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Abstract

\textit{Aim.} – This study aimed to evaluate changes in the prevalence of glucose-lowering agents in a large, unselected general French population from 1997 to 2007, with specific focus on changes in other cardiovascular risk factors in relation to diabetic status during 2001–2002 and 2006–2007.

\textit{Methods.} – The prevalence of treated diabetes was assessed in a large population who had a health check-up at the “Investigations Préventives et Cliniques” Center between 1997–2007. Baseline characteristics and risk profiles of individuals with and without treatment for diabetes were assessed and compared with data for 2001–2002 and 2006–2007.

\textit{Results.} – From 1997 to 2007, the prevalence of treatment for diabetes increased from 0.75% to 1.73% in men and from 0.7% to 2.28% in women. In 2006–2007 compared with 2001–2002, the odds ratios for receiving glucose-lowering agents, adjusted for age, body mass index (BMI) and educational level, were 1.54 (95% CI: 1.28–1.86) in men and 1.59 (95% CI: 1.26–2.03) in women. In those treated for diabetes compared with untreated subjects, greater decreases in blood pressure, cholesterol and glycaemia were found, stress and depression scores improved, and a greater increase in BMI was found. Smoking decreased in both treated and untreated individuals. Physical activity decreased in treated individuals, but remained unchanged in the general population.

\textit{Conclusion.} – The prevalence of people treated with diabetes increased in the Paris area. Although most concomitant risk factors decreased more in treated individuals than in the general population, physical activity and BMI worsened, thus, emphasizing the need for improving patient education.

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Keywords: Diabetes; Cardiovascular risk; Epidemiology; Prevalence

Résumé


\textit{Résultats.} – Entre 1997 et 2007, l’utilisation de traitements du diabète a augmenté de 0,75 % à 1,73 % chez les hommes et de 0,70 % à 2,28 % chez les femmes. Comparativement à 2001–2002, le risque de prendre un traitement antidiabétique en 2006-2007 est 1,54 (1,28–1,86) chez les hommes.

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Type 2 diabetes is one of the most common non-communicable diseases today. In the adult population (those aged 20–79 years) worldwide, the prevalence of diabetes was estimated to be 9.4% in 2011 and is expected to reach 11.0% by 2030 [1]. Furthermore, diabetes is one of the major factors associated with cardiovascular (CV) mortality. Risk of CV and all-cause mortality is two to three times higher among diabetics compared with non-diabetics [2]. Despite the recent overall decrease in mortality rates in industrialized countries, the difference observed between the two groups persists [1].

A recent study [2], in the French population, evaluated treating diabetes using ‘EPAS’ (a permanent sample of people insured by the general French national health service) for 2000–2005 and the National Information System for Health Insurance (SNIIRAM) for 2006–2009. In that study, the prevalence of the population treated for diabetes increased from 2.6% to 4.4% from 2000 to 2009, with an annual growth rate of approximately 6% from 2000 [2].

A large French study (Échantillon National Témoin Représentatif des Personnes Diabétiques, ENTRED; National Representative Sample of People with Diabetes Control), composed of 3324 people with diabetes randomly selected from the French national health insurance system database, was carried out to compare the treatment and evolution of CV risk during two time periods (2001 and 2007) [3]. However, the study design did not allow characteristics of the diabetic population to be compared with those of the general population, nor did it take into account general changes in population characteristics.

The Framingham study previously showed a decrease in CV risk from 1970 to 2005 [4]. Clinical trials in populations with diabetes have clearly shown the beneficial effect of medication (cholesterol-lowering, blood pressure-lowering) on CV risk [5,6], yet, patients with diabetes often remained undertreated [7].

The primary aim of the present study was to evaluate changes in the prevalence of medication use for diabetes in a large urban French population from 1997 to 2007, with a focus on the evolution between two periods, 2001–2002 and 2006–2007, while taking into account any changes in population characteristics between the latter two periods. A secondary aim was to compare the evolution of major biological, clinical, treatment and lifestyle characteristics in people treated for diabetes vs untreated individuals between the two latter time periods.

1. Research design and methods

1.1. Population

The study population included all men and women who were examined at the Investigations préventives et cliniques (IPC; Preventive and Clinical Investigations) Centre in Paris, France. This medical centre, which is subsidized by the French national health care system [Sécurité Sociale (Social Security)–CNAMTS], offers all working and retired people and their families free medical examinations every 5 years. Approximately 25,000 examinations per year are carried out for subjects living in the Paris area. The prevalence of medication use for treating diabetes was studied in the population who had undergone health check-ups during 1997–2007.

More in-depth analyses were carried out using populations from the same two time periods (2001–2002 and 2006–2007) and analyzed in the ENTRED study. For the first (from January 2001 to December 2002), the population included 31,204 untreated people (20,497 men and 10,707 women) and 308 who were treated (197 men and 111 women). For the second period (January 2006 to December 2007), the population, aged 17 to 97 years, included 31,555 untreated individuals (18,986 men and 12,569 women) and 557 who were treated (308 men and 249 women).

1.2. Baseline clinical and biological data

Supine blood pressure (BP) was measured in the right arm using a manual mercury sphygmanometer after a 10-min rest period. The first and fifth Korotkoff phases were used to define systolic BP (SBP) and diastolic BP (DBP). The mean of three measurements was considered the BP value. Pulse pressure (PP = SBP–DBP) was also determined. Standard biological parameters (using the enzymatic method and a Hitachi 917 analyzer, and the colorimetric method for albumin dosage and haematology using a Horiba ABX Pentra 120 device) were measured under fasting conditions; high-density lipoprotein (HDL) cholesterol was measured by a direct enzymatic method with cyclohexetrin. All clinical and biological parameters were evaluated on the same day as the examination. Tobacco use, physical activity, personal medical history, current medications and educational level (1 = illiterate; 2 = no diploma; 3 = junior
high or middle school, or technical school; 4 = high school graduate; 5 = two-year college or equivalent; and 6 = university or other graduate degrees) were assessed using a self-administered questionnaire.

1.3. Psychological status: anxiety and depression scores

Perceived anxiety and depression scores were assessed for each consultant, using validated self-administered questionnaires. Perceived anxiety was evaluated using the questionnaire from Cohen et al. [8], comprising four questions, and depression was evaluated using a questionnaire from Beck et al. [9], consisting of 13 yes/no questions.

1.4. Regulatory issues

The IPC Centre received authorization from the Comité National d’Informatique et des Libertés (CNIL; National Commission for Information Technology and Civil Liberties) to conduct these analyses. All study participants gave their informed consent at the time of the examination.

1.5. Statistical analysis

The prevalence of glucose-lowering agents in the population from 1997 to 2007 was calculated as the ratio of patients using glucose-lowering agents in relation to the entire population visiting the medical centre each year. The second step in the analysis compared the change between two specific periods of time, 2001–2002 and 2006–2007. For each of these periods, the population was classified into two groups, treated and untreated, for the analyses. The risk (odds ratios and 95% confidence interval, CI) for using glucose-lowering agents between the two periods was evaluated by logistic regression, including age, gender, body mass index (BMI) and educational level. Because of the potential causal link between BMI and development of diabetes, the analyses were repeated without BMI as a co-variable. Period effect was compared between untreated and treated individuals using multiple regression variance analysis for quantitative variables and logistic regression models for qualitative variables, including the time period and treatment interaction terms.

All statistical analyses were carried out using the SAS statistical software package, version 8.2.

2. Results

2.1. Evolution of medication use for diabetes from 1997 to 2007

The total population included 209,188 men and 120,440 women, with a mean age of 45 ± 12.8 years (range: 14–97 years). In the overall population from 1997 to 2007, 0.88% and 0.90% of men and women, respectively, were treated. The percentage increased from 0.75% in 1997 to 1.73% in 2007 in men, and from 0.7% in 1997 to 2.28% in 2007 in women (Fig. 1).


Fig. 2 compares the percentages of individuals treated for diabetes between the two periods, according to age. Regardless of age, the percentage of treated people was higher in 2006–2007 compared with 2001–2002. In each age group, the percentage of treated people was approximately twice as high in 2006–2007 as in 2001–2002. The odds of receiving treatment for diabetes, after adjusting for age, BMI and level of education, were also significantly higher in 2006–2007 than in 2001–2002, regardless of age (only a trend was noted in individuals <45 years of age) and gender. Before adjusting for BMI and level of education, the risk of being treated was 1.55 (1.09–2.20) and 2.17 (1.47–3.20) in men and women, respectively. The risk of being treated remained significant after taking into account age, level of education [1.55 (1.29–2.36) and 1.87 (1.48–2.36)] and BMI [1.54 (1.28–1.86) and 1.59 (1.26–2.03)] in men and women, respectively (Table 1).

In contrast, the proportion of individuals with high fasting glucose not treated for diabetes was similar in 2001–2002 and 2006–2007 (2.35% in men and 1.05% in women).

The age of the overall population decreased between the two periods (45.6 ± 12.3 years in 2001–2002 vs 43.7 ± 13.4 years in 2006–2007), while the percentage of women increased between the two periods (34.3% in 2001–2002 vs 39.9% in 2006–2007). Age remained unchanged in people treated for diabetes, but decreased in untreated individuals.

When age-adjusted analyses were carried out separately in those treated and untreated (Table 2), as expected, blood glucose levels were higher in those treated than in those untreated (P < 0.0001). Also, glycaemia decreased between the two periods more significantly in those treated than in untreated individuals (P < 0.0001 for interaction).

Despite the low cholesterol levels among those treated for diabetes, the decrease in cholesterol was greater in treated than in untreated individuals.

The percentage of current smokers was significantly lower among individuals treated for diabetes. The percentage of current smokers significantly decreased between the two periods and was similar in both groups.

The score for depression was positively associated with the presence of treatment, and decreased significantly between the two periods. The score decreased to a greater extent among those treated for diabetes (with the score of treated individuals in 2006–2007 reaching the level of untreated subjects in 2001–2002). Stress levels were also positively associated with treatment. Between the two periods, this decreased only among treated individuals and tended to increase among those who received no treatment.

Regular physical activity was reported in similar proportions among the treated and untreated in 2001–2002; it remained stable for the population without treatment, but significantly decreased in those treated in 2006–2007 compared with the earlier period.

Educational level was lower among people treated for diabetes, and the difference was greater for the 2006–2007 period.

Overall, glycaemia, cholesterol and psychological parameters were better controlled in treated people in 2006–2007.

Table 2
Age-adjusted biological, clinical, lifestyle and medical treatment characteristics between two time periods.

<table>
<thead>
<tr>
<th>Model</th>
<th>Age</th>
<th>Gender</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Odds ratio</td>
<td>1.41</td>
<td>1.52</td>
<td>1.8</td>
<td>1.43</td>
</tr>
<tr>
<td>(95 % CI)</td>
<td>(0.86–2.32)</td>
<td>(1.15–2.02)</td>
<td>(1.40–2.30)</td>
<td>(1.05–1.96)</td>
</tr>
</tbody>
</table>

SBP: Systolic blood pressure; GGT: gamma-glutamyl transpeptidase; ECG: electrocardiography.

a Treatment effect.

b Period × treatment interaction effect.

c SBP < 130 mmHg and DBP < 80 mmHg.
However, BMI increased similarly among treated and untreated populations, while SBP and triglycerides decreased between the two periods in both treated and untreated populations.

As for other medications, lipid-lowering treatment was more often used among treated individuals, regardless of time period. Antihypertensive treatment was also more prevalent and tended to increase more among the population treated for diabetes.

Finally, the percentage of men and women with abnormalities on electrocardiography (ECG) was higher among individuals receiving treatment for diabetes; it decreased in untreated individuals, but not in those receiving glucose-lowering medications ($P < 0.05$ for interaction).

3. Discussion

3.1. Evolution of the prevalence of treated diabetes

In the present study, the prevalence of treated diabetes increased consistently from 1997 to 2007. In 2007, it reached 1.73% in men and 2.28% in women. The study design also allowed evaluation of the progression of treatment for diabetes between two time periods. After taking into account changes in the population, in terms of age, BMI and educational level, the prevalence of treated diabetic patients increased by 55% between 2001–2002 and 2006–2007. This was observed in every age group. As the proportion of untreated individuals with high fasting glucose remained stable, it is unlikely that this increase was related to suboptimal diagnosis in the earlier time period.

This progression is in keeping with the data observed at a nationwide level in France [2], showing that the number of patients treated for diabetes had increased from 1.6 million in 2000 to 2.9 million in 2009. There were, however, important regional and local disparities. In Paris and the surrounding areas in 2009, the prevalence of treated diabetes was 2.7% in Paris proper and reached 4.5% in the neighboring Seine-Saint-Denis (an area immediately north of Paris with a high rate of social deprivation among its population), a difference that persisted after age standardization [2]. These local differences and the potential social differences in the populations studied make it important to interpret changes in prevalence according to a global view of the populations, taking into account not only social characteristics, but also other demographic, clinical and biological factors that could potentially be related to changes in the use of medications to treat diabetes.

In the recent (2012) national epidemiological survey of obesity (ObEpi), progression of the prevalence of treatment for diabetes between 2000 and 2006 increased from 1.4% to 2% (30%) among people with a BMI $\leq 24.9$ kg/m$^2$, and from 4.7% to 5.7% (18%) among those with a BMI of 25–30 kg/m$^2$ [10].

In a previous study [11] of a population with similar characteristics (2003–2006), the overall prevalence of diabetes was 2.9% in men and 2.41% in women. The prevalence was 1.8% in men of higher socioeconomic status and reached 4.0% in deprived men. In women, these prevalences were 1.6% and 8.5%, respectively. These results were similar to those observed by Ricci et al. [2].

3.2. Trends in cardiovascular risk factors in untreated and treated subjects

In treated individuals, depression and anxiety scores improved between the first period and the second, whereas no such improvement was noted in untreated people. With the exceptions of regular physical activity, which decreased in those treated for diabetes, and BMI, which increased in the whole population, the risk profile of individuals treated for diabetes improved notably over a mere interval of 5 years. However, despite improvements in a large number of CV risk factors in the second period, ECG abnormalities remained more prevalent in those receiving treatment for diabetes.

Preis et al. [4] studied the evolution of risk factors from 1970 to 2005 in relation to diabetes in 4195 people 50 years of age, including 205 with diabetes, and 3495 people 60 years of age, including 317 diabetics with diabetes, from the Framingham Heart Study. Both low-density lipoprotein (LDL) levels and SBP improved in patients with and without diabetes. BMI, however, increased much more markedly in patients with diabetes. These results are in keeping with those observed in our population although, in our study, most CV risk factors were better controlled in people treated for diabetes.

These results are also similar to those observed in the diabetic patients in the ENTRED study in 2001. Marant et al. [12] concluded that prevention of CV risk was greater among men and women with diabetes. However, despite the recent progress observed in the diabetic sample of ENTRED in 2007 [3], the quality of care remains insufficient to reduce CV risk in those with diabetes to a level comparable to that of non-diabetic populations.

3.3. Study limitations

The present study was a comparison of two cross-sectional cohorts in which diabetic status was defined by the use of glucose-lowering medications. This was clearly only an approximation of diabetic status, as some patients may have been managed by diet and lifestyle recommendations alone. On the other hand, the possibility that medications for diabetes may have been prescribed to people not meeting the strict definition of diabetes cannot be excluded. Because of our recruitment method, which was based on voluntary decision-making, it was not possible to assess a person’s motivation for coming to the IPC Centre for a general health check-up. Also, the observed increased prevalence of treated patients may have been underestimated, as patients already being treated by their practitioners may not have felt the need to have this type of check-up. Likewise, compared with the general French adult population, our population was comprised of fewer elderly individuals, which could also have led to the underestimation of the prevalence of diabetes compared with the general population.

Another study limitation was that the duration of diabetes was not available. Results may have varied if the exposure time were different between the two periods. However, the age of people treated for diabetes was similar between the two periods,
suggesting that any significant difference in exposure time was unlikely.

The exact level of physical activity and nutritional habits were also unavailable for our study population. Likewise, glycaemic control evaluated by HbA1c measurement was not available for comparing long-term glycaemic control between the two time periods.

4. Conclusion

A significant increase in the prevalence of treated diabetes was observed between 2001–2002 and 2006–2007 in a population residing in Paris and the surrounding area. This change was accompanied by a marked evolution of other CV risk factors. Among those treated for diabetes, the level of concomitant CV risk factors changed more favorably during this period, notably for lipids and BP levels, in parallel with the increased use of antihypertensive drugs. The evolution of BMI, however, was clearly less favorable, as it increased twice as much in patients treated for diabetes as in the general population. Also, a negative change in terms of physical activity was observed in patients treated for diabetes. This highlights the importance of implementing specific measures to promote a healthy lifestyle in those being treated for diabetes.

Finally, despite the reduction in anxiety and depression levels between the two time periods, psychological factors remained higher among people treated for diabetes, thus, emphasizing the persistent importance of these factors in such a population. Finally, whether the overall improvement in the risk profile of patients treated for diabetes translates into improved long-term outcomes remains to be examined in future studies.

Disclosure of interest

FT, EE, KB, BP declare that they have no conflicts of interest concerning this article.

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