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The Impact of Patient-Centered versus Didactic Education Programs in Chronic Patients by Severity: The Case of Type 2 Diabetes Mellitus

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ABSTRACT

Background: Education leads to better health-related decisions and protective behaviors, being especially important for patients with chronic conditions. Self-management education programs have been shown to be beneficial for patients with different chronic conditions and to have a higher impact on health outcomes than does didactic education. **Objective:** To investigate improvements in glycemic control (measured by glycated hemoglobin A1c) in patients with type 2 diabetes mellitus. **Methods:** Our comparative trial involved one group of patients receiving patient-centered education and another receiving didactic education. We dealt with selection bias issues, estimated the different impact of both programs, and validated our analysis using quantile regression techniques. **Results:** We found evidence of better mean glycemic control in patients receiving the patient-centered program, which engaged better patients. Nevertheless, that differential impact is nonmonotonic. Patients initially at the healthy range at the patient-centered program maintained their condition better. Patients close to, but not within, the healthy range benefited equally from attending either program. Patients with very high glycemic level benefited significantly more from attending the patient-centered program. Finally, patients with the worst initial glycemic control (far from the healthy range) improved equally their diabetic condition, regardless of which program they attended. **Conclusions:** Different patients are sensitive to different categories of education programs. The optimal, cost-effective design of preventative programs for patients with chronic conditions needs to account for the different impact in different "patient categories." This implies stratifying patients and providing the appropriate preventative education program, or looking for alternative policy implementations for unresponsive patients who have the most severe condition and are the most costly.

Keywords: chronic disease self-management, patient-centered education, quantile regression.

Introduction

Education is a key input in the health production function [1]. It leads individuals to take better health-related decisions and develop improved preventative behavior in terms of diet, exercise, and lifestyle, both for themselves [2–5] and for their children [6,7]. Empirical studies identify strong correlations between education background and health status [8–10] and between income levels and health status [11,12]. Education is especially important for patients with chronic conditions or individuals at risk of developing chronic conditions; they suffer (or are at risk of suffering) from long-lasting conditions with persistent effects [13] that progressively diminish their quality of life, functional status, and productivity [14,15]. Therefore, it is important for patients with chronic conditions to learn how to live with their conditions, or for individuals at risk to prevent them. Moreover, the way in which chronic conditions are prevented and treated is of public concern because at present these account for more than 70% of health expenditures [16,17], are estimated to account for 70% of the global disease burden, and will be responsible for 80% of deaths across the world by 2030 [18,19].

Patient self-management education programs have been shown to be beneficial for patients with different chronic conditions, such as asthma [20], cardiac disease [21], chronic obstructive pulmonary disease [22], and type 2 diabetes [23–27]. They have the potential to make patients' lifestyle healthier, improve

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their quality of life, and so decrease the demand of health services provision and their health expenditures.

In this article, we focus on education programs for patients with diabetes mellitus (type 2 diabetes). Diabetes mellitus is a chronic disease in which the body fails to create, release, and/or respond to insulin, resulting in hyperglycemia (raised blood sugar levels) and systemic damage to many areas of the body, including the circulatory system, the nervous system, and internal organs. It is a major cause of morbidity and mortality, estimated to globally affect 9% adults 18 years and older [28]. Diabetes is responsible for enormous individual health costs related to direct and indirect effects of hyperglycemia on the human vascular tree. Its impact on patients' life expectancy and health-related quality of life depends on the severity and duration of hyperglycemia, that is, the extent by which a person's glycated hemoglobin A_{1c} (HbA_{1c}) blood sugar levels lie outside the healthy range (4.0–7.0 mmol/L) and the length of time for which this occurs. In fact, the largest prospective, randomized study to date involving patients with type 2 diabetes (UK Prospective Diabetes Study [UKPDS 35]) [29] estimated that each 1% reduction in HbA_{1c} level reduces the risk of deaths related to diabetes by 21%, myocardial infarction by 14%, and microvascular complications by 37%. Other studies with data from the United States [30–32] relate better glycemic control with fewer complications, hospital admissions, and lower health expenditures.

Diabetes is a largely "self-managed" condition. Day-to-day management is overwhelmingly in the hands of the patient, who must make long-term healthy lifestyle changes involving diet, exercise, and medication. Consequently, the quality of the diabetes education that patients receive shortly after initial diagnosis significantly influences their health choices, promoting diet, exercise, and lifestyle changes required to achieve and maintain healthy glycemic levels (i.e., within the range of 4.0–7.0 mmol/L).

In patient-centered education, self-management plans are developed and maintained through collaboration between patients, who raise their concerns, priorities, knowledge, and resources, and the clinical expertise of health care professionals. This definition of roles and responsibilities between patients and health care professionals is claimed to increase the intrinsic motivation of diabetic patients to persistently follow agreed plans and attend medical checks [33–36]. This patient-centered approach is part of a wider shift in health policy for long-term care toward the "empowered patient" model in many countries, and responds to rapidly rising diabetes-related health costs in national health systems [37,38].

The didactic education model is very different. In the didactic model, the patient is a passive recipient of standardized information provided to all patients. The health care professional is an expert who prescribes and defines good practice in diet, exercise, and lifestyle choices. The passive patient is then expected to adhere to the plans and prescriptions devised by the health care expert [23,33].

Hence, it is important to evaluate the impact of different education programs for diabetic patients. It has been proposed that patient-centered education programs for type 2 diabetes are more effective than didactic programs in changing behavior and ensuring compliance [24–27,39]. Nevertheless, empirical evidence on their benefits is mixed [25,26,40] and different issues have been raised in connection with previous trials. First, they do not directly compare patient-centered and didactic programs. Rather, control groups have consisted of patients receiving a mix of alternatives, or no formal education at all [26,40]. There might be selection bias because some trials include patients on medication to control their HbA_{1c} level. For these, reductions in recorded HbA_{1c} level may be due to teaching these patients how to take their prescriptions rather than how to make improvements in diet, exercise, and lifestyle. Second, the reporting period is many times too short. The literature finds [25] a difference of 0.92% ($P = 0.01$) in HbA_{1c} level between groups 6 months after the education program. This period, however, is generally considered too short a period for permanent lifestyle changes to occur [40] and it is commonly agreed that using a reporting period of 12 or 18 months is preferable. Third, there are important differences in the patient-centered programs in the trials, and there is a lack of consensus regarding the definition of patient-centered program, its content, or its delivery [41].

Our trial study addressed all the aforementioned issues. Furthermore, a novel contribution of our analysis is the application of simultaneous quantile regression analysis. Previous research on diabetes education has not considered whether differential improvements in diabetes control vary across the patient distribution. There are a priori reasons to expect differentials to be nonmonotonic. At one end of the distribution are patients who are healthy or close to the healthy glycemic range when initially checked and diagnosed. These patients may only need to make small lifestyle changes to improve their condition. At the other end are patients with the worst health conditions (including obesity). They face the biggest challenge in terms of making sustainable, long-term changes to diet, exercise, and lifestyle. Education programs, regardless of category, might not have enough impact on these patients to make them reach the healthy range. This article contributes to the literature by examining the relative impacts of alternative education programs across the patient distribution.

Methods

The Salford Trial

A total of 203 patients with type 2 diabetes were involved in the Salford trial. The trial group received a patient-centered program and the control group received a didactic education program. Issues of patient self-selection and general practitioner (GP) selection were dealt with. In Salford, all patients diagnosed with type 2 diabetes are referred to a specialist education unit and receive a formal education program within 1 month of diagnosis. In the trial, patients were randomly selected to attend either the didactic program or the patient-centered program. Of the 203 patients in the trial, 109 received the didactic program and 94 the patient-centered program. Other issues were taken into account. First, patients receiving medication to control their glycemic levels received education but were excluded from the trial. Second, all patients were drawn from the same set of six GP surgeries conforming to the Salford Primary Care Trust to guarantee homogeneity in patients—the city of Salford is a poor socioeconomic area with high unemployment, poor housing and social conditions, below national average education attainment, and overwhelmingly white, British ethnic background. All the same specialist education team delivered both programs in the same number of sessions (three 2-hour sessions held over 3 consecutive weeks) free for patients, at a set of venues that were local to patients within Salford.

In the didactic program, medical specialists stand in front of the group and deliver the same presentation to all the patients attending each session. The same information is provided to all the patients who may raise questions. It is not tailored to individual patients. The content of the didactic course provides information on the causes of the condition and symptoms, on diet and exercise, and on foot care. Besides the verbally provided information, patients receive a set of leaflets available for free from the National Health Service (NHS) and Diabetes UK.

The Salford patient-centered program had a “mediated learning” approach based on learning sets applied to groups of 10 to 20 people. In such a program, health care professionals (trained in a 2-day course) mediate discussions between patients on key areas of diabetes health and self-management. It delivers basic information so that patients can learn to use and critically appraise information on diabetes. It shows patients how they can translate this information to their own individual circumstances and helps them learn how best to interact with other patients who face the same set of issues as themselves. Importantly, patients also learn how to frame questions and engage in an open discourse with health care professionals mediating the program. Consequently, patients gain confidence in voicing their concerns and interacting with health care professionals. This set of skills and experiences is not developed in the didactic education program. The patient-centered program is supported by an “education pack” with the same basic information as in the didactic program but its delivery is patient-centered, and patients are made to reflect on their own present behavior and health choices. The pack is divided into three sections, with session-specific material designed to be read by patients before each session. This initiates the process of patient self-reflection before each of the relevant education sessions. Having read the supporting material, and having reflected upon it, patients use the materials as the basis for discussion in their group sessions. The patient-centered program ends with the drawing up of a personal “action plan” with practical steps to change diet, exercise, and lifestyle, and the key goals that they will strive to achieve, supervised by the GP.

The difference in marginal costs between the two programs is small and depends on two components. First, the cost of printed materials provided to patients, which was £2.00 per pack for the patient-centered program, whereas in the didactic program these materials were provided free of charge to the Salford Diabetes Education Team by the NHS and Diabetes UK. Second, the patient-centered program included a 2-day training course for the education team in the mediated learning approach that underpins the patient-centered program. The opportunity cost for the 2 days, based on the wages of the Salford Diabetes Education Team, was £2,211.00 (the annual salary of the team leader was £51,718 [NHS band 8B], the average salary of 10 nurses, dieticians, and podiatrists was £35,184 [NHS bands 6 and 7], and the annual salary of the team administrator was £20,804). For the 94 patients attending the patient-centered education program, the additional cost per patient was £26.00. It is important to note that these marginal costs fall over time, as more patients receive the patient-centered program, to the limit of £2.00 per patient (i.e., the differential cost of printed materials) when we adopt the perspective of the Salford Diabetes Education Team, or to 0 when we consider the societal perspective (under which we take into account that the NHS and Diabetes UK have still to assume the cost of the printed materials for individuals in the didactic program and that it was equally of £2.00 per pack).

Data Set

For each of the 203 patients, there were two fasting HbA_{1c} scores recorded by the patients’ GPs (406 observations). HbA_{1c_Month0} was the fasting glucose level recorded when the patient was first diagnosed with type 2 diabetes. It indicated the patient’s diabetes control before receiving one or other education intervention. $HbA_{1c\_Month12}$ was recorded 12 months after diagnosis, as part of the patient’s annual diabetes checkup. It indicated the patient’s diabetes control 12 months after the education program. The data set included three demographic variables that were standard control variables: age of the patients at the time they attended the education program, sex (indicated by the dummy variable *female*), and ethnic background (indicated by the dummy variable *white_eur*).

Table 1 provides descriptives for the variables in the data set. There were no statistically significant differences in sex, age, or ethnicity of patients attending the two education programs. Difference in mean female representation in the patient-centered and didactic groups was −0.03 (54% and 57% in the patient-centered and didactic groups, respectively). With respect to age, the mean difference between the patient-centered and didactic groups was the same (65.35 ± 8.45 in the didactic group and 65.8 ± 9.69 in the patient-centered group). Regarding ethnicity, the means and SDs for white European ethnicity were identical because Salford residents are overwhelmingly white European.

Table 1 – Means, SDs, minimum and maximum values, 25th percentile, median, and 75th percentile.

HbA_{1C} scores and demographic variables	Didactic group	Patient-centered group	Pooled sample
HbA_{1c_Month0} (mmol/L)			
Mean ± SD	7.749 ±1.629	7.759 ±1.621	7.754 ± 1.621
Minimum	5.4	5.5	5.4
25th percentile	6.7	6.6	6.6
Median	7.4	7.3	7.3
75th percentile	8.5	8.7	8.6
Maximum	14.4	14.1	14.4
$HbA_{1c\_Month12}$ (mmol/L)			
Mean ± SD	7.163 ± 1.009	6.838 ± 0.859	7.012 ± 0.954
Minimum	5.6	5.3	5.3
25th percentile	6.4	6.3	6.4
Median	6.8	6.6	6.7
75th percentile	7.9	7.5	7.7
Maximum	11.5	9.3	11.5
Age (y), mean ± SD	65.35 ± 8.45	65.35 ± 9.69	65.35 ± 9.05
Sex: female, mean ± SD	0.54 ± 0.5	0.57 ± 0.49	0.55 ± 0.49
White_eur, mean ± SD	0.99 ± 0.1	0.99 ± 0.1	0.99 ± 0.1
N	109	94	203

HbA_{1c}, glycated hemoglobin A_{1c}.

The difference of 0.01 mmol/L (at the 5% level) between the mean HbA_{1c_Month0} scores of patients in both programs was nonsignificant: 7.759 ± 1.621 mmol/L in the patient-centered program and 7.749 ± 1.629 mmol/L in the didactic program, with $t = -0.0438$ and -0.0439 for the two-sample t test with equal and unequal variances, respectively (critical $t_{0.05;203} = 1.9718$). After 12 months, however, there was a significant difference of −0.325 mmol/L in the $HbA_{1c\_Month12}$ scores, which was lower for patients attending the patient-centered program (at the 5% level): 6.838 ± 0.859 mmol/L in the patient-centered program and 7.163 ± 1.009 mmol/L in the didactic program, with $t = -2.4479$ and -2.4770 for the two-sample t test with equal and unequal variances, respectively (critical $t_{0.05;203} = -1.9718$).

In terms of individual and social costs, the estimated mean differences are highly important. The mean glycemic control of the patient-centered education group was at the upper limit of the healthy glycemic range in month 12 (6.838 mmol/L), whereas for the didactic education group it was above that upper limit (7.163 mmol/L). The median score was within the healthy range in both groups although it was lower for the patient-centered group than for the didactic group (6.6 and 6.8 mmol/L, respectively). At the same time, the maximum value found in month 12 within patients in the patient-centered group was 9.3 mmol/L compared with 11.5 mmol/L in the didactic group, which meant that patients with the worst conditions behaved better in the patient-centered group than in the didactic group, although all of them were still far from the healthy range.

We observed large differences in within-group changes recorded in months 0 and 12. A reduction of 0.7 mmol/L was recorded in median scores of the patient-centered group (month 12 = 6.6 mmol/L; month 0 = 7.3 mmol/L) and a reduction of 0.6 mmol/L was recorded in median scores of the didactic group (month 12 = 6.7 mmol/L; month 0 = 7.4 mmol/L). This difference increases in the distribution for patients with worse glycemic control, being 1.2 and 0.6 mmol/L at the 75th percentile (month 12 = 7.5 mmol/L and month 0 = 8.7 mmol/L for the patient-centered group; month 12 = 7.9 mmol/L and month 0 = 8.5 mmol/L for the didactic group) and 4.8 and 2.9 mmol/L at the maximum value or for patients with the worst glycemic control (month 12 = 9.3 mmol/L and month 0 = 14.1 mmol/L for the patient-centered group; month 12 = 11.9 mmol/L and month 0 = 14.4 mmol/L for the didactic group). We also observed a notable difference in the estimated mean scores. Subject to rounding errors, the mean difference-in-difference improvement in glycemic control, over 12 months, for the average patient attending the patient-centered program compared with the average patient attending the

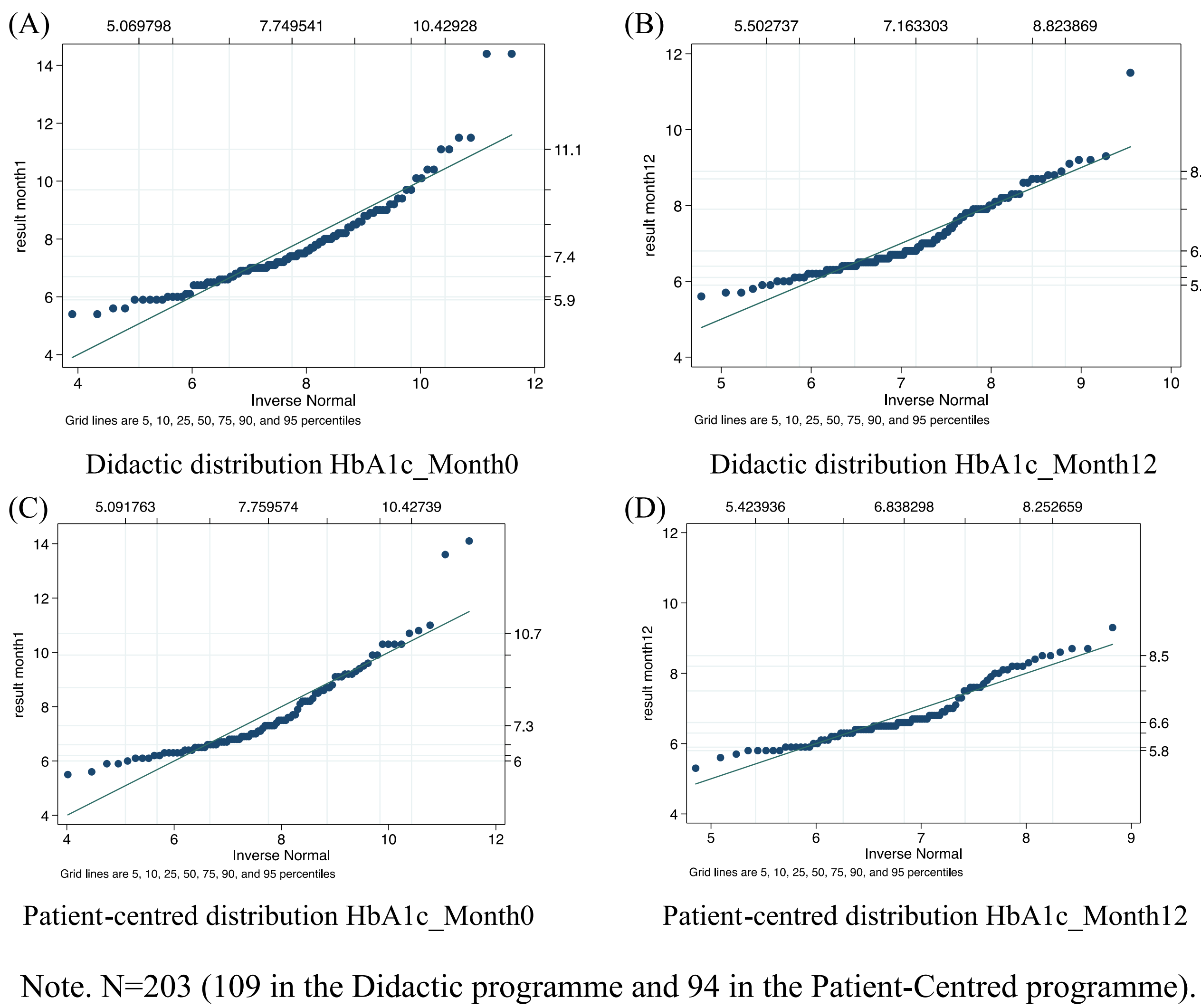

Fig. 1 – Quantile plots of initial HbA_{1c} scores (in mmol/L) when receiving an education program (HbA_{1c_Month0}) and 12 months after the program ($HbA_{1c\_Month12}$). HbA_{1c}, glycated hemoglobin A_{1c}. (Color version of figure available online).

didactic program was 0.335 mmol/L (calculated as [7.759 − 6.838] – [7.749 − 7.163]). Table 1 also offers the same statistics for the pooled sample with patients attending both patient-centered and didactic education programs, with N = 203.

Figure 1 presents quantile plot graphs of the distributions of HbA_{1c_Month0} and $HbA_{1c\_Month12}$ scores for both groups of patients including the normal (Gaussian) distribution on the diagonal line. These distributions are not right-skewed but have tails that lie above the diagonal line. Therefore, the distribution matters for the effect of education, and deviations from normality lie closer to the center of the distribution.

Estimation Analysis

We applied the ordinary least squares (OLS) estimation strategy with fixed effects to test whether there was a statistical difference in the mean improvement in HbA_{1c} level control (month 12 − month 0) of patients attending the patient-centered program relative to those attending the didactic program (pc − didactic). The estimated statistical model was:

$$\text{Diff}(\text{HbA1c}_i)=\beta_0+\delta_0\text{pc}_i+\beta_2\text{olderthan65}_i+\beta_3\text{female}_i+\varepsilon_i, \quad (1)$$

where the dependent variable $\text{Diff}(HbA_{1c})$ is the total set of 203 observations, with the difference in the blood score at month 0 and the blood score taken at month 12 for each individual. Our variable of interest is the dichotomous variable pc_i (patient-centered program) that takes value 1 when the patient has attended the patient-centered program and 0 if the patient has attended the didactic program. *Older than 65* and *female* are demographic variables, and ε is the white noise error term.

A key issue not explored in previous research in diabetes education studies is whether the impact of different education programs varies across the patient distribution. We estimated, as a robustness check, an OLS model containing a set of dummy variables (Equation 2) with coefficients for different ranges depending on the initial glycemic level [$IG(1)_i = 1$ at the healthy range when blood score at month 0 was lower than 7 mmol/L; $IG(2)_i = 1$ when it was high but close to the healthy range when blood score was between 7 and 8.5 mmol/L; $IG(3)_i = 1$ at very high initial glycemic level when it was between 8.5 and 10 mmol/L; and $IG(4)_i = 1$ at extreme initial glycemic level when blood score was greater than 10 mmol/L at month 0]. In this estimation, we were interested in the coefficients (δ) for the interactions between patient-centered program and the initial glycemic levels.

$$\text{Diff}(\text{HbA1c}_i)=\sum_{j=1}^{4}\alpha_j\text{IG}(j)_i+\sum_{j=1}^{4}\delta_j\left[pc_i * IG(j)_i\right]+\beta_2\text{olderthan65}_i+\beta_3\text{female}_i+\varepsilon_i, \quad (2)$$

Applying simultaneous quantile regression methods, one can consider the differential impact on diabetes control in the patient-centered program at individual points over the conditional patient distribution.

Quantile methods are appropriate where distributions are non-Gaussian or, as here, where there is heterogeneity between segments of the analyzed conditional distribution [42]. Quantile regression is a semiparametric method. The conditional quantile has a linear form but does not impose a set of assumptions regarding the conditional distribution, and minimizes the weighted absolute deviations to estimate conditional quantile (percentile) functions [43,44]. For the median (0.5 percentile), symmetric weights are used. For all other percentiles (e.g., 0.1, 0.2, …, 0.9), asymmetric weights are used. In contrast, classical OLS regression minimizes the sums of squared residuals to estimate models for conditional mean functions.

Quantile regression is preferable to the alternative of segmenting the dependent variable into subsets according to its unconditional distribution and then applying OLS on the subsets because such truncation of the dependent variable can create biased parameter estimates [45]. Because quantile regression uses the full data set, the sample selection problem does not arise. We dealt with the issue of heteroskedacity in standard errors using Gould's bootstrapping procedure [46,47]. Standard errors were obtained via 1000 replications of a panel bootstrap. This was drawn using a fixed initial seed (i.e., 1000), with each individual bootstrapped sample containing the same number of observations as the original sample (i.e., 109 for the didactic sample and 94 for the patient-centered sample). The software used in all our estimations was Stata version 12 (StataCorp, College Station, TX).

Results

Table 2 presents the estimated coefficients for our first model. The constant being negative and significant (constant = −0.709; $P = 0.001$), the effect of any type of education is, on average, positive with a fall in HbA_{1c} scores indicating improved glycemic control 12 months after receiving education. Notably, the estimated OLS coefficient is −0.338 mmol/L ($P = 0.076$), indicating that, on average, patients attending the patient-centered program better control their diabetes after receiving their program than does the control patient group receiving a didactic education program.

Table 2 also provides information on estimated simultaneous quantile regression models at the 25th, 50th, and 70th percentiles. In these estimated models, the estimated coefficient is negative but is significant only for the 50th and 70th percentiles [−0.299 mmol/L ($P = 0.041$) and −0.199 mmol/L ($P = 0.077$), respectively]. This indicates that net gains are nonmonotonic.

Age and sex tend not to be statistically significant in the estimated OLS and quantile models in Table 2. This is in line with previous random control trials. To investigate this further, we estimated an OLS model that contained a set of dummy variables for different ranges of initial glycemic level (healthy, high but close to healthy, very high, and extreme). In this way, one could take into account the initial condition of patients when entering one or other education program. We estimated the different effects of patient-centered versus didactic education programs for each range, through the interaction of these dummies and their attendance of one or other program. Estimates are provided in Table 3. For individuals within the healthy range, the intercept is not significant, but the patient-centered program is shown to be significantly more beneficial than the didactic program, with a coefficient of −0.572 ($P = 0.014$). For all other ranges of initial glycemic control, with HbA_{1c} level greater than 7 mmol/L (high, very high, and extreme), the intercept is negative, statistically significant, and increasing (−0.495 with $P = 0.004$; −1.293 with $P = 0.000$; and −3.643 with $P = 0.000$).

These results also indicate that education is increasingly beneficial at the initial HbA_{1c} level (in mmol/L), whereas net difference in the glycemic control of patients receiving a patient-centered education relative to those receiving a didactic program is nonmonotonic and depends on their initial condition. For individuals with high initial HbA_{1c} level but close to the healthy range (7–8.5 mmol/L), both programs are equally effective (i.e., the estimated coefficient is not statistically significant). Nevertheless, for individuals with a very high initial HbA_{1c} level (between 8.5 and 10 mmol/L), the patient-centered program is more effective than the didactic program in improving the glycemic control, with a coefficient of −0.490 ($P = 0.083$). Finally, for individuals with an extreme initial HbA_{1c} level (> 10 mmol/L) also, there is no statistical difference in the glycemic control of patients receiving either program.

Table 2 – OLS and quantile regressions on the difference between HbA_{1c} scores of patients attending the patient-centered program and the control group attending the didactic program.

Explanatory variable	OLS		25th percentile		50th percentile		70th percentile	
	Coefficient	Robust SE	Coefficient	Robust SE	Coefficient	Robust SE	Coefficient	Robust SE
Patient-centered program (differential impact relative to didactic program)	−0.338*	(0.189)	-4.77×10^{-07}	(0.387)	−0.299†	(0.145)	−0.199*	(0.112)
Control variables								
Female	0.157	(0.192)	0.500	(0.372)	0.299*	(0.163)	1.09×10^{-19}	(0.226)
Older than 65 y	0.052	(0.192)	0.200	(0.338)	0.199	(0.232)	7.42×10^{-17}	(0.161)
Constant	−0.709‡	(0.207)	−1.600‡	(0.356)	−0.599‡	(0.873)	-2.36×10^{-16}	(0.172)
N		203	203		203		203	
F		1.18						
R^2		0.0185						
Pseudo R^2			0.0148		0.0180		0.0090	

Note. Dependent variable: difference between the HbA_{1c} blood scores (mmol/L) in month 0 and month 12. Quantile bootstrap replications = 1000.

HbA_{1c}, glycated hemoglobin A_{1c}; OLS, ordinary least squares; SE, standard error.

* $P < 0.10$.

† $P < 0.05$.

‡ $P < 0.01$.

These results are consistent with the predicted difference (month 0 – month 12) in blood scores for the patient-centered program compared with the didactic program shown in Figure 2A, with significant differences at the healthy initial range and also at the third range of very high initial HbA_{1c} level. In the case of the patient-centered program, the predicted difference is always negative (beneficial), whereas for the didactic program it is not.

To understand the difference in effectiveness of both programs, it is useful to look at the 35 individuals (8 in the patient-centered program and 27 in the didactic program) for whom the program has not produced any benefit and their glycemic control has worsened (Fig. 2B). For them, the average difference is 0.425 (patient-centered) and 0.837 (didactic), and is significant for those individuals at the healthy initial range, and the only range of the initial HbA_{1c} level in which the conditions of the individuals at the patient-centered program worsen more than those of individuals at the didactic program is between 7 and 8.5 mmol/L. Once again, age and sex are found to be statistically nonsignificant.

Table 3 – OLS estimation of the effect of patient-centered program relative to the didactic program in the variation of HbA_{1c} blood scores by IG.

Explanatory variable	Coefficient	SE	P > |t|
Constant by range of IG			
IG(1): initial HbA_{1c} < 7 mmol/L	0.182	0.231	0.430
IG(2): 7.0 mmol/L ≤ initial HbA_{1c} < 8.5 mmol/L	−0.495*	0.169	0.004
IG(3): 8.5 mmol/L ≤ initial HbA_{1c} < 10 mmol/L	−1.293*	0.195	0.000
IG(4): initial HbA_{1c} ≥ 10 mmol/L	−3.643*	0.411	0.000
Differential effect (patient-centered relative to didactic program)			
IG(1) × patient-centered	−0.572†	0.231	0.014
IG(2) × patient-centered	−0.053	0.180	0.769
IG(3) × patient-centered	−0.490‡	0.281	0.083
IG(4) × patient-centered	−0.044	0.585	0.940
Demographic variables			
Older than 65 y	0.085	0.135	0.532
Female	0.094	0.127	0.458
N		203	
R^2		0.6847	

Note. Dependent variable: difference (month 0 – month 12) in the HbA_{1c} blood scores (mmol/L).

HbA_{1c}, glycated hemoglobin A_{1c}; IG, initial glycemic level; OLS, ordinary least squares.

* $P < 0.01$.

† $P < 0.05$.

‡ $P < 0.10$.

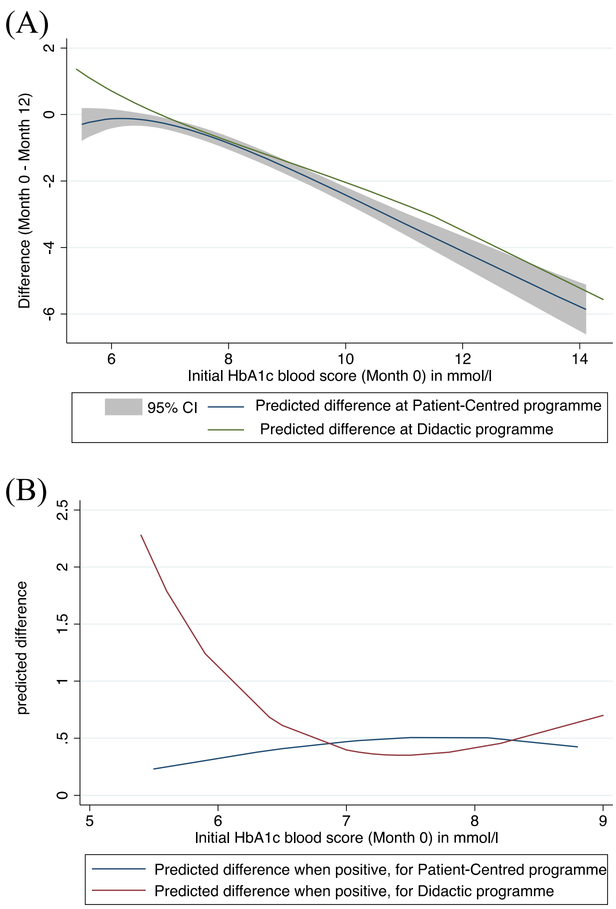

Fig. 2 – (A) Predicted difference in the blood score (in mmol/L) for individuals receiving either the patient-centered program or the didactic program. (B) Predicted difference in the blood score (in mmol/L) for individuals worsening their glycemic control (month 0 − month 12) at both the patient-centered program and the didactic program. (Color version of figure available online).

Table 4 presents the percentage of success, by education program, in patients achieving a healthy glycemic range after 12 months. The most significant differences are for individuals at the healthy initial level and for those with the initial glycemic level between 8.5 and 10 mmol/L.

To explore more extensively the different effectiveness of both programs across the distribution, a set of simultaneous quantile regression models were estimated at 0.05 percentile intervals, from the 0.05 to the 0.95 percentile. Table 5 presents the coefficients for the intercept and the patient-centered differential effect for such models (demographic variables were included but not reported because they were mostly nonsignificant). Results are consistent with our previous estimations. Nevertheless, it is important to note that where in the OLS analysis we ascertained the average improvement effects for individuals who started with different glycemic control levels, with the quantile regression we can examine the effects on the q quantile itself.

We observe a nonmonotonic relationship across the patient distribution. In the first half of the HbA_{1c} distribution, the difference between blood scores at month 0 and month 12 is mostly explained by the intercept, which is negative, large, and statistically significant (percentiles 0.05–0.50). The differential effect of the patient-centered program is negative but nonsignificant.

Progressing further along the distribution (percentiles 0.50–0.90), the differential becomes larger and the effect of education is more often explained by attendance of a specific program than by the intercept (the receiving of education in general). This indicates that there is a strong effect because of the patient-centered program for patients within this range.

Figure 3 shows the coefficients for the intercept and the differential effect of the patient-centered program across the distribution. We see that the net difference in glycemic control is always negative and mostly significant (95% confidence interval) between the 50th and the 90th percentiles of the distribution. The difference, however, is nonmonotonic, decreasing in absolute value between the 50th percentile (−0.300; $P = 0.041$) and the 70th percentile (−0.200; $P = 0.077$). Above the 70th percentile, the differential increases up to the 90th percentile (−0.400; $P = 0.042$), after which the estimated differential becomes nonsignificant for the remainder of the HbA_{1c} distribution.

Table 4 – Percentage of patients within the healthy glycemic range by month 12, according to IG.

IG	Patient-centered (%)	Didactic (%)
IG(1): initial HbA_{1c} < 7 mmol/L	100.00	88.57
IG(2): 7.0 mmol/L < initial HbA_{1c} < 8.5 mmol/L	62.96	56.52
IG(3): 8.5 mmol/L < initial HbA_{1c} < 10 mmol/L	47.37	22.22
IG(4): initial HbA_{1c} > 10 mmol/L	22.22	20.00

HbA_{1c}, glycated hemoglobin A_{1c}; IG, initial glycemic level.

Conclusions

Education leads individuals to take better health-related decisions and develop improved preventative behavior. Education is thus an important component in preventative health policy, especially for patients with chronic conditions such as diabetes. In this article, we considered two categories of education programs designed to promote behavioral change to healthier lifestyles among people with type 2 diabetes, and thereby prevent or reduce significantly the severity of the complications associated with this condition. In contrast with chronic obstructive pulmonary disease, cardiac disease, asthma, and type 1 diabetes for which there is strong evidence of a relationship between education and improved health outcomes [20–22], empirical evidence for type 2 diabetes is mixed [25,26,40].

The empirical results clearly indicate improvements in the mean glycemic control of patients receiving the patient-centered program after 12 months compared with patients receiving the didactic program. On the basis of a well-specified control group, the average effect estimated by OLS is −0.338 mmol/L, at the upper end of previous trials reported in the meta-studies [26,40]. This level of improved metabolic control represents a significant reduction in complications and improvement in quality of life.

By also applying OLS at different ranges of the glycemic level and quantile regression methods, the present study sheds new light on the effectiveness of education programs. In particular, it has identified four distinct categories of patients within the diabetic population. On the basis of the findings of our study, patients initially at the healthy range need to understand their condition and undertake preventive measures to avoid future complications. For them, patient-centered education is significantly more effective than the didactic program. In fact, the didactic program is not effective for those patients because on average they worsen their glycemic control. Hence, patients initially at the healthy range should attend patient-centered

Table 5 – Estimates of the differential improvement in glycemic control of patients attending patient-centered programs compared with those attending didactic programs, and intercept in the simultaneous quantile regressions (distribution 5%–95%).

Percentile	Differential (patient-centered relative to didactic program)			Intercept		
	Coefficient	SE	P > |t|	Coefficient	SE	P > |t|
0.05	−1.300	0.922	0.160	−2.000*	0.977	0.042
0.1	−0.600	0.575	0.298	−1.900†	0.572	0.001
0.15	−0.300	0.488	0.539	−1.900†	0.406	0.000
0.2	0.000	0.454	1.000	−1.700†	0.380	0.000
0.25	0.000	0.388	1.000	−1.600†	0.357	0.000
0.3	−0.100	0.300	0.740	−1.300†	0.333	0.000
0.35	−0.200	0.228	0.381	−1.100†	0.295	0.000
0.4	−0.200	0.198	0.313	−0.800†	0.247	0.001
0.45	−0.200	0.177	0.261	−0.700†	0.184	0.000
0.5	−0.300*	0.145	0.041	−0.600†	0.142	0.000
0.55	−0.200	0.123	0.106	−0.500†	0.143	0.001
0.6	−0.300†	0.113	0.009	−0.400*	0.172	0.021
0.65	−0.200‡	0.113	0.079	−0.200	0.189	0.290
0.7	−0.200‡	0.112	0.077	0.000	0.173	1.000
0.75	−0.100	0.112	0.375	0.000	0.153	1.000
0.8	−0.200‡	0.111	0.073	0.200	0.150	0.185
0.85	−0.300*	0.116	0.011	0.300‡	0.156	0.056
0.9	−0.400*	0.195	0.042	0.500‡	0.284	0.080
0.95	−0.800	0.685	0.244	1.000	0.811	0.219

SE, standard error.
* $P < 0.05$.
† $P < 0.01$.
‡ $P < 0.10$.

education. They should attend patient-centered education. Second, patients with high glycemic levels but close to the healthy range are able to make changes in their lifestyles within 12 months. For them, any education program is effective and beneficial compared with the alternative of no education. Although results are better for the patient-centered program, the difference is not significant, probably because being close to the healthy range, but already unhealthy, patients enrolled in

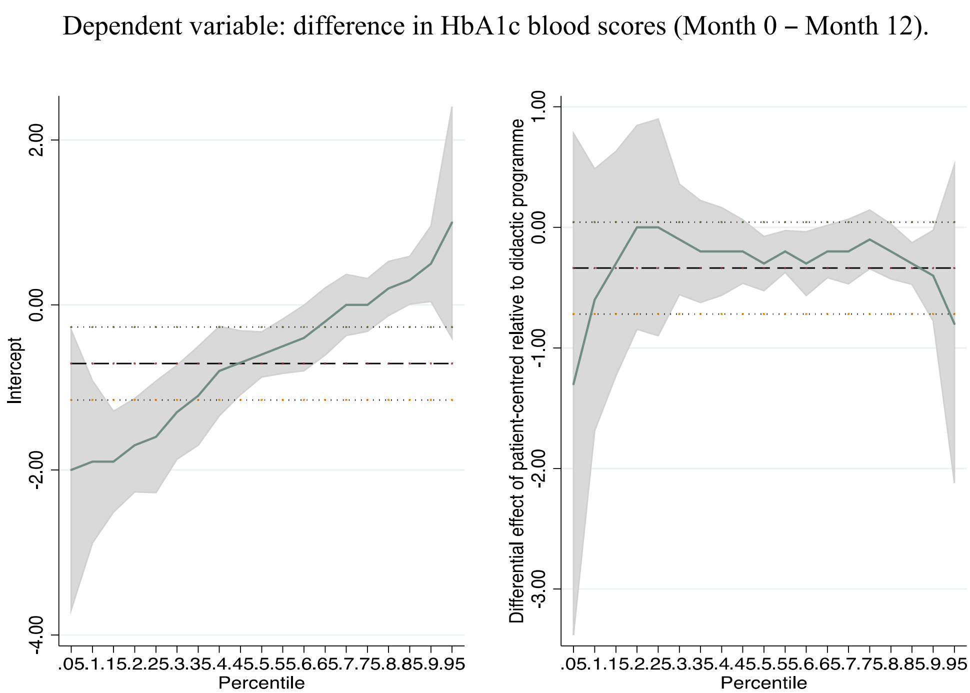

Fig. 3 – Percentile distribution of the intercept and differential impact of the patient-centered relative to the didactic program in simultaneous quantile regressions [dependent variable: difference in HbA_{1c} blood scores (month 0 − month 12)]. HbA_{1c}, glycated hemoglobin A_{1c}.

any program obtain a high rate of success. Third, patients with very high glycemic levels need specific education to contribute to their behavioral change. Being far from the healthy glycemic level, engaging patients becomes more important and our findings suggest that for this category of patients, again, patient-centered education is more effective than didactic education. Finally, for patients with the worst health conditions, including obesity, and, as a consequence, the highest individual health costs, we find that patients receiving patient-centered education do not benefit more than do patients receiving didactic education. For this category of patients, aware of their need, both patient-centered and didactic preventative education programs are very effective in changing lifestyles and improving health choices, and all of them improve their glycemic control even if most of them do not get to the healthy range in 12 months.

Our research findings highlight the need for a stratified health policy. Preventative health policy can be effective for most patients at initially healthy, high, or very high glycemic level, and the patient-centered program presents better results. Our results present several limitations. First, they are based on our case study with a sample size of 203 individuals. As a consequence, to generalize our results and policy recommendations for education programs, they should be confirmed by similar studies. Also, the focus in our article was not to do a full cost-effectiveness analysis of the two education programs. Nevertheless, previous work on the economic evaluation of diabetes education programs [48], literature relating improvement in the control of glycemic levels and a lower demand of health services and expenditures [29–32], and the minimum additional cost per patient (£26.00) of the patient-centered program point to significant savings in health expenditures for patients in the relatively healthy and intermediate categories at the initial diagnosis.

Nevertheless, for the last patient category—made up of patients with the most severe condition—education is effective in improving glycemic control but not in getting patients into the healthy range, and guidelines are required for finding their most effective treatment or complement to education. This may include alternative interventions such as bariatric surgical procedures (gastric banding, gastric bypass, or sleeve gastrectomy). The cost-benefit implications for health expenditure of surgical procedures such as these are different from those of preventative health education programs. Although further research is needed on this topic, our results point to policy stratification as a requirement to achieve an optimal resource allocation, which produces the correct mix of education and other health interventions for different patient categories.

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