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Study Of SENYUMANIS Web-Based Application Impact on Dental Behaviour and Glycaemic Control among Diabetes Patients during COVID-19 Pandemic

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ABSTRACT

Background: Diabetes mellitus (DM) and periodontal disease share a bidirectional relationship as chronic non-communicable conditions. However, limited awareness of this connection in Malaysia hampers patient empowerment, self-care practices, and glycaemic control. Additionally, inadequate coordination between primary medical and dental services exacerbates these challenges. This study investigates the impact of oral health awareness on adults with DM receiving conventional care and Senyumanis© at university-based primary medical clinics in Malaysia.

Materials and Methods: A cluster-randomized, single-blinded trial was conducted among adults with DM (aged ≥18 years) who owned smartphones. Participants were randomized into two groups: one received conventional care with dental education materials, while the other used a web-based educational tool, Senyumanis©, during routine diabetic follow-ups. Developed collaboratively by medical and dental healthcare experts, Senyumanis© aimed to enhance oral health awareness, includes 18 topics covering oral health and medical advice for patients with diabetes (PwD). Eligible criteria included adults aged 18 years old and above, with a confirmed diagnosis of T2DM, receiving standardized treatment as per Malaysian Clinical Practice Guidelines Ministry of Health (MOH), able to understand spoken Malay or English language, owns and able to operate a smartphone. Data were analysed using SPSS version 26.0, with continuous data reported as means and standard deviations, and categorical

data as frequencies and percentages. Bivariate analysis using independent t-test and Chi-square test were used to compared outcomes between the Senyumanis© and conventional care groups.

Results: Of 844 individuals screened, 244 were recruited and analysed. At study completion, fasting blood sugar (FBS) levels were significantly lower in the Senyumanis© group compared to conventional care (P=0.014). A higher proportion of Senyumanis© participants (43.8%) attended dental visits versus the conventional care group (28.6%), although 27.7% deferred visits due to COVID-19 concerns. Participants who attended dental clinics reported improved glycaemic control.

Conclusion: The use of Senyumanis© helps in increasing oral health awareness, increased utilisation of dental clinic services and subsequently aided improvement of glycaemic control in PwD attending primary medical care clinics. Integrating dental education into primary medical care visits is crucial for improving dental clinic attendance and glycaemic outcomes among PwD. Web-based tools like Senyumanis© effectively promote healthy behaviors, underscoring the potential of digital interventions in enhancing holistic diabetes management in Malaysia.

Keywords: primary medical care, dental healthcare, diabetes, periodontal disease, cluster randomized trial, integrated care

1.0 Introduction

Diabetes mellitus (DM) prevalence continues to increase globally, with about 463 million people (9.3%) diagnosed by 2019 and estimated to rise to 700 million (10.9%) by 2045 [1]. Similarly, the World Health Organization (WHO) reported that 10–15% of the world population suffers from severe periodontitis [2]. Periodontitis is defined as chronic inflammation of the teeth's supporting tissues which can lead to loss of attachment and alveolar bone resorption as a result of an induced inflammatory host response [3]. The upregulated systemic inflammation due to periodontitis leads to insulin resistance and hyperglycemia [4]. Patients with uncontrolled diabetes are predisposed to periodontitis, most likely as a result of their hypersensitivity to oral dysbiosis and weakened healing processes, both of which contribute to periodontal breakdown [5]. In diabetes, there are increased depositions of advanced glycation end-products in periodontal tissue, reducing blood flow to the gingiva and lower resistance to bacteria [4]. Prevalence, severity, and periodontal disease progression are significantly increased in patients with diabetes [6]. Patients living with DM (PwD) are two to three times more likely to have periodontitis than patients without diabetes and this is related to long-term metabolic control and duration of diabetes [7, 8]. Oral health complications associated with DM include chronic periodontitis, gingivitis, dental caries, burning mouth syndrome, tooth loss, mouth dryness, taste impairment, and sialosis [9, 10]. Patients with both diabetes and severe periodontitis have a greater risk of developing more severe medical complications, including retinopathy, nephropathy, cardiovascular complications and even risk of cardiorenal mortality [11] Some clinical trials showed that educational intervention effectively increases patients' compliance towards periodontitis treatment [12, 13] Subsequently studies have also shown that

improvements in oral health i.e. periodontal health among patients with type 2 diabetes mellitus (T2DM) have resulted in improvements in metabolic or glycaemic control [14, 15, 16]

The prevalence of diabetes in Malaysia ranges between 15.6-18.9% in the last five years [17, 18], while periodontal diseases affect 48.5% of Malaysians [19]. However, the oral health status of diabetes patients attending primary medical care facilities is largely unknown in Malaysia, and the lack of awareness regarding the bidirectional relationship between periodontal diseases and DM among both healthcare personnel and patients in Malaysia compounds the problem [20]. Therefore, increasing efforts by the primary medical care team to improve the metabolic control of diabetes may be augmented by improvements in oral health status. The International Diabetes Federation (IDF) recommends that oral health education should be provided to all patients with diabetes [21, 22]. In Malaysia, the latest clinical practice guideline on management of T2DM (2020), recommends that all patients with newly diagnosed diabetes should be referred for oral health examination as part of management and followed by an annual periodontal examination should be arranged if the baseline examination was normal [23].

The majority of public primary healthcare centres across Malaysia provide onsite primary medical care as well as primary dental care services within the same healthcare facility. However, care delivery remains uncoordinated, suboptimal and not holistic as it aims to achieve. A notable attempt to consolidate care delivery at healthcare centre level using a common clinical information system such as Teleprimary Care and Oral Health Clinical Information (TPC-OCHIS). TPC-OCHIS is a holistic clinical information system for health and dental outpatient treatments [24]. However, this system is available only at selected public healthcare centers in each district and nationwide access has not been achieved. TPC-OCHIS provides a platform for primary medical and dental care personnel in the same healthcentre to navigate a more inclusive approach for DM-related oral health issues for the patient receiving care for DM or other non-communicable diseases, via clinical data sharing as well as online referral system between doctors at the public primary healthcare centers. On the other hand, despite availability of TPC-OCHIS facilities, minimal progress has been made to include opportunistic oral health screening or even intervention among DM patients seen at outpatient clinics, despite established evidence that periodontal treatment can help to improve glycaemic control of diabetes patients by reduction of HbA1c between 0.23% to 1.03% [25]. However, TPC-OCHIS is not available at private or university based primary healthcare facilities. To date, no study has been conducted on oral health educational intervention in Malaysia especially among PwD attending primary medical care facilities. This study aimed to compare the effectiveness of educational intervention comparing Senyumanis web-based educational tool and conventional care in improving oral healthcare practices i.e., dental clinic attendance and glycaemic control of PwD, particularly T2DM patients attending university based primary medical care clinics.

2.0 Materials and Methods

Study design

This was a cluster, randomised, single-blinded trial, conducted among T2DM patients attending two university based primary medical care clinics, Klinik Primer Hospital Canselor Tuanku Muhriz (KPHCTM) and International Islamic University Family Health Clinic Kuantan (IIUMFHC). Both clinics provide primary medical care services including non-communicable diseases i.e., DM. On average, there were about 2300 PwD attending these clinics within the 6 months period during the COVID-19 pandemic movement control order. This study recruited a total of 244 T2DM patients, 174 patients from KPHCTM and 70 patients from IIUMFHC, through a convenient sampling method, within the study period between 1st June 2020 until 31st May 2021. The inclusion criteria for this study included adults aged 18 years old and above, with a confirmed diagnosis of T2DM, receiving standardized treatment as per Malaysian Clinical Practice Guidelines Ministry of Health (MOH), able to understand spoken Malay or English language, owns and able to operate a smartphone. Those who were fully edentulous, with Type 1 Diabetes Mellitus or Gestational Diabetes Mellitus were excluded from this study. This trial was registered retrospectively with the Australian New Zealand Clinical Trials Registry (ANZCTR) on 22/11/2022 (ACTRN12622001469707).

Based on Figure 1 for the conceptual framework, dependent variables which were also the research outcomes were glycaemic control and dental clinic visits. Meanwhile, the independent variables were the intervention, risk factors including sociodemographic data, clinical profile, medication adherence and lifestyle. For operational definitions:

- Educational intervention: Oral health education provided to PwD, either through the web-based educational tool on health practices (Senyumanis) or conventional care with a Ministry of Health Malaysia pamphlet.
- Dental clinic attendance: Patient attended dental clinic after given educational intervention.
- Glycaemic control: measured glycated haemoglobin (HbA1c), which reflects average plasma glucose concentration over the preceding 3 months and fasting blood sugar (FBS).

Sample Size

In terms of the first objective, regarding self-reported oral health practices among diabetes patients attending primary medical care clinics, the sample size was calculated using OpenEpi version 3, estimating sample size for frequency in a population at a 90% confidence level, the sample size needed is 243 diabetes patients as total attendance of diabetes patients in 6 months is expected to be 2327 patients. As for the second objective, for the cluster-randomised study of Senyumanis and conventional care, the sample size was calculated using Power & Sample Size Calculator, based on a power of 90% (β=0.10), alpha of 0.05, an expected outcome difference of 25% improvement in glycaemic control and self-reported oral health practices [26] between the two study interventions, the calculated sample size for each group is 40 patients. Allowing for a 20% dropout, a final sample size of 48 T2DM patients per group was required. A minimum total of 96 subjects was required for the sample size. Therefore, to meet

both objectives, at least 243 T2DM patients were needed for this study, with 121 patients recruited per arm for Senyumanis and conventional care.

Study Recruitment and Study Tools

Figure 2 illustrated the flow of subject enrolment for this study. All T2DM patients who attended KPHCTM and IIUMFHC during the data collection period were screened for eligibility. A total of 844 patients were approached during the study period, however, only 244 patients fulfilled the study criteria and consented to participate. Interventions were clustered into three-month intervals. Specifically, during the initial three months, all recruited patients received conventional care. Once the sampling targets were met at the study site, the subsequent three months were dedicated to recruiting patients to receive the Senyumanis app. The researcher was blinded to the intervention received by the respondents. 115 patients were assigned the Senyumanis and 129 patients received the standard conventional care. At the baseline, we obtained information regarding the sociodemographic data, comorbidities, dental utilisation and oral hygiene practice, Life's Simple 7, medications and compliance (Malaysian Medication Adherence Assessment Tool MyMAAT), baseline clinical parameters including fasting blood sugar, HbA1c, blood pressure, calculated glomerular filtration rate (eGFR) and body mass index (BMI).

Malaysian Medication Adherence Assessment Tool (MyMAAT)

MyMAAT [27] was granted permission to be used among PwD and has a Cronbach's alpha of 0.91. It consists of 12 questions regarding medication adherence with a 5-point Likert scale from strongly disagree, disagrees, neither agree nor disagree, agree, and strongly agree. The total score of $\leqslant$ 50 indicates the patient has good medication adherence and a total score > 50 indicates moderate or poor medication adherence. This measurement was included in the study to ensure that both interventions groups had comparable medication adherence.

Life's Simple 7 (LS7)

Life's Simple 7 (LS7) is a questionnaire by the American Heart Association designed to assess the patients' lifestyle and their cardiovascular health [28]. It consists of 7 items on smoking, BMI, physical activity, total cholesterol, blood pressure, fasting blood sugar and healthy diet score with local food items used that had been validated by two certified dietitians using the Malaysian Nutrition Guideline [29]. Each item had 3 categories with corresponding points: 2 points = ideal, 1 point = intermediate, 0 point = poor. Total of all points interpreted as total points 10-14 = optimal, 5-9 points = intermediate and 0-4 = poor.

All patients received a referral letter to the nearest dental clinic of their choice for oral health assessment and information regarding treatments received for their diabetes and/or complications. The referral letters also contained a RSVP section to help update the primary medical care team regarding the patients' oral health status and treatment plans if any.

The data collected during the follow-up visit included self-reported dental utilisation and oral hygiene practice, LS7, MyMAAT, repeated clinical parameters which included fasting blood sugar, HbA1c, blood pressure, eGFR and BMI during the exit visit. During the follow-up visit, respondents were asked if they had visited the dentist or not. If they had visited the dentist, the diagnosis or treatment received were checked. For respondents who did not visit the dentist, the reason why they did not visit the dentist was obtained.

Senyumanis©

A web-based educational tool that can be assessed through http://senyumanis.my/. It was developed by a team of researchers from Faculty of Dentistry, UKM, based on literature on the use of the web-based educational tool in behavioural change in clinical settings [30, 31, 32], taking into consideration the work done by a dental team on oral health literacy among Malaysians and the expertise of multidisciplinary team members with regards to technology-based education [33, 34] This oral health educational package consist of 18 short topics which address oral health related content (14 topics) and medical advice for PwD (4 topics). The oral health content includes practical advice on choosing the correct toothbrush as well as a video on how to brush teeth properly. The medical advice orientates the user on the bidirectional relationship between diabetes and periodontitis, complications of poorly controlled diabetes, healthy diet, exercise advice and most importantly, tips on sourcing correct and responsible medical advice/information regarding diabetes or non-communicable diseases. The progressive web application (PWA) was tested among 30 patients visiting a university-based primary medical care clinic for its usability via the Skala Kebolehgunaan Aplikasi Mudah Alih (SKAMA) which is the validated Malay version of the System Usability Scale Questionnaire, consisting of 10-item survey rated from 1 (strongly disagree) to 5 (strongly agree) on a 5-point Likert scale. A trained research assistant introduced and explained Senyumanis© to patients during the recruitment for the Senyumanis© group. This session took about 30 minutes on average per individual patient. Following the session during recruitment, the patients were able to browse Senyumanis© at their own time and convenience.

Conventional care

Patients recruited under this arm were shown the self-educational pamphlet and posters (hardcopies) by the Ministry of Health Malaysia which explained regarding oral health, DM and their relationship, during the recruitment stage. This is a single exposure to the materials which are usually displayed at the general information board in the primary medical care clinic. During this trial, an A4-sized version of the posters are made available at the researcher's table in the clinic.

Data analysis

Data analysis was carried out using Statistical Package Social Science (SPSS) version 26.0. For descriptive analysis of the study population, continuous data were reported using means and standard deviation (SD) for normally distributed data while categorical data were reported as frequencies and percentages. Bivariate analysis using independent t-test and Chi-square (□2) test were used to compare differences of outcomes between Senyumanis and conventional care groups. In all tests, a p-value of <0.05 was considered to be statistically significant.

3.0 Results and Discussion

3.1 Sociodemographic and clinical profile

At the 4-month follow-up visit, 10 patients were lost to follow-up in the conventional care group, resulting in a dropout rate of 7.7%. Similarly, in the Senyumanis group, the dropout rate was 8.6% with 10 patients lost to follow-up.

Table 1 shows the baseline sociodemographic profile, clinical characteristics and dental behaviour of the study participants at the two study locations according to the health education interventions. There was no significant difference in the sociodemographic and clinical profiles of patients allocated to the two different interventions. Out of total 244 patients, the mean age was 59.55 (SD 10.5) years old and most of the patients were in the age group of 55-64 years old (39.8%). The proportion of patients according to gender was almost similar, male (50.8%) and female (49.2%). Majority were Malays (82.8%) and had studied at least up to secondary school (91.3%); nearly half were retirees (52.9%) and had monthly income < RM 1000 (50.0%).

The clinical profile for both groups were relatively similar, with the majority having dyslipidemia (89.9%), hypertension (72.1%) and slightly more than one-third obese (38.5%). Based on LS7, the majority of patients (82.8%) indicated intermediate score for lifestyle and cardiovascular health. All patients had good medication adherence (100%) based on MyMAAT. With regards to their dental behaviour, there were no significant differences in the frequency of brushing teeth per day among conventional care and the Senyumanis group at baseline. Out of 244 patients recruited, 215 patients (88.1%) brushed teeth twice or more per day and 29 patients (11.9%) only brushed teeth once per day. There was no statistically significant difference between both intervention groups for dental care utilisation during recruitment. Only about one-third of patients (33.6%) had dental clinic visits less than one year prior to recruitment and 7.8% (19 patients) never visited a dentist before. The differences in the clinical profile of patients in both arms at baseline were not significantly different. However, post intervention, the mean changes in the fasting blood sugar of the patients were significant (95%CI -0.25, 1.29, p=0.014). (**Table 2**)

3.2 Clinical and dental outcomes of the dental health education

Table 3 demonstrates that the clinical outcomes of both intervention groups were not significantly different at the exit visit, except for fasting blood sugar (FBS). FBS in the Senyumanis group was observed to be significantly lower than the conventional care group (p=0.014). As for the dental outcomes, a significantly (p=0.018) higher proportion of patients in the Senyumanis group (43.8%) reported having had a dental visit during the study period as compared to the conventional group (28.6%).

3.3 Clinical outcomes according to dental visit status

The post-intervention values of HbA_{1c} and FBS were compared with their baseline values and classified into unchanged, increased or decreased (**Table 4**). The proportions of the patients in each of these categories were compared between those who had attended dental clinic du
ring the study and those who did not. There was a higher proportion (65.0%) of patients who had decreased HbA_{1c} levels among those who had seen a dentist during the study period

(p<0.001). However, there were no significant differences for the FBS levels at the exit visit between both groups of patients.

3.4 Reasons for no dental care utilisation during the study period

The main reasons given for not seeing a dentist in spite of being advised by the primary medical care doctor was that they had "no need for dental treatment" and "were worried of COVID-19 infection, hence decided to wait" (**Table 5**). There were similar findings between conventional care with 36 patients (42.3%) having "no need for dental treatment" and in the Senyumanis group, 28 patients (47.4%) had a similar reason.

3.5 Discussion

Despite the well-known fact that DM and periodontitis have a bidirectional relationship [3, 4, 6], dental behaviors and dental clinic attendance in T2DM patients in this study were still poor [35]. Based on the results of this study, only 82 out of 244 patients had visited a dental clinic less than one year before recruitment. Our findings were slightly lower than those of a local study, which found that 48.4% of T2DM patients visited a dental clinic [20]. This figure was also much lower compared to other studies conducted in England and the United States, where an average of 60-85% of patients had been to a dental clinic for less than one year [36, 37]. The findings also showed that the majority of patients brushed their teeth twice or more a day, and these results are consistent with earlier local studies and in other countries [36, 37, 38]. These different findings could be related to the socioeconomic status of patients. This demonstrated a lack of awareness of the importance of good oral hygiene practice and dental clinic utilization in patients with diabetes, as good oral health behaviors are favorably associated with adequate oral health literacy and knowledge they received from health care providers [39, 40, 41]

This study found a significant increase in post-intervention dental clinic visits in patients who received Senyumanis© as an educational tool. This significant improvement is possibly due to educational intervention guidance and encouraging patients to change risky health behaviors through personal action, thereby increasing the motivation to act and subsequently leading to improved health behaviour [42, 43]. These noticeable improvements were comparable to those reported in previous studies [44, 45, 46]. While the knowledge of the participants was not measured directly, the observed improvements in behaviours and attitudes can be reasonably attributed to the educational intervention provided by Senyumanis©. Educational interventions typically aim to enhance knowledge, which in turn influences attitudes and behaviours [42]. However, to our knowledge, there is no local educational intervention targeted at improving oral health practice and dental clinic visits among diabetes patients in Malaysia. This showed a great need for effective educational intervention measures that can help to increase dental clinic visits among T2DM patients. Ongoing reinforcement will also help to increase awareness, subsequently improving dental clinic attendance for long-term patients' self-care [47, 48].

In patients who received Senyumanis© as an intervention, significant differences were noted in mean FBS levels. In addition, patients who visited their dentists experienced reduction in HbA_{1C} levels. A previous study found that, when compared to usual standard care, a web-based educational tool improved blood glucose among PwD, with the mean differences in HbA_{1C} was –0.71% (95% CI –1.00, –0.43) [49]. The web-based educational tool has gradually been recognised as an effective medium for promoting health behaviour [50], as demonstrated in this

study, it aids in promoting dental clinic visits, subsequently providing impact on glycaemic control. Furthermore, with the widespread use of smartphones nowadays, web-based educational tool allows for self-directed learning at any place, which is very convenient for patients [51]. Moreover, a web-based educational tool can be a source of information for many patients and at a low cost [52]. However, this might be influenced by other factors, including patients' motivation or enthusiasm for using the web-based educational tool [53, 54]

The integration of dental care demonstrated the need for multidisciplinary care as an effective therapy in improving patients' glycaemic control [54, 55, 56] Oral health educational intervention among PwD in other countries that emphasized periodontal therapy including toothbrush instruction, oral health education and dental clinic visits reported improved glycaemic control by decreasing HbA_{1c} and periodontal status [15, 55, 57]. However, during the COVID-19 pandemic, dental clinic visits were affected [58]. This study found that 27.7% of patients did not visit the dental clinic post intervention because they were concerned about COVID-19 infection, hence they decided to wait or postpone the visit. Health promotions, on the other hand, such as those distributed through newspapers and social media, can help to reassure the public that if they visit a dental clinic, strictly enforced infection control and physical distancing will be in place so that they are at reduced risk for contracting COVID-19 [59].

Multidisciplinary interventions will be able to impact clinical outcomes if all disciplines involved work together to achieve a common goal, and this may be a challenge to sustain. The cooperation between primary medical care and primary dental care requires consistent conscientious effort to promote systemic effects of oral health into clinical practice to achieve holistic care for PwD, and also other non-communicable diseases in general. Commitment and dedication are essential to influence changes in clinical practice as well as healthcare policies.

This study is the first in Malaysia for web-based oral health educational intervention especially among PwD in primary medical care. There were no published local studies that look at dental clinic utilisation association with glycaemic control. Hence, this study provides fundamental information for future studies. This study also had a low dropout rate of patients' post-intervention in both groups due to its study design which allowed opportunistic dental intervention while patients received ongoing medical care for diabetes.

Nevertheless, there were limitations to this study. First, the convenience sampling of the study sites limits the generalisation of the study findings due to the selection bias. The stratified random sampling should be considered for the next research. Secondly, this study did a follow-up of the patients for 4 months post intervention only, which was a shorter duration to observe the actual practice on dental clinic visits and glycaemic control. Future studies should have a duration of at least 6 to 12 months post intervention to assess actual practice and observe the effect of multiple dental clinic visits and its association with glycaemic control. As observed in this study, some patients still did not go to a dental clinic, hence, future studies should explore patient's perception of the need for the dental clinic visits and other factors associated with dental clinic utilisation. Moreover, it was not known what dental treatment was done for those who attended dental clinics hence further exploration could be done to investigate the impact of specific dental procedures on the glycaemic control of T2DM patients. Finally, this study findings represent study populations from two university based primary medical care clinics only and generalizations on the nation's healthcare system should be interpreted with caution.

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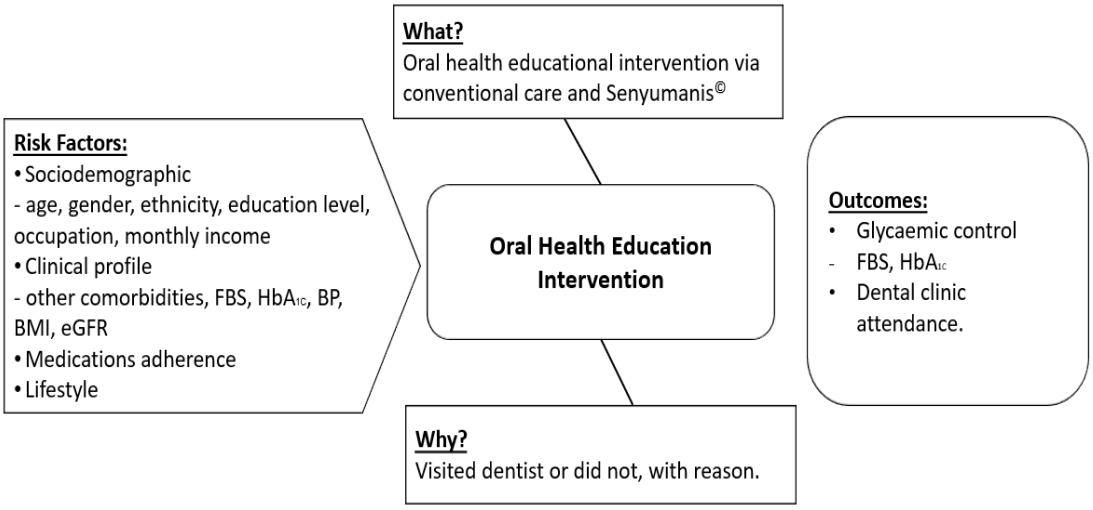

Figure 1: Conceptual Framework

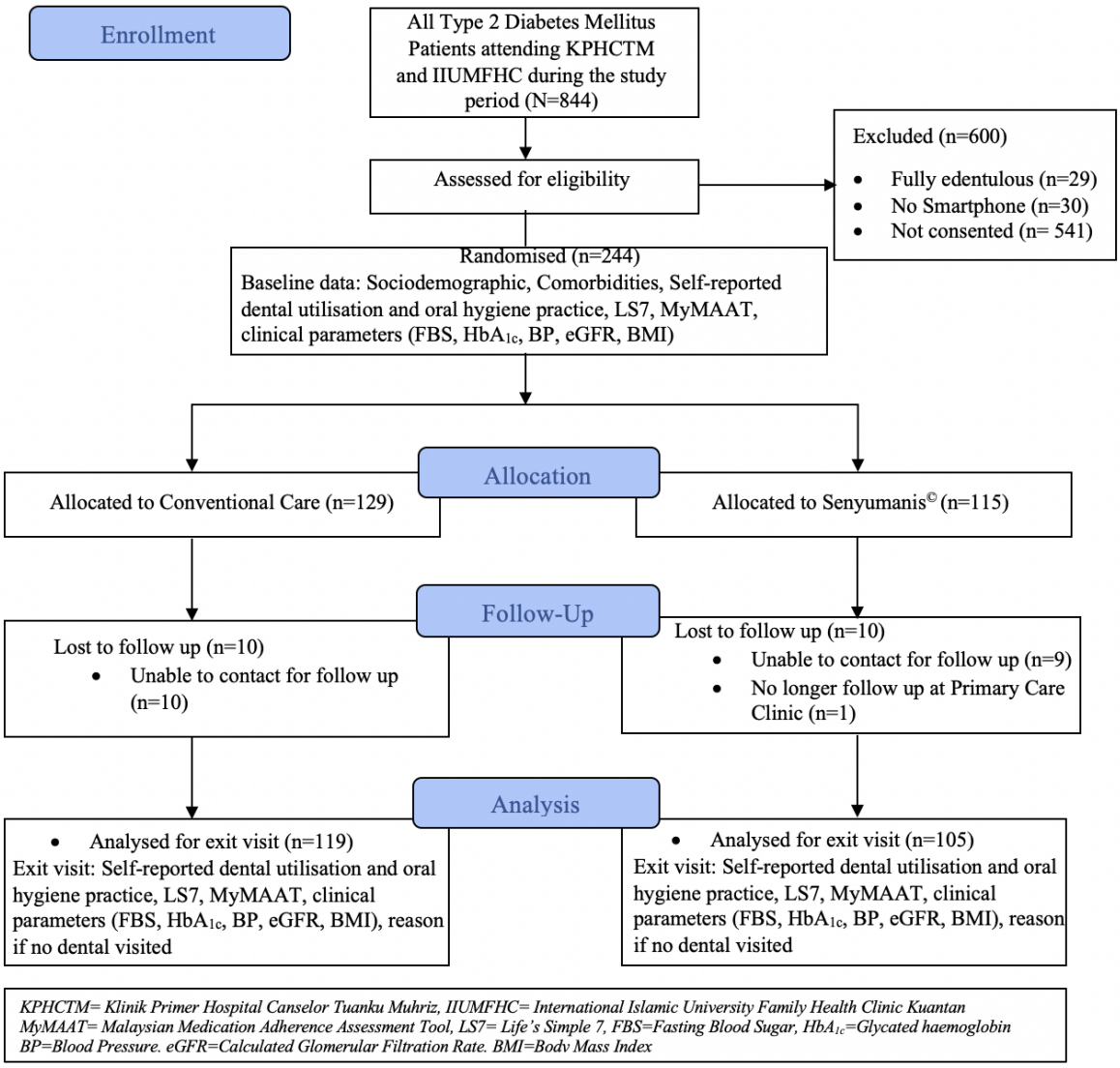

Figure 2: Study flow diagram

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Table 1 Baseline sociodemographic profile, clinical characteristics and dental behaviour of study participants

Variables	Total		Conventional Care		Senyumanis©	
Sociodemographic profile	**N = 244**	**(%)**	**N = 129**	**(%)**	**N = 115**	**(%)**
Age (Years), mean±SD	59.55±10.5		60.53±11.5		58.43±8.92	
< 45	27	(11.1)	14	(10.9)	13	(11.3)
45 – 54	36	(14.8)	19	(14.7)	17	(14.8)
55 – 64	97	(39.8)	44	(34.1)	53	(46.1)
> 65	84	(34.4)	52	(40.3)	32	(27.8)
Gender						
Male	124	(50.8)	70	(54.3)	54	(47.0)
Female	120	(49.2)	59	(45.7)	61	(53.0)
Ethnicity						
Malay	200	(82.0)	99	(76.7)	101	(87.8)
Chinese	26	(10.7)	21	(16.3)	5	(4.3)
Indian	18	(7.3)	9	(7.0)	9	(7.8)
Education						
Primary school	21	(8.6)	16	(12.4)	5	(4.3)
Secondary school	137	(56.1)	72	(55.8)	65	(56.5)
College or university	86	(35.2)	41	(31.8)	45	(39.1)
Occupation						
Retired	106	(43.4)	60	(46.5)	46	(40.0)
Employed	84	(34.4)	42	(32.6)	42	(36.5)
Unemployed	54	(22.1)	27	(20.9)	27	(23.5)
Monthly Income (RM)						
<1000	122	(50.0)	67	(51.9)	55	(47.8)
1001-3000	60	(24.6)	33	(25.6)	27	(23.5)
3001-5000	34	(13.9)	18	(14.0)	16	(13.9)
>5000	27	(11.1)	10	(7.8)	17	(14.8)
Clinical profiles						
Comorbidity						
Hypertension	176	(72.1)	96	(74.4)	80	(69.6)
Dyslipidemia	219	(89.9)	120	(93.0)	99	(86.1)
Chronic kidney disease	22	(9.0)	9	(7.0)	13	(11.3)
Obesity	94	(38.5)	49	(40.5)	45	(39.8)
LS7						
Optimal (Score 10-14)	23	(9.4)	12	(9.3)	11	(9.6)
Intermediate (Score 5-9)	202	(82.8)	107	(82.9)	95	(82.6)
Poor (Score 0-4)	19	(7.8)	10	(7.8)	9	(7.8)
MyMAAT						
Good (≤50)	244	(100)	129	(100)	115	(100)
Poor or moderate (>50)	0	(0)	0	(0)	0	(0)

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Dental behaviour						
Brush teeth at least twice daily	215	(88.1)	115	(89.1)	100	(87.0)
Yes	29	(11.9)	14	(10.9)	15	(13.0)
No						
Last dental visit within the past year	82	(33.6)	46	(35.7)	36	(31.3)
Yes	162	(66.4)	83	(64.3)	79	(68.7)
No						

LS7= Life's Simple 7. MyMAAT=Malaysian Medication Adherence Assessment Tool
p>0.05 for all variables

Table 2 Clinical parameters among patients before and after intervention with conventional care or Senyumanis©

Clinical parameters	Total mean, SD	Conventional care mean, SD	Senyumanis© mean, SD	Mean diff	(95% CI)	p value
Pre-intervention (baseline)						
Fasting blood sugar	8.20 ± 3.61	8.10 ± 3.47	8.32 ± 3.77	-0.22	(-1.14,0.70)	0.488 [a]
HbA_{1c}	7.95 ± 2.00	7.88 ± 2.09	8.03 ± 1.91	-0.14	(-0.66,0.36)	0.247 [a]
Systolic BP	137.71 ± 14.79	138.84 ± 14.43	136.46 ± 15.14	2.37	(-1.37,6.13)	0.208 [a]
Diastolic BP	79.45 ± 9.40	79.57 ± 9.95	79.31± 8.79	0.26	(-2.13,2.66)	0.952 [a]
Body mass index	29.33 ± 5.16	29.24 ± 5.14	29.43 ± 5.19	-0.19	(-1.51,1.12)	0.943 [a]
eGFR	82.54 ± 28.11	79.80 ± 26.22	85.68 ± 29.94	-5.87	(-13.22,1.46)	0.443 [a]
Post-intervention						
Fasting blood sugar	7.83 ± 2.96	8.07 ± 3.21	7.55 ± 2.63	0.51	(-0.25,1.29)	0.014 [a]
HbA_{1c}	7.79 ± 1.73	7.89 ± 1.83	7.67 ± 1.62	0.21	(-0.24,0.67)	0.108 [a]
Systolic BP	138.02 ± 14.29	138.60 ± 13.92	137.34 ± 14.74	1.25	(-2.29,5.19)	0.951 [a]
Diastolic BP	79.15 ± 8.69	79.73 ± 8.59	78.41 ± 8.80	1.24	(-0.96,3.60)	0.610 [a]
Body mass index	29.44 ± 5.39	29.33 ± 5.31	29.57 ± 5.52	-0.32	(-1.66,1.17)	0.683 [a]
eGFR	79.26 ± 25.32	78.44 ± 25.49	80.23 ± 25.21	-1.79	(-8.50,4.90)	0.575 [a]

HbA_{1c}=Glycated haemoglobin, BP=Blood pressure, eGFR=calculated Glomerular Filtration Rate
[a] Independent t-test, Level of significance: $p < 0.05$

Table 3 Clinical and dental outcomes of the health education intervention as per protocol

Outcome	Conventional care		Senyumanis©		p-value
Clinical	Mean	SD	Mean	SD	
Fasting blood sugar	8.07	± 3.21	7.55	± 2.63	**0.014**
HbA_{1c}	7.89	± 1.83	7.67	± 1.62	0.108
Systolic BP	138.60	± 13.92	137.34	± 14.74	0.951
Diastolic BP	79.73	± 8.59	78.41	± 8.80	0.610
Body mass index	29.33	± 5.31	29.57	± 5.52	0.683
eGFR	78.44	± 25.49	80.23	± 25.21	0.575
Dental	n	%	n	%	
Brushing teeth at least twice daily	110	92.4	98	93.3	0.795
Attended dental clinic during study period	34	28.6	46	43.8	**0.018**

HbA_{1c}=Glycated haemoglobin, BP=Blood pressure, eGFR=calculated Glomerular Filtration Rate

Table 4 Change of FBS and HbA_{1c} by Dental Visit Status

Clinical Parameter	Dental Visit	Post-intervention change			p-Value
		Unchanged	Increased	Decreased	
HbA_{1c}		n (%)	n (%)	n (%)	
	Yes	13 (16.3)	15 (18.8)	52 (65.0)	**<0.001**
	No	36 (25.0)	65 (45.1)	43 (29.9)	
FBS					
	Yes	7 (8.8)	33 (41.3)	40 (50.0)	0.14
	No	24 (16.7)	64 (44.4)	56 (38.9)	

Chi-square test, HbA_{1c}=Glycated haemoglobin, FBS=Fasting Blood Sugar

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Table 5 Reason for no dental visit during the study period (N=144)

Reasons	Total		Conventional care		Senyumanis©	
	N = 144	(%)	n = 85	(%)	n = 59	(%)
No need for dental treatment	64	44.4	36	42.3	28	47.4
Worried about COVID-19 infection, decided to wait	40	27.7	18	21.2	22	37.3
Busy with work	8	5.5	7	8.2	1	1.7
Staying in COVID-19 Red Zone	7	4.8	6	7.1	1	1.7
Dental treatment expensive	6	4.1	4	4.7	2	3.4
Could not get an appointment	6	4.1	4	4.7	2	3.4
Afraid of dental treatment	5	3.4	3	3.5	2	3.4
Given a dental appointment, but the date is too long	4	2.7	3	3.5	1	1.7
Dental clinic is far from house/work	2	1.3	2	2.4	0	0.0
Afraid of dentist	1	0.6	1	1.2	0	0.0
Need to be accompanied by son/daughter, both busy	1	0.6	1	1.2	0	0.0

4.0 Conclusion and recommendation

The use of web-based educational tool (Senyumanis©) helps in increasing oral health awareness, increased utilisation of dental clinic services and subsequently aided improvement of glycaemic control in patients with T2DM attending primary medical care clinics. However, the actual practice of the patients during the study period might be influenced by travel restrictions imposed during COVD-19 movement control order. Future studies should aim to obtain input from dental clinic attendance and feedback on oral health status of PwD

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Approval to conduct the study was obtained from the Research and Ethics Committee of Universiti Kebangsaan Malaysia (UKM PPI/111/8/JEP-2020-150). The study was also registered with the National Medical Research Registry (NMRR). Verbal and formal (i.e., signed) informed consent were obtained from all eligible patients. Throughout the research phase, their anonymity was maintained. The research was performed in accordance with the Declaration of Helsinki.

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Declaration

The authors declare that they have no competing interests

Authors contribution

AFAA and TNMD designed the study, while SLMAR and NSZ conducted it. SLMAR performed the statistical analysis, supervised by TNMD and HR. AFAA, AHS, HR, and AH provided technical and content expertise throughout the project. SLMAR, AFAA, and TNMD drafted the manuscript, which was read and approved by all authors.

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