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Influence of pharmaceutical care on health outcomes in patients with Type 2 diabetes mellitus

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WHAT IS ALREADY KNOWN ABOUT THIS SUBJECT

- Pharmaceutical care programmes delivered by pharmacists are known to improve quality of care for both ambulatory and hospitalized patients with a variety of chronic and acute conditions.
- Reduction of HbA_{1c} and normalization of blood pressure are key targets for diabetes care programmes, since they are key to reducing diabetes complications.
- Good knowledge about disease, medications, diet and exercise requirements can improve the effectiveness of self-management of diabetes.

WHAT THIS STUDY ADDS

- In a randomized, controlled clinical trial, a comprehensive pharmaceutical care programme (consisting of patient education and advice on medication adherence, metabolic control and life style) delivered by a clinical pharmacist over a 12-month period, significantly improved glycaemic control and health-related quality of life in Type 2 diabetes patients attending a military hospital outpatient clinic in the United Arab Emirates (UAE).
- A significant reduction in HbA_{1c} was important in the reduction of the 10-year coronary heart disease risk scores (by British National Formulary and Framingham methods) seen in patients who received the present care programme.
- The outcomes of this study advocate an increased role for clinical pharmacists in the healthcare system in the UAE.

AIMS

To examine the influence of a pharmaceutical care programme on disease control and health-related quality of life in Type 2 diabetes patients in the United Arab Emirates.

METHODS

A total of 240 Type 2 diabetes patients were recruited into a randomized, controlled, prospective clinical trial with a 12-month follow-up. A range of clinical measures, medication adherence and health-related quality of life (Short Form 36) were evaluated at baseline and up to 12 months. Intervention group patients received pharmaceutical care from a clinical pharmacist, whereas control group patients received their usual care from medical and nursing staff. The primary outcome measure was change in HbA_{1c}. British National Formulary and Framingham scoring methods were used to estimate changes in 10-year coronary heart disease risk scores in all patients.

RESULTS

A total of 234 patients completed the study. Significant reductions ($P < 0.001$) in mean values (baseline *vs.* 12 months; 95% confidence interval) of HbA_{1c} [8.5% (8.3, 8.7) *vs.* 6.9% (6.7, 7.1)], systolic [131.4 mmHg (128.1, 134.7) *vs.* 127.2 mmHg (124.4, 130.1)] and diastolic blood pressure [85.2 mmHg (83.5, 86.8) *vs.* 76.3 mmHg (74.9, 77.7)] were observed in the intervention group; no significant changes were noted in the control group. The mean Framingham risk prediction score in the intervention group was 10.56% (9.7, 11.4) at baseline; this decreased to 7.7% (6.9, 8.5) ($P < 0.001$) at 12 months but remained unchanged in the control group.

CONCLUSIONS

The pharmaceutical care programme resulted in better glycaemic control and reduced cardiovascular risk scores in Type 2 diabetes patients over a 12-month period.

Introduction

Diabetes mellitus is a chronic metabolic disease that directly affects well being and poses a high morbidity risk [1]. Most patients with Type 2 diabetes have a combination of risk factors, including abdominal obesity, high triglycerides, low high-density lipoprotein-cholesterol (HDL-C) levels and hypertension [2, 3]. The long-term vascular complications associated with Type 2 diabetes account for the majority of morbidity and mortality in patients [4]. The Hypertension in Diabetes Study Group revealed a sevenfold increase in risk of mortality in Type 2 diabetic patients with hypertension compared with non-diabetic, normotensive patients [5]. The co-existence of Type 2 diabetes and hypertension carries significantly increased risk of coronary heart disease (CHD) and renal disease [6].

Pharmaceutical care (PC) programmes developed and implemented by pharmacists have been found useful in improving the quality of care of both ambulatory and hospitalized patients with various diseases such as hypertension [7], asthma [8], dyslipidaemia [9], heart failure [10] and tuberculosis [11]. Considering the complications of Type 2 diabetes and its high prevalence, many disease management strategies have been developed and implemented in various clinical settings across the world. Together with hospital-based clinician-monitored programmes, pharmacist-led community/hospital-based PC programmes can be devised in an attempt to achieve better glycaemic, metabolic and blood pressure control in this patient group [12].

The latter involves working closely with the patient in designing, implementing and monitoring therapeutic plans to produce improved therapeutic outcomes through a reduction of medicine-related problems [13]. The primary means of improving disease management in diabetic patients are via prudent pharmacological therapy and through lifestyle changes, both of which require significant cooperation and participation from patients [14]. Concerning pharmacological therapy, the aims are to optimize the patient's medication and, second, to ensure that the patient is able and willing to adhere to the prescribed treatments [15]. Such adherence can be assisted by improved patient awareness of their disease state and also by the application of a self-monitoring programme [16]. The concept of PC delivery in Type 2 diabetes is well explored [17–21]. However, many of these studies have limitations, such as small sample size [16], nonrandomized design [22] and lack of consideration of glycosylated haemoglobin (HbA_{1c}) [23].

According to the Centre for Arab Genomic Studies, the United Arab Emirates (UAE) has a high and increasing prevalence of diabetes in its native population. A national survey conducted jointly by the World Health Organization and the UAE Ministry of Health between 1998 and 2000 indicated a 19.6% prevalence of diabetes mellitus among its nationals. Furthermore, it has been revealed by recent studies in the UAE that prevalence of diabetes is higher in people aged ≥60 years [24].

In the UAE, clinical pharmacy services are at an early stage of development. The overall aim of the present study was to investigate, via a randomized controlled clinical trial, the effect of a pharmacist-led PC programme on disease control and health-related quality of life in Type 2 diabetes patients within the UAE. Specific objectives of the study were:

1 to measure the impact of the PC programme on the quality of care of Type 2 diabetic patients as measured by a range of clinical and humanistic outcomes. The primary outcome measure chosen was HbA_{1c} (reduction) by the end of the 12-month study period
2 to evaluate the impact of PC (at 12 months' follow-up) on 10-year risk of CHD (intervention group *vs.* control group).

Methods

Study design

The study was a randomized, controlled, longitudinal, prospective clinical trial with a 12-month patient follow-up. The study protocol was approved by the Research Ethical Committee, Faculty of Medicine, Emirates University, UAE. The study site was Zayed Military Hospital, UAE, a 400-bed facility. Patients were recruited from the general medical wards and from endocrinology and medical outpatient clinics.

Sample size

A sample size calculation, based on published data on the variability of HbA_{1c} in Type 2 diabetes patients [25], indicated that to detect an absolute difference of >1% in HbA_{1c}, with $\alpha = 0.05$ and a power of 0.90 (90%), a sample size of 104 patients in each of the control and intervention groups was required. Based on these data, to ensure sufficient statistical power and to account for 'drop-outs' during the study, a target sample size of 240 patients (120 control and 120 intervention) was selected. The target population was recruited over a period of approximately 1 year.

Study subjects

Patients with Type 2 diabetes mellitus who fulfilled the entrance criteria (i.e. confirmed diagnosis of Type 2 diabetes mellitus by a hospital consultant, receiving oral hypoglycaemic therapy, hospital consultant consented to patient entering trial, patient provided written informed consent to their participation in the research) and had no exclusion criteria present (i.e. secondary forms of hypertension, serum creatinine >184 mmol l^{-1}, macroalbuminuria >300 mg 24 h^{-1}, history of cerebrovascular accidents, convulsive disorder, diabetic proliferative retinopathy or diabetic autonomic neuropathy) were identified for inclu-

sion in the study. Patients who were willing to participate were provided with additional written information and asked to sign the study consent form. If patients themselves were unable to sign the consent form, their next of kin or caregivers were asked to sign on their behalf.

After recruitment, patients were randomly assigned to one of two groups: intervention group or control group. The group allocations were carried out using restricted randomization [26] with both groups being matched as closely as possible for gender and presence of hypertension i.e. diastolic blood pressure ≥90 mmHg (hypertensive) or <90 mmHg (normotensive) [27].

Baseline measurements and assessments

After randomization, each patient was interviewed face-to-face (for approximately 20 min) by the research pharmacist and/or clinical pharmacy staff and a chart review undertaken to obtain details on demographics, family history of diabetes, medications being used, diabetes symptoms, frequency of daily home blood glucose monitoring, diabetes and medication knowledge, adherence to medication and lifestyle advice and to record baseline values of body weight and body mass index (BMI), fasting blood glucose, HbA_{1c}, systolic and diastolic blood pressure, serum total cholesterol, serum creatinine, serum HDL-C, serum low-density lipoprotein-cholesterol (LDL-C) and serum triglycerides [9]. Patients were also asked to self-complete questionnaires on health-related quality of life [Short Form (SF) 36] [28]. Arabic versions of the questionnaires were used when the patient was unable to read/understand English.

Pharmaceutical care interventions

For all patients randomized to the intervention group, the research pharmacist had discussions with their physicians regarding drug therapy and, if necessary, treatment modification was recommended, e.g. more intensive management of hypertension or simplification of dosage regimens if deemed appropriate [29], taking account of the latest American Diabetes Association (ADA) recommendations [30].

Patients who were randomized to the intervention group were educated on their illness and their medication in a structured fashion, including discussion on risk of diabetes complications, proper dosage, side-effects and storage of medications, healthy lifestyle and management of diabetes mellitus signs and symptoms through self-monitoring [31].

A printed leaflet to assist with the education programme was developed and the patient was given a copy to take home. Supplementary leaflets containing information about hypertension and hyperlipidaemia were also given to the patients if they suffered from these conditions. The educational advice was reinforced when patients came to the hospital pharmacy to collect their prescribed medicines on their monthly schedule.

In addition, behavioural modification aspects of the PC intervention involved advice on the following: self-monitoring of glycaemic control (patients were encouraged to monitor their blood glucose levels three times per day, to record these values and bring a record book to all subsequent appointments); physical exercise (this involved initiation of an exercise plan that could be incorporated into the patient's daily schedule, after taking into consideration their level of fitness, e.g. 1-h walk daily; diet (the patient was assisted with the identification of dietary behaviour that adversely influences blood glucose control, lipid levels, weight management, and of the times of day when the patient was most vulnerable to overeating, and given improved understanding of the relative effects of certain food choices on blood glucose control); medication adherence (patients were asked about any problems that they had encountered with regard to taking their medication and were offered education and practical help to encourage them to take the medicines prescribed for them by their physician); and smoking cessation (patients were encouraged to stop smoking by advising them about the danger of smoking to health, with emphasis on the increased dangers of smoking in diabetic patients).

The patients randomized to the control group received their normal care (from medical and nursing staff), but did not receive the clinical pharmacy service, i.e. did not receive pharmacist input into treatment plans or patient education; the patients did, however, receive advice on self-monitoring their blood glucose by medical or nursing staff.

Outcome measures

Both groups of patients were asked to return to the hospital outpatient clinic at the scheduled appointment intervals followed by the hospital (4-month intervals) to allow follow-up assessments. All patients (intervention and control group) were assessed as per initial baseline assessment at their scheduled clinic visits (4, 8 and 12 months) by pharmacy staff. Where subjective measures were used, i.e. adherence and health-related quality of life, a standard protocol for questionnaire administration was used to reduce potential bias. The latter outcome measures were only assessed at baseline and 12 months.

Scores for medication knowledge were obtained from answers given by patients when asked to name their prescribed diabetes medicines, the daily dosage, the strength and purpose of each medicine and any significant adverse effects that could result from each medicine. Each correct answer was awarded one mark, with no marks awarded if the patient did not know or gave an incorrect answer. A percentage score was calculated by adding all the marks together, dividing by the maximum possible score and multiplying by 100. Medication knowledge was graded as good (when scored ≥50%) or poor (when scored <50%) [10].

Regarding self-reported adherence to medication, those patients who reported forgetting doses, intentionally missing or taking extra doses were classed as non-adherent [10]. No account was taken of intelligent non-adherence, i.e. when a patient decides for good reason, for example, to take an extra dose or miss a dose. Adherence to lifestyle advice (diet, exercise, smoking, alcohol intake) was scored. Each positive parameter answer was awarded one mark, with no marks awarded if the patient had not made the suggested lifestyle adjustment. A percentage score was calculated by adding all the marks together, dividing by the maximum possible individualized score and multiplying by 100. Adherence with lifestyle adjustment was graded as poor adherence (if score was <75%) or adherence (if the score was ≥75%).

Furthermore, a 10-year risk assessment was carried out for all patients using British National Formulary (BNF) prediction charts [32] and the Framingham scoring method [33, 34] at baseline and at the end of the study period. These methodologies take account of age, gender, smoking status, total cholesterol, HDL and systolic blood pressure.

Data analysis

Statistical analyses were performed using the SPSS package v. 13 (SPSS Inc., Chicago, IL, USA). A per protocol approach was used. Data were summarized as (means ± SD), geometric means or mean differences with 95% confidence intervals (CI). Area under the curve values (AUC) were used as a summary measure to compare parameters, which were assessed at 4, 8 and 12 months. A *P*-value of <0.05 was considered statistically significant. Two-sample comparisons were made using Student's *t*-tests for normally distributed variables or Mann–Whitney *U*-tests for non-normally distributed data (0 and 12 months). Comparisons of proportions were carried out using χ^2, Fisher's exact or McNemar's tests.

Results

A total of 240 patients were recruited in the study. Out of 120 patients recruited to each group, 117 completed the study, i.e. three patients dropped out in each group (four patients left the UAE to go to their home country and two patients left their military work and were no longer eligible to receive military hospital services). Figure 1 illustrates the flow of patients through the study and describes various stages at which data were collected. The age, gender, duration of diabetes and family history of diabetes for the two groups are presented in Table 1. Statistical analyses indicated that the groups were well matched ($P > 0.05$ in all cases). Table 2 indicates medications used for diabetes and other concomitant diseases such as hypertension and or hyperlipidaemia in the study population.

Table 1

Baseline demographics of the study participants

Variable		Intervention group (n = 120)	Control group (n = 120)
Gender	Male	84 (70%)	82 (68.3%)
	Female	36 (30%)	38 (31.7%)
Mean age (years)		48.7 ± 8.2	49.9 ± 8.3
Age group (years)	35–50	74 (61.7%)	70 (58.3%)
	51–65	43 (35.8%)	47 (39.2%)
	>65	3 (2.5%)	3 (2.5%)
Duration of diabetes (years)		6.1 ± 2.9	6.2 ± 2.7
Family history of diabetes	Yes	53 (44.2%)	45 (37.5%)
	No	67 (55.8%)	75 (62.5%)

Values are given as geometric mean (percent of total participants of intervention/control group) or geometric mean ± standard deviation.

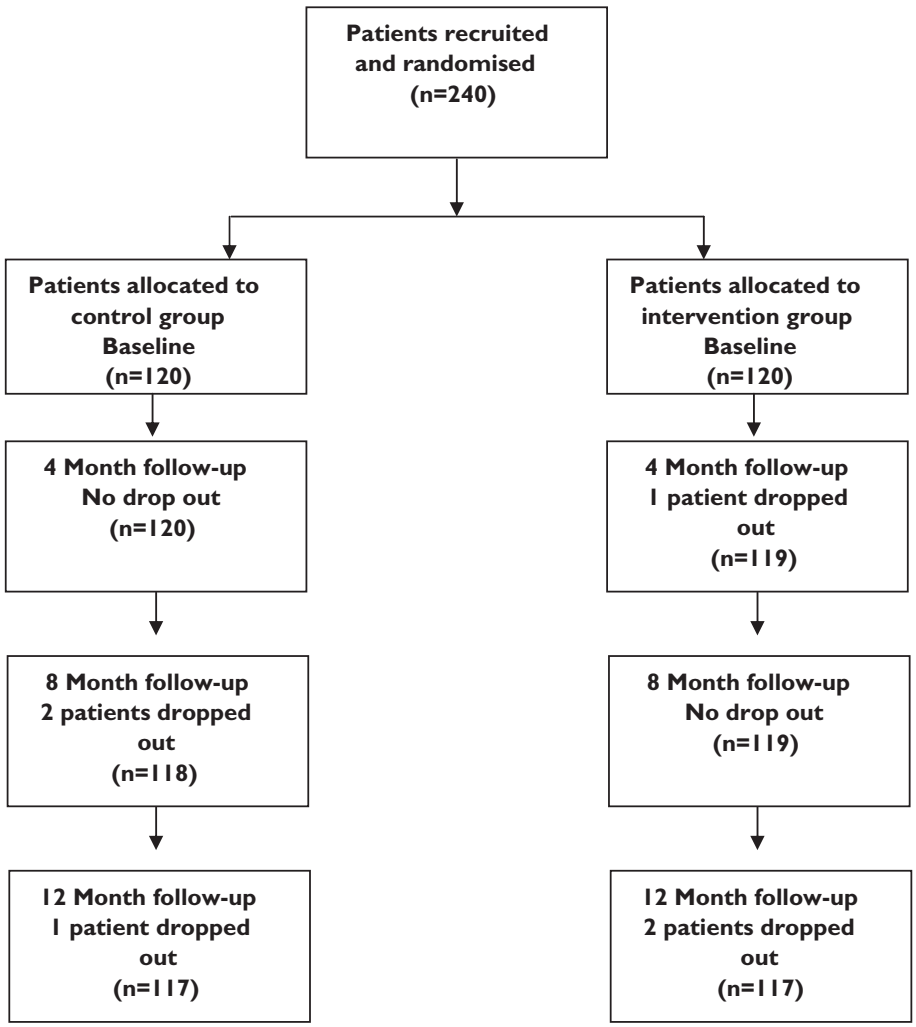
Clinical outcome measures

No intervention approach or data collection instrument presented any major difficulties during the study. Changes in key clinical variables over 12 months in the two groups are shown in Table 3, including statistically significant changes in the area under the curve (AUC; summary measure) for the outcomes measured at 0, 4, 8 and 12 months. BMI was used to categorize patients into normal BMI (<25 kg m^{-2}), overweight (25–30 kg m^{-2}) and obese (>30 kg m^{-2}). Data over the study period indicated that the number of the intervention and control group patients who were placed in these three categories did not vary over time ($P > 0.05$). Mean BMI decreased significantly in the intervention group over time (baseline *vs.* 12-month values; $P < 0.005$; Table 3), with no corresponding change in the control group ($P > 0.05$).

Intervention group patients had slightly higher mean fasting blood glucose readings at baseline, but this was not statistically significant ($P > 0.05$). Mean fasting blood glucose levels decreased (Table 3) for both groups over the 12-month study period, but intervention group patients showed higher decreases ($P < 0.001$).

In the case of HbA_{1c}, the primary outcome measure of the study, mean baseline values in both groups were approximately the same (Table 3). A significant reduction ($P < 0.001$) in HbA_{1c} levels (intervention *vs.* control) was achieved at 12 months (mean reduction 1.66%; Table 3). There were significant differences at 4, 8 or 12 months ($P < 0.05$) between the two groups.

At the baseline assessment, intervention group and control group patients exhibited approximately the same mean systolic and diastolic blood pressure. There were significant differences at 4, 8 and 12 months ($P < 0.05$) between the two groups. In addition, diastolic blood pressure of patients in the intervention group decreased over time. Lipid profiles also showed significant reductions ($P < 0.001$) in mean values of serum total cholesterol, serum LDL-C and serum triglycerides (intervention group *vs.*



Pharmaceutical care was initiated at baseline in the intervention group and education/advice reinforced at 4 and 8 month follow-up visits. Control group patients received normal care from medical and nursing staff only throughout the study period, i.e. no clinical pharmacy input. Outcome measure data were measured at baseline, 4, 8 and 12 months (with exception of SF36, adherence and CHD risk prediction scores which were evaluated only at baseline and 12 months).

Figure 1

Flow chart relating to various phases of randomized controlled clinical trial

control group), whereas the mean value of serum HDL-C was significantly ($P < 0.05$) increased (baseline *vs.* 12 months; 1.20 to 1.32 mmo l^{-1}).

Health-related quality of life (SF36 Questionnaire)

SF36 scores at baseline and at 12 months are given in Table 4. Although in some cases the mean control group domain scores for the SF36 were higher than the intervention group values at baseline, in all cases the 12-month domain scores were higher in the intervention group patients (Table 4). Intervention group patients' quality of life scores improved over time ($P < 0.001$), whereas those of control group patients remained relatively constant.

Diabetes knowledge and medication adherence

The assessment of medication knowledge is an important outcome measure in evaluating the effectiveness of diabetes education programmes [35]. The analysis of data showed that 60.8% ($n = 73$) of intervention group patients and 64.2% ($n = 77$) of control group patients had poor medication knowledge at baseline. However, at 12 months, 47% (55 out of 117) of the intervention group patients had poor knowledge compared with 64.1% (75 out of 117) in the control group, indicating a positive impact on medication knowledge of intervention group patients.

Non-adherence (self-reported) with prescribed medications was 48.3% in the intervention group at baseline and 49.1% in the control group. At the 12-month assessment, these values were reduced to 21.4 and 32.5%, respectively.

Table 2

Medications used for diabetes and other concomitant diseases such as hypertension and/or hyperlipidaemia in the study population

Medicine used (daily doses)		No. of patients	% Patients
Oral hypoglycaemic drugs	Glibenclamide (5 mg)	115	47.9
	Gliclazide (80 mg)	112	46.6
	Metformin (500 mg)	159	66.3
	Rosiglitazone (4 mg)	12	5.0
ACE inhibitors	Lisinopril (10 mg), Perindopril (4 mg), Enalapril (10 mg), Captopril (25 mg)	74	30.8
Angiotensin IIA antagonist	Valsartan (80 mg)	7	2.9
Others Antihypertensive drugs	Calcium channel blocker, (Amlodipine 5 mg, Nifedipine 10 mg); Diuretics (Indapamide, 2.5 mg); β-blocker (Atenolol, 100 mg)	42	17.5
Statins	Simvastatin, Pravastatin, Atorvastatin, Fluvastatin	71	29.6
	Analgesics or nonsteroidal anti-inflammatory drugs	14	20.9
	Herbal products or cough syrups	22	32.8
OTC drugs	Antacids or laxatives	2	3
	Vitamins	29	43.3
	Total patients taking OTC drugs	67	27.9

χ^2 analyses were used to compare self-reported adherence with the lifestyle adjustments (1-h walk daily, carbohydrate-restricted diet and cessation of smoking and alcohol) between the intervention group and control group patients at baseline and at 12 months. At baseline the number of intervention group and control group patients who were deemed to be adherent (≥75% score) with recommended lifestyle adjustments was approximately the same (85 *vs.* 81, respectively; $P > 0.05$). At the 12-month assessment, an increase in the number of intervention group patients who reported adherence ($n = 95$) was observed, whereas there was the opposite effect in the control group ($n = 75$). Overall medication knowledge, medication adherence and lifestyle adherence were significantly higher at the 12-month assessment in the intervention patients when compared with control group patients ($P < 0.05$).

Ten-year CHD risk using BNF and Framingham prediction scores

The mean (CI) Framingham prediction scores were 10.6 (9.7, 11.4) at baseline for the intervention group and 11.4 (10.6, 12.2) for the control group. At the 12-month assessment the value decreased to 7.7 (6.9, 8.5; $P < 0.001$) in the intervention group but remained unchanged at 11.5 (10.5, 12.3) in the control group ($P > 0.05$). The BNF risk prediction indicated a marked increase in the number of patients at low risk (63.3–85.5%) in the intervention group at 12 months (Table 5). Patients at moderate risk also decreased from 36.7 to 13.7% in the intervention group over the study period. Correspondingly, there was a slight reduction in the number of patients in the low-risk group from 65.0 to 59.0% and a slight increase in the moderate-risk group from 31.7 to 37.6% in the control group patients. A similar approach in CHD risk score comparison at baseline and over a period of 12 months to assess the effect of a PC programme in Type 2 diabetes patients has been reported by the Australian Fremantle Diabetes Study [36].

Discussion

The present study was designed to measure the impact of a PC programme on a wide range of clinical and humanistic outcomes related to the different aspects of healthcare in patients with Type 2 diabetes mellitus. The broad range of data in the present study allowed comprehensive assessment of the potential benefits of the intervention. Enhanced patient outcomes were noted in the intervention group, e.g. a reduction in HbA_{1c} and fasting blood glucose levels, improvement in health-related quality of life as measured by SF36, decreased systolic and diastolic blood pressure, improved adherence to the prescribed medication and lifestyle advice and a reduction in CHD risk factors. All intervention approaches (e.g. diabetic education booklet) and data collection instruments were without any major difficulties during the research study.

Main findings of the study

An important outcome of the study was a significant reduction in HbA_{1c} levels in intervention group patients. Although decreases in HbA_{1c} in this study were better than earlier data reported by Berringer *et al.* [37], the decrease in mean fasting blood glucose in the intervention group did not reach the ADA target goal (5–7.2 mmol l^{-1}). The Diabetes Control and Complications Trial Research Group (DCCT) study reported a 1.90% reduction in HbA_{1c} levels [38] in the intervention group compared with 1.66% in the present study; however, the DCCT study involved younger patients with Type 1 diabetes.

Based on well-established epidemiological data [39], the improvements achieved in HbA_{1c} values, if maintained,

Table 3

Values of clinical parameters at various time intervals in intervention and control groups

Clinical parameter	Baseline IG	CG	4 months IG	CG	8 months IG	CG	12 months IG	CG	AUC values for IG	AUC values for CG	*P*-value*	*P*-value**	*P*-value***
BMI (kg m^{-2})	28.34 (27.55, 29.13)	27.98 (27.09, 28.86)	–	–	–	–	27.29 (26.57, 28.02)	27.99 (27.15, 28.83)	–	–	0.545	0.004	–
Fasting blood glucose (mmol l^{-1})	10.83 (10.28, 11.38)	10.26 (9.82, 10.70)	8.21 (7.88, 8.53)	10.05 (9.63, 10.47)	7.91 (7.65, 8.17)	9.89 (9.44, 10.34)	7.78 (7.50, 8.06)	9.48 (9.04, 9.91)	100.55 (97.96, 103.14)	120.63 (116.84, 124.43)	0.113	<0.001	<0.001
HbA_{1c} (%)	8.5 (8.3, 8.7)	8.4 (8.2, 8.6)	7.6 (7.4, 7.8)	8.0 (7.8, 8.2)	7.1 (6.9, 7.2)	8.4 (8.2, 8.6)	6.9 (6.7, 7.1)	8.3 (8.1, 8.5)	88.6 (87.0, 90.2)	101.3 (98.8, 103.8)	0.405	<0.001	0.003
Systolic blood pressure (mmHg)	131.4 (128.1, 134.7)	132.6 (129.0, 136.2)	124.0 (121.4, 126.6)	130.7 (127.5, 133.9)	126.8 (124.4, 129.3)	132.2 (129.6, 135.3)	127.2 (124.4, 130.1)	132.1 (130.8, 135.1)	1485.9 (1436.9, 1534.9)	1563.7 (1510.7, 1616.7)	0.638	<0.001	0.028
Diastolic blood pressure (mmHg)	85.2 (83.5, 86.8)	83.9 (82.0, 85.8)	78.4 (77.2, 79.6)	83.7 (82.0, 85.5)	77.4 (76.3, 78.6)	82.1 (80.3, 84.0)	76.3 (74.9, 77.7)	84.1 (82.4, 85.8)	922.2 (893.3, 951.1)	1000.1 (987.7, 1015.5)	0.338	<0.001	<0.001
Serum total cholesterol (mmol l^{-1})	5.26 (5.06, 5.45)	5.27 (5.07, 5.47)	4.65 (4.51, 4.78)	5.33 (5.11, 5.55)	4.49 (4.35, 4.62)	5.24 (5.05, 5.44)	4.47 (4.33, 4.61)	5.32 (5.12, 5.52)	55.98 (54.72, 57.24)	63.51 (61.65, 65.37)	0.937	<0.001	<0.001
Serum HDL-C (mmol l^{-1})	1.20 (1.16, 1.25)	1.19 (1.13, 1.24)	1.30 (1.24, 1.37)	1.21 (1.16, 1.26)	1.29 (1.25, 1.35)	1.17 (1.12, 1.23)	1.32 (1.27, 1.38)	1.20 (1.14, 1.25)	15.46 (14.92, 16.00)	14.29 (13.78, 14.81)	0.652	<0.01	0.002
Serum LDL-C (mmol l^{-1})	3.55 (3.37, 3.74)	3.48 (3.31, 3.64)	3.11 (2.99, 3.24)	3.51 (3.33, 3.69)	3.08 (2.94, 3.21)	3.59 (3.42, 3.75)	3.04 (2.92, 3.16)	3.61 (3.44, 3.78)	37.84 (36.68, 39.01)	42.66 (41.08, 44.23)	0.531	<0.001	<0.001
Serum triglycerides (mmol l^{-1})	1.60 (1.46, 1.74)	1.55 (1.43, 1.67)	1.34 (1.24, 1.44)	1.58 (1.46, 1.71)	1.26 (1.18, 1.35)	1.61 (1.46, 1.76)	1.25 (1.17, 1.33)	1.74 (1.61, 1.87)	15.88 (14.96, 16.80)	19.53 (18.25, 20.81)	0.616	<0.001	<0.001

P-values: *when baseline values of IG and CG are compared; **when 12-month values of IG and CG are compared; ***when AUCs for IG and CG are compared. Data are geometric mean (CI). AUC, area under the curve; CG, control group; IG, intervention group; BMI, body mass index; HDL-C, high-density lipoprotein-cholesterol; LDL-C, low-density lipoprotein-cholesterol.

have the potential for major health gains in Type 2 diabetic patients. The impact achieved in the cohort of patients in this UAE study was comparable to improvements achieved by other researchers, using a range of intervention approaches. In the present research an important finding was that more patients in the intervention group (45.4%) than in the control group (30.3%) achieved the ADA target goal for HbA_{1c} of <7% at the 12-month assessment ($P < 0.0213$). Corresponding data from the McWhorter and Oderda [40] study, conducted in a Utah community health centre, indicated that 38.4% of patients in the intervention group and 27.7% in the control group achieved the ADA target over 6 months ($P < 0.0412$).

The improvements in HbA_{1c} in the present study were probably due to improved adherence to prescribed medication and lifestyle modifications [15]. The Australian Fremantle Diabetes Study [36] showed that pharmacist participation in patient care can significantly improve HbA_{1c} independent of pharmacotherapeutic changes. This latter community-based study involved 180 Type 2 diabetic patients whose HbA_{1c} was decreased by a mean of 0.5% over 12 months from a baseline of 7.5%, whereas there was no change in the control group. Another long-term study [22] showed a reduction in mean HbA_{1c} levels from 7.5 to 7.1% over 4 years. Taken together with the results of the present study, it is clear that PC can result in significant patient benefit in a range of environments over a range of intervention durations.

A positive impact on blood glucose levels was seen in the present study. Earlier work by Berringer *et al*. [37] evaluated the effects of a PC model on outcomes of self-monitored blood glucose (SMBG), SMBG frequency, and medication adherence rates for patients with diabetes at two independent community pharmacies in Richmond (USA). In the first setting, average morning blood glucose values ($n = 27$) decreased from 9.9 to 8.8 mmol l^{-1}, from baseline to 6 months, respectively ($P = 0.07$). In the second setting, blood glucose values ($n = 23$) decreased from 9.94 to 8.32 mmol l^{-1} from baseline and 12 months ($P < 0.05$). There was no statistical difference in SMBG frequency. The mean fasting blood glucose level in the present study decreased dramatically from 10.8 to 7.8 mmol l^{-1} in the intervention patients, whereas it decreased from 10.3 to 9.5 mmol l^{-1} in the control patients. The change in fasting blood glucose level in the control group was 0.8 mmol l^{-1} and 3.0 mmol l^{-1} in the intervention group at the 12-month assessment, i.e. exceeded the drop reported by Berringer *et al*. [37].

Irons *et al*. reported a retrospective cohort analysis of the clinical effectiveness of a physician–pharmacist collaborative drug therapy management diabetes programme in which they concluded that pharmacist-managed diabetes care was effective in improving glycaemic control and was not associated with an increased risk of hypoglycaemic events or unscheduled diabetes-related clinic visits [41].

Table 4

Summary of Short Form 36 data for the different quality of life domains

Domain	Score at baseline* IG	CG	*P*-value	Score at 12 months* IG	CG	*P*-value
Bodily pain	43.2 (40.1, 46.4)	52.8 (49.1, 56.5)	0.054	66.7 (63.5, 69.8)	45.9 (42.6, 49.1)	<0.001
General health	67.8 (66.4, 69.3)	66.6 (64.8, 68.5)	0.318	77.6 (76.4, 78.8)	69.2 (67.6, 76.8)	<0.001
Mental health	60.4 (58.0, 62.7)	64.8 (62.4, 67.2)	0.009	71.5 (69.5, 73.5)	60.9 (58.6, 63.2)	<0.001
Physical functioning	40.3 (36.6, 44.1)	49.3 (45.6, 53.1)	0.090	62.4 (58.8, 65.9)	48.0 (43.8, 52.2)	<0.001
Role-emotional	31.7 (24.7, 38.6)	40.0 (31.7, 48.3)	0.128	60.1 (52.6, 67.6)	48.8 (22.1, 50.4)	<0.001
Role-physical	37.3 (20.8, 43.8)	42.7 (34.7, 50.7)	0.010	67.1 (60.7, 73.5)	46.9 (20.4, 53.4)	<0.001
Social functioning	66.6 (63.3, 69.8)	74.4 (70.9, 77.9)	0.010	87.2 (85.0, 89.3)	66.9 (64.0, 69.7)	<0.001
Vitality	49.7 (47.1, 52.3)	55.1 (52.6, 57.7)	0.030	63.6 (61.1, 66.0)	49.9 (47.5, 52.3)	<0.001

*Values are given as mean (95% CI). CG, control group; IG, intervention group.

Table 5

Classification and comparison of patients for 10-year coronary heart disease (CHD) risk scores calculated by British National Formulary (BNF) and Framingham methods

	BNF 10-year CHD risk prediction method					
	No. of patients in different risk categories at baseline			No. of patients in different risk categories at 12 months		
Group	**<15% (mild)**	**15–30% (moderate)**	**>30% (severe)**	**<15% (mild)**	**15–30% (moderate)**	**>30% (severe)**
Intervention (*n* (%))	76 (63.3%)	44 (36.7%)	0	100 (85.5%)	16 (13.7%)	1 (0.9%)
Control (*n* (%))	78 (65.0%)	38 (31.7%)	4 (3.3%)	69 (59.0%)	44 (37.6%)	4 (3.4%)
P*-value	0.125			<0.001		
	Framingham 10-year CHD risk prediction method					
	No. of patients in different risk categories at baseline			No. of patients in different risk categories at 12 months		
	<10% (mild)	**10–20% (moderate)**	**>20% (severe)**	**<10% (mild)**	**10–20% (moderate)**	**>20% (severe)**
Intervention (*n* (%))	58 (48.3%)	60 (50%)	2 (1.7%)	80 (68.4%)	37 (31.6%)	0
Control (*n* (%))	48 (40%)	71 (59.2%)	1 (0.8%)	43 (36.8%)	74 (63.2%)	0
P*-value	0.392			<0.001		

*When comparing control and intervention groups.

The research data (Table 3) revealed that there were significant differences over time between the two groups with regard to blood pressure control (systolic and diastolic). There was no evidence that the improvements in the intervention group were due to improved prescribing, since patients in both groups were prescribed a similar range of effective antihypertensive medication. These outcomes were therefore probably due to better adherence to medications and lifestyle advice [42–47]. In the present research an important finding was that more patients in the intervention group (33.6%) than in the control group (25.4%) achieved target blood pressure (systolic and diastolic) values < 130/80 as recommended in hypertension guidelines [3, 48]. These UAE results were an improvement on those reported by McFarlane *et al*., where a target blood pressure of <130/80 mmHg was achieved in 28% of their study patients [49]. Improved adherence to medication and lifestyle advice was also likely to be the main factor in improving lipid profiles.

The improvement in health-related quality of life may in part be attributed to the increased contact of diabetic patients with the clinical pharmacist, but is also likely to be associated with improved adherence to lifestyle advice. The results of the present study lend support to the use of the SF36 as an outcome for evaluating health education programmes in patients with diabetes, as suggested by Brown *et al*. [50]. The results of the present study indicate that PC interventions can have a positive impact on how diabetes patients are able to cope with daily activities [36, 51, 52].

Good knowledge about medications, diet, exercise, self-monitoring of blood glucose and treatment modifications is necessary in the effective self-management of diabetes [53]. However, knowledge alone does not guarantee requisite behaviour modifications or effective self-management. The assessment of diabetes-related knowledge is an important outcome measure in diabetes education programmes [54–56]. The present results indicate that the intervention group patients achieved greater medication knowledge during the 12-month assessment period. A study by McWhorter *et al*. [57] has confirmed that more patients who were provided care, such as education

about their disease and medication by the pharmacist, reached the ADA HbA_{1c} target goal of <7%.

Researchers have estimated that, in general, the rate of non-adherence to prescribed medications ranges from 25 to 50% [58]. Non-adherence has been implicated as a major cause of unnecessary hospitalization of patients with diabetes or unscheduled diabetes-related clinic visits [41]. Patient counselling and education are essential for improving outcomes, including patient adherence [52]. The intensive education by the clinical pharmacist in the present study improved adherence (self-reported) at the 12-month assessment period.

Epidemiological analysis (UKPDS) links a 0.5% HbA_{1c} reduction to an estimated 7% reduction in the risk of myocardial infarction and an estimated 12% reduction in risk of stroke [38]. The outcomes of the 10-year CHD risk predictions using BNF and Framingham prediction scores showed a clear positive impact of the present intervention in reducing the risk of CHD in intervention group patients. The present study has paved the way towards integration of clinical pharmacy services into overall healthcare delivery to Type 2 diabetes mellitus patients in the UAE.

Conclusions

The present study has clearly demonstrated the value of comprehensive PC provision to this patient group and provides evidence for negotiation with healthcare managers in the UAE regarding increased pharmacy staffing levels within the hospital service. The main strengths of the study are the diverse outcome measures used and the low drop-out rate. However, it covered a period of only 12 months. Furthermore, consideration must be given to the differences that can occur between a statistically significant difference and a clinically important difference. There is a need therefore to conduct longer studies to see if these improvements can be sustained and true clinical benefits demonstrated. Furthermore, the study was carried out in a UAE military hospital, where adherence to advice may be high; generalizability of the intervention methodology needs to be tested in other clinical settings to include evaluation of the economic impact of the service.

Competing interests

None declared.

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REFERENCES

1 Koopmanschap M. Coping with Type II diabetes: the patient's perspective. Diabetologia 2002; 45: S18–22.

2 Abuissa H, Bel DS, O'Keefe JH Jr. Strategies to prevent type 2 diabetes. Curr Med Res Opin 2005; 21: 1107–14.

3 Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr. Seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure. Hypertension 2003; 42: 1206–52.

4 Adler AI, Stratton IM, Neil HA, Yudkin JS, Matthews DR, Cull CA, Wright AD, Turner RC, Holman RR. Association of systolic blood pressure with macrovascular and microvascular complications of type 2 diabetes (UKPDS 36): prospective observational study. BMJ 2000; 321: 412–19.

5 The Hypertension in Diabetes Study Group. Hypertension in Diabetes Study (HDS): II. Increased risk of cardiovascular complications in hypertensive type 2 diabetic patients. J Hypertens 1993; 11: 319–25.

6 Viberti G, Wheeldon NM. Microalbuminuria reduction with Valsartan in patients with type 2 diabetes mellitus. A blood pressure-independent effect (MARVAL). Circulation 2002; 106: 672–8.

7 Garcao JA, Cabrita J. Evaluation of a pharmaceutical care program for hypertensive patients in rural Portugal. J Am Pharm Assoc (Wash) 2002; 42: 858–64.

8 Gonzalez-Martin G, Joo I, Sanchez I. Evaluation of the impact of a pharmaceutical care program in children with asthma. Patient Educ Couns 2003; 49: 13–18.

9 Paulos CP, Nygren CE, Celedon C, Carcama CA. Impact of a pharmaceutical care program in a community pharmacy on patients with dyslipidemia. Ann Pharmacother 2005; 39: 939–43.

10 Sadik A, Yousif M, McElnay JC. Pharmaceutical care of patients with heart failure. Br J Clin Pharmacol 2005; 60: 183–93.

11 Clark PM, Karagoz T, Apikoglu-Rabus S, Izzettin FV. Effect of pharmacist-led patient education on adherence to tuberculosis treatment. Am J Health Syst Pharm 2007; 64: 497–505.

12 Wermeille J, Bennie M, Brown I, McKnight J. Pharmaceutical care model for patients with type 2 diabetes: integration of the community pharmacist into the diabetes team – a pilot study. Pharm World Sci 2004; 26: 18–25.

13 Rubin RR. Adherence to pharmacologic therapy in patients with type 2 diabetes. Am J Med 2005; 118: 27S–34S.

14 McClean MT, McElnay JC, Andrews J. The importance of patient education and patient involvement in the treatment of diabetes. Pharm J 2000; 265: 108–10.

15 Krass I, Susan J, Carlene ST, Armour CL. Impact on medication use and adherence of Australian pharmacists' diabetes care services. J Am Pharm Assoc 2005; 45: 33–40.

16 Lerman I. Adherence to treatment: the key for avoiding long-term complications of diabetes. Arch Med Res 2005; 36: 300–6.

17 Coast-Senior EA, Kroner BA, Kelley CL, Trilli LE. Management of patients with type 2 diabetes by pharmacists in primary care clinics. Ann Pharmacother 1998; 32: 636–41.

18 Cioffi ST, Caron MF, Kalus JS, Hill P, Buckley TE. Glycosylated hemoglobin, cardiovascular, and renal outcomes in a pharmacist-managed clinic. Ann Pharmacother 2004; 38: 771–5.

19 Choe HM, Mitrovich S, Dubay D, Hayward RA, Krein SL, Vijan S. Proactive case management of high-risk patients with type 2 diabetes mellitus by a clinical pharmacist: a randomized controlled trial. Am J Manag Care 2005; 11: 253–60.

20 Suppapitiporn S, Chindavijak B, Onsanit S. Effect of diabetes drug counselling by pharmacist, diabetic disease booklet and special medication containers on glycemic control of type 2 diabetes mellitus: a randomized controlled trial. J Med Assoc Thai 2005; 88: S134–41.

21 Brooks AD, Rihani RS, Derus CL. Pharmacist membership in a medical group's diabetes health management program. Am J Health Syst Pharm 2007; 64: 617–21.

22 Cranor CW, Bunting BA, Christensen DB. The Asheville project: long-term clinical and economic outcomes of a community pharmacy diabetes care program. J Am Pharm Assoc 2003; 43: 173–84.

23 Baran RW, Crumlish K, Patterson H, Shaw J, Erwin WG, Wylie JD, Duong P. Improving outcomes of community dwelling older patients with diabetes through pharmacist counselling. Am J Health Syst Pharm 1999; 56: 1535–9.

24 Taher ES. Diabetes in the United Arab Emirates and other Arab countries: need for epidemiological and genetic studies. Genetic disorders in the Arab world: UAE 2004; 1: 75.

25 Kinmonth AL, Woodcock A, Griffin S, Spiegal N, Campbell MJ. Randomised controlled trial of patient centred care of diabetes in general practice: impact on current wellbeing and future disease risk. The Diabetes care from diagnosis research team. BMJ 1998; 317: 1202–8.

26 Gore S. Assessing clinical trials – restricted randomisation. BMJ (Clin Res Ed) 1981; 282: 2114–17.

27 WHO/ISH Guidelines subcommittee: World Health Organisation. International Society of Hypertension; guidelines for the management of hypertension. J Hypertens 1999; 17: 151–83.

28 Brown GC, Brown MM, Sharma S. Quality of life associated with diabetes mellitus in an adult population. J Diabet Complications 2000; 14: 18–24.

29 Bhattacharyya A. Treatment of type 2 diabetes mellitus. Hospital Pharmacist 2001; 8: 10–16.

30 American Diabetes Association. Standards of medical care in diabetes [consensus Statement]. Diabetes Care 2005; 28: S4–36.

31 American Diabetes Association. Self-monitoring of blood glucose [consensus Statement]. Diabetes Care 1996; 19: S62–6.

32 Wood DA, De Backer G, Faergeman O. Prevention of coronary heart disease in clinical practice. Recommendations of the second joint task force of the European Society of Cardiology, European Atherosclerosis Society and European Society of Hypertension. Eur Heart J 1998; 19: 1434–503.

33 Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults. Executive summary of the third report of the national cholesterol education program (NCEP) Expert Panel on detection, evaluation and treatment of high blood cholesterol in adults (Adult treatment Panel III). JAMA 2001; 285: 2486–97.

34 Brindle P, Emberson J, Lampe F. Predictive accuracy of the Framingham coronary risk score in British men: prospective cohort study. BMJ 2003; 327: 1267–70.

35 Hedges LV, Brown SA. Predicting metabolic control in diabetes: a pilot study using meta-analysis to estimate a linear model. Nurs Res 1994; 43: 362–8.

36 Clifford RM, Davis WA, Batty KT, Davis TM. Effect of a pharmaceutical care program on vascular risk factors in type 2 diabetes: the Fremantle Diabetes Study. Diabetes Care 2005; 28: 771–6.

37 Berringer R, Shibley MC, Cary CC, Pugh CB, Powers PAG, Rafi JA. Outcomes of a community pharmacy-based diabetes monitoring program. J Am Pharm Assoc 1999; 39: 791–7.

38 Diabetes Control and Complications Trial Research Group (DCCT). The effects of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. N Engl J Med 1993; 329: 977–86.

39 UK Prospective Diabetes Study (UKPDS) Group. Intensive blood glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). Lancet 1998; 352: 837–53.

40 McWhorter LS, Oderda GM. Providing diabetes education and care to underserved patients in a collaborative practice at a Utah Community Health Center. Pharmacotherapy 2005; 25: 96–109.

41 Irons BK, Lenz RJ, Anderson SL, Wharton BL, Habeger B, Anderson HG Jr. A retrospective cohort analysis of the clinical effectiveness of a physician–pharmacist collaborative drug therapy management diabetes clinic. Pharmacotherapy 2002; 22: 1294–300.

42 Laakso M. Benefits of strict glucose and blood pressure control in type II diabetes: lessons from the UK prospective Diabetes Study. Circulation 1999; 99: 461–2.

43 English GN, Poirier S. Optimizing adherence to pharmaceutical care plans. J Am Pharm Assoc 2000; 40: 475–85.

44 Boule NG, Weisnagel SJ, Lakka TA. Effects of exercise training on glucose homeostasis: the HERITAGE family study. Diabetes Care 2005; 28: 108–14.

45 Tessier D, Menard J, Fulop T. Effects of aerobic physical exercise in the elderly with type 2 diabetes mellitus. Arch Gerontol Geriatr 2000; 31: 121–32.

46 Solberg LI, Jay R, Desai JR, O'Connor PJ, Bishop DB, Devlin HM. Diabetic patients who smoke: are they different? Ann Fam Med 2004; 2: 26–32.

47 Cerveny JD, Leder RD, Weart CW. Issues surrounding tight glycaemic control in people with type 2 diabetes mellitus. Ann Pharmacother 1998; 32: 896–905.

48 American Diabetes Association. Hypertension management in adults with diabetes. Diabetes Care 2004; 27: 65–7.

49 McFarlane SI, Castro J, Kaur J, Shin JJ, Kelling D, Farag A, Simon N, El-Atat F, Sacerdote A, Basta E, Flack J, Bakris G, Sowers JR. Control of blood pressure and other cardiovascular risk factors at different practice settings: outcomes of care provided to diabetic women compared to men. J Clin Hypertens 2005; 7: 73–80.

50 Brown GC, Brown MM, Sharma S. Quality of life associated with diabetes mellitus in an adult population. J Diabetes Complications 2000; 14: 18–24.

51 Clifford RM, Batty KT, Davis TM, Davis W, Stein G, Stewart G, Plumridge RJ. A randomised controlled trial of a pharmaceutical care programme in high-risk diabetic patients in an outpatient clinic. Int J Pharm Pract 2002; 10: 85–9.

52 Posey LM. Proving that pharmaceutical care makes a difference in community pharmacy [editorial]. J Am Pharm Assoc 2003; 43: 136–9.

53 Speight J, Bradley C. The ADKnowl: identifying knowledge deficits in diabetes care. Diabet Med 2001; 8: 626–33.

54 Nicolucci A, Ciccarone E, Consoli A, Di Martino G, La Penna G, Latorre A, Pandolfi A, Vitacolonna E, Capani F. Relationship between patients' practice-oriented knowledge and metabolic control in intensively treated type 1 diabetes patients: results of the validation of the knowledge and practices diabetes questionnaire. Diabetes Nut Metab 2000; 5: 276–83.

55 Daly A, Kulkarni K, Boucher J. The new credential: advanced diabetes management. J Am Diet Assoc 2001; 101: 940–3.

56 Mensing C, Boucher J, Cypress M, Weinger K, Mulcahy K, Barta P, Hosey G, Kopher W, Lasichak A, Lamb B, Mangan M, Norman J, Tanja J, Yauk L, Wisdom K, Adams C. National standards for diabetes self-management education. Diabetes Care 2003; 26: S149–56.

57 McWhorter LS, Fermo JD, Bultemeier NC, Oderda GM. National survey of pharmacist certified diabetes educators. Pharmacotherapy 2002; 22: 1579–93.

58 Vermeire E, Hearnshaw HP, Van Royen P, Denekens J. Patients adherence to treatment: three decades of reseach. A comprehensive review. J Clin Pharm Ther 2001; 26: 331–42.