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# How does the utilization of diabetes dietitian and educator service in Saudi Arabia affect glycemic outcomes?

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**Abstract:**

**BACKGROUND:** Despite the acknowledgment that the services of diabetes educator and dietician affect outcome, the level of utilization of these services in the Saudi Arabian public health-care system is not known. The aims of the study were to establish the percentage of patients with diabetes mellitus (DM) followed up by a diabetic educator and a dietician in a tertiary center in Saudi Arabia and associations between follow-up by a diabetic educator and a dietician and glycemic control.

**MATERIALS AND METHODS:** This was a cross-sectional study of 490 diabetic patients who attended the diabetic outpatient clinic consecutively at a public health-care institution in Riyadh. Patients answered interview questions on clinicodemographic variables and diabetic educator or dietitian follow-up during their care. Hemoglobin A1C (HbA1C [%, mmol/mol]) and fasting blood glucose (mg/dL, mmol/L) levels were recorded.

**RESULTS:** The majority of patients were male (68.8%), Saudi (71%), married (91.6%), high school or college educated (55.5%), had type 2 DM (85.5%), and were taking oral hypoglycemics (57.3%). 69.0% and 19.8% of the patients had had at least some follow-up with a diabetic educator and dietician, respectively. HbA1C levels were significantly lower in patients who had had a follow-up with a dietitian (9.1 ± 4.5% [76 ± 26 mmol/mol] vs. 7.8 ± 2.2% [62 ± 13 mmol/mol]; unadjusted odds ratio [OR]: 0.80, 95% confidence intervals [CIs]: 0.71–0.89, $P < 0.0001$), including in multivariable analysis (adjusted OR: 0.84, 95% CIs: 0.72–0.99, $P = 0.04$). Follow-up with a diabetic educator was not associated with glycemic control.

**CONCLUSIONS:** Follow-up with a diabetic dietitian had the greatest impact on glycemic control in type 1 and type 2 DM patients. A review of the national standards of best practice of diabetes education and nutrition in Saudi Arabia is required to optimize the outcomes.

**Keywords:**

Diabetes dietitian, diabetes educator, diabetes mellitus, glycemic control, hemoglobin A1C, public healthcare

## Introduction

Diabetes mellitus (DM) remains a rapidly growing global health-care problem that has reached epidemic proportions in some countries. In 2014, almost 422 million people were estimated to be suffering from diabetes.[1,2] Of the top 10 countries with the highest prevalence of diabetes, Saudi Arabia (23.9%) ranks the seventh after several small Pacific Island communities with endemic obesity-related type 2 diabetes stimulated by a rapid cultural change,[1,3,4] in contrast to the global prevalence of 8.3%.[1] The underlying reasons for the extremely high burden of diabetes in Saudi Arabia are likely to be similar; major socioeconomic changes and "westernization" of lifestyles over the last forty years have resulted

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in an increase in the consumption of calorie-dense, high-sugar, and high-fat food and drink and decreased physical activity. Besides an aging population, there is a persistence in tobacco smoking.[5] Even in countries with relatively low prevalence of DM, health-care expenditure on diabetes accounts for 11% of the total (548 billion USD in the US alone in 2013[1]), and although Saudi diabetes-related public health-care expenditure on DM was roughly similar in terms of proportion of the total (0.9 billion USD on diabetes vs. 9.4 billion USD total spend) in 2010, this is expected to rise to 18.3% by 2020.[6] Furthermore, these figures do not take into account indirect costs of absenteeism, loss of productivity from complications, unemployment, disability, training, research, and infrastructure.[5]

This situation has led to a coordinated implementation of multidisciplinary diabetes care together with aggressive public health awareness campaigns, screening, health education, and early intervention in Saudi Arabia.[5] In addition to medical management of their type I and II DM, patients treated in public health facilities should be offered a follow-up with diabetic dieticians and diabetic educators, in line with the American Diabetes Association (ADA) guidelines that recognize the integral role played by nutritional therapy, including the collaborative development of a personalized eating plan, on the overall management of diabetes in adults.[7] To this end, the ADA recommends that diabetic patients should be referred to a registered dietitian at or soon after diagnosis and/or referral to a diabetes self-management education (DSME) program.[7] However, even in the US, only about a half of the patients with DM report to have had any diabetes education intervention,[8] and only about 9% had any dietitian input over a 9-year period.[9]

The extent to which the services of the diabetic dietitian and educator are used in the Saudi Arabian public health-care system is unknown. To find out this, a cross-sectional analysis of all patients with diabetes attending a diabetes outpatient clinic at a public health-care institution in Riyadh over a 3-month period was undertaken. The aims of the study were to (i) discover the percentage of patients followed up by a diabetic educator and dietician and (ii) discover associations between follow-up by a diabetes educator and a dietician and glycemic control.

## Materials and Methods

This was a cross-sectional study of patients attending diabetic outpatient clinic between February and April 2017 at King Saud Medical City, a tertiary governmental hospital, Riyadh, Saudi Arabia. Inclusion criteria were (i) known cases of DM, (ii) patients aged 18–70 years, (iii) patients on treatment for at least 6 months, and (iv) patients not included in other studies and willing to give informed consent. Exclusion criteria were (i) patients with gestational diabetes, (ii) patients with any psychiatric illness, and (iii) those not using diabetic medications for diabetes; this was to avoid the inclusion of prediabetic patients attending the same clinic. All patients provided written informed consent, and the ethical review board of King Saud Medical City approved the study protocol.

Patients were interviewed after giving informed consent while attending an outpatient clinic. Patients answered questions on their age in years, nationality, marital status (single, married, widowed, and divorced), educational level (no formal education, primary school, high school, or college educated), DM type (1 or 2), length of diagnosis (years), use of oral hypoglycemic agents or insulin, and whether they had been followed up with a diabetic educator or dietitian at any point during their care. Hemoglobin A1C (HbA1C [%, mmol/mol]) and fasting blood glucose (mg/dL, mmol/L) levels were extracted from patient records at the time of interview.

The primary study endpoints were fasting blood glucose and HbA1C levels. Statistical analyses were done in SPSS V23 (IBM Corp., Chicago, IL, USA). Data were described with frequencies (categorical variables) and means ± standard deviations (continuous variables). Univariable associations between demographic and clinical variables and follow-up by a dietitian or diabetic educator were first reviewed by logistic regression to examine unadjusted odds ratios (ORs). Finally, all variables were included in a multiple logistic regression model to evaluate their associations with dietitian or educator follow-up and assess adjusted ORs. $P = 0.05$ was considered statistically significant.

## Results

Four-hundred and ninety patients were available for analysis [Table 1]; the majority were male (68.8%), Saudi (71%), married (91.6%), and had a high school or college level education (55.5%). The majority of patients had type 2 DM (85.5%); 57.3% were taking oral hypoglycemic medications and 52.7% were on insulin (11.0% were taking both) at the time of interview. The average length of diagnosis was 11.2 ± 9.4 years.

The majority (69.0%) of patients had had at least some follow-up with a diabetes educator. However, only 19.8% of the patients had had some follow-up with a diabetes dietician. Overall, glycemic control was quite poor with the average HbA1C levels of 8.9 ± 4.2% (74 ± 22 mmol/mol) and an average fasting blood glucose of 216 ± 526 mg/dL (12.0 ± 29.2 mmol/L).

**Table 1: Demographics of the study participants (*n*=490)**

| Variable | Number | Percentage |
|---|---|---|
| Age (years) | | |
| Mean±SD | 52.8±13.4 | |
| Sex | | |
| Male | 337 | 68.8 |
| Female | 153 | 31.2 |
| Nationality | | |
| Saudi Arabian | 348 | 71.0 |
| Non-Saudi | 142 | 29.0 |
| Marital status | | |
| Married | | |
| Single | 449 | 91.6 |
| Widowed | 38 | 7.8 |
| Educational level | 3 | 0.6 |
| No primary education | 104 | 21.2 |
| Primary school | 85 | 17.3 |
| High school | 170 | 34.7 |
| College | 102 | 20.8 |
| Unknown | 29 | 5.9 |
| Type of DM | | |
| Type 1 | 71 | 14.5 |
| Type 2 | 419 | 85.5 |
| Length of diagnosis (years) | | |
| Mean±SD | 11.2±9.4 | |
| Oral hypoglycemic agents | | |
| Yes | 281 | 57.3 |
| No | 208 | 42.4 |
| Unknown | 1 | 0.2 |
| Insulin | | |
| Yes | 258 | 52.7 |
| No | 231 | 47.1 |
| Unknown | 1 | 0.2 |
| Follow-up with diabetic educator | | |
| Yes | 338 | 69.0 |
| No | 152 | 31.0 |
| Follow-up with diabetic dietitian | | |
| Yes | 97 | 19.8 |
| No | 392 | 80.0 |
| Unknown | 1 | 0.2 |
| HbA1C (% mmol/mol) | | |
| Mean±SD | 8.9±4.2 | |
| Fasting blood glucose (mmol/L) | | |
| Mean±SD | 12.0 (29.2) | |

DM=Diabetes mellitus, SD=Standard deviation

Table 2 shows the relationship between glycemic control endpoints and other clinicodemographic variables and dietitian follow-up. Patients who had seen a dietician had better glycemic control (HbA1c 7.8 ± 2.2%; fasting blood glucose level 9.1 ± 4.3 mmol/L) than those who had not seen a dietitian (HbA1c 9.1 ± 4.5%; fasting blood glucose level 12.8 ± 32.6 mmol/L), which was statistically significant ($P < 0.05$). On univariable analysis, patients who had had follow-ups with a dietitian were more likely to have lower HbA1c (unadjusted OR: 0.80, 95% CIs: 0.71–0.89, $P < 0.0001$) and more likely to have lower fasting blood glucose levels (unadjusted OR: 0.90, 95% CIs: 0.85–0.95, $P < 0.0001$) than patients who had not had any follow-up with a dietitian. In a full multiple logistic regression model, only a lower HbA1C remained significantly associated with dietitian follow-up (adjusted OR: 0.84, 95% CIs: 0.72–0.99, $P = 0.04$).

With regard to associations between diabetes educator follow-up and clinicodemographic variables [Table 3], patients taking oral hypoglycemic agents were more likely to be seeing an educator than patients who were not taking any oral hypoglycemic agents (unadjusted OR: 1.64, 95% CIs: 1.12–2.42, $P = 0.012$). However, in a full multiple logistic regression model, this association was not statistically significant (unadjusted OR: 1.79, 95% CIs: 0.87–3.64, $P = 0.11$).

## Discussion

This study examined the proportion of patients who had had the services of diabetes dietitian and educator as part of their diabetes management in an urban tertiary hospital in Saudi Arabia. Although these services are, in theory, provided without charge to all patients with diabetes attending the institution's clinic, only 20% and 69% of patients actually had had follow-up with a dietitian or educator, respectively. Despite the association between dietitian follow-up and lower HbA1C levels, educator follow-up was not associated with any change in glycemic control.

There are only limited data on the use of allied health services by individuals with diabetes in general[10,11] and none from Saudi Arabia, although one historical study from the Qassim region of Saudi Arabia reported that there were no diabetes dietitian or educator services in 2004.[12] Only 20% of patients reported seeing a dietitian in the current study, which compares favorably with a US sample of over 18,000 patients, only 9.1% of whom reported seeing a dietitian at least once after diagnosis.[9] Likewise, in the national data from the US, about half of the patients reported some input from the diabetes educator after diagnosis[13] in comparison with 69% in the current study. In a rural setting in Australia, with presumed limited accessible and affordable services, 21.4% of diabetes patients had seen a dietitian and 40.2% a diabetes educator in the preceding year alone, and so their utilization of diabetes dietitian services over the entire course of their disease was likely to be much higher.[10] In both the rural and urban settings, a lack of awareness of the availability of these services by patients and providers was partly responsible for the lack of utilization of the service.[9,10] However, in the rural setting, nonreferral (35%–44%) and the lack of perceived need (40%–49%) also contributed to over a third of nonutilization of service;[10] only about

**Table 2: Univariable and multivariable associations between clinicodemographic variables and diabetic dietitian follow-up**

| Variable | Dietitian follow-up Number (*n*=97) | No dietitian follow-up Number (*n*=392) | Unadjusted OR (95% CI) | *p*-Value | Adjusted OR (95% CI) | *p*-Value |
|---|---|---|---|---|---|---|
| Age | | | | | | |
| Mean±SD | 52.9±12.7 | 52.8±13.7 | 1.00 (0.98-1.02) | 0.92 | 0.99 (0.96-1.01) | 0.42 |
| Sex | | | | | | |
| Male | 30 | 123 | 1.02 (0.63-1.65) | 0.93 | 1.12 (0.65-1.95) | 0.68 |
| Female | 67 | 269 | | | | |
| Nationality | | | | | | |
| Saudi Arabian | 68 | 280 | 0.99 (0.94-1.05) | 0.78 | 0.99 (0.94-1.05) | 0.86 |
| Non-Saudi | 29 | 112 | | | | |
| Marital status | | | | | | |
| Married | 90 | 358 | 0.99 (0.44-2.18) | 0.98 | 1.07 (0.40-2.90) | 0.83 |
| Single | 7 | 31 | | | | |
| Widowed | 0 | 3 | | | | |
| Educational level | | | | | | |
| No primary education | 14 | 90 | 1.11 (0.88-1.39) | 0.36 | 1.10 (0.86-1.41) | 0.44 |
| Primary school | 14 | 71 | | | | |
| High school | 33 | 137 | | | | |
| College | 25 | 76 | | | | |
| Type of DM | | | | | | |
| Type 1 | 17 | 53 | 0.74 (0.41-1.34) | 0.32 | 0.55 (0.24-1.28) | 0.17 |
| Type 2 | 80 | 339 | | | | |
| Length of diagnosis (years) | | | | | | |
| Mean±SD | 12.0±10.4 | 11.1±9.1 | 1.01 (0.99-1.03) | 0.39 | 1.02 (0.98-1.05) | 0.23 |
| Oral hypoglycemic agents | | | | | | |
| Yes | 60 | 221 | 1.25 (0.79-1.97) | 0.34 | 1.83 (0.82-4.10) | 0.14 |
| No | 37 | 170 | | | | |
| Insulin | | | | | | |
| Yes | 51 | 206 | 1.00 (0.64-1.55) | 0.96 | 1.3 (0.55-3.08) | 0.56 |
| No | 46 | 185 | | | | |
| HbA1C (%; mmol/mol) | | | | | | |
| Mean±SD | 7.8 (2.2); 62 (13) | 9.1 (4.3); 164 (78) | 0.80 (0.71-0.89) | <0.0001 | 0.84 (0.72-0.99) | 0.04 |
| Fasting blood glucose (mmol/L) | | | | | | |
| Mean±SD | 9.1 (4.3); 164 (78) | 12.8 (32.6); 231 (587) | 0.90 (0.85-0.95) | <0.0001 | 0.98 (0.90-1.06) | 0.57 |

DM=Diabetes mellitus, SD=Standard deviation, OR=Odds ratio, CI=Confidence interval

12% of this rural population were concerned about affordability, availability, and accessibility. It is not immediately clear that why there was suboptimal use or a complete lack of the use of diabetic service by a significant proportion of the patients in the current study, especially when the services are offered without charge as part of the provision of public health service. It is likely, however, that the contributory factors for both patients and providers are similar. The finding that having a non-Saudi nationality, and the marital status were associated with lower diabetic educator follow-up may suggest that specific cultural or language barriers may impede the utilization of the service in Saudi Arabia. Scrutiny of the reasons for nonreferral or lack of uptake is required urgently to address any modifiable factors that might improve the utilization of service, and the Saudi health-care system would benefit from rigorous quality improvement initiatives similar to those in place in the US to improve goals in diabetes care.[13]

Glycemic control is the cornerstone of diabetes management, and a reduction of HbA1C levels reduces the risk of microvascular[14,15] and cardiovascular disease[16] and indeed mortality.[16] Given that carbohydrate intake and glycemic control are directly and intimately related, medical nutrition therapy, preferably provided by a registered dietitian, provides the foundation for short- and long-term diabetes care. A recent meta-analysis of high-quality (grade 1, strong) evidence including 14 randomized controlled trials showed that medical nutrition therapy significantly improved HbA1C levels in patients with type 2 DM by between 0.3% and 1.8%, even after 12 months.[17] In the same vein, in patients with type 1 diabetes, individualized medical nutrition therapy using carbohydrate counting to determine premeal insulin doses decreased HbA1C levels by between 1% and 1.9%.[17] This is consistent with the current data which shows increased

**Table 3: Univariable and multivariable associations between clinicodemographic variables and diabetic educator follow-up**

| Variable | Educator follow-up (*n*=338) Number | No educator follow-up (*n*=152) Number | Unadjusted OR (95% CI) | *p*-Value | Adjusted OR (95% CI) | *p*-Value |
|---|---|---|---|---|---|---|
| Age (years) | | | | | | |
| Mean±SD | 52.5±123.2 | 53.6±13.9 | 0.99 (0.98-1.00) | 0.39 | 0.98 (0.96-1.00) | 0.09 |
| Sex | | | | | | |
| Male | 233 | 104 | 1.02 (0.68-1.55) | 0.91 | 1.16 (0.74-1.83) | 0.52 |
| Female | 105 | 48 | | | | |
| Nationality | | | | | | |
| Saudi | 244 | 104 | 0.98 (0.94-1.02) | 0.37 | 0.99 (0.94-1.03) | 0.54 |
| Non-Saudi | 94 | 48 | | | | |
| Marital status | | | | | | |
| Married | 315 | 134 | 1.14 (0.59-2.24) | 0.69 | 1.50 (0.64-3.51) | 0.35 |
| Single | 23 | 15 | | | | |
| Widowed | 0 | 3 | | | | |
| Educational level | | | | | | |
| No primary education | 74 | 30 | 0.85 (0.70-1.04) | 0.11 | 0.85 (0.70-1.04) | 0.12 |
| Primary school | 49 | 36 | | | | |
| High school | 122 | 48 | | | | |
| College | 77 | 25 | | | | |
| Type of DM | | | | | | |
| Type 1 | 46 | 25 | 1.25 (0.74-2.12) | 0.41 | 0.92 (0.45-1.88) | 0.83 |
| Type 2 | 292 | 127 | | | | |
| Length of diagnosis (years) | | | | | | |
| Mean±SD | 11.0±9.5 | 11.8±9.2 | 0.99 (0.97-1.01) | 0.42 | 1.00 (0.98-1.03) | 0.83 |
| Oral hypoglycemic agents | | | | | | |
| Yes | 207 | 74 | 1.64 (1.12-2.42) | 0.012 | 1.79 (0.87-3.64) | 0.11 |
| No | 131 | 77 | | | | |
| Insulin | | | | | | |
| Yes | 169 | 89 | 0.70 (0.47-1.03) | 0.07 | 1.12 (0.51-2.46) | 0.77 |
| No | 169 | 62 | | | | |
| HbA1C (% mmol/mol) | | | | | | |
| Mean±SD | 8.8 (4.8); 73 (29) | 9.1±2.6 | 0.98 (0.94-1.03) | 0.44 | 0.99 (0.95-1.04) | 0.74 |
| Fasting blood glucose (mmol/L; mg/dL) | | | | | | |
| Mean±SD | 12.4±35.0 | 11.3 (4.8); 203 (86) | 1.00 (0.99-1.01) | 0.72 | 1.00 (0.90-1.02) | 0.67 |

DM=Diabetes mellitus, SD=Standard deviation, OR=Odds ratio, CI=Confidence interval

odds of a lower HbA1C level in patients who had seen a dietitian at some point during their management, in spite of the heterogeneity of the study population, cross-sectional study design, and variable input provided by the dietitian. Similarly, the same meta-analysis provides grade 1 evidence that dietitian support lowers fasting blood glucose levels by 1–3.3 mmoL/L (18–60 md/dL) both in the short and long term (>6 years) in type 1 and 2 DM patients.[17] Although the current result was not significant in multivariable analysis, there was a similar trend of lower fasting blood glucose levels in patients with dietitian follow-up in univariable analysis (by 2.7 mmol/L; 49 mg/dL). Although the cohort patients studied here may have decided on their own to see a dietitian and therefore been more motivated in their own diabetes management, as in the published data our study strongly supports the encouragement of all patients to utilize the services of the dietitian service.

It is also well-established that diabetes educational interventions improve glycemic control, albeit to a lesser extent than dietitian intervention (by about 0.5%),[18] and are likely to bring about additional positive effects on psychosocial outcomes.[19] This lower magnitude effect and the heterogeneity in the current cohort may explain why no significant differences in glycemic control were observed in patients who had had educator follow-up. A difference was, however, observed in oral hypoglycemic use in individuals utilizing educator services, suggesting some observable effect from this intervention. Since it is possible that the current educator programs offered are not effective, there needs to be review of the type of DSME being delivered at present to diabetes patients in Saudi Arabia, perhaps using the ADA best practice and national standards guidelines as a frame of reference.[20]

This study has a number of limitations. Being a cross-sectional study, it was susceptible to misclassification

and recall bias. Besides the associations cannot be deemed to be definitely causal. Patients self-reported on the questionnaire items so the results are susceptible to recall bias. The type and duration of follow-up provided by the dietitians and educators were unknown, so it could not be determined whether specific interventions had an effect on the study endpoints. The reasons for nonutilization of a particular service were not recorded nor were some important parameters such as body mass index. Finally, the sample was limited to diabetic patients attending clinic only over a 3-month period, so may not be representative of the entire target population.

## Conclusions

This study highlights the fact that there is significant room for improvement in the utilization of diabetes dietitian and educator service in the public health system in Saudi Arabia. Physicians and their managers have to find out the reasons why only a relatively small proportion of patients currently utilize these important services, particularly that of dietitians. This should be addressed through formal qualitative and quantitative research to establish the exact reasons why patients do not make use of these services in order to target specific groups with interventions that promote the use of the services of dietitians and educators. Interventions might include, for example, the use of e-Health (text messaging or smartphone apps) to remind patients of follow-up appointments. This study and previous data show that a follow-up with a diabetes dietitian has the greatest impact on glycemic control in type 1 and type 2 DM patients and, therefore, is likely to improve the long-term health of these patients and reduce societal and healthcare-associated costs from diabetes. It is necessary to review the delivery of national standards of diabetes education and best practice in Saudi Arabia in order to optimize outcomes.

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### Conflicts of interest
There are no conflicts of interest.

## References

1. Aguiree F, Brown A, Cho NH, Dahlquist G, Dodd S, Dunning T, *et al*. IDF Diabetes Atlas. Basel, Switzerland: International Diabetes Federation; 2013.
2. Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. PLoS Med 2006;3:e442.
3. Foliaki S, Pearce N. Prevention and control of diabetes in Pacific people. BMJ 2003;327:437-9.
4. Alqurashi KA, Aljabri KS, Bokhari SA. Prevalence of diabetes mellitus in a Saudi community. Ann Saudi Med 2011;31:19-23.
5. Naeem Z. Burden of diabetes mellitus in Saudi Arabia. Int J Health Sci (Qassim) 2015;9:V-VI.
6. Alhowaish AK. Economic costs of diabetes in Saudi Arabia. J Family Community Med 2013;20:1-7.
7. Marathe PH, Gao HX, Close KL. American diabetes association standards of medical care in diabetes 2017. J Diabetes 2017;9:320-4.
8. Ali MK, Bullard KM, Gregg EW. Achievement of goals in U.S. Diabetes care, 1999-2010. N Engl J Med 2013;369:287-8.
9. Robbins JM, Thatcher GE, Webb DA, Valdmanis VG. Nutritionist visits, diabetes classes, and hospitalization rates and charges: The urban diabetes study. Diabetes Care 2008;31:655-60.
10. Madden J, Barnard A, Owen C. Utilisation of multidisciplinary services for diabetes care in the rural setting. Aust J Rural Health 2013;21:28-34.
11. Sale MM, Hazelwood K, Zimmet PZ, Shaw JE, Stankovich JM, Greenaway TM, *et al*. Trends in diabetes management practices of patients from an Australian insulin-treated diabetes register. Diabet Med 2004;21:165-70.
12. Al-Alfi MA, Al-Saigul AM, Saleh MA, Surour AM, Riyadh MA. Audit of structure, process, and outcome of diabetic care at Al Asyah primary health care centre, qassim region, Saudi Arabia. J Family Community Med 2004;11:89-96.
13. Ali MK, Bullard KM, Saaddine JB, Cowie CC, Imperatore G, Gregg EW, *et al*. Achievement of goals in U.S. Diabetes care, 1999-2010. N Engl J Med 2013;368:1613-24.
14. Effect of intensive blood-glucose control with metformin on complications in overweight patients with type 2 diabetes (UKPDS 34). UK Prospective Diabetes Study (UKPDS) Group. Lancet 1998;352:854-65.
15. Diabetes Control and Complications Trial Research Group, Nathan DM, Genuth S, Lachin J, Cleary P, Crofford O, *et al*. The effect 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.
16. Holman RR, Paul SK, Bethel MA, Matthews DR, Neil HA. 10-year follow-up of intensive glucose control in type 2 diabetes. N Engl J Med 2008;359:1577-89.
17. Franz MJ, MacLeod J, Evert A, Brown C, Gradwell E, Handu D, *et al*. Academy of nutrition and dietetics nutrition practice guideline for type 1 and type 2 diabetes in adults: Systematic review of evidence for medical nutrition therapy effectiveness and recommendations for integration into the nutrition care process. J Acad Nutr Diet 2017;117:1659-79.
18. Gary TL, Genkinger JM, Guallar E, Peyrot M, Brancati FL. Meta-analysis of randomized educational and behavioral interventions in type 2 diabetes. Diabetes Educ 2003;29:488-501.
19. Brown SA. Interventions to promote diabetes self-management: State of the science. Diabetes Educ 1999;25:52-61.
20. Haas L, Maryniuk M, Beck J, Cox CE, Duker P, Edwards L, *et al*. National standards for diabetes self-management education and support. Diabetes Care 2014;37 Suppl 1:S144-53.