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DIABETES

Patient characteristics do not predict poor glycaemic control in type 2 diabetes patients treated in primary care

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Abstract. Many diabetic patients in general practice do not achieve good glycaemic control. The aim of this study was to assess which characteristics of type 2 diabetes patients treated in primary care predict poor glycaemic control ($HbA_{1c} \geqslant 7\%$). Data were collected from the medical records. 1641 patients were included who had mean HbA_{1c} 7.1(SD 1.7)% , and 42% had $HbA_{1c} \geqslant 7\%$. On univariate analysis younger age; longer duration of diabetes; higher levels of blood glucose at diagnosis; most recent fasting blood glucose (FBG), total cholesterol, and triglyceride; higher body mass index (BMI); treatment with oral hypoglycaemic agents (OHA); treatment with insulin; more GP-visits for diabetes in the last year; and lower educational level were associated with poor control. Both in multiple linear regression and in multiple logistic regression higher levels of FBG (odds ratio (OR): = 1.6, 95% confidence interval (CI): 1.49, 1.70), treatment with OHA (OR: 2.1, 95% CI: 1.41, 3.04), treatment with insulin (OR: 7.2, 95% CI: 4.18, 12.52), lower educational level (OR: 1.26, 95% CI: 1.01, 1.56) were independently associated with poor levels of HbA_{1c}. When FBG levels were excluded from the model, higher blood glucose at diagnosis, higher values for triglyceride and total cholesterol, and younger age predicted poor glycaemic control, but these variables explained only 15% of the variation in HbA_{1c}. In conclusion prediction of poor glycaemic control from patient characteristics in diabetic patients in general practice is hardly possible. FBG appeared to be a strong predictor of HbA_{1c}, which underlines the usefulness of this simple test in daily diabetes care. The worse metabolic control in those treated with either OHA or insulin suggests that current treatment regimes might be not sufficiently applied to reach the targets of care. Providers of diabetes care should be attentive to patients with lower educational level.

Key words: Glycaemic control, Multivariate analysis, Primary care, Type 2 diabetes

Introduction

Improved glycaemic control reduces the risk of diabetic complications and mortality, although in patients with type 2 diabetes the effect on macrovascular outcome is less clear [1]. In current guidelines $HbA_{1c} < 7\%$ is considered as treatment goal for most patients [2, 3]. However, many patients in general practice do not meet this target [4, 5]. To improve quality of care, information might be helpful on patient and treatment characteristics that are possibly associated with poor levels of HbA_{1c}. In previous studies a variety of factors are identified that may influence the outcome of care, but results are conflicting and in most studies more than half of the variance of HbA_{1c} remained unexplained [6–9]. Therefore we collected a large number of patient-, disease-, and treatment characteristics in a primary care population of patients with type 2 diabetes, including data of both compliant and non-compliant patients. The aim of the study was to assess which of these characteristics could predict poor glycaemic control in this population.

Materials and methods

Setting and participants

The study was carried out in the Utrecht region between July 1999 and October 2000. Of 110 general practices invited to take part, 52 (67 doctors) were willing to participate. Twenty-seven practices (52%) were connected to the Utrecht Diabetes Project (UDP), a shared-care project providing remote diabetologist support for GPs [10]. Of the practices that refused to participate, 55% were involved in the UDP.

The study was approved by the medical-ethical committee of the University Medical Centre Utrecht. All patients provided written informed consent.

Design and patients

The practices covered 131,000 people and included 2140 patients diagnosed with type 2 diabetes. The criterion to be included in the study was treatment for diabetes in primary care. Two research assistants

retrieved relevant information from the patients' medical records. This included information on socio-demographic and disease factors (age, sex, educational level, marital status, duration of diabetes, blood glucose at diagnosis, number of diabetes-related disorders); clinical parameters (fasting blood glucose (FBG), HbA_{1c}, lipid status, body mass index (BMI), blood pressure, and actual smoking); and factors related to treatment processes (actual treatment for diabetes, shared care involvement, and number of visits for diabetes in the past 12 months). When data were missing or outdated (i.e. if data not had been measured within the past 14 months before the audit; for FBG we set a limit of 4 months), GPs were requested to update the medical records by reviewing the patients. This was supported by sending invitations to the patients to report to their GPs [5]. For data on diabetes-related morbidity the medical records were searched for 13 relevant micro- and macrovascular disorders, recorded by the GPs based on their own criteria. Except for FBG, which was mostly measured at the practices, all laboratory data were measured in the GP Lab Corporation of Utrecht, using standard biochemical essays. HbA_{1c} was measured with turbidimetric inhibition immunoassay Hitachi 917, Roche (normal range 4.0–6.0%).

Statistical analysis

Statistical analyses were performed by using SPSS release 11.0. Means are expressed with standard deviation (SD). The associations between glycaemic control and potential predicting factors were evaluated with univariate and multiple linear regression analyses using HbA_{1c} as dependent variable. In addition, logistic regression was performed considering glycaemic control as 'poor' when HbA_{1c} was $\geqslant 7.0\%$. Variables were included in forward stepwise multiple regression analyses if there was a significant association in univariate analysis ($p < 0.05$), or if they were likely to be a confounder.

Results

Of 2140 patients with type 2 diabetes, 1641 (77%) were treated in primary care. The clinical characteristics of these patients are shown in Table 1. After reviewing patients with missing or outdated data, more than 90% of the patients records were complete, except for blood glucose at diagnosis, that could be assessed in 61% of the patients. With average HbA_{1c} of 7.1% glycaemic control was moderate, but 42% of the patients had values over 7%.

Table 1. Characteristics of type 2 diabetes patients treated in general practice N = 1641

Age (years)	65.3 (13.3)
Male (%)	44
Educational level (%)	
Low	59
Middle	31
High	10
Living with a partner (%)	68
Duration of diabetes (years)	5.5 (6.0)
BG at diagnosis (mmol/l)	12.5 (5.4)
Diabetes-related complications (% of patients)	
None	49
1 or 2	44
$\geqslant 3$	7
FBG (mmol/l)	9.0 (3.2)
HbA_{1c} (%)	7.1 (1.7)
Patients with $HbA_{1c} \geqslant 7\%$ (%)	42
Total cholesterol (mmol/l)	5.8 (1.2)
Triglyceride (mmol/l)	2.2 (2.0)
BMI (kg/m^2)	28.7 (5.2)
Blood pressure (mmHg)	148 (21)/84 (11)
Actual smoking (%)	18
Treatment (%)	
Diet only	22
OHA('s)	66
Insulin + OHA('s)	5
Insulin	7
Enrolled in shared care (%)	37
Number of GP-visits for diabetes in past 12 months	4.2 (2.7)

Results as means (SD) or percentages.
FBG = fasting blood glucose; BMI = body mass index; OHA = oral hypoglycaemic agent.

Table 2. Associations between patient characteristics and HbA_{1c} level in type 2 diabetes patients treated in general practice N = 1641

Independent variable	B[a]	95% CI for B	*p*-Value
Age (year)	−0.01	−0.02; −0.003	0.004[b]
Female	0.11	−0.06; 0.28	0.21[b]
Duration of diabetes (year)	0.03	0.01; 0.04	<0.001[b]
BG at diagnosis (mmol/l)	0.07	0.05; 0.09	<0.001[b]
FBG (most recent) (mmol/l)	0.34	0.33; 0.37	<0.001[b]
Total cholesterol (mmol/l)	0.12	0.05; 0.19	<0.001[b]
Triglyceride (mmol/l)	0.09	0.04; 0.14	<0.001[b]
BMI (kg/m^2)	0.02	0.004; 0.04	0.01[b]
SBP (mmHg)	−0.003	−0.007; 0.001	0.19
DBP (mmHg)	0.002	−0.006; 0.010	0.65
Smoking	−0.003	−0.22; 0.22	0.98
Number of diabetes-related complications	−0.055	−0.14; 0.027	0.18
Enrolled in shared care program (UDP)	−0.008	−0.18; 0.17	0.92
Treatment with OHA('s)	0.37	0.19; 0.56	<0.001[b]
Treatment with insulin	0.83	0.57; 1.1	<0.001[b]
Number of GP-visits for diabetes past 12 months	0.08	0.051; 0.11	<0.001[b]
Educational level	−0.3	−0.4; −0.12	<0.001[b]
Marital state	−0.07	−0.2; 0.1	0.45

CI = confidence interval; (F)BG = (fasting) blood glucose; BMI = body mass index; SBP = systolic blood pressure; DBP = diastolic blood pressure; UDP = Utrecht Diabetes Program (see text); OHA = oral hypoglycaemic agent.
[a] The regression coefficient B reflects the estimated difference in HbA_{1c} level as a result of one unit increase in the independent variable; [b] Variables used in multiple linear regression analysis.

Table 2 shows that in univariate regression, most variables tested were associated with HbA_{1c} levels. The variables significantly associated in univariate regression, and also sex, were entered in stepwise multiple regression analysis. Variables left in the model are shown in Table 3. These variables accounted for 46% of the variance in HbA_{1c} (total $R^2 = 0.462$), and 43% of the variance was explained by FBG on its own. Therefore in additional analyses we omitted FBG from the models. The results of the new multivariate model are given in Table 4. The variables in this model explained 15% of the variance in HbA_{1c}. Besides treatment and lower educational level, higher blood glucose at diagnosis, higher levels of triglyceride and total cholesterol, and younger age, contributed to the model.

Subsequently, multiple logistic regression was performed to investigate which factors predict poor glycaemic control ($HbA_{1c} \geqslant 7.0\%$). As in multiple linear regression higher levels of FBG (odds ratio (OR): 1.6, 95% confidence interval (CI): 1.49, 1.70), treatment with oral hypoglycaemic agents (OHA) (OR: 2.1, 95% CI: 1.41, 3.04), treatment with insulin (OR: 7.2, 95% CI: 4.18, 12.52), and lower educational level (OR: 1.26, 95% CI: 1.01, 1.56), were independently associated with poor levels of HbA_{1c}.

Discussion

In this general practice population of type 2 diabetes patients nearly half of the patients had levels of HbA_{1c} over 7.0%, the current target for good control. We found that higher level of FBG, treatment with OHA or insulin, and lower educational level predicted a higher level of HbA_{1c}. After excluding

Table 3. Multiple linear regression analyses between patient characteristics and HbA_{1c} in type 2 diabetes patients treated in general practice N = 1641

Independent variable	B[a]	95% CI for B	*p*-Value
FBG (mmol/l)	0.34	0.32; 0.36	<0.001
Treatment with insulin[b]	0.98	0.72; 1.25	<0.001
Treatment with OHA('s)[b]	0.44	0.26; 0.62	<0.001
Educational level	−0.13	−0.24; −0.03	0.02

CI = confidence interval; FBG = fasting blood glucose; OHA = oral hypoglycaemic agent. Excluded variables were: age, sex, triglyceride, total cholesterol, duration of diabetes, frequency of visits for diabetes in past 12 months, blood glucose at diagnosis, and BMI. 46% of the variance of HbA_{1c} was explained by the variables in the model (total $R^2 = 0.462$).
[a] The regression coefficient B reflects the estimated difference in HbA_{1c} level as a result of one unit increase in the independent variable; [b] Compared to patients with diet alone.

Table 4. Multiple linear regression analyses between patient characteristics and HbA_{1c} in type 2 diabetes patients treated in general practice N = 1641

Independent variable	B[a]	95% CI for B	*p*-Value
Blood glucose at diagnosis (mmol/l)	0.05	0.03; 0.08	<0.001
Treatment with insulin[b]	1.7	1.2; 2.2	<0.001
Treatment with OHA('s)[b]	0.7	0.4; 1.0	<0.001
Educational level	−0.3	−0.5; −0.1	0.001
Age (year)	−0.02	−0.03; −0.006	0.001
Triglyceride (mmol/l)	0.11	0.03; 0.20	0.006
Total cholesterol (mmol/l)	0.13	0.03; 0.20	0.008

CI = confidence interval; OHA = oral hypoglycaemic agents. 15% of the variance of HbA_{1c} was explained by the variables in the model (total $R^2 = 0.154$). Analysis without fasting blood glucose.
[a] The regression coefficient B reflects the estimated difference in HbA_{1c} level as a result of one unit increase in the independent variable; [b] Compared to patients with diet alone.

FBG from the model, also blood glucose at diagnosis, triglyceride, total cholesterol, and age did contribute to the model. These variables could explain only 15% of the variance in HbA_{1c}, so we found little evidence that in this population the characteristics studied provide sufficient explanation for the variation in HbA_{1c}.

The data in this study were collected both directly from the patients' records, and by an active approach of patients in case of missing or outdated variables as well. With this procedure it seems plausible that under-representation of patients non-compliant to medical care was limited. The prevalence of diabetes, mean age, sex, glycaemic control, treatment of patients, and the known duration of the disease were comparable to other recent investigations in general practice [10–12]. Thus, it is highly likely that our findings were representative of general practice in The Netherlands.

Of the clinical parameters the most recently measured FBG appeared to be a strong predictor, with 0.34 point% increase of HbA_{1c} per mmol/l FBG. Although this association underlines the usefulness of this simple and cheap test to assess glycaemic control in daily diabetes care, caution is necessary. A study of Bouma et al. in non-insulin-using patients revealed that the prediction of HbA_{1c} from good fasting plasma glucose levels (<7.8 mmol/l) tended to be too optimistic, especially in patients using OHA, with therefore a risk for under-treatment [13]. Overweight was not significantly related to glycaemic control in this study, which confirms the findings from another cross-sectional study in primary care [14]. The well-known metabolic relationship between lipids and glycaemia is likely to explain in this study the association of an unfavourable lipid status with worse glycaemic control.

The association of treatment with OHA or insulin with higher levels of HbA_{1c} is consistent with results of other studies [15, 16]. This finding reflects both the deterioration of diabetes over the time, as well as that current treatment regimens might be not sufficiently applied to reach the targets of care. From the UKPDS it is known that even with intensive treatment only 50% of patients achieved the target HbA_{1c} level of 7%, and this percentage decreased dramatically in the long term [17]. However, a recent study in primary care revealed a 17% reduction in HbA_{1c} in 288 poorly controlled patients, after supporting GPs with flow-charts, treatment schemes for OHA and visits from facilitators, suggesting a certain degree of under-performance [18]. No matter how, these findings force us to be realistic regarding the control of hyperglycaemia that can be achieved with current treatment regimens, in particular insulin therapy [19]. Other treatment factors as involvement in shared care, and more visits for diabetes, were not associated with better glycaemic control. This confirms the results of a study by Hansen et al. who found that none of a set of GP – and practice related characteristics could predict glycaemic control [8]. However, the finding that shared care was not associated with better glycaemic control must be interpreted with caution, because our study design might be less suitable to assess the effects of the UDP in this population. In the first place GPs are inclined to select for shared care only patients with a more problematic condition of their diabetes [10]. Secondly, it is not unlikely that within the UDP-practices also patients not included in shared care had profited by the support from the diabetologist. Finally, non-UDP GPs could have improved their performance by attending the three-monthly free accessible local UDP courses, resulting in a so-called contamination effect.

Younger age appeared to be associated with worse control, although the effect was small and clinical insignificant [20]. Finally, a moderate inverse relationship was observed between educational level and glycaemic control. Other authors have emphasised the significance of health literacy in diabetes care [21, 22]. In our population almost 60% of the patients had a low educational level. Since diabetes is a 'complex' disease, it seems of importance that pro-

viders of diabetes care are conscious of the potential influence of educational level on the outcomes of diabetes care.

In conclusion, we found that prediction of poor glycaemic control from patient characteristics in diabetic patients in general practice is hardly possible; that in daily diabetes care in addition to measurements of HbA_{1c}, measuring of FBG is useful to assess glycaemic control; that treatment with OHA or insulin were associated with inadequate glycaemic control; and that providers of diabetes care should be attentive to patients with lower educational level.

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