Improvement in diabetes self-efficacy and glycaemic control using telemedicine in a sample of older, ethnically diverse individuals who have diabetes: the IDEATel project

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Abstract

Background: with increasing prevalence of diabetes in older people, it is important to understand factors that affect their outcomes. The Informatics for Diabetes Education and Telemedicine (IDEATel) project is a demonstration project to evaluate the feasibility and effectiveness of telemedicine with diverse, medically underserved, older diabetes patients. Subjects were randomised to telemedicine case management or usual care. This intervention has been shown to result in improved medical outcomes and self-efficacy. Self-efficacy refers to one’s belief that (s)he can successfully engage in a behaviour. Self-efficacy has been shown to relate to behaviour change and glycaemic control in middle-aged individuals, but not studied in older individuals.

Objectives: to assess whether (a) diabetes self-efficacy relates to the primary medical outcome of glycaemic control, and to secondary outcomes (blood pressure and cholesterol), and (b) whether, after an intervention, change in diabetes self-efficacy relates to change in these medical outcomes in a group of older, ethnically diverse individuals.

Methods: three waves of longitudinal data from participants in IDEATel were analysed.

Results: diabetes self-efficacy at baseline correlated with glycaemic control, blood pressure and cholesterol. An increase in diabetes self-efficacy over time was related to an improvement in glycaemic control ($P < 0.0001$), but not in blood pressure and lipid levels. The intervention was significantly related to improved self-efficacy over time ($P < 0.0001$), and both directly ($P = 0.022$) and indirectly through self-efficacy ($P < 0.001$) to improved glycaemic control. The mediation effect of self-efficacy was also significant ($P < 0.004$).

Conclusions: diabetes self-efficacy is a relevant construct for older diabetes patients. Thus, interventions that target enhanced self-efficacy may also result in improved glycaemic control.

Keywords: diabetes, self-efficacy, glycaemic control, elderly

Introduction

Diabetes education has not consistently resulted in improved glycaemic control [1, 2]; new concepts are needed to help patients change self-management behaviours [3]. ‘Self-efficacy’, a key tenet of social cognitive theory [4], has been found to relate to diabetes self-care behaviour change.

Self-efficacy refers to one’s belief that (s)he can plan and accomplish behaviour change, the belief that ‘I can do it’. Self-efficacy can be defined as a global attitude or specific to particular behaviours (e.g. diet self-efficacy) [5]. Self-efficacy is affected by experience, perceptions of others’ experiences and persuasion. Self-efficacy affects motivation, choices, control and thoughts [6]. Individuals with high self-efficacy are more likely to initiate, persist in and succeed at behaviour change.
Many studies find a relationship between self-efficacy and health behaviours (e.g., [7, 8]). For diabetes, higher diabetes self-efficacy has been shown to relate to better self-care [9–12] and glycaemic control [13, 14]. In one prospective study, using structural equation modelling, baseline self-efficacy was found to directly reinforce adherence to self-care [15].

These studies generally assessed self-efficacy of middle-aged individuals. Yet, diabetes is a disease of advancing age. A Medicare survey (a US government run health insurance plan for elderly and disabled) found that diabetes prevalence increased by 36%, and adjusted diabetes incidence increased by 36.9%, from 1993 to 2001 [16]. Among US adults aged ≥65 years, the prevalence of diagnosed diabetes is 15.3%, with 6.9% undiagnosed [17]. Since the number of adults aged >65 years will double by 2020 [18], the incidence of diabetes, and numbers of older patients living with complications, will explode [19, 20].

There are few studies of the relationship between diabetes self-efficacy and health behaviours or outcomes in older individuals. Perhaps we can extrapolate ‘adult’ self-efficacy findings to older adults; we have not identified theoretical links between self-efficacy and aging. However, as self-efficacy is affected by one’s experiences and perceived experiences of others, older patients may hold unique self-efficacy beliefs. In a study of 2,542 Medicare patients, those with higher self-efficacy had better health and lower health risk [21]. It is important to assess whether self-efficacy is relevant to the health of this growing and understudied group.

Also, while some recommend that interventions be designed to increase self-efficacy as an outcome [22], and behavioural interventions can result in improved diabetes self-efficacy [23–25], change in self-efficacy was not the primary target in these studies.

A related question is whether improvement in self-efficacy results in improvement in diabetes-related medical outcomes. Social cognitive theory proposes that those high in diabetes self-efficacy will be more motivated to change behaviour, more likely to make healthy choices, more positive in self-attributions and have a greater sense of control. Since high self-efficacy relates to better diabetes self-care, improvements in glycaemic control, blood pressure and weight may follow. In the only prospective study of the relationship between self-efficacy and glycaemic control, self-efficacy related directly to self-care, and self-care predicted glycaemic control 6 months later [15]. However, the sample comprised relatively well, middle-aged individuals.

The primary purpose of the current analyses was to examine the role of diabetes self-efficacy in glycaemic control in older, ethnically diverse patients with diabetes, and to assess whether improvement in diabetes self-efficacy over time following intervention would relate to enhanced glycaemic control. We also examined the relationship between change in self-efficacy and blood pressure (BP) and lipids, both important for diabetes patients’ health. The intervention resulted in improvement in BP and lipids, and, much as self-efficacy might affect adherence to self-care affecting glycaemic control (e.g., adherence to diet, medications), it may also play a role in the behavioural changes for healthy SBP and lipid levels.

Methodology

Participants

Longitudinal data were from the Informatics for Diabetes Education and Telemedicine (IDEATel) project. Using an intent-to-treat design, all participants randomised (n = 1,665) were included in analyses. Respondents with baseline and two waves of data collected annually were included in the analyses if they had at least one measure of the outcome over time (n = 1,443; 222 lost to follow-up). IDEATel was a demonstration project, funded by the Centers for Medicare and Medicaid services, to evaluate the feasibility and effectiveness of telemedicine with ethnically diverse, medically underserved, older diabetes patients. A detailed description of IDEATel study design has been reported [26, 27]. Subjects were recruited through primary care providers (PCPs) and included if they were receiving Medicare benefits, were ≥55 years of age, and diagnosed with type 2 diabetes. Individuals were excluded if they had moderate/severe physical, cognitive, or visual impairments or severe comorbid disease. Subjects were randomised within PCPs to telemedicine case management (TCM) or usual care. Trained research nurses blinded to group assignment conducted physical and psychosocial assessments at baseline, 1 and 2 years’ follow-ups. The study was approved by the Institutional Review Boards at Columbia University, SUNY Upstate Medical University, and other organisations.

Intervention

Intervention subjects received a home telemedicine unit (HTU), i.e. a web-enabled computer to upload blood glucose (BG) and blood pressure (BP) readings, to videoconference with a dietitian/nurse case manager (all CDEs) and to access education and data. Televisits followed a specified case management protocol using case management software, were 30–60 minutes long, and occurred every 4–6 weeks. Discussion included diabetes education, nutrition and activity counselling, and collaborative goal setting. The patients and CDE collaboratively formulated a plan to address patient concerns, especially about BG, BP and lipid control. The patients set specific, attainable behaviour change goals to lead towards improved health management. A televisit summary was sent to the PCP and, under endocrinologist supervision, CDEs provided consultation to PCPs (providers made all treatment decisions). The Veterans Health Administration Clinical Practice Guidelines for the Management of Diabetes Mellitus in the Primary Care Setting [28] guided the intervention.

Prior results

Published results of a randomised trial of this TCM intervention for older diabetes patients [29] indicate that TCM (vs. usual care) resulted in significant improvements in the
primary medical outcomes of A1c, BP and total and LDL-cholesterol. While not a target, the intervention resulted in significant improvement in diabetes self-efficacy, but not in depression or diabetes-related distress [25]. This study is a further analysis of the prior research.

**Measures**

Measures were completed at baseline and 1 and 2 year annual visits. All examinations were performed by certified personnel not involved in the intervention or clinical care, blinded, to the extent possible, to treatment assignment.

(i) **Glycaemic control:** assessed by measuring glycated haemoglobin levels (A1c). A1c was analysed by boronate affinity chromatography with the Primus CLC 385 (Primus, Kansas City, MO, USA). A1c, reflecting average blood glucose readings over the preceding 2–3 months, is widely accepted as a reliable and valid index of glycaemic control [30]. A higher value represents poorer glycaemic control.

(ii) **Blood pressure (BP):** Resting BP was measured using a Dinamap Monitor Pro 100 (Critikon, Tampa, FL, USA) automated oscillometric device. Three measurements were obtained following 5 min of rest using a standardised protocol. The average of the second and third measurements was recorded.

(iii) **LDL cholesterol** was measured directly using a homogeneous assay (Polymedco, Cortland Manor, NY, USA) for those with total cholesterol >240 mg/dL or HDL <35 mg/dL or triglyceride level >300 mg/dL.

(iv) **Diabetes self-efficacy scale (DSES)** [31]: a 21-item self-report measure of perceived ability to adhere to the diabetes care regimen. Sample items are: ‘I think I am able to manage my diabetes’, ‘I think I am able to check my blood sugar if necessary’ and ‘I think I am able to select the right foods’. Subjects reply on a 0 (‘No, definitely not’) to 4 (‘Yes, definitely’) scale (possible range: 0–84; current range: 0–68). Test–retest reliability was 0.79. A principal component factor analysis identified four DSES factors, with alphas ranging from 0.71 to 0.79 [32] but the scale developers do not interpret these as four subscales. The DSES has been shown to be a reliable predictor of initiating and continuing self-care behaviour of diabetes patients (Cronbach’s alpha = 0.81) and also for their significant-others (Cronbach’s alpha = 0.90) [31]. Cronbach’s alpha for the current sample was 0.90. Scoring was reversed, i.e. higher score connotes lower self-efficacy.

**Analyses**

**Randomisation**

Subjects were randomised within clusters defined by physician practices [26]. Thus, the design effect of clustering within PCP, as well as the correlation across repeated measures required modelling.

**Selection of covariates**

$T$-tests and Pearson’s correlation assessed significance of associations between baseline self-efficacy and possible covariates. Variables were examined as covariates using an alpha level of 0.10, a conservative approach. The primary analyses did not include covariates because the randomisation was successful. However, for these secondary analyses, it is important to consider variables that might compete in terms of explanatory power. Thus, we chose to err on the conservative side in the selection of covariates. Gender and race/ethnicity did correlate with baseline self-efficacy, with females and whites reporting lower self-efficacy. Other variables with potential clinical significance (age, education, duration of diabetes) were also included as covariates in all analyses.

**Longitudinal models**

We have previously demonstrated that the IDEATel intervention resulted in improved medical outcomes and improved diabetes self-efficacy over 1 year. In these analyses, we examined whether a change in diabetes self-efficacy related to a change in medical outcomes over two annual visits. We also explored the role of self-efficacy in glycaemic control through examination of direct and indirect effects. A mixed model approach that incorporated random effects to adjust for clustering within PCP practice was performed, using SAS Proc Mixed (SAS 9.0). Consistent with the original approach, the $P$-value was set at 0.05 for each outcome examination, and separate models were fit for each outcome.

Self-efficacy was treated as a time-varying covariate in the analyses; that is, change in self-efficacy was linked to change in the medical outcomes at each point in time. Consistent with the primary analyses, the outcome variables were not transformed.

Several steps were taken to ensure that a proper longitudinal model was fit. The covariance structure was assessed; based on Akaike’s Information Function, the best fitting covariance structure for A1c was first order autoregressive (decreasing correlations of each outcome with subsequent measurements of the outcome over time), and for BP and lipids, compound symmetry (equal correlations between waves over time) was best. Additionally, it was determined that heterogeneity in cluster and residual variances required modelling. Finally, consistent with the primary analyses, it was necessary to model A1c as non-linear. In order to elucidate the findings and examine the direct and indirect effects of the intervention on glycaemic control, in addition to the test of the hypothesis shown in Table 2, a path analysis depicting the main findings pictorially is presented in Figure 1. The mediating effect of self-efficacy was tested using several methods recently recommended [33, 34].

**Results**

Table 1 provides baseline demographic data ($n = 1,665$). All subjects (intervention and usual care) with at least one wave
Figure 1. Path analysis using mixed model regression analyses to summarise direct and indirect effects of baseline characteristics and the intervention on self-efficacy and glycaemic control. All analyses were performed using SAS Proc Mixed repeated measures and were adjusted for clustering within PCP and for heterogeneity in cluster and group variances (randomisation group). Diabetes self-efficacy and haemoglobin A1c were measured such that a high score indicates worse outcomes. *P < 0.05; **P < 0.01; ***P < 0.001. aExponential(-Admin) by group term, P = 0.0881. In the model without self-efficacy and baseline characteristics, this term was significant (est. = 0.219, P = 0.0219). bAn unstructured covariance structure was used. cNon-linear terms were included to model non-linearity of haemoglobin A1c over time. A first order autoregressive covariance structure was used. Diabetes self-efficacy was entered as a time varying covariate. The mediation effect of self-efficacy was significant (P < 0.004).

of outcome data were included in intent-to-treat analyses. Recruitment and retention data have been reported [29]. A comparison of baseline demographic and clinical variables showed no significant differences between intervention and control groups. Also, subjects lost to follow-up did not differ on demographic or clinical variables from subjects who remained.

Examination of the results provided confirmation for the main hypothesis that change in diabetes self-efficacy would be related to change in A1c (P < 0.0001) (see Table 2). Thus, subjects whose diabetes self-efficacy improved also were likely to demonstrate improved glycaemic control. Change in self-efficacy was not related significantly to change in BP or LDL. Examination of correlations between baseline diabetes self-efficacy and baseline medical measures showed that poorer diabetes self-efficacy was correlated with higher A1c (r = 0.077, P = 0.002), but not with LDL or diastolic/systolic BP. Other variables significant at the multivariate level were age, gender, diabetes duration and race/ethnicity. Poor glycaemic control over time was associated with longer duration of diabetes, and being younger, male and black or Hispanic. Older age, diabetes duration and being black was related to worsening SBP.

Turning to the intervention, as reported [26], the three-wave longitudinal effect of the intervention on A1c was significant (P = 0.022). The path diagram depicts the role of self-efficacy in relation to glycaemic control. The intervention has a direct and indirect effect (through change in self-efficacy) on glycaemic control. In fact, introduction of self-efficacy (and other covariates) into the model weakens somewhat the direct effect of the intervention on glycaemic control. The mediation effect of self-efficacy on glycaemic control was significant (P < 0.004 for all methods used).

Discussion

Diabetes self-efficacy has been studied as a correlate of behaviour change and glycaemic control in middle-aged individuals. In this study of older diabetes patients, diabetes self-efficacy related to glycaemic control and also a change in diabetes self-efficacy related to change in glycaemic control following a TCM intervention. Diabetes self-efficacy appears to be a relevant variable in the understudied group of older diabetes patients. Thus, interventions that lead to improved diabetes self-efficacy may benefit glycaemic control.

Change in self-efficacy did not relate to change in BP or lipids. Also, baseline diabetes self-efficacy related to A1c but not to lipids or BP. Thus, diabetes self-efficacy may only be relevant to glycaemic control. The reasons for this discrepancy are unclear. A1c is the gold standard of diabetes outcomes, and perhaps the interventionists focused on
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Table 1. Participant characteristics

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemoglobin A1c(^a)</td>
<td>1,631</td>
<td>7.38</td>
<td>1.54</td>
</tr>
<tr>
<td>Systolic BP</td>
<td>1,657</td>
<td>142.63</td>
<td>23.92</td>
</tr>
<tr>
<td>LDL cholesterol(^b)</td>
<td>1,610</td>
<td>107.50</td>
<td>35.35</td>
</tr>
<tr>
<td>Diabetes Self-efficacy scale</td>
<td>1,661</td>
<td>17.76</td>
<td>11.82</td>
</tr>
<tr>
<td>Age (years)</td>
<td>1,665</td>
<td>70.82</td>
<td>6.63</td>
</tr>
<tr>
<td>Gender</td>
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<tr>
<td>Male</td>
<td>619</td>
<td>37.18</td>
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<tr>
<td>Female</td>
<td>1,046</td>
<td>62.82</td>
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<tr>
<td>How many years of school completed</td>
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<td>9.77</td>
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</tr>
<tr>
<td>Race/ethnicity</td>
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<tr>
<td>White</td>
<td>821</td>
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<td>248</td>
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<td>Hispanic</td>
<td>585</td>
<td>35.20</td>
<td></td>
</tr>
<tr>
<td>Other</td>
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<td>.48</td>
<td></td>
</tr>
<tr>
<td>Marital status</td>
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</tr>
<tr>
<td>Not married</td>
<td>978</td>
<td>58.81</td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>685</td>
<td>41.19</td>
<td></td>
</tr>
<tr>
<td>Duration of diabetes (years)</td>
<td>1,646</td>
<td>11.09</td>
<td>9.38</td>
</tr>
<tr>
<td>Participant takes insulin to control diabetes?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1,173</td>
<td>70.49</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>491</td>
<td>29.51</td>
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</tr>
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<td>Region</td>
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<td>Downstate</td>
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</tr>
<tr>
<td>Upstate</td>
<td>890</td>
<td>53.45</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)Note that the number of respondents with baseline data is somewhat lower than the number included in the longitudinal analyses shown in Table 2. This is because a few individuals did not have a value of the outcome at baseline, but did have at least one follow-up value.

Table 2. Predicting medical outcomes using diabetes self-efficacy and controlling for other covariates in a repeated measures model with up to three waves of data for self-efficacy and medical outcomes.\(^a\)

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Std. Err.</th>
<th>P-value</th>
<th>Estimate</th>
<th>Std. Err.</th>
<th>P-value</th>
<th>Estimate</th>
<th>Std. Err.</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>7.322</td>
<td>0.352</td>
<td>&lt;0.0001</td>
<td>109.240</td>
<td>5.817</td>
<td>&lt;0.0001</td>
<td>107.930</td>
<td>9.043</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Administration</td>
<td>0.207</td>
<td>0.089</td>
<td>0.0200</td>
<td>-0.484</td>
<td>0.450</td>
<td>0.2820</td>
<td>-3.406</td>
<td>0.730</td>
<td>0.0001</td>
</tr>
<tr>
<td>Group</td>
<td>-0.337</td>
<td>0.149</td>
<td>0.0238</td>
<td>-1.933</td>
<td>0.947</td>
<td>0.0413</td>
<td>-5.342</td>
<td>1.458</td>
<td>0.0003</td>
</tr>
<tr>
<td>Administration by group</td>
<td>0.164</td>
<td>0.123</td>
<td>0.1825</td>
<td>-2.100</td>
<td>0.617</td>
<td>0.0007</td>
<td>-2.318</td>
<td>1.006</td>
<td>0.0213</td>
</tr>
<tr>
<td>Exponential (administration)</td>
<td>0.261</td>
<td>0.070</td>
<td>0.0002</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group by exponential (administration)</td>
<td>0.165</td>
<td>0.091</td>
<td>0.0881</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Diabetes self-efficacy</td>
<td>0.009</td>
<td>0.002</td>
<td>&lt;0.0001</td>
<td>-0.013</td>
<td>0.031</td>
<td>0.6773</td>
<td>-0.013</td>
<td>0.050</td>
<td>0.7986</td>
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<td>Age (years)</td>
<td>-0.015</td>
<td>0.004</td>
<td>0.0004</td>
<td>0.453</td>
<td>0.073</td>
<td>&lt;0.0001</td>
<td>-0.059</td>
<td>0.113</td>
<td>0.6019</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.131</td>
<td>0.057</td>
<td>0.0215</td>
<td>0.765</td>
<td>0.997</td>
<td>0.4434</td>
<td>5.220</td>
<td>1.533</td>
<td>0.0007</td>
</tr>
<tr>
<td>Education (years)</td>
<td>0.013</td>
<td>0.008</td>
<td>0.1375</td>
<td>-0.283</td>
<td>0.148</td>
<td>0.0561</td>
<td>-0.433</td>
<td>0.228</td>
<td>0.0573</td>
</tr>
<tr>
<td>Black</td>
<td>0.431</td>
<td>0.087</td>
<td>&lt;0.0001</td>
<td>3.719</td>
<td>1.464</td>
<td>0.0111</td>
<td>1.862</td>
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</tr>
<tr>
<td>Hispanic</td>
<td>0.725</td>
<td>0.063</td>
<td>&lt;0.0001</td>
<td>0.042</td>
<td>1.380</td>
<td>0.9760</td>
<td>-3.277</td>
<td>2.176</td>
<td>0.1321</td>
</tr>
<tr>
<td>Duration of diabetes (years)</td>
<td>0.024</td>
<td>0.003</td>
<td>&lt;0.0001</td>
<td>0.127</td>
<td>0.051</td>
<td>0.0127</td>
<td>-0.172</td>
<td>0.078</td>
<td>0.0279</td>
</tr>
</tbody>
</table>

\(^a\)All analyses were performed using SAS Proc Mixed repeated measures analyses and are adjusted for clustering within PCP and group heterogeneity in cluster and residual variances. Self-efficacy was entered as a time-varying covariate. Administration was centred on its means to avoid collinearity.

\(^b\)Non-linear terms were included to model non-linearity of haemoglobin A1c over time. First order autoregressive covariance structure was used.

\(^c\)A compound symmetry covariance structure was used.

Administration refers to time of assessment, i.e. baseline, follow-up 1 or follow-up 2.

Group refers to intervention vs. usual care groups.

An exponential (group^e^−administration) term was tested to model the rapid decline in HbA1c over time within the randomisation groups. A significant exponential term indicates that the treatment and usual care groups experienced different rates of decline over time, with greater decline observed among the treatment respondents. It is noted that while the effect of the intervention was not significant in the above model with A1c as an outcome (\(P = 0.088\), the direct effect of A1c in the model without covariates and self-efficacy in a direct intent-to-treat analysis, conducted as part of the primary analyses, was significant (\(P = 0.022\)).
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failed to establish good glycaemic control, and these experiences over a lifetime may contribute to low self-efficacy in this domain. An exploration of self-efficacy beliefs concerning A1c change could represent a new area for self-efficacy research.

Future research should explore the impact of interventions that specifically target self-efficacy as well as prospective studies of the relationship between diabetes self-efficacy and diabetes self-care regimen adherence.

Key points

• Diabetes self-efficacy has not been studied in older individuals, yet they are a growing proportion of the population.
• Diabetes self-efficacy was found to relate to glycaemic control.
• Following 2 years of a TCM intervention, change in diabetes self-efficacy was found to relate to change in glycaemic control.
• Future research should assess the potential benefits of targeting self-efficacy as the primary outcome of interventions.

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Conflicts of interest

No conflicts of interest

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