UNIVERSITE DE LAUSANNE - FACULTE DE BIOLOGIE ET DE MEDECINE

Département de médecine
Faculté de biologie et médecine et Centre Hospitalier et Universitaire Vaudois (CHUV)

Prevalence, awareness and treatment of type 2 diabetes mellitus in Switzerland. The COLAUS study

THESE

préparée sous la direction du Professeur Peter Vollenweider
(avec la co-direction du Professeur Gérard Waeber)
(avec la collaboration du Docteur Pedro Marques-Vidal)

et présentée à la Faculté de biologie et de médecine de l'Université de Lausanne pour l'obtention du grade de

DOCTEUR EN MEDECINE

par

Aline KAISER

Médecin diplômé de la Confédération Suisse
Originaire de Soleure (Soleure)

Lausanne

2011

UNIL | Université de Lausanne
Faculté de biologie
et de médecine

Ecole Doctorale
Doctorat en médecine

Imprimatur

Vu le rapport présenté par le jury d'examen, composé de

Directeur de thèse	*Monsieur le Professeur* **Peter Vollenweider**
Co-Directeur de thèse	*Monsieur le Professeur* **Gérard Waeber**
Expert	*Monsieur le Professeur* **Luc Tappy**
Directrice de l'Ecole doctorale	*Madame le Professeur* **Stephanie Clarke**

la Commission MD de l'Ecole doctorale autorise l'impression de la thèse de

Madame Aline Kaiser

intitulée

Prevalence, awareness and treatment of type 2 diabetes mellitus in Switzerland. The COLAUS study

Lausanne, le 17 avril 2012

pour Le Doyen
de la Faculté de Biologie et de Médecine

Madame le Professeur Stephanie Clarke
Directrice de l'Ecole doctorale

Rapport de synthèse: Prevalence, awareness and treatment of type 2 diabetes mellitus in Switzerland. The COLAUS study

Le diabète de type 2 (DT2) a une prévalence élevée dans les pays industrialisés, et on s'attend à une augmentation dans les années à venir en raison du vieillissement de la population ainsi que des modifications du mode de vie. Il existe malheureusement peu de données épidémiologiques sur la prévalence et la prise en charge du diabète en Suisse. Les objectifs de cette étude étaient donc 1) évaluer la prévalence du DT2 dans une cohorte lausannoise ; 2) caractériser la prise en charge des patients atteints de DT2, et 3) identifier les facteurs associés à la prévalence, la connaissance par les patients de leur maladie et le traitement du DT2.

Pour ce faire, 6181 sujets (3246 femmes), âgés de 35 à 75 ans et vivant à Lausanne ont été inclus dans l'étude. La prévalence totale du DT2 était de 6.3% (intervalle de confiance à 95%: 5.7-7.0%), une valeur comparable à celle des pays avoisinants. La prévalence était plus élevée chez les hommes que chez les femmes (9.1% contre 3.8%, $p<0.001$), et augmentait avec l'âge. Deux tiers des patients avec DT2 (65.3% ; 60.4-70.0%) avaient connaissance de leur situation, et plus de trois-quarts d'entre eux étaient traités. Les hommes étaient plus fréquemment traités que les femmes (91.3% contre 75.9%, $p<0.001$). La plupart des patients suivait une monothérapie (majoritairement par biguanides). Parmi les sujets avec une thérapie multiple, une prévalence plus élevée de glycémie à jeun ≥7 mmol/l était présente. L'analyse multivariée a montré que le sexe masculin, l'âge croissant et un indice de masse corporelle élevé étaient associés à une plus grande prévalence du DT2, alors qu'aucune association n'a été trouvée pour l'activité physique et la consommation d'alcool. Parmi les sujets atteints de DT2, l'âge croissant était positivement associé à la connaissance du diabète, de même que l'âge croissant et le sexe masculin étaient associés à une plus grande prévalence du traitement. Le faible taux de connaissance de diabète pourrait être dû à un manque de dépistage par les médecins de premier recours. La présence d'autres facteurs de risque cardiovasculaire devrait inciter les médecins à un dépistage du diabète pour obtenir un meilleur profil de risque.

Cette étude a des limitations. D'abord, aucune mesure de l'hémoglobine glyquée n'a été mesurée, et par conséquent la détermination de la prise en charge uniquement par la glycémie à jeun peut être difficile. Ensuite, le taux de participation était bas et pourrait limiter l'interprétation des résultats ; néanmoins, il est comparable à celui d'autres études effectuées dans les pays occidentaux. Il existe peu de données épidémiologiques du DT2 en Suisse, cette étude permet donc d'évaluer la situation actuelle et de déterminer la prévalence et la prise en charge du diabète à Lausanne à travers la cohorte CoLaus. Une telle étude a par conséquent son importance dans le contexte actuel, au vu du vieillissement de la population et de l'augmentation des facteurs de risque cardio-vasculaires.

Received Date : 18-May-2010
Revised Date : 18-Apr-2011
Accepted Date : 19-Aug-2011
Article type : Epidemiology

Article Type: Epidemiology

Prevalence, awareness and treatment of type 2 diabetes mellitus in Switzerland: the CoLaus study

Aline Kaiser*, Peter Vollenweider*, Gérard Waeber* and Pedro Marques-Vidal†

*Department of Medicine and †Institute of Social and Preventive Medicine (IUMSP), Faculty of Biology and Medicine and Centre Hospitalier Universitaire Vaudois (CHUV), Lausanne, Switzerland

Correspondence: Pedro Marques-Vidal, Institute of Social and Preventive Medicine (IUMSP), Centre Hospitalier Universitaire Vaudois and University of Lausanne, Bugnon 17, CH–1005 Lausanne, Switzerland.
E-mail: pedro-manuel.marques-vidal@chuv.ch

Accepted??

Abstract

Aims To assess the prevalence, awareness and treatment levels of Type 2 diabetes in a Swiss city.
Methods Population-based cross-sectional study of 6181 subjects (3246 women) aged 35–75 years living in Lausanne, Switzerland. Type 2 diabetes was defined as fasting plasma glucose ≥ 7 mmol/l and/or oral hypoglycaemic treatment and/or insulin.
Results Total prevalence of Type 2 diabetes was 6.3% (95% confidence interval: 5.7–7.0%), higher in men (9.1%) than in women (3.8%, $P < 0.001$) and increased with age. Two-thirds (65.3%; 60.4–70.0%) of participants with Type 2 diabetes were aware of their status and among those aware 86.0% (81.5–90.3%) were treated. Treatment was more frequent in men (91.3%) than in women (75.9%, $P < 0.001$). Two-thirds of those treated for Type 2 diabetes were on monotherapy. Biguanides were prescribed in 65.0% of Type 2 diabetes patients and represented 48% of all antidiabetic drugs. Multivariable analysis showed male gender, increasing age, waist or BMI to be positively associated with prevalence of Type 2 diabetes, while leisure-time physical activity and alcohol consumption were negatively associated. Among participants presenting with Type 2 diabetes, increasing age was positively associated with awareness of Type 2 diabetes. Among subjects diagnosed with Type 2 diabetes, male gender and increasing age were positively associated with treatment.
Conclusion Prevalence of Type 2 diabetes in Switzerland is estimated to be between 5.7% and 7.0%. Two-thirds of patients with Type 2 diabetes are aware of their status, and over three quarters of those aware are treated.

Keywords: cross-sectional study, epidemiology, prevalence; treatment, Type 2 diabetes, Switzerland.

Introduction

Type 2 diabetes has a relatively high prevalence in industrialized countries [1] and it is expected that between 2010 and 2030 there will be a 69% increase in the number of adults with diabetes in developing countries and a 20% increase in developed countries [2]. This increase will be mainly caused by ageing of the population and lifestyle changes (lack of physical activity, modifications of eating habits, etc.) [3], making Type 2 diabetes an important public health problem. Several studies have shown that management of diabetes is far from optimal [4–6], with a sizable proportion of treated diabetic subjects not achieving adequate glucose levels. Further, little if no epidemiological data are available regarding prevalence and management of diabetes and Type 2 diabetes in Switzerland. A study conducted among patients from medical practitioners led to a prevalence estimation of 10% [7] but no specific diagnostic criteria were defined. Another study conducted in a random sample of the Geneva population reported a prevalence of self-reported antidiabetic treatment of 5% in men and less than 2% in women [8], but no prevalence data was available. Hence, the objectives of this study were: (1) to assess the prevalence of Type 2 diabetes in a population-based study; (2) to characterize the management of Type 2 diabetes patients; and (3) to identify the factors associated with Type 2 diabetes prevalence, awareness and treatment.

Materials and methods

The CoLaus study

The objectives and design of the CoLaus study have been described previously [9]. Briefly, the CoLaus Study was designed to investigate the prevalence and genetic determinants of risk factors for cardiovascular disease. The survey started in 2003 and was approved by the Institutional Ethics Committee of the University of Lausanne (Switzerland). The target sample size was 6000 subjects. All subjects aged between 35 and 75 years living in Lausanne were identified from a city register, and a random sample of 19 830 subjects (35% of the overall population) was invited to participate by mail. Subjects who volunteered to participate were then contacted by phone within 14 days by one of the staff members to set up an appointment. Subjects who did not answer were sent a second invitation letter. If no answer was obtained, they were contacted by telephone. Subjects were considered as non-participants if they declined to participate and as non-responders if contact could not be made after two successive letters and three successive phone calls. Individuals who did not live in Lausanne anymore, who were dead or who did not meet the age criteria were considered as non-eligible. Inclusion criteria also included providing written informed consent and being of Caucasian origin. The latter inclusion criterion was chosen because of the genetic aspect of the study. Of the initial 19 830 subjects sampled, 54 subjects were considered as non-eligible before contact and 15 109 (76%) responses were obtained. A total of 4667 subjects did not respond. Among responders, 6189 (41%) subjects declined to participate in the study and 799 (5%) were considered as non-eligible. The sample of 8121 subjects who agreed to participate represented 41% of the initially sampled population, 54% of all responders and 57% of all eligible responders. As there were more eligible participants than requested for the initial study, the final 1383 subjects were not included and did not attend the health examination. As the CoLaus study focused on the genetics of cardiovascular disease, it only included subjects of Caucasian origin; hence, a further 549 non-Caucasian participants were also excluded after benefiting from the health examination. Finally one participant initially included withdrew from the study, thus leaving 6188 participants (participation rate 41%). No data regarding non-participants was available. Of the initial 6188 participants, seven were excluded because of missing information regarding glucose and diabetic status.

Participants were asked to attend the outpatient clinic at the Centre Hospitalier Universitaire Vaudois (CHUV), Lausanne, in the morning after an overnight fast. Data were collected by trained field interviewers during a single visit lasting about 60 min. Information on demographic data, socio-economic and marital status, lifestyle factors, personal and family history of disease and cardiovascular risk factors and treatment was collected.

Anthropometric data

Body weight and height were measured with participants standing without shoes in light indoor clothes. Body weight was measured in kilograms to the nearest 100 g using a Seca® scale, which was calibrated regularly. Height was measured to the nearest 5 mm using a Seca height gauge. Body mass index was calculated as weight/height^2. Overweight was defined as a BMI $\geq$ 25 kg/m^2 and $<$ 30 kg/m^2; obesity was defined as a BMI $\geq$ 30 kg/m^2.

Waist was measured with a non-stretchable tape over the unclothed abdomen at the narrowest point between the lowest rib and the iliac crest. Two measures were made and the mean (expressed in centimetres) used for analyses. Abdominal obesity was considered for a waist $\geq$ 102 cm for men and $\geq$ 88 cm for women.

Biological analyses

Most biological assays were performed by the CHUV Clinical Laboratory on fresh blood samples within 2 h of blood collection, and additional aliquots were stored at –80°C. All measurements were conducted in a Modular P apparatus (Roche Diagnostics, Switzerland). The following analytical procedures (with maximum inter-batch and intra-batch CVs) were used: total cholesterol was determined by CHOD-PAP (cholesterol oxidase–*p*-aminophenazone; Roche Diagnostics, Mannheim, Germany) (1.6%–1.7%); HDL-cholesterol was determined by CHOD-PAP + PEG (polyethylene glycol) + cyclodextrin (3.6%–0.9%); glucose was determined by glucose dehydrogenase (2.1%–1.0%).

Diabetes

Diabetes was defined as fasting plasma glucose (FPG) ≥ 7 mmol/l [10] and/or presence of oral hypoglycaemic treatment and/or insulin. In the current analyses, only subjects with Type 2 diabetes were included. Type 1 diabetes was defined by a positive answer to the question 'Do you have type 1 (juvenile) diabetes?'. Awareness of diabetes was defined as a positive answer to the question 'Have you ever been told by a doctor that you have diabetes?' Treated diabetic subjects were defined as those taking oral anti-diabetic drugs and/or insulin. Oral anti-diabetic drugs were assessed by systematically checking all medicines taken and brought to the study site by the participants and categorized into insulin, biguanides and others (all non-insulin, non-biguanide antidiabetic drugs such as sulphonamides, thiazolidinediones, α-glucosidase inhibitors and dipeptidyl peptidase 4 inhibitors). Age at diagnosis of Type 2 diabetes was provided whenever possible; no selection was performed.

Awareness of dyslipidaemia (respectively hypertension) was defined as a positive answer to the question 'Did a doctor ever tell you that you had high cholesterol (resp. high blood pressure) levels?'. Alcohol consumption was categorized in drinkers and non-drinkers. Smoking status was categorized into never, former and current smoker. Leisure-time physical activity was considered when the subject reported exercising at least 20 min once per week.

Statistical analysis

Statistical analyses were performed using STATA v.11.0 (Stata Corp, College Station, TX, USA) and SAS v9.2 (SAS Inc, Cary, NC, USA). Results were expressed as number of subjects and (percentage) or as mean ± standard deviation. For prevalence, awareness and treatment rates, exact binomial 95% confidence intervals were also estimated using the cii command of STATA. Statistical analysis was made by χ^2 for categorical variables and by Student's *t*-test, non-parametric Kruskall–Wallis test or ANOVA for continuous variables. Bivariable correlations between continuous variables were assessed using a Spearman correlation. The variables significantly and independently associated with prevalence, awareness and treatment were identified using forward stepwise logistic regression with a 0.10 significance level for removal from the model and a significance level of 0.05 for addition to the model; the results were expressed as Odds ratio (OR) and 95% confidence interval. The variables studied in the multivariable analysis were gender, education (four groups), age (four groups), BMI (normal, overweight, obese), abdominal obesity (yes/no), smoking status (never, former, current), physical activity (yes/no), alcohol drinker (yes/no), parental history of Type 2 diabetes (yes/no), awareness of hypertension (yes/no), systolic blood pressure (continuous), awareness of dyslipidaemia (yes/no), total cholesterol (continuous) and baseline cardiovascular disease (yes/no). For all statistical testing, we used two-sided hypothesis testing with an α level of 0.05.

Results

Prevalence, awareness, treatment and control of diabetes

Of the 6181 participants, 14 (prevalence 0.2%) presented with Type 1 diabetes and 392 (prevalence 6.3%) presented with Type 2 diabetes. Prevalence, awareness and treatment of Type 2 diabetes for the overall sample and according to gender are summarized in Table 1. Approximately two-thirds of participants with Type 2 diabetes were aware of their status; no difference was found between genders (between gender comparison: χ^2 test = 0.22, $P = 0.65$). Awareness of Type 2 diabetes was associated with higher treatment levels among men (between gender comparison: χ^2 test = 11.31, $P < 0.001$). Two-thirds of treated subjects were on monotherapy. Biguanides were the most frequent antidiabetic drug prescribed, either alone or in combination with other drugs; insulin was the least used drug (Table 2).

Fasting plasma glucose levels were 5.55 ± 1.14 mmol/l (mean ± SD) in the overall sample, 8.29 ± 2.61 mmol/l in participants with Type 2 diabetes, 8.38 ± 2.84 mmol/l among participants aware of having Type 2 diabetes and 8.45 ± 2.79 mmol/l among treated Type 2 diabetes participants.

In 123 Type 2 diabetes patients, age at diagnosis was obtained and averaged 49 ± 13 years, with no differences between genders. Conversely, age at diagnosis was lower among patients with family history of diabetes (43 ± 13 vs 53 ± 12 years for those with and without family history, respectively, $P < 0.001$). The duration of diabetes was also significantly longer among subjects treated with insulin (15.4 ± 10.8 vs 9.6 ± 10.5 years, Kruskal–Wallis test $P < 0.005$) and positively correlated with the number of antidiabetic drugs prescribed (Spearman $r = 0.39$, $P < 0.001$).

Factors associated with prevalence, awareness, treatment and control of diabetes

Participants with Type 2 diabetes were more frequently male, of lower educational level, had a lower frequency of moderate drinking and of leisure-time physical activity, were older and had a higher BMI than non-diabetic participants (Table 3). Participants with Type 2 diabetes presented more frequently with abdominal obesity and more frequently reported a family history of Type 2 diabetes (Table 3). Finally, women with Type 2 diabetes reported more frequently a personal history of gestational diabetes than non-diabetic female participants (4% vs 1%, $P < 0.001$). As Type 2 diabetes is a strong determinant of cardiovascular diseases because of its association with cardiovascular risk factors, no correlation between the latter and diabetes was assessed. Multivariable logistic regression analysis showed male gender, increasing age and BMI, abdominal obesity and family history of Type 2 diabetes to be positively associated with the prevalence of Type 2 diabetes and leisure-time physical activity and alcohol consumption to be negatively associated with prevalence of Type 2 diabetes (Table 4).

Among participants with diabetes, awareness of Type 2 diabetes was significantly associated with BMI category, alcohol consumption, leisure-time physical activity, awareness of hypertension and dyslipidaemia, and personal history of cardiovascular disease upon bivariable analysis. Multivariable logistic regression analysis showed increasing age and BMI (overall P-value for trend < 0.05) to be positively associated with awareness of Type 2 diabetes and alcohol consumption and leisure-time physical activity to be negatively associated with awareness of Type 2 diabetes (Table 4).

Among participants aware of presenting with Type 2 diabetes, bivariate analysis showed antidiabetic drug treatment to be significantly associated with gender and smoking status (not shown). Multivariable logistic regression analysis showed male gender and increasing age to be positively and significantly associated with antidiabetic drug treatment (Table 4).

Finally, among participants treated for Type 2 diabetes, taking two or more antidiabetic drugs was significantly associated with higher fasting plasma glucose levels (41.5% vs 21.6% of multi-therapy among participants with fasting plasma glucose (FPG) ≥ 7 mmol/l and < 7 mmol/l, respectively, $P < 0.005$).

Discussion

There is little information regarding the prevalence and management of Type 2 diabetes in the Swiss population. Thus, our data thus provide important information for the Public Health management of Type 2 diabetes. Further, with the current increase in overweight and obesity observed in Switzerland [11], it is likely that the prevalence of Type 2 diabetes will increase in the future.

Prevalence of Type 2 diabetes was 6.3%, with higher rates in men. Those values are comparable to those reported for Italy [4] or Germany [12], but higher than those reported in other Italian [13], French [14] or German [15] studies, although in the last two cases only self-reported prevalence of Type 2 diabetes was obtained. Nevertheless, the reported prevalence of Type 2 diabetes in our study was 4.2%, higher than in the two aforementioned studies [14,15]. The prevalence found in this study was lower than reported for Switzerland [7,16]: a possible explanation is that both prevalence rates were estimated either among consulting patients [7] or using data from Germany, not from Switzerland. As there is no nationwide study assessing prevalence of diabetes using fasting plasma glucose, this study provides a first estimation of the prevalence of Type 2 diabetes in Switzerland using a population-based sample. Overall, our data indicate that the prevalence of Type 2 diabetes in Switzerland is comparable to neighbouring countries.

Approximately two-thirds of subjects with Type 2 diabetes were aware of their status. A possible explanation for this rather low awareness rate might be a lack of screening by primary care physicians, as has been shown in other countries [17], although no information on screening procedures is currently available for Switzerland. Hence, it would be helpful to implement more thoroughly the World Health Organization or American Diabetes Association recommendations regarding Type 2 diabetes screening [18,19]. Indeed, early screening and management of Type 2 diabetes in the population aged over 45 years has shown to be cost effective [20], even among younger subjects [21].

Slightly less than nine out of 10 Type 2 diabetes aware patients were treated with antidiabetic drugs, a value

comparable to that found in other studies conducted in Switzerland [7], the USA [6] or Germany [15] but higher than that found in a study conducted in Italy [4]. Almost two-thirds of treated Type 2 diabetes patients were on monotherapy, which is higher than reported for Italy (33%) [4] or Germany (40%) [22] but slightly lower or comparable to that reported for France (66–83%) [5,23]. Biguanides (metformin) represented 48% of all antidiabetic medicines prescribed and were prescribed to 65% of Type 2 diabetes patients, a value that is higher than in France [5,23], close to that for Germany [15] and lower than in Italy [4]. In addition, 19% of treated Type 2 diabetes patients received insulin treatment (alone or in combination), a value comparable to that for France [23–25], higher than that for Italy [4] and lower than that for Germany [22], although the subjects in the German and US studies with Type 1 diabetes were also included. Overall, our results suggest that antidiabetic drug treatment prescription habits in Switzerland resemble more closely those of France than of the other neighbouring countries, although some differences in the choice of oral antidiabetic drug were found.

In agreement with other studies [23,26,27], the prevalence of Type 2 diabetes increased with age, waist and BMI status. Similarly, subjects who were physically active had a lower risk of Type 2 diabetes, a finding also in agreement with the literature [3].

Contrary to some studies conducted in Italy [30] or the USA [31], but in agreement with others [32], no differences were found between educational levels regarding Type 2 diabetes prevalence, awareness and treatment rates. Regarding awareness and treatment, the most likely explanation is the fact that, in Switzerland, health insurance is mandatory [33], and thus the lack of screening or treatment among uninsured subjects [34] is minimized. Nevertheless, other possibilities such as the lack of power because of a small sample size cannot be ruled out. Finally, the higher prevalence and awareness of Type 2 diabetes among elderly subjects or subjects with other comorbidities is in agreement with the literature [35,36] and is probably associated with a risk factor clustering or higher likelihood of being screened as a result of a greater number of consultations. Indeed, the presence of other cardiovascular risk factors might prompt medical practitioners to screen for diabetes in order to obtain a better cardiovascular risk profile of their patients.

A higher prevalence of fasting plasma glucose levels ≥ 7 mmol/l was found among subjects on multitherapy. Possible explanations include the fact that patients received more drug items because of previous poor glycaemic control, differential adherence to recommended standards of diabetes care by Swiss practitioners [38] or the fact that Type 2 diabetes patients tend to give glycaemic control a lower rating than their doctors [39]. Another explanation is that subjects on multitherapy have a disease that progresses over a long time and is more difficult to control even though they are on multidrug regimen (they have a longer history of diabetes) but further studies are needed to better assess this issue.

The present study has some limitations. First, no measurement of HbA1c was performed. Hence, glycaemic control could be assessed only by fasting plasma glucose and comparison with data from the literature is difficult. Also, no data was available regarding antidiabetic posology or presence of dietary management. Nevertheless, our results indicate that a sizable fraction of patients with Type 2 diabetes present with high fasting plasma glucose values, stressing the need for a stronger Type 2 diabetes surveillance and increased patient motivation, as this leads to better glycaemic control and lower treatment costs [40]. The participation rate was also low (41%), which might limit the generalization of our findings. Nevertheless, low participation rates are typical of surveys in Western countries and comparable with the MONICA surveys conducted in Switzerland and other countries [41]. Only subjects of Caucasian origin were included in this study, and whether the Lausanne population is representative of the whole country might be questionable. A considerable proportion of the Lausanne population is non-Swiss or comes from other cantons: in 2006, out of the 128 231 Lausanne inhabitants, 49 330 (38%) were non-Swiss – 38 513 (30%) came from other cantons, and only 40 388 subjects (32%) were actually from the Vaud canton. Further, the prevalences of reported antidiabetic treatment in men and women are identical to the 2003 values reported in a study conducted in random samples of the Geneva population [8]. It has also been shown that a single fasting plasma glucose measurement might overestimate the prevalence of diabetes [42], although the inverse result has been found [43]. Yet, separate measurements of fasting plasma glucose would be difficult to perform in an epidemiological setting and, as there is currently no nationwide study assessing prevalence of diabetes using fasting plasma glucose, this study thus provides a first estimation of the prevalence of Type 2 diabetes in Switzerland using a population-based sample. Owing to its cross-sectional nature, this current study might not be able to assess the best correlates of Type 2 diabetes prevalence and control; the ongoing follow-up of the CoLaus cohort will provide more precise information on this topic. Also, the diagnosis of Type 1 diabetes was based on personal anamnesis and not on objective measurements of anti-GAD (glutamic acid decarboxylase) antibodies; however, this methodology is not commonly used in epidemiological practice. Finally, we have no information regarding non-responders; as the prevalence of diabetes might be higher among non-responders [22], our estimates might be underrated.

In summary, our results indicate that the prevalence of Type 2 diabetes in Switzerland is estimated at between 5.7% and 7.0%. Although one-third of Type 2 diabetes patients are unaware of their status, most patients with Type 2 diabetes are treated but control of glycaemia is low.

Acknowledgements

The CoLaus study was supported by research grants from GlaxoSmithKline, the Faculty of Biology and Medicine of the University of Lausanne, Switzerland and the Swiss National Science Foundation (grant no: 33CSCO-122661). The authors also express their gratitude to the participants in the Lausanne CoLaus study and to the investigators who have contributed to the recruitment, in particular Yolande Barreau, Anne-Lise Bastian, Binasa Ramic, Martine Moranville, Martine Baumer, Marcy Sagette, Jeanne Ecoffey and Sylvie Mermoud for data collection. We also thank Lucienne Boujon for copy-editing of the manuscript.

Competing Interests

Nothing to declare

References

1 Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care* 2004; **27:** 1047–1053.
2 Shaw JE, Sicree RA, Zimmet PZ. Global estimates of the prevalence of diabetes for 2010 and 2030. *Diabetes Res Clin Pract* 2010; **87:** 4–14.
3 Meisinger C, Löwel H, Thorand B, Döring A. Leisure time physical activity and the risk of type 2 diabetes in men and women from the general population. The MONICA/KORA Augsburg Cohort Study. *Diabetologia* 2005; **48:** 27–34.
4 Mazzaglia G, Yurgin N, Boye KS, Trifiro G, Cottrell S, Allen E *et al.* Prevalence and antihyperglycemic prescribing trends for patients with type 2 diabetes in Italy: a 4-year retrospective study from national primary care data. *Pharmacol Res* 2008; **57:** 358–363.
5 Monnier L, Grimaldi A, Charbonnel B, Iannascoli F, Lery T, Garofano A *et al.* Management of French patients with type 2 diabetes mellitus in medical general practice: report of the Mediab observatory. *Diabetes Metab* 2004; **30:** 35–42.
6 Ong KL, Cheung BM, Wong LY, Wat NM, Tan KC, Lam KS. Prevalence, treatment, and control of diagnosed diabetes in the US National Health and Nutrition Examination Survey 1999–2004. *Ann Epidemiol* 2008; **18:** 222–229.
7 Pechère-Bertschi A, Greminger P, Hess L, Philippe J, Ferrari P. Swiss Hypertension and Risk Factor Program (SHARP): cardiovascular risk factors management in patients with type 2 diabetes in Switzerland. *Blood Pressure* 2005; **14:** 337–344.
8 Morabia A, Costanza MC. The obesity epidemic as harbinger of a metabolic disorder epidemic: trends in overweight, hypercholesterolemia, and diabetes treatment in Geneva, Switzerland, 1993–2003. *Am J Public Health* 2005; **95:** 632–635.
9 Firmann M, Mayor V, Vidal PM, Bochud M, Pecoud A, Hayoz D *et al.* The CoLaus study: a population-based study to investigate the epidemiology and genetic determinants of cardiovascular risk factors and metabolic syndrome. *BMC Cardiovasc Disord* 2008; **8:** 6.
10 Diagnosis and classification of diabetes mellitus *Diabetes Care* 2008; 31(Suppl): S55-S60.
11 Marques-Vidal P, Bovet P, Paccaud F, Chiolero A. Changes of overweight and obesity in the adult Swiss population according to educational level, from 1992 to 2007. *BMC Public Health* 2010; **10:** 87.
12 Stock SA, Redaelli M, Wendland G, Civello D, Lauterbach KW. Diabetes – prevalence and cost of illness in Germany: a study evaluating data from the statutory health insurance in Germany. *Diabet Med* 2006; **23:** 299–305.
13 Bruno G, Merletti F, Bargero G, Melis D, Masi I, Ianni A *et al.* Changes over time in the prevalence and quality of care of type 2 diabetes in Italy: the Casale Monferrato surveys, 1988 and 2000. *Nutr Metab Cardiovasc Dis* 2008; **18:** 39–45.
14 Ricordeau P, Weill A, Vallier N, Bourrel R, Schwartz D, Guilhot J *et al.* The prevalence and cost of diabetes in metropolitan France: what trends between 1998 and 2000?. *Diabetes Metab* 2003; **29:** 497–504.
15 Meisinger C, Heier M, Döring A, Thorand B, Löwel H. Prevalence of known diabetes and antidiabetic therapy between 1984/1985 and 1999/2001 in southern Germany. *Diabetes Care* 2004; **27:** 2985–2987.
16 Sicree R, Shaw J, Zimmet P. The global burden: diabetes and glucose intolerance. *IDF Diabetes Atlas*, 4th edn. ??: International Diabetes Federation, 2009: 1–105.
17 von dem Knesebeck O, Gerstenberger E, Link C, Marceau L, Roland M, Campbell S *et al.* Differences in the diagnosis and management of type 2 diabetes in 3 countries (US, UK, and Germany): results from a factorial experiment. *Med Care* 2010; **48:** 321–326.
18 Screening for type 2 diabetes *Diabetes Care* 2004; 27(Suppl): S11–S14.
19 World Health Organization. *Screening for Type 2 Diabetes. WHO/NMH/MNC/03.1.* Geneva: World Health Organization, 2003;1–54.
20 Kahn R, Alperin P, Eddy D, Borch-Johnsen K, Buse J, Feigelman J *et al.* Age at initiation and frequency of screening to detect type 2 diabetes: a cost-effectiveness analysis. *Lancet* 2010.
21 Centers for Disease Control and Prevention (CDC) Diabetes Cost-Effectiveness Study Group. The cost-effectiveness of screening for type 2 diabetes. *JAMA* 1998; **280:** 1757–1763.
22 Meisinger C, Döring A, Heier M, Thorand B, Löwel H. Type 2 diabetes mellitus in Augsburg – an epidemiological overview. *Gesundheitswesen* 2005; **67**(Suppl 1): S103–S109.
23 Bringer J, Fontaine P, Detournay B, Nachit-Ouinekh F, Brami G, Eschwege E. Prevalence of diagnosed type 2 diabetes mellitus in the French general population: the INSTANT study. *Diabetes Metab* 2009; **35:** 25–31.
24 Charpentier G, Genès N, Vaur L, Amar J, Clerson P, Cambou JP *et al.* Control of diabetes and cardiovascular risk factors in

patients with type 2 diabetes: a nationwide French survey. *Diabetes Metab* 2003; **29:** 152–158.
25 Kusnik-Joinville O, Weill A, Salanave B, Ricordeau P, Allemand H. Prevalence and treatment of diabetes in France: trends between 2000 and 2005. *Diabetes Metab* 2008; **34:** 266–272.
26 Faeh D, William J, Tappy L, Ravussin E, Bovet P. Prevalence, awareness and control of diabetes in the Seychelles and relationship with excess body weight. *BMC Public Health* 2007; **7:** 163.
27 Meisinger C, Döring A, Thorand B, Heier M, Löwel H. Body fat distribution and risk of type 2 diabetes in the general population: are there differences between men and women? The MONICA/KORA Augsburg cohort study. *Am J Clin Nutr* 2006; **84:** 483–489.
28 Faeh D, Bopp M. Increase in the prevalence of obesity in Switzerland 1982–2007: birth cohort analysis puts recent slowdown into perspective. *Obesity (Silver Spring)* 2010; **18:** 644–646.
29 Lamprecht M, Fischer A, Stamm H. *Sport Suisse 2008: Comportement Sportif de la Population Suisse.* Macolin: Office fédéral du Sport. 2008; 1–44.
30 Gnavi R, Karaghiosoff L, Costa G, Merletti F, Bruno G. Socio-economic differences in the prevalence of diabetes in Italy: the population-based Turin study. *Nutr Metab Cardiovasc Dis* 2008; **18:** 678–682.
31 McWilliams JM, Meara E, Zaslavsky AM, Ayanian JZ. Differences in control of cardiovascular disease and diabetes by race, ethnicity, and education: US trends from 1999 to 2006 and effects of medicare coverage. *Ann Intern Med* 2009; **150:** 505–515.
32 Okosun IS, Dever GE. Abdominal obesity and ethnic differences in diabetes awareness, treatment, and glycemic control. *Obes Res* 2002; **10:** 1241–1250.
33 LAMAL – Loi Fédérale sur l'Assurance Maladie. 832.10. 18-3-1994.
34 Wilper AP, Woolhandler S, Lasser KE, McCormick D, Bor DH, Himmelstein DU. Hypertension, diabetes, and elevated cholesterol among insured and uninsured US adults. *Health Aff (Millwood)* 2009; **28:** w1151–w1159.
35 Rozenfeld Y, Hunt JS, Plauschinat C, Wong KS. Oral antidiabetic medication adherence and glycemic control in managed care. *Am J Manag Care* 2008; **14:** 71–75.
36 Bays HE, Bazata DD, Clark NG, Gavin JR, III, Green AJ, Lewis SJ *et al.* Prevalence of self-reported diagnosis of diabetes mellitus and associated risk factors in a national survey in the US population: SHIELD (Study to Help Improve Early evaluation and management of risk factors Leading to Diabetes). *BMC Public Health* 2007; **7:** 277.
37 Thayer S, Arondekar B, Harley C, Darkow TE. Adherence to a fixed-dose combination of rosiglitazone/glimepiride in subjects switching from monotherapy or dual therapy with a thiazolidinedione and/or a sulfonylurea. *Ann Pharmacother* 2010; **44:** 791–799.
38 Bovier PA, Sebo P, Abetel G, George F, Stalder H. Adherence to recommended standards of diabetes care by Swiss primary care physicians. *Swiss Med Wkly* 2007; **137:** 173–181.
39 Puder JJ, Endrass J, Moriconi N, Keller U. How patients with insulin-treated type 1 and type 2 diabetes view their own and their physician's treatment goals. *Swiss Med Wkly* 2006; **136:** 574–580.
40 Weber C, Schneider B, Lodwig V, Holm MV, Neeser K. Cost impact of blood glucose self-monitoring on complications of type 2 diabetes: a Swiss perspective (ROSSO study No.11). *Swiss Med Wkly* 2007; **137:** 545–550.
41 Tolonen H, Koponen P, Aromaa A, Conti S, Graff-Iversen S, Grøtvedt L *et al.* Review of health examination surveys in Europe. B18/2008 Helsinki: National Public Health Institute (KTL), 2008; 1–379.
42 Selvin E, Crainiceanu CM, Brancati FL, Coresh J. Short-term variability in measures of glycemia and implications for the classification of diabetes. *Arch Intern Med* 2007; **167:** 1545–1551.
43 Thomas MC, Walker MK, Emberson JR, Thomson AG, Lawlor DA, Ebrahim S *et al.* Prevalence of undiagnosed Type 2 diabetes and impaired fasting glucose in older British men and women. *Diabet Med* 2005; **22:** 789–793.

Table 1. Prevalence, awareness and treatment of type 2 diabetes, overall and by gender

	All	Women	Men
All subjects	6181	3246	2935
Diabetes	392 (6.3)	124 (3.8)	268 (9.1)
	[5.7–7.0]	[3.2–4.5]	[8.1–10.2]
Subjects with diabetes	392	124	268
Aware	256 (65.3)	83 (66.9)	173 (64.6)
	[60.4–70.0]	[57.9–75.1]	[58.5–70.3]
Subjects aware of diabetes	256	83	173
Treated	221 (86.3)	63 (75.9)	158 (91.3)
	[81.5–90.3]	[65.3–84.6]	[86.1–95.1]
Subjects treated for diabetes	221	63	158
Fasting plasma glucose < 7 mmol/l	74 (33.5)	25 (39.7)	49 (31.0)
Fasting plasma glucose < 6.5 mmol/l	46 (20.8)	15 (23.8)	31 (19.6)

Results are expressed as number of subjects (percentage) and .exact binomial 95% confidence intervals are also provided (in square brackets) for prevalence, treatment and control rates.

Table 2. Antidiabetic treatment prescribed, overall and by gender, among subjects treated for diabetes

	All (N = 221)	Women (n = 63)	Men (n = 158)
Monotherapy (total)	144 (65.2)	44 (69.8)	100 (63.3)
Insulin	20 (9.0)	8 (12.7)	12 (7.6)
Biguanides	73 (33.1)	24 (38.1)	49 (31.0)
Other antidiabetics*	51 (23.1)	12 (19.1)	39 (24.7)
Combined therapy (total)	77 (34.8)	19 (30.2)	58 (36.7)
Insulin + biguanides	9 (4.0)	2 (3.2)	7 (4.4)
Insulin + others	7 (3.2)	1 (1.6)	6 (3.8)
Biguanides + others	55 (24.9)	12 (19.1)	43 (27.2)
Insulin + biguanides + others	6 (2.7)	4 (6.4)	2 (1.3)

Results are expressed as number of subjects and (percentage). *Except insulin and analogues.

Table 3: Characteristics of subjects with Type 2 diabetes compared with subjects without diabetes

	Subjects with Type 2 diabetes (n = 392)	Subjects without diabetes (n = 5789)	P
Women (%)	124 (31.6)	3122 (53.9)	< 0.001
Age (years)	60.3 ± 8.7	52.6 ± 10.7	< 0.001
Education (%)			
Basic	100 (25.5)	1190 (20.5)	
Apprenticeship	170 (43.4)	2112 (36.5)	< 0.001
High school/college	87 (22.2)	1382 (23.9)	
University	35 (8.9)	1105 (19.1)	
BMI (kg/m^2)	30.2 ± 5.4	25.5 ± 4.3	< 0.001
BMI categories (%)			
Normal	64 (16.3)	2905 (50.2)	
Overweight	133 (33.9)	2121 (36.6)	< 0.001
Obese	195 (49.7)	763 (13.2)	
Abdominal obesity (%)	251 (64.0)	1599 (27.6)	< 0.001
Smoking status (%)			
Never	123 (31.4)	2355 (40.7)	
Former	171 (43.6)	1860 (32.1)	< 0.001
Current	98 (25.0)	1574 (27.2)	
Alcohol drinking (%)	277 (70.7)	4232 (73.1)	0.29
Physically active (%)	160 (40.8)	3270 (56.5)	< 0.001
Personal history of (%)			
Cardiovascular disease	63 (16.1)	332 (5.7)	< 0.001
Stroke	12 (3.1)	58 (1.00)	< 0.001
Myocardial infarction	17 (4.3)	83 (1.4)	< 0.001
Peripheral arterial disease	25 (6.4)	136 (2.4)	< 0.001
Parental history of (%)			
Cardiovascular disease	136 (34.7)	1871 (32.3)	0.33
Myocardial infarction	92 (23.5)	1185 (20.5)	0.16
Stroke	60 (15.3)	894 (15.4)	0.92
Diabetes	126 (32.1)	1021 (17.6)	< 0.001

Menopause (%) [a]	108 (27.6)	1700 (29.4)	0.43
Hypertension in pregnancy (%) [a]	4 (1.0)	114 (2.0)	0.18
Diabetes in pregnancy (%)[a]	4 (1.0)	27 (0.5)	0.13
Systolic blood pressure (mmHg)	139 ± 18	128 ± 18	< 0.001
Diastolic blood pressure (mmHg)	83 ± 11	79 ± 11	< 0.001
Total cholesterol (mmol/l)	5.45 ± 1.17	5.60 ± 1.03	< 0.01
LDL cholesterol (mmol/l)	3.18 ± 1.01	3.35 ± 0.91	< 0.01
HDL cholesterol (mmol/l)	1.38 ± 0.36	1.65 ± 0.44	< 0.001
Triglycerides (mmol/l)[§]	1.7 [1.2–2.6]	1.1 [0.8–1.6]	< 0.001

Results are expressed as number of subjects and (percentage), as mean ± standard deviation and as median and [interquartile range] (for triglycerides). [a]For women only. Statistical analysis by χ^2 for categorical variables and by Student's *t*-test or nonparametric Kruskall–Wallis test (§) for continuous variables.

Table 4. Multivariable analysis of the factors associated with prevalence, awareness and treatment of Type 2 diabetes

	Prevalence (n = 6181)	Awareness (n = 392)	Treatment (n = 256)
Gender (man vs woman)	3.01 (2.33–3.88)	–	3.75 (1.74–8.05)
Age group (years)			
35–44	1 (ref.)	1 (ref.)	1 (ref.)
45–54	2.32 (1.47–3.65)	1.82 (0.71–4.64)	2.09 (0.52–8.34)
55–64	6.22 (4.07–9.51)	2.60 (1.09–6.17)	3.02 (0.85–10.7)
65–75	8.20 (5.22–12.9)	4.68 (1.87–11.7)	13.8 (2.95–64.2)
BMI group			
Normal	1 (ref.)	1 (ref.)	–
Overweight	1.51 (1.07–2.12)	0.82 (0.44–1.56)	–
Obese	5.14 (3.39–7.78)	1.55 (0.84–2.88)	–
Abdominal obesity*	1.43 (1.04–1.96)	–	–
Physical activity*	0.64 (0.51–0.80)	0.58 (0.37–0.91)	–
Alcohol intake*	0.72 (0.56–0.93)	0.39 (0.23–0.67)	–
Parental history of Type 2 diabetes*	2.47 (1.93–3.16)	–	–
Baseline cardiovascular disease*	1.41 (1.02–1.96)	–	–

Statistical analysis by forward stepwise logistic regression with a 0.10 significance level for removal from and a significance level of 0.05 for addition to the model. The variables studied were gender, education (four groups), age (four groups), BMI (normal, overweight, obese), abdominal obesity (yes/no), smoking status (never, former, current), physical activity (yes/no), alcohol drinker (yes/no), parental history of Type 2 diabetes (yes/no), awareness of hypertension (yes/no), systolic blood pressure (continuous), awareness of dyslipidaemia (yes/no), total cholesterol (continuous) and baseline cardiovascular disease (yes/no). Results are expressed as Odds ratio and (95% confidence interval).*, Odds ratio calculated for presence vs absence of the condition; –, not retained in the model.