Family Support-Based Intervention Using A Mobile Application By Pharmacists For Older Adults With Diabetes: A Randomised Controlled Trial

Potjana Poonprapai

Sadao Hospital

Sanguan Lerkiatbundit

Prince of Songkla University

Woranuch - Saengcharoen (✉ woranuch.s@psu.ac.th)

Prince of Songkla University <https://orcid.org/0000-0002-5157-9783>

Research Article

Keywords: Family support, mobile application, older adults, diabetes, pharmacists

Posted Date: August 12th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-772978/v1>

License: This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Abstract

Background Family support is crucial in the care of elderly patients with diabetes. Pharmacists have proven to play an important role in assisting patients to achieve goals of drug therapy. However, more information is needed to evaluate the potential benefits of family-based intervention through a mobile application by pharmacists in the elderly diabetes patients.

Objective To evaluate the influences of family support-based intervention using a mobile application on glycaemic control and diabetes control-related outcomes in the older adults with diabetes.

Setting A hospital in the south of Thailand.

Method A randomised controlled trial was conducted with 9 months of follow-up. Family members in the intervention group ($n = 78$) received diabetes educational courses and encouragement via a mobile application from pharmacists to help their elderly relatives with diabetes in self-management tasks. The control group received usual care ($n = 79$). *Main outcome measure* Glycosylated haemoglobin (HbA_{1c}).

Results As compared to baseline, significant improvements were observed in the intervention patients for HbA_{1c} , blood pressure, family behaviour in diabetes care, diabetes knowledge, self-management practices and medication adherence ($P \leq 0.001$). The intervention group showed greater decline in HbA_{1c} levels relative to the control group (-0.97% vs. -0.12% ; $P = 0.001$). Significant differences between groups for changes in blood pressure levels including scores of family behaviour, diabetes knowledge, self-management and medication adherence were found ($P \leq 0.001$), with the intervention group showing greater improvement.

Conclusion Family support intervention via a mobile application by pharmacists is beneficial to diabetes care for the elderly.

Trial registration number: TCTR20200615001 (date 13 June 2020, retrospectively registered).

Impact Of Findings On Practice

- Family support via a mobile application delivered by pharmacists provides benefits for glycaemic control in older adults with diabetes.
- Its effectiveness also involves corresponding improvements of family behaviour, diabetes knowledge, self-management activities and medication adherence.
- The family-based mobile intervention can be integrated into healthcare services targeted for the elderly to improve diabetes outcomes.

Introduction

Diabetes is a major health problem worldwide and may affect an estimated 700 million in 2045. The highest prevalence of diabetes in numerous countries including low and middle income countries was found in elderly people (aged 65 years and over) [1, 2].

The elderly patients with diabetes frequently have multimorbidity and higher premature mortality than those without this disease [2]. In addition, geriatric syndromes, such as impaired cognition, depression and multiple medications are the major presentations related diabetes in advanced age. These diabetes-associated conditions of the elderly may change a patient's self-management ability that results in adverse diabetes outcomes [2, 3]. The approach to diabetes care in the older adults should be individualized according to heterogeneity of their coexisting illnesses and geriatric syndromes [4].

Evidence suggests that social support promotes better health outcomes in chronic diseases including diabetes [5, 6]. Low and middle income countries tend to have strong kinship networks. Family members have a key role in the care of the elderly [7]. They may have insufficient awareness of patient care. Previous studies provided educational interventions for both family members and patients and reported improvement in diabetes control [8–10]. Family members represent as considerable sources of support for diabetes patients particularly the older adults [11]. The impact of family involvement on self-management practices was found to be significant. The success of self-management is the key to positive diabetes outcomes [2]. A family caregiver may or may not accompany patients during their hospital visits; he or she is unlikely to obtain complete information about the care of patients from the health professional for various reasons. The intervention strategy is critical to help family caregivers in acquiring regular education from health experts.

Nowadays, mobile phone has been engaged in daily life of people globally. Mobile applications (mobile apps) are used in not only managing many tasks in everyday life but also providing healthcare delivery beyond hospital borders [12]. Published articles have indicated that mobile apps are advantageous to assist self-management in diabetes [13, 14]. For health providers, pharmacists can play a meaningful role in advising patients on drug therapy. Likewise, they have been found to help patients in achieving lifestyle and therapeutic goals [15, 16]. An earlier research reported that pharmacist-led intervention was helpful to support family members in patients' self-management tasks and improved diabetes outcome [10]. To our knowledge, there is a lack of reports of models incorporating mobile apps into family support intervention by pharmacists in elderly diabetes care.

We designed a randomised controlled trial to examine the impact of family support intervention using mobile app to improve glycaemic control and other diabetes control-related outcomes targeted for older adults with type 2 diabetes. The educational intervention was delivered via mobile app by pharmacists to family members. Afterwards, the family members would inform the contents received to the patients. Using mobile app as a tool to deliver information could overcome cognitive overload found in face-to-face education where large amount of information is provided in a short time. Short interesting and easy-to-digest information provided through mobile app over a long time period is more likely to attract attention and facilitate learning, compared to traditional methods of education.

Aim of the study

The aim of this study was to evaluate the effectiveness of family support-based intervention via a mobile app by pharmacists on clinical outcomes, family behaviour, diabetes knowledge, self-management practices and medication adherence in older adults with type 2 diabetes.

Ethical considerations

Ethical approval for the study was granted from the Research Ethics Committees of Faculty of Pharmaceutical Sciences, Prince of Songkla University (ST. 0521.1.07/1105). Written informed consent was obtained from all participants and their family caregivers.

Methods

Study design

The study was designed as a two-arm randomised controlled trial. The setting was outpatient diabetes clinic at one hospital in the southern part of Thailand.

Participants

A research pharmacist recruited outpatients from the diabetes clinic at the study site.

Inclusion criteria were (1) ≥ 65 years of age, (2) a diagnosis of type 2 diabetes, (3) inadequate glycaemic control (glycosylated haemoglobin (HbA_{1c}) level $> 7\%$ or 53 mmol/mol), (4) receipt of oral antihyperglycaemic agents, and (5) having a family member as a caregiver. The eligible family members were (1) ≥ 18 years old, (2) a spouse, child or relative of the patient, and (3) able to participate in this study by using mobile phone. Patients who received insulin therapy were excluded from the study.

All participants were randomly assigned to either the intervention group or the control group. The allocated sequence was generated by stratified randomisation method based on age of patients, HbA_{1c} levels and duration of diabetes.

To calculate sample size, determination performed using HbA_{1c} from the study by Wichit et al. [9]. At the end of the study, HbA_{1c} levels in the intervention and control groups were $7.0 \pm 1.2\%$ and $7.3 \pm 1.4\%$, respectively. With 0.05 for type 1 error and 80% for power of test, a sample size of 74 patients within each group was needed.

Control group

The control group received usual care provided by health professionals at the diabetes clinic. In the usual care, pharmacists normally examined the prescription validity and identified drug-related problems.

Intervention group

Beyond usual care, study patients also received family-based intervention via a mobile app. The goal of the intervention was to facilitate family members' assistance in the patients' self-management tasks for achieving the diabetes goals. Physicians were blinded to the intervention.

The research pharmacist provided diabetes care information to family members in the form of infographics via a mobile app. The information on infographics was based on the "Standard of Medical Care in Diabetes – 2018" [17]. The contents of the education strategy consisted of 6 main sessions: (1) diabetes knowledge; (2) self-management practices; (3) pharmacological therapy; (4) common comorbidities and management (hypertension, dyslipidaemia); (5) stimulating family caregivers' motivation to help patients in diabetes care, and (6) reminders for medication taking and medical appointment.

The research pharmacist delivered diabetes education every day for 3 months. At the end of each session, 1–3 quizzes were released to family caregivers. Additionally, medication reminders were distributed 4 times a day: 6.00 am, 12.00 pm, 6.00 pm and 8.00 pm, and physician appointment reminders sent 1 week before the appointment date. If family caregivers had any diabetes-related problems, they were able to send their queries to the research pharmacist anytime that they wanted to. After that, the feedback would be tailored to the questioner directly.

Outcomes

The primary outcome was change in HbA_{1c} of the intervention group relative to the control group. Secondary outcomes were changes in (1) family behaviour (supportive and obstructive behaviour) in the diabetes care measured by the revised version of the Diabetes Family Behaviour Checklist [18], for which Cronbach's alpha was 0.84 for this study, (2) diabetes knowledge evaluated by the General Knowledge of Patients with Diabetes [19], for which Kuder-Richardson Formula 20 (KR-20) was 0.7 for this study, (3) self-management practices assessed by the modified version of the Summary of Diabetes Self-Care Activities Scale [20], for which Cronbach's alpha was 0.54 for the current study, (4) medication adherence, and (5) blood pressure. Except for diabetes knowledge, which was measured in both patients and their families, all outcomes were assessed in patients. The outcomes were determined at baseline and at 9 months after the intervention. Nonetheless, adherence to medications was assessed at every visit, 3 month apart, until the end of the study.

Adherence to diabetes medication was based on pill count during hospital visit and calculated using the formula: [(number of pills received - number of pills remaining)/number of pills received] x 100.

Statistical analysis

Participant characteristics were presented as frequency with percentage for categorical data and mean with standard deviation (SD) for continuous data. Differences in demographic characteristics between the intervention and control groups were analysed using chi-square test for categorical variables and independent samples *t*-test for continuous variables. To compare primary and secondary outcomes of the two groups, between-group differences were examined using independent samples *t*-test and within-group differences were tested using paired *t*-test. Comparisons of changes in medication adherence scores between groups at different time were evaluated using split-plot ANOVA. Statistical significance was considered at *P*-values < 0.05. The analyses were conducted with SPSS version 22.0 (SPSS Inc., Chicago, IL, USA).

Results

The patient enrolment began in January 2019 and the final follow-up of the study participants finished in January 2021.

The flow chart of participants throughout the study is illustrated in Fig. 1. The 166 eligible patients who agreed and took part in the study, were allocated to the intervention group (*n* = 83) and the control group (*n* = 83). However, 5 intervention patients and 4 control patients were dropouts during the follow-up.

For characteristics of patients and their family caregivers, no significant differences in patients' characteristics were apparent between the two groups at baseline (*P* > 0.05) (Table 1), whereas their relatives' characteristics

were significantly different between groups in gender, age, education, patient’s relationship and living in the same house as patients ($P < 0.05$).

Table 1Characteristic details of patients and their family caregivers

	Intervention group (n = 78)	Control group (n = 79)	<i>P</i> value
<i>Patients</i>			
Gender			
Male	31 (39.7)	32 (40.5)	0.922
Female	47 (60.3)	47 (59.5)	
Age (mean $\pm$ SD)	67.36 $\pm$ 5.72	67.80 $\pm$ 6.18	0.645
Education			
$\leq$ Primary school	63 (80.8)	59 (74.7)	0.654
Secondary school	10 (12.8)	13 (16.5)	
> Secondary school	5 (6.4)	7 (8.9)	
Marital status			0.538
Single	2 (2.6)	0	
Married	54 (69.2)	55 (69.6)	
Divorced/widowed	22 (28.2)	24 (30.4)	
Duration of diabetes (mean $\pm$ SD) (years)	6.97 $\pm$ 3.32	6.87 $\pm$ 3.20	0.847
Comorbidity			
Hypertension	73 (93.6)	71 (89.9)	0.398
Dyslipidaemia	67 (85.9)	63 (79.7)	0.307
Antidiabetic medication			
Metformin	16 (20.5)	22 (27.8)	0.260
Glipizide	5 (6.4)	3 (3.8)	
Metformin + glipizide	37 (47.4)	43 (54.4)	
Glipizide + pioglitazone	1 (1.3)	0	
Metformin + glipizide + pioglitazone	19 (24.4)	11 (13.9)	
<i>Family caregivers</i>			
Gender			
Male	20 (25.6)	35 (44.3)	0.014

Female	58 (74.4)	44 (55.7)	
Age (mean $\pm$ SD)	41.24 $\pm$ 12.90	48.53 $\pm$ 13.16	0.001
Education			
$\leq$ Primary school	11 (14.1)	26 (32.9)	0.021
Secondary school	23 (29.5)	19 (24.1)	
> Secondary school	44 (56.4)	34 (43.0)	
Relationship			
Husband/wife	13 (16.7)	29 (36.7)	0.017
Son/daughter	56 (71.8)	42 (53.2)	
Others (e.g. niece, nephew)	9 (11.5)	8 (10.1)	
Living in the same house			
Yes	56 (71.8)	67 (84.8)	0.048
No	22 (28.2)	12 (15.2)	
Duration of patient care (mean $\pm$ SD) (years)	6.87 $\pm$ 3.20	6.75 $\pm$ 3.24	0.808

At baseline, clinical outcomes (HbA_{1c} and blood pressure) were not significantly different between groups (Table 2). Within the intervention group, HbA_{1c} and blood pressure significantly declined from baseline to 9 months ($P < 0.001$). At the end of the study, changes in HbA_{1c} and blood pressure were significantly different between the intervention and control groups ($P \leq 0.001$).

Table 2 Comparisons of changes in clinical outcomes within and between groups (mean $\pm$ SD)

	Baseline			At 9 months (change from baseline)		Between-group difference at 9 months	
	Intervention group (n = 78)	Control group (n = 79)	<i>P</i> value	Intervention group (n = 78)	Control Group (n = 79)	Mean (95% CI)	<i>P</i> value
HbA _{1c} (mmol/mol)	71.33 ± 17.46	71.61 ± 18.43	0.922	-10.61 ± 17.60	-1.31 ± 18.09	-9.30 (-14.93, -3.68)	0.001
<i>P</i> value*				< 0.001	0.522	-	
HbA _{1c} (%)	8.68 ± 1.60	8.70 ± 1.69	0.922	-0.97 ± 1.61	-0.12 ± 1.66	-0.85 (-1.37, -0.34)	0.001
<i>P</i> value				< 0.001	0.522	-	
SBP (mmHg)	141.06 ± 12.47	138.18 ± 14.82	0.189	-9.05 ± 11.31	2.72 ± 14.92	-11.77 (-15.95, -7.60)	<0.001
<i>P</i> value				< 0.001	0.109	-	
DBP (mmHg)	77.26 ± 9.67	74.28 ± 10.63	0.068	-4.91 ± 11.07	1.85 ± 12.00	-6.76 (-10.40, -3.12)	<0.001
<i>P</i> value				< 0.001	0.175	-	

HbA_{1c} = Glycosylated haemoglobin; SBP = systolic blood pressure; DBP = diastolic blood pressure

* Within group comparison using paired *t*-test

There were no significant differences between groups in diabetes control-related outcomes (scores of family behaviour, patients' knowledge, caregivers' knowledge and self-management) at baseline (Table 3). Compared to baseline, all items of diabetes control-related outcomes significantly increased in the intervention group ($P < 0.05$). Significant increase in patients' knowledge and self-management scores also occurred in the control group ($P = 0.014$). After the 9-month intervention, changes scores in all diabetes control-related outcomes differed significantly between groups ($P \leq 0.001$).

Table 3 Comparisons of changes in diabetes control-related outcomes within and between groups (mean ± SD)

	Baseline			At 9 months (change from baseline)		Between-group difference at 9 months	
	Intervention group (n = 78)	Control group (n = 79)	<i>P</i> value	Intervention group (n = 78)	Control Group (n = 79)	Mean (95% CI)	<i>P</i> value
Family behaviour	18.63 ± 4.20	18.38 ± 4.23	0.712	1.78 ± 3.50	-0.28 ± 4.28	2.06 (0.83, 3.29)	0.001
<i>P</i> value*				< 0.001	0.565	-	
Supportive	12.47 ± 3.07	12.62 ± 2.96	0.762	1.45 ± 2.88	-0.27 ± 3.07	1.72 (0.78, 2.65)	< 0.001
<i>P</i> value				< 0.001	0.443		
Obstructive	6.15 ± 1.43	5.76 ± 1.66	0.113	0.33 ± 1.46	-0.01 ± 1.80	0.35 (-0.17, 0.86)	0.188
<i>P</i> value				0.047	0.950		
Diabetes knowledge					-		
Patients	14.47 ± 2.56	14.54 ± 3.58	0.888	2.86 ± 1.99	0.63 ± 2.23	2.22 (1.56, 2.89)	< 0.001
<i>P</i> value				< 0.001	0.014		
Caregivers	14.53 ± 3.29	14.70 ± 3.89	0.767	3.15 ± 2.86	0.29 ± 1.62	2.86 (2.13, 3.60)	< 0.001
<i>P</i> value				< 0.001	0.114		
Self-management	42.06 ± 9.96	41.86 ± 9.56	0.896	5.95 ± 7.46	1.94 ± 6.83	4.01 (1.76, 6.27)	0.001
<i>P</i> value				< 0.001	0.014	-	

* Within group comparison using paired *t*-test

Medication adherence scores between groups showed no significant differences at the beginning of the study (*P* = 0.750) (Table 4). The intervention group had greater increases in the adherence scores than the control group at different time from 3 months to 9 months, with interaction of group x time and between-group differences in change patterns being significant (*P* < 0.001).

Table 4
Comparisons of changes in medication adherence scores between groups overtime (mean $\pm$ SD)

	Intervention group (n = 78)	Control group (n = 79)	Between-group difference at 9 months	
			Mean (95% CI)	Pvalue*
Baseline	87.17 $\pm$ 2.04	87.28 $\pm$ 2.29	-0.11 (-0.79, 0.57)	0.750
3 months**	1.65 $\pm$ 1.39	0.13 $\pm$ 1.43	1.41 (0.72, 2.09)	< 0.001
6 months**	0.99 $\pm$ 1.79	0.13 $\pm$ 1.33	2.27 (1.57, 2.96)	< 0.001
9 months**	1.61 $\pm$ 3.40	0.94 $\pm$ 1.71	2.94 (1.96, 3.91)	< 0.001
* Repeated measures ANOVA				
An interaction of group x time ($P < 0.001$)				
** Change from baseline				

Discussion

This randomised controlled trial demonstrated that family support-based intervention delivered through a mobile app had positive effect on glycaemic control for older adults with diabetes. The improvement in family support, diabetes knowledge, self-management behaviour and medication adherence was also in accordance with the family-involved intervention.

Significant improvement in glycaemic control was seen in the family-based intervention group compared with the control group. The results of this study were agreement with those obtained from studies by Shi et al. [8] and Withidpanyawong et al. [10] which indicated that family support was beneficial for diabetes control. The previous studies had family caregivers accompanied with the patients to take part in the intervention courses, whereas the present study had the family members participate in the intervention sessions only via mobile app. Unlike the current study, a trial by Wichit et al. [9] found lack of difference between groups in glycaemic control when using a family-involved method. However, the follow-up period in the prior trial [9] was only 13 weeks, which is shorter than that in this study (9 months follow-up). Wichit et al. [9] study also provided additional education to participants at week 9. Nevertheless, after this education delivery no further data were gathered 3 months later, that is the optimal timing for HbA_{1c} measurement [2]. Accordingly, it may not be possible to measure the small changes in HbA_{1c}. Findings here confirmed the results of an earlier meta-analysis [21] which indicated that family involvement in patient care was a substantial resource for the control of diabetes outcomes. Adequate glycaemic control is a key aspect of prevention of diabetes-related microvascular and macrovascular complications, particularly in the elderly [22, 23].

Apart from diabetes content of the intervention in this study, the education for family caregivers focused on hypertension-related lifestyle modification. Accordingly, the results showed positive impact on systolic and diastolic blood pressure in the intervention group with significant differences from those in the control group. Lee et al. [24] reported that family assistance was a strong factor for self-regulation in the elderly patients with

uncontrolled hypertension. The American Diabetes Association [2] recommends blood pressure targets $< 140/90$ mm Hg for elderly patients with diabetes. Although baseline blood pressure levels in the intervention group (141/77 mm Hg) were slightly higher than the guideline target, family members' participation presented as the considerable factor for improvement in these outcomes (132/72 mm Hg). Strict blood pressure control leads to diminished risks of mortality and diabetes complications including nephropathy and cardiovascular diseases [2, 22].

The present findings pointed out that significant increases for supportive and obstructive family behaviour were observed in the intervention group compared to baseline, similar to those of Withidpanyawong et al. [10] study. Helpful family involvement was associated with better self-management of diabetes, on the other hand harmful involvement was related to worse self-management adherence. However, the intervention group experienced significantly greater positive care from family members than did the control group. This may make the participants manage their diabetes more effectively and lead to the improved glycaemic control that was seen in our results.

Elderly diabetes patients are at high risk for developing geriatric syndromes including cognitive dysfunction [2]. A low education level was a significant factor for the insufficient knowledge regarding diabetes self-management in the elderly [25]. The majority of study participants here completed their education at primary school or lower (intervention group 81% vs. control group 75%). Furthermore, the usual hospital education for patients with diabetes was similar in both the intervention and control groups. Nevertheless, the intervention group had a larger improvement in knowledge than did the control group that may be attributed to information acquired from family caregivers using mobile app. Higher diabetes knowledge was significantly associated with better self-management practices and lower HbA_{1c} [26].

Effective self-management behaviour is essential to meet glycaemic goals [2]. Results here observed that self-management practices improved significantly more in the family intervention group than in the control group. The results were consistent with findings in the study by Wichit et al. [9]. Previous research by Getie et al. [27] supported our findings that having family members as caregivers positively affected diabetes self-management. Intervention family caregivers here were predominantly spouses or children (88.5%) and in-home partners (71.8%). Caregivers who were spouses or children acted as the key providers for assistance in terms of self-management [28]. Likewise, more frequent contact or being in-home supporters was correlated with better control of diabetes [29]. However, significant increments in self-management activities were also detected in the control group when compared to baseline. There may be contamination bias from the intervention patients and/or Hawthorne effects from intensive follow-up that may change the behaviour of the control patients.

The intervention group had significantly better medication adherence than did the control group. The family intervention was effective for improving adherence as shown in a trial conducted by Withidpanyawong et al. [10]. Mayberry et al. [29] suggested that greater caregiver closeness had an association with adherence to diabetes medications. Accordingly, the intervention patients who received more support from their family members may increasingly adhere to medication taking. In contrast, patients who perceived taking medications to be unimportant were more likely to have non-adherence [30]. The current study informed the intervention patients about the importance of taking prescribed medications through family-based education via mobile app. This matter may enhance patients' awareness and improve their behavior in taking medications. Medication adherence was an important factor related to glycaemic target (HbA_{1c} $< 7\%$) in patients with diabetes [2, 31].

The utilisation of mobile app incorporating with family support for elderly diabetes care is the strength of this study. The mobile app has capacity to provide diabetes education as well as facilitate interactions between family caregivers and health providers such as pharmacists. This mobile technology saves family members time and expense by decreasing travel to clinics, which is especially helpful for persons who have hectic schedules or distance barriers [32]. However, there are several limitations to the current study. The participants were recruited from a single hospital in Thailand, hence there is a limitation on generalisability of the findings. In addition, differences in demographic characteristics of family caregivers between the intervention and control groups may affect the research findings. Finally, this study investigated only patients who received oral antidiabetic agents; the results may differ for those who used insulin injections, where the administration is more complicated than that of oral medications.

Conclusion

The present study demonstrated that family-involved intervention based on a mobile app can help older adults with diabetes to achieve better glycaemic control, the primary outcome, than the traditional care. Additionally, favourable changes related to the intervention were detected in secondary outcomes including blood pressure, family behaviour, diabetes knowledge, self-management activities and medication adherence. Further research is important to evaluate the long term effects of family intervention and to design the superior delivery of diabetes care services for the elderly.

Declarations

Acknowledgement The authors are grateful to all participants and their family members for contribution in this study. We would like to acknowledge Prof. Dr. Deborah J. Toobert, Prof. Dr. Russell E. Glasgow and Prof. Dr. Supakit Wongwiwatthanakul for granting the permission to use their instruments. We also acknowledge Dr. Alan Geater for editorial assistance with the manuscript.

Funding This study was supported by Faculty of Pharmaceutical Sciences, Prince of Songkla University, Songkhla, Thailand (grant number PHA6104057S).

Conflicts of interest All authors have no conflicts of interest relevant to this study.

References

1. International Diabetes Federation (IDF). IDF diabetes atlas. 2019. <http://www.diabetesatlas.org>. Accessed 1 Jul 2021.
2. American Diabetes Association. Standards of medical care in diabetes-2021. *Diabetes Care*. 2021;44(suppl 1):1–179.
3. Atif M, Saleem Q, Babar ZU, Scahill S. Association between the vicious cycle of diabetes-associated complications and glycemic control among the elderly: a systematic review. *Medicina*. 2018;54(5):73.
4. Sesti G, Antonelli Incalzi R, Bonora E, Consoli A, Giaccari A, Maggi S, et al. Management of diabetes in older adults. *Nutr Metab Cardiovasc Dis*. 2018;28(3):206–18.
5. Lee AA, Piette JD, Heisler M, Rosland AM. Diabetes distress and glycemic control: the buffering effect of autonomy support from important family members and friends. *Diabetes Care*. 2018;41(6):1157–63.

6. Shao Y, Liang L, Shi L, Wan C, Yu S. The effect of social support on glycemic control in patients with type 2 diabetes mellitus: the mediating roles of self-efficacy and adherence. *J Diabetes Res.* 2017;2017:2804178.
7. Lambert SD, Bowe SJ, Livingston PM, Heckel L, Cook S, Kowal P, et al. Impact of informal caregiving on older adults' physical and mental health in low-income and middle-income countries: a cross-sectional, secondary analysis based on the WHO's study on global ageing and adult health (SAGE). *BMJ Open.* 2017;7(11):e017236.
8. Shi M, Xu MY, Liu ZL, Duan XY, Zhu YB, Shi HM, et al. Effectiveness of family involvement in newly diagnosed type 2 diabetes patients: a follow-up study. *Patient Educ Couns.* 2016;99(5):776–82.
9. Wichit N, Mnatzaganian G, Courtney M, Schulz P, Johnson M. Randomized controlled trial of a family-oriented self-management program to improve self-efficacy, glycemic control and quality of life among Thai individuals with type 2 diabetes. *Diabetes Res Clin Pract.* 2017;123:37–48.
10. Withidpanyawong U, Lerkiatbundit S, Saengcharoen W. Family-based intervention by pharmacists for type 2 diabetes: a randomised controlled trial. *Patient Educ Couns.* 2019;102(1):85–92.
11. Kristianingrum ND, Wiarsih W, Nursasi AY. Perceived family support among older persons in diabetes mellitus self-management. *BMC Geriatr.* 2018;18(suppl 1):304.
12. Yu Y, Yan Q, Li H, Li H, Wang L, Wang H, et al. Effects of mobile phone application combined with or without self-monitoring of blood glucose on glycemic control in patients with diabetes: a randomized controlled trial. *J Diabetes Investig.* 2019;10(5):1365–71.
13. Agarwal P, Mukerji G, Desveaux L, Ivers NM, Bhattacharyya O, Hensel JM, et al. Mobile app for improved self-management of type 2 diabetes: multicenter pragmatic randomized controlled trial. *JMIR Mhealth Uhealth.* 2019;7(1):e10321.
14. Jeffrey B, Bagala M, Creighton A, Leavey T, Nicholls S, Wood C, et al. Mobile phone applications and their use in the self-management of type 2 diabetes mellitus: a qualitative study among app users and non-app users. *Diabetol Metab Syndr.* 2019;11:84.
15. Bukhsh A, Nawaz MS, Ahmed HS, Khan TM. A randomized controlled study to evaluate the effect of pharmacist-led educational intervention on glycemic control, self-care activities and disease knowledge among type 2 diabetes patients: a consort compliant study protocol. *Medicine.* 2018;97(12):e9847.
16. Korcegez EI, Sancar M, Demirkan K. Effect of a pharmacist-led program on improving outcomes in patients with type 2 diabetes mellitus from Northern Cyprus: a randomized controlled trial. *J Manag Care Spec Pharm.* 2017;23(5):573–82.
17. American Diabetes Association. Standards of medical care in diabetes-2018. *Diabetes Care.* 2018;41(suppl 1):1–159.
18. Glasgow RE, Toobert DJ. Social environment and regimen adherence among type II diabetic patients. *Diabetes Care.* 1988;11(5):377–86.
19. Wongwiwatthanakit S, Krittiyanunt S, Wannapinyo A. Development and validation of an instrument to assess the general knowledge of patients with diabetes. *Thai J Pharm Sci.* 2004;28:17–29.
20. Toobert DJ, Hampson SE, Glasgow RE. The summary of diabetes self-care activities measure: results from 7 studies and a revised scale. *Diabetes Care.* 2000;23(7):943–50.
21. Kodama S, Morikawa S, Horikawa C, Ishii D, Fujihara K, Yamamoto M, et al. Effect of family-oriented diabetes programs on glycemic control: a meta-analysis. *Fam Pract.* 2019;36(4):387–94.

22. Dal Canto E, Ceriello A, Ryden L, Ferrini M, Hansen TB, Schnell O, et al. Diabetes as a cardiovascular risk factor: an overview of global trends of macro and microvascular complications. *Eur J Prev Cardiol.* 2019;26(2 suppl):25–32.
23. McGurnaghan S, Blackbourn LAK, Mocevic E, Haagen Panton U, McCrimmon RJ, Sattar N, et al. Cardiovascular disease prevalence and risk factor prevalence in type 2 diabetes: a contemporary analysis. *Diabet Med.* 2019;36(6):718–25.
24. Lee E, Park E. Self-care behavior and related factors in older patients with uncontrolled hypertension. *Contemp Nurse.* 2017;53(6):607–21.
25. Borba A, Arruda IKG, Marques APO, Leal MCC, Diniz ADS. Knowledge and attitude about diabetes self-care of older adults in primary health care. *Cien Saude Colet.* 2019;24(1):125–36.
26. Bukhsh A, Khan TM, Sarfraz Nawaz M, Sajjad Ahmed H, Chan KG, Goh BH. Association of diabetes knowledge with glycemic control and self-care practices among Pakistani people with type 2 diabetes mellitus. *Diabetes Metab Syndr Obes.* 2019;12:1409–17.
27. Getie A, Geda B, Alemayhu T, Bante A, Aschalew Z, Wassihun B. Self-care practices and associated factors among adult diabetic patients in public hospitals of Dire Dawa administration, Eastern Ethiopia. *BMC Public Health.* 2020;20(1):1232.
28. Pesantes MA, Del Valle A, Diez-Canseco F, Bernabe-Ortiz A, Portocarrero J, Trujillo A, et al. Family support and diabetes: patient's experiences from a public hospital in Peru. *Qual Health Res.* 2018;28(12):1871–82.
29. Mayberry LS, Piette JD, Lee AA, Aikens JE. Out-of-home informal support important for medication adherence, diabetes distress, hemoglobin A1c among adults with type 2 diabetes. *J Behav Med.* 2019;42(3):493–501.
30. Xu N, Xie S, Chen Y, Li J, Sun L. Factors influencing medication non-adherence among Chinese older adults with diabetes mellitus. *Int J Environ Res Public Health.* 2020;17(17):6012.
31. Horii T, Momo K, Yasu T, Kabeya Y, Atsuda K. Determination of factors affecting medication adherence in type 2 diabetes mellitus patients using a nationwide claim-based database in Japan. *PLoS One.* 2019;14(10):e0223431.
32. Ashrafzadeh S, Hamdy O. Patient-driven diabetes care of the future in the technology era. *Cell Metab.* 2019;29(3):564–75.

Figures

Figure 1

Study participant flow diagram