Association Among Individual Deprivation, Glycemic Control, and Diabetes Complications

The EPICES score

HÉLÈNE BIHAN, MD[1]
SILVANA LAURENT, MD[1]
CATHERINE SASS, MD[2]
GÉRARD NGUYEN, MD[1]
CAROLINE HUOT, MD[1]
JEAN JACQUES MOULIN, MD[2]
RENÉ GUEGEN, MD[2]
PHILIPPE LE TOUMELIN, MD[3]
HERVÉ LE CLÉSIAU, MD[4]
EMILIO LA ROSA, MD[4]
GÉRARD REACH, MD[1]
RÉGIS COHEN, MD[1]

OBJECTIVE — Previous studies have related poor glycemic control and/or some diabetes complications to low socioeconomic status. Some aspects of socioeconomic status have not been assessed in these studies. In the present study, we used an individual index of deprivation, the Evaluation de la Précarité et des Inégalités de santé dans les Centres d'Examens de Santé (Evaluation of Precarity and Inequalities in Health Examination Centers [EPICES]) score, to determine the relationship among glycemic control, diabetes complications, and individual conditions of deprivation.

RESEARCH DESIGN AND METHODS — We conducted a cross-sectional prevalence study in 135 consecutive diabetic patients (age 59.41 ± 13.2 years [mean ± SD]) admitted in the hospitalization unit of a French endocrine department. Individual deprivation was assessed by the EPICES score, calculated from 11 socioeconomic questions. Glycemic control, lipid levels, blood pressure, retinopathy, neuropathy, and nephropathy were assessed.

RESULTS — HbA_{1c} level was significantly correlated with the EPICES score ($r = 0.366$, $P < 0.001$). The more deprived patients were more likely than the less deprived patients to have poor glycemic control ($\beta = 1.984$ [SE 0.477], $P < 0.001$), neuropathy (odds ratio 2.39 [95% CI 1.05–5.43], $P = 0.037$), retinopathy (3.66 [1.39–9.64], $P = 0.009$), and being less often admitted for 1-day hospitalization (0.32 [0.14–0.74], $P = 0.008$). No significant relationship was observed with either nephropathy or cardiovascular risk factors.

CONCLUSIONS — Deprivation status is associated with poor metabolic control and more frequent microvascular complications, i.e., retinopathy and neuropathy. The medical and economic burden of deprived patients is high.

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Accumulated evidence has demonstrated that achievement of near-normal glycemic control in diabetes care reduces the development and progression of microvascular complications (1,2). This approach is also cost-effective compared with other treatments (3). As a chronic disease, diabetes needs specific self-management care and adherence to treatment. Therefore, poor socioeconomic conditions could influence the outcome of diabetic patients. Increased mortality has also been reported in relation to socioeconomic status (4–7). Some studies have reported a higher prevalence of poor glycemic control and/or complications in patients with low socioeconomic status (8). In these studies, socioeconomic status has been assessed by several indicators that may represent different dimensions of the socioeconomic status (9), i.e., occupation (10), education (11,12), income (12), or area deprivation (13). Instead of being interchangeable determinants of health, studies have shown that these indicators are independent and partially interdependent determinants of health (8,14,15). Socioeconomic status also encompasses other dimensions such as social support and relationships, childhood/adult life events, and accommodation status. Traditional socioeconomic indicators are not always a good means to assess the socioeconomic status or deprivation of an individual in its full dimension. It has also been proposed that different approaches to the assessment of socioeconomic status are necessary to have a fuller picture of the relationship between socioeconomic status and health (8). Therefore, the aim of the present study was to assess the association among glycemic control, diabetes complications, and an individual score of deprivation that takes into account the multiple dimensions of socioeconomic conditions including psychological, social, and economic aspects.

RESEARCH DESIGN AND METHODS

We conducted a cross-sectional study in the endocrinology unit of Avicenne Hospital in 2000. During a 6-week period, 135 consecutive diabetic patients were included. Only 123 patients (91%) completed the form. Fifty-one were admitted for conventional hospitalization and 72 for 1-day hospitalization. For each patient a medical report indicating all the characteristics of the disease was available. Type 1 diabetes was de-

From the [1]Université Paris XIII (CRNH) et Services de Médecine Interne et d'Endocrinologie, de l'Hôpital Avicenne, Bobigny, France; [2]Cetaf, Centre Technique d'Appui et de Formation des Centres d'Examens de Santé, Saint-Etienne, France; the [3]Service d'Information Médicale et Statistique de l'Hôpital Avicenne, Bobigny, France; and the [4]Centre de Prévention Sanitaire et Sociale de Seine Saint Denis, Bobigny, France.

Address correspondence and reprint requests to Dr. Régis Cohen, Hôpital Avicenne, Service de Médecine Interne et d'Endocrinologie, 93009 Bobigny Cedex, France. E-mail: regis.cohen@avc.aphp.fr.

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Abbreviations: EPICES, Evaluation de la Précarité et des Inégalités de santé dans les Centres d'Examens de Santé (Evaluation of Precarity and Inequalities in Health Examination Centers); UKPDS, U.K. Prospective Diabetes Study.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

fined as initiation of insulin therapy in subjects <30 years and/or C-peptide <200 pmol/l. With these criteria, only 8 patients had type 1 diabetes. Current therapy was ascertained by using a questionnaire. Height, weight, and blood pressure were measured. Neuropathy was assessed clinically by specific symptoms, monofilament, and knee and ankle reflexes. Hypertension was defined as blood pressure >130/85 mmHg. Funduscopy was used to assess the degree of retinopathy. Diabetes history was defined as the duration of diabetes since its diagnosis.

Deprivation assessment: the EPICES score

Deprivation was assessed using the Evaluation de la Précarité et des Inégalités de santé dans les Centres d'Examens de Santé (Evaluation of Precarity and Inequalities in Health Examination Centers [EPICES]) score computed on the basis of individual conditions of deprivation (16). A first questionnaire exploring the multiple aspects of deprivation was administered to 7,208 subjects aged 16–59 years examined at 18 French Health Examinations Centers in 1999. The 42 socioeconomic questions selected from a bibliographic study on determinants of deprivation included traditional socioeconomic indicators (education, income, and occupation) and also questions related to family structure, housing conditions, employment, social benefits, financial difficulties, leisure activities, social support, childhood/adult life events, self-perceived health, and health care utilization. Data from the questionnaire were first analyzed by correspondence analysis (17). Correspondence analysis allows the construction of principal components that optimally summarize the data and enable the construction of graphical displays. These graphs show associations and discrepancies among categories, possibly suggesting profiles among individuals. The analysis provided a main axis that corresponded to a continuous factor, from the best to the worst material and social situation. The coordinate of each individual on the deprivation axis can be calculated given his or her answers to the 42 socioeconomic questions.

To reduce the number of variables, multiple regression analysis was used to select a subset of indicator variables, giving a satisfactory explanation of the individual coordinate on the principal axis associated with deprivation. The regression analysis showed that 11 variables of the 42 questions explained 90% of the variance of the deprivation axis. The EPICES score is derived by summing the estimated regression coefficients corresponding to the responses to the 11 selected questions (Appendix 1). The score varied from 0 to 100, from the least deprived to the most deprived situation.

The EPICES score was validated in 2002 in ~200,000 subjects examined at 58 French Health Examination Centers (18). Briefly, the EPICES score was related to several socioeconomic indicators (occupation, education, and employment status), to health-related behaviors (smoking and health care use), and morbidity (self-perceived health, dental health, obesity, and diabetes). The EPICES score was found to be associated with health status independently of the occupational category and the French administrative definition of deprivation (18).

In the present study the EPICES questionnaire was administered during a short interview during the stay of the patients in one of our units (1-day or conventional hospitalization).

Biology

Plasma glucose was measured by the glucose oxidative method. HbA_{1c} (A1C) (normal range 4–5.5%) was measured by microcolumn chromatography (Bio-Rad, Hercules, CA). Serum lipid levels were measured by automated enzymatic methods (Randox, Drumlin, U.K.). Urinary albumin was measured by immunonephelometry (Immage, Beckman, Villepinte, France). Serum creatinine was measured by an automated Jaffe method. Creatinine clearance was calculated by the Cockcroft formula [(140 − age) × weight × K)/creatinine, with $K = 1.25$ in men and $K = 1$ in women].

Statistical analysis

Diabetes duration, triglyceride levels, creatinemia, and microalbuminuria were log transformed to reduce the skewness of the distribution. The EPICES score was used to investigate the association between deprivation with diabetic control and diabetes complications. The EPICES score was used as a quantitative or as a dichotomous variable with the EPICES median considered as the cutoff value to divide the population into two subgroups: less deprived with a score ≤38.5 and more deprived with a score >38.5.

Bivariate analyses were first conducted to investigate the relationship among deprivation, glycemic control, and diabetes complications. Correlations among the EPICES score, patient characteristics, glycemic control, and clinical, biological, and metabolic variables were calculated by Pearson coefficients. Comparisons of less deprived with more deprived patients (as defined above) for patient characteristics, clinical and biological variables, A1C level, neuropathy, and retinopathy were analyzed by χ^2 tests and t tests as appropriate. Multivariate analysis (multiple linear regression and logistic regression) was also conducted to control for sex, age, BMI, and diabetes history.

Associations were first considered statistically significant at two-tailed $\alpha = 0.05$. Bonferroni adjustment was also applied to correct for the number of primary outcomes tested (i.e., for 10 primary outcomes, $\alpha = 0.005$).

RESULTS

— The response rate to all questions on the EPICES questionnaire was 91% (123 of 135). Nonresponders tended to have higher fasting glucose levels than responders (mean glucose levels 2.03 and 1.56 g/l, respectively, $P = 0.023$). There were no significant differences between nonresponders and responders for the other study variables.

The sociodemographic and clinical characteristics of the 123 responders are reported in Table 1. The age was 59 ± 13.3 years (mean ± SD) and 51.2% were male. The EPICES score was 38.9 ± 22.9 (median 38.5). On admission, 48 patients (39%) were treated by oral antidiabetic drugs, 42 (34%) by insulin, 23 (19%) by both oral agents and insulin, and 9 (7%) by diet alone. The blood pressure-lowering drugs used in the study were β-blockers in 26 patients (21%), calcium channel blockers in 31 (25%), ACE inhibitors or angiotensin II receptor antagonists in 38 (31%), and diuretics in 27 (22%). Other treatments were aspirin or other antiplatelet drugs in 25 patients (20%) and hypolipidemic agents in 33 (27%).

The EPICES score was strongly correlated to A1C (positive correlation, $r = 0.366$; $P < 0.001$) and Hb levels (negative correlation, $r = 0.266$; $P = 0.003$) and, to a lesser extent, to fasting glucose level (positive correlation, $r = 0.202$; $P = 0.021$).

Table 2 shows the characteristics of the patients according to deprivation assessed by the EPICES score (see RESEARCH DESIGN AND METHODS). Age, sex, blood pressure, creatinemia, microalbuminuria, and

Table 1—*Characteristics of the population*

	n	Value
Age (years)	123	59.3 ± 13.3
Male sex (%)	123	51.2
1-day hospitalization (%)	123	58.5
Diabetes history (years)	120	8.5 (4.0–15.0)
BMI (kg/m^2)	118	28.6 ± 5.6
A1C (%)	114	9.69 ± 2.64
Fasting blood glucose (g/l)	118	1.56 ± 0.62
Cholesterol (mmol/l)	122	5.16 ± 1.07
HDL cholesterol (mmol/l)	116	1.33 ± 0.53
Triglycerides (g/l)	122	1.57 ± 1.00
Hb (g/l)	123	13.1 ± 1.7
Creatinemia (μmol/l)	122	85.1 ± 41.0
Creatinine clearance (ml/min)	118	95.6 ± 39.1
Microalbuminuria (mg/l)	118	12.0 (5.1–34.4)
Systolic blood pressure (mmHg)	112	130.9 ± 19.6
Diastolic blood pressure (mmHg)	112	75.0 ± 10.9
Self-reported hypertension (%)	123	62.6
Neuropathy (%)	120	38.3
Retinopathy (%)	106	34.9
EPICES score	123	38.9 ± 22.9

Data are means ± SD or median (interquartile range), unless otherwise indicated.

total cholesterol and HDL cholesterol levels were not significantly different among EPICES groups. In contrast, poor glycemic control, retinopathy, neuropathy, and anemia were more common among the most deprived subjects (i.e., EPICES score >38.5). The more deprived subjects had higher A1C values ($P < 0.001$) and fasting blood glucose levels ($P = 0.009$) than the less deprived. About 82% of the more deprived patients had inadequate glycemic control (A1C >8.0%) compared with 56.9% of the less deprived ($P = 0.003$). Retinopathy, neuropathy, and anemia were also about twice more frequent in the more deprived patients ($P = 0.005$, $P = 0.037$, and $P = 0.023$, respectively). More deprived patients were more likely to have higher Hb levels ($P = 0.023$) than were less deprived patients. The relative frequency of 1-day hospitalization was lower among the more deprived patients (45% vs. 71.4%, $P < 0.01$). More deprived patients tended to have a higher prevalence of neuropathy and hypertriglyceridemia ($P = 0.053$ and $P = 0.050$, respectively) and lower creatinine clearance ($P = 0.087$).

The associations between deprivation and A1C value, neuropathy, retinopathy, and 1-day hospitalization remained significant after adjustment for the effect of sex, age, BMI, and diabetes history (Table 3). On average, more deprived patients had A1C values ~2% higher than those of less deprived patients ($P < 0.001$). Adjusted odds ratios (ORs) for retinopathy and neuropathy were about two ($P = 0.009$) and three ($P = 0.037$) times higher in the more deprived than in the less deprived patients, respectively. The adjusted OR for 1-day hospitalization was about one-third lower in the more deprived than in the less deprived subjects ($P = 0.008$).

After adjustment for potential confounding variables, there was no significant association between hypertriglyceridemia and deprivation ($P = 0.254$). The association between deprivation and anemia and creatinine clearance became marginally nonsignificant ($P = 0.088$ and $P = 0.079$, respectively) (Table 3).

After adjustment for the effect of glycemic control, the association between deprivation and neuropathy persisted (OR 2.67 [95% CI 1.09–6.58]). The associations with retinopathy (2.4 [0.87–6.67]), creatinine clearance ($P = 0.051$), anemia (OR 2.57 [0.90–7.38]), and 1-day hospitalization (0.41 [0.17–1.02]) were marginally nonsignificant.

CONCLUSIONS — This is the first study investigating diabetes control and complications in relation to individual deprivation status. Our study showed that the most deprived patients had poorer glycemic control and experienced microvascular complications more often. They also had more expensive management care because they were more often admitted for conventional hospitalizations.

The most important limitation of our study is the small sample size of the study population. Our study may thus suffer from a lack of power to detect some associations and may contain some type 2 errors. For instance, the lack of significant association between the EPICES score and microalbuminuria does not preclude an absence of a real relationship. In contrast, it is less probable that the relationships we observed among the EPICES score and A1C, neuropathy, and type of hospitalization might be spurious as the relationships were highly significant.

The EPICES score offers the opportunity to take into account the multidimensional aspect of deprivation at the individual level (material, psychological, and social aspects) as does, for example, the Mini Mental State test for dementia (memory, language, and disturbance of cognition). We can expect that the use of such an indicator could improve the identification of disadvantaged subjects and, therefore, could reduce classification bias. It may therefore reflect more accurately the deprivation and the socioeconomic status of the patients. The psychometric properties of the EPICES score in the study sample were assessed by Cronbach's α. Cronbach's α of 0.669 was found. This low value of Cronbach's α assumes that each item of the EPICES score had an informative value and that the EPICES measured not one but several dimensions as expected according to the construction of the score.

This finding is of interest because our aim was to assess the importance of the relationship among diabetes control, complications, and deprivation. Traditional indicators of socioeconomic status as different dimensions of socioeconomic status may have different implications for health outcomes (9) and, therefore, may only reflect one aspect of the association. In line with this, Bachmann (12) found that the associations with glycemic control and diabetes complications were not consistent among indicators, i.e., income and education. The EPICES score has additional advantages compared with other indexes of deprivation. The deprivation indexes described in the literature are aggregate scores (19–24) whereas EPICES is an individual index, escaping the problem of "ecological fallacy." Whereas most of the scores described are based on material deprivation, the EPICES score en-

Table 2—*Metabolic characteristics and diabetic complications according to deprivation as defined by the EPICES score*

	Deprivation		
	Less deprived	More deprived	
	EPICES ≤38.5	EPICES >38.5	*P*
Age (years)	57.5 ± 13.5	61.3 ± 12.9	0.121
Male sex (%)	58.7	43.3	0.088
One-day hospitalization (%)	71.4	45.0	0.003*
Diabetes history (years)	10.3 ± 9.2	11.1 ± 8.1	0.198
BMI (kg/m²)	27.9 ± 5.7	29.3 ± 5.4	0.175
Obesity (%)	29.5	40.4	0.216
A1C (%)	8.83 ± 2.36	10.57 ± 2.64	<0.001†
A1C class (%)			0.007‡
5.0–6.5	13.8	5.4	
6.6–8.0	29.3	12.5	
>8.0	56.9	82.1	
High A1C (%)	56.9	82.1	0.003†
Glucose (g/l)	1.41 ± 0.53	1.71 ± 0.68	0.009‡
Cholesterol (mmol/l)	5.22 ± 1.00	5.09 ± 1.16	0.495
HDL cholesterol (mmol/l)	1.37 ± 0.54	1.28 ± 0.53	0.370
Triglycerides (g/l)	1.42 ± 0.74	1.72 ± 1.20	0.098
Hypertriglyceridemia (%)	14.3	28.8	0.050
Hb (g/l)	13.5 ± 1.5	12.8 ± 1.8	0.023
Anemia (%)	19.0	35.0	0.046
Creatinemia (μmol/l)	83.3 ± 37.1	87.2 ± 45.0	0.507
Creatinine clearance (ml/min)	101.5 ± 43.5	89.2 ± 32.7	0.087
Microalbuminuria (mg/l)	13.0 (4.3–37.8)	12.0 (6.5–36.2)	0.663
Low creatinine clearance (%)	16.1	17.5	0.837
Systolic blood pressure (mmHg)	130.9 ± 20.6	131.0 ± 18.7	0.989
Diastolic blood pressure (mmHg)	75.5 ± 12.1	74.5 ± 9.6	0.636
High blood pressure (%)	64.3	60.7	0.696
Self-reported hypertension (%)	63.5	61.7	0.834
Neuropathy (%)	30.2	47.4	0.053
Retinopathy (%)	22.2	48.1	0.005†

Data are mean ± SD or median (interquartile range) by *t* test and χ^2 tests, unless otherwise indicated. †$P < 0.05$, ‡$P < 0.10$, after adjustment for Bonferroni correction (10 principal outcomes).

compasses social and material deprivation.

The question of the transposition of the EPICES score to other cultures may be raised because some items could be less relevant in some cultures. The rationale behind the 11 items of the EPICES score is that they were based on 42 items exploring all the different components of deprivation. Therefore, the EPICES score could be used in any other country or population, provided that the 11 questions are in accordance with the local cultures. If it is not the case, the method we used to construct the EPICES score could be applied to any population (i.e., questionnaire, correspondence analysis, and regression analysis).

Another strength of our study is the fact that few studies have investigated both glycemic control and diabetes complications in the same study (10–12). These studies were multicenter and were performed in nonhospitalized patients with different methods of recording and with nondetailed information about current therapy. Nevertheless, our results strengthen the inverse relationship between socioeconomic conditions and glycemic control reported for education (11,12), deprivation area (25), and lack of insurance (26).

Among diabetes complications associated with deprivation we reported that retinopathy and neuropathy were more frequent in the more deprived patients. This is in accordance with the fact that they had poorer glycemic control. Indeed, these complications are related to glycemic control as demonstrated in the U.K. Prospective Diabetes Study (UKPDS) (2) and Diabetes Control and Complications Trial studies (1). Nevertheless, we found that the association with retinopathy persisted after adjustment for glycemic control. Thus, glycemic control did not fully account for the association we observed. Similar results have been reported for retinopathy and education (11). Our findings confirm the relationship observed between retinopathy and socioeconomic status in diabetes (11–13,27). Diabetic neuropathy has been less studied. In line with our results, a study conducted in diabetic patients among English general practices showed a marginally nonsignificant relationship with income (12). Interestingly, our results indicate a potential relationship between anemia and deprivation in diabetic patients. Many reports found that anemia independently of gastrointestinal causes is related to diabetes. Although anemia seems to be a common finding in diabetes especially in the presence of renal disease, the origin of the association is unknown (23,24). The association with deprivation could lead to analysis of other parameters modified in this condition, such as nutritional factors.

We found no significant relationships with either diabetic nephropathy or cardiovascular risk factors. Microalbuminuria and creatinemia were similar in both groups, but creatinine clearance was marginally nonsignificant. An association among education, occupation, and diabetic nephropathy has been described in other studies (10,11,27,28). The fact that we did not find a significant relationship may be due to the relatively limited number of subjects. Nevertheless, control of hypertension and dyslipidemia by therapies could also be one potential explanation. In our study, blood pressure and/or hypertension did not differ according to deprivation, and many studies demonstrated that the treatment of hypertension was effective in the prevention and treatment of nephropathy (29) (UKPDS, Micro-Heart Outcomes Prevention Evaluation [HOPE], Reduction of Endpoints in NIDDM with the Angiotensin II Antagonist Losartan [RENAAL], Irbesartan in Diabetic Nephropathy Trial [IDNT], and Microalbuminuria Reduction with Valsartan [MARVAL]). The explanation may be that in diabetic patients, blood pressure control is easier than glycemic control. The lack of association with cardiovascular risk factors (i.e., serum lipids and blood pressure) is in line with data showing no relationship between glycemic control and macrovascular complications (1–3,30).

Obesity, usually associated with deprivation in nondiabetic subjects (31) and

Table 3—*Diabetes control and complications: multivariate analysis*

Independent variable	A1C (%) (n = 107)		Creatinine clearance (ml/min) (n = 115)		Neuropathy (n = 114)		Retinopathy (n = 101)		Anemia (n = 116)		Hypertriglyceridemia (n = 115)		1-day hospitalization (n = 116)	
	β ± SE	*P*	β ± SE	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Female	0.173 ± 0.491	0.725	−11.12 ± 5.15	0.033	0.80 (0.35–1.83)	0.601	1.65 (0.65–4.20)	0.295	1.00 (0.40–2.53)	0.990	3.46 (1.11–10.80)	0.033	0.75 (0.33–1.71)	0.496
Age	−0.040 ± 0.018	0.020	−1.530 ± 0.195	<0.001	1.01 (0.98–1.04)	0.576	0.98 (0.94–1.01)	0.181	0.99 (0.96–1.03)	0.927	1.02 (0.97–1.06)	0.474	1.02 (0.99–1.06)	0.185
BMI	−0.091 ± 0.042	0.014	3.326 ± 0.455	<0.001	0.96 (0.89–1.04)	0.276	0.92 (0.84–1.01)	0.080	0.96 (0.88–1.05)	0.372	1.10 (1.00–1.20)	0.038	1.05 (0.98–1.14)	0.177
Diabetes history	0.052 ± 0.028	0.062	−0.783 ± 0.290	0.008	1.04 (0.99–1.09)	0.095	1.08 (1.02–1.15)	0.012	1.06 (1.01–1.11)	0.021	0.98 (0.92–1.04)	0.494	0.95 (0.91–0.99)	0.045
EPICES >38.5	1.984 ± 0.477	<0.001	−8.945 ± 5.043	0.079	2.39 (1.05–5.43)	0.037	3.66 (1.39–9.64)	0.009	2.25 (0.89–5.69)	0.088	1.83 (0.65–5.19)	0.254	0.32 (0.14–0.74)	0.008

Anemia was defined as Hb <13 or 12 g/l in men or women, respectively. Hypertriglyceridemia was defined as triglycerides >2 g/l.

also to some extent in diabetic subjects (10,12), was not found to be significantly related to deprivation in our diabetic population. This could be due to the compliance with dietary recommendations in our population and/or to the limited number of patients studied.

The clinical relevance of the differences observed has to be discussed. The difference of ~2% in A1C levels between deprived and nondeprived subjects is clinically relevant because this size effect is comparable to that obtained for intensive treatment in the UKPDS Group (2). The same study has found that an 11% reduction in A1C level was associated with a 12% lower risk in any diabetes-related end point. Therefore, it is necessary to identify diabetic patients in deprivation situations to conduct specific policies in these populations. Indeed, studies have shown that diabetes case management added to primary care improves glycemic control in populations with poor socioeconomic conditions (32,33).

Several mechanisms have been proposed to explain the relationships between socioeconomic status and diabetes outcomes. These include poorer access to care, competing demands, financial barriers, poorer quality of life, and worse health behaviors and stress with the subsequent hormonal changes (8,34).

In summary, our study showed the importance of evaluating deprivation conditions in diabetic patients. Because the cost burden of deprivation and diabetes complications is important for our societies (35), the EPICES score, an individual index of deprivation, which is easy to calculate in clinical practice, is an interesting and relevant tool to focus on people who need specific policies for diabetes management.

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