variables of LTA. Similarly, Hanauer and colleagues found out that compared to the e-mail group, users in the cell phone group received more reminders (180.4 vs. 106.6 per user) and responded with BG results significantly more often (30.0 vs. 6.9 per user, P=0.04) [10].

Lastly, the SMS group was seen to have an increased CEHBS from 404.15 ± 34.09 to 427.96 ± 32.38 ($p = 0.001$) when EHBS and LTAS were added while there were no significant changes seen for the non – SMS arm. High mean score greater than 260 of the SMS group also affirmed the effectiveness of DSMSET.

4.4 Conclusions

DSMSET is effective, proven by modest increase in the EHBS, LTAS, CEHBS and DCP of the SMS group while only a margin of -0.01% was observed in the HbA1c levels. Further studies should delve towards adherence to treatment. In – depth analyses of participants' answers should be done through qualitative techniques. Other metrics should be captured to have a bigger picture of clinical cues such as Body Mass Index (BMI), blood pressure and capillary blood glucose. DSMSET, as a plug – in in an EMR, is an example of how eHealth systems should be designed, as a patient – centric monitoring tool. Effectively, regular patient reminders affect the belief system. Eventually, this also affects personal healthcare management.

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