Established in 1871

Swiss Medical Weekly

Formerly: Schweizerische Medizinische Wochenschrift

An open access, online journal • www.smw.ch

Original article | Published 19 March 2021 | doi:10.4414/smw.2021.20478
Cite this as: Swiss Med Wkly. 2021;151:w20478

Prevalence of diabetes mellitus in the greater Bern region (Bern-Mittelland) 2010–2014

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Summary

OBJECTIVE: Concerning diabetes mellitus, one of the greatest burdens in public health in the 21st century, epidemiological data in Switzerland are scarce. To address this issue, this study intended to use a little-known but convenient way to quantify the prevalence of diabetes mellitus in the Swiss region of Bern-Mittelland.

METHODS: In a population of approximately 330,000 people, the prevalence for the years 2010–2014 in adult persons was estimated using the capture-recapture method based on data collected routinely at the University Hospital in Bern (Inselspital) using outpatient lists and the registry of persons insured with Helsana Insurance Group.

RESULTS: The estimated prevalence of diabetes mellitus was 3.97% (95% confidence interval [CI] 3.41–4.53%) in 2010, with a slight decrease to 3.65% (95% CI 3.24–4.06%) in 2014. An average of 3430 patients with diabetes or 26% of the total number appeared on at least one patient list. The remaining 74% were unknown patients identified by the capture-recapture method.

CONCLUSIONS: The estimated prevalence of diabetes mellitus was in a range comparable to national and international studies. Thus, administratively collected data in clinics and insurance companies constitute a convenient data source for epidemiological studies. In conjunction with the capture-recapture method an approach with comparatively low effort and costs for the surveillance of chronic disease can be provided.

Introduction

Diabetes mellitus is a great burden in public health of the 21st century worldwide. The World Health Organization (WHO) estimates that after hypertension and tobacco abuse, elevated blood glucose levels represent the most important risk factor for premature death. In most countries, the prevalence of diabetes mellitus rose simultaneously with quick sociocultural change, an aging population, increased sugar consumption and less physical activity [1].

Currently, this metabolic disease affects 415 million humans worldwide, resulting in a prevalence of 8.8% in people aged 20 to 79 years. This includes 193 million undiagnosed patients, but ignores a further 318 million adults with impaired glucose tolerance. It has been claimed that this value will rise to 642 million people by 2040 [1]. Several studies have shown a worldwide increase in the prevalence of diabetes mellitus [2–4].To preserve public health and allocate resources reasonably, precise and current monitoring of the population is important [5].

In Switzerland, epidemiological data concerning prevalence of diabetes mellitus are scarce. Estimates of previous studies were based on drug sales, prescriptions, discharge letters, death registers and other extrapolations [6–10]. Further studies estimated the prevalence of diabetes mellitus based on self-evaluation, which results in a sizable effort and allows bias to easily occur [11].

Diagnostic tests, such as fasting glucose, oral glucose tolerance testing or glycated haemoglobin (HbA_{1c}) are time-consuming in the laboratory and thus are expensive, especially if performed on a large scale. Therefore, population-based studies involving such testing are carried out comparatively rarely. Alternatively, administrative data provided through the processes of in- and outpatients or considering medical expenses of health insurance companies can be used. Linked with capture-recapture, the prevalence can be estimated even with incomplete registers of diabetes patients [12].

Capture-recapture methods were originally developed to establish the size of populations of wild animals. For this purpose, a first sample was caught, marked and released. Later, a second sample was caught. Based on the proportion of marked animals compared with unmarked animals, the size of the population could be estimated [13].The prevalence of human disease can be similarly calculated using various sources [12].

The method has previously been used to estimate the prevalence of various diseases and health issues such as cancer, drug abuse and diabetes mellitus. It offers a cost-effective way to monitor prevalence of chronic diseases [12]. In a preliminary analysis we used this technique in Switzerland [14].

The aim of this study was to estimate the prevalence of diabetes mellitus in the greater Bern region (Bern-Mittelland) from 2010–2014 in adult persons (aged 18 years or old-

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er). The data required were provided by the health insurance Group Helsana and the University Hospital of Bern from the responsible department in each institution. The results were compared with previous epidemiological studies; therefore, accuracy can be assessed. Hence this study aimed to enhance epidemiologic data in Switzerland.

Methods

Population

The size of the population of the region of Bern-Mittelland has been determined by the Swiss Federal Office of Statistics. The size of the mature population (18 years or older) for the years 2010–2014 according to the Finance Administration of Bern [15] is as follows: 2010 – 324,193 persons, 2011 – 326,514 persons, 2012 – 330,266 persons, 2013 – 333,708 persons, 2014 – 336,780 persons.

Data sources

According to Bishop and Feinberg et al. [16], the following conditions must apply when the capture-recapture method is used, assuming a closed population: If those conditions cannot be fulfilled, estimates of prevalence become inaccurate.

1. Independence of data sources
2. Equal probability of being listed in a databank for each individual

Two independent patient collectives were used. First, patients at the outpatient clinic of the Division of Endocrinology, Diabetes and Clinical nutrition, Inselspital, University of Bern; second, persons insured with the Helsana Group. All types of diabetes mellitus were included.

Helsana provided a list of adult patients (18 years or older) with diabetes mellitus, who had a compulsory health insurance (OKP) offered by the insurance companies of the Helsana group. Since no ICD-10 coded diagnoses were available, patients were identified with the aid of the Anatomical Therapeutic Chemical (ATC) classification system. Any patient with a drug prescription for the treatment of diabetes mellitus including oral blood glucose-lowering drugs (ATC code A10B), insulin (ATC code A10A), or other drugs used in diabetes (ATC code A10X), has been classified. Furthermore, patients with a prescription in a specific year were considered as prevalent in the following years.

In the context of medical checks, various patient data are collected routinely at the Inselspital. Thus, a list of patients who consulted the diabetes outpatient clinic each separate year could be extracted. All adult patients (aged 18 years or older) were included in the study. As the health insurance provider of the patients is noted with their personal information, the number of patients who are insured by Helsana Group and consulted the diabetes outpatient clinic could be determined, which corresponds to the overlap of both patient collectives.

Statistics

To estimate the patients with diabetes mellitus missing in both lists, the capture-recapture method was applied. Therefore, a formula by Chapman [16], which contains the two data sources (M and n) and the overlap (m) as variables, was used. Thus, the total number of patients with diabetes mellitus (N) in our study population was estimated. The proportion of that amount from the total study population corresponds to the prevalence, calculated for each year separately (fig. 1).

The prevalence as a point estimate was supplemented by a 95% confidence interval (CI), by adding/subtracting two standard deviations of the square root of the variance of the total number of patients. A trend line was calculated by linear regression using Microsoft Excel (365 MSO, 2012, Redmond USA). (see fig. 3 below)

Results

An average of 13,063 patients with diabetes mellitus were found each year. Overall, 3430 or 26.34% of the calculated total number of patients with diabetes mellitus were detected directly from the databases of Helsana and Inselspital. The remaining 73.66% are patients identified by the capture-recapture method only (table 1 and fig. 2).

In 2010, the prevalence of diabetes mellitus in the adult population of the greater Bern region (Bern-Mittelland) was 3.97% (95% CI 3.41–4.53%). The prevalence decreased to 3.65% (95% CI 3.24–4.06%) in 2014. The highest prevalence was found in the year 2012 (4.29%, 95% CI 3.66–4.92%). The greatest overlap (214 patients) and consequently the smallest 95% CI was seen in 2014 (table 1 and figs 2 and 3).

Linear regression revealed that prevalence over the 5 years observed was decreasing by 0.07% each year (fig. 3).

Figure 1: Formula by Chapman [14] with a schematic illustration of the capture-recapture method.N corresponds to the total of patients with diabetes mellitus in our study population, M to the number of patients identified by means of Helsana and n the number of identified patients through the Inselspital; m is the overlap of the patients found in both collectives.

$$N = \frac{(M+1)(n+1)}{(m+1)} - 1$$

$$\mathrm{Var}\,(N) = \frac{(M+1)(n+1)(M-m)(n-m)}{(m+1)^2(m+2)}$$

$$95\%\mathrm{CI} = \pm 1.96\sqrt{\mathrm{Var}(N)}$$

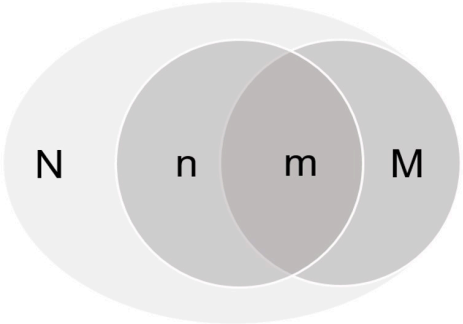
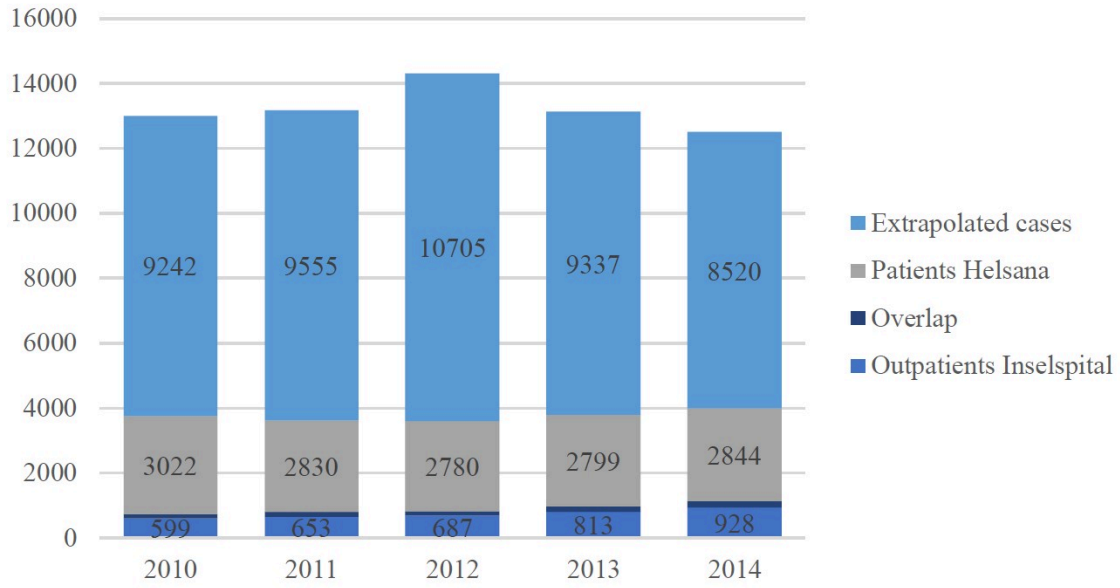


Figure 2: Identified patients with diabetes mellitus 2010–2014. 2010: 12,863 (overlap 140); 2011: 13,038 (overlap 141); 2012 14,172 (overlap 134); 2013: 12,949 (overlap 175); 2014: 12,292 (overlap 214).

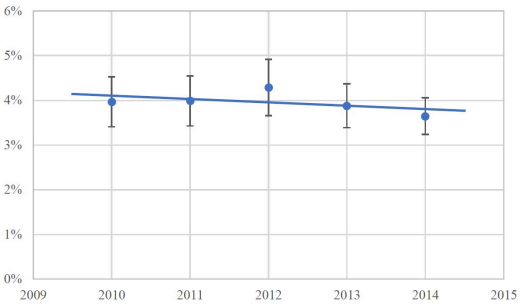


Discussion

The epidemiological data obtained in this study are well within an expected range compared with national and international studies that estimated the prevalence of diabetes mellitus.

Previous studies performed in Switzerland during the period from 2007 to 2013 estimated a prevalence of 3.5–6.3% in adults. In these studies, the term "adult" was used differently. The age range of populations included varied between 18+ [11], 19+ [10], 20+ [8] and 35–75-year-old people [7].

Figure 3: Prevalence of diabetes mellitus 2010–2014 with 95% confidence intervals (CIs) and a linear regression (y = −0.0007x + 1.5486). 2010: 3.97% (CI 3.49–4.45%) ; 2011: 3.99% (CI 3.50–4.48%) ; 2012: 4.29% (CI 3.75–4.83%); 2013: 3.88% (CI 3.46–4.30); 2014: 3.65% (CI 3.30–4.00).



Other regional or national studies calculating the prevalence by means of the capture-recapture method were in Northern Italy [17, 18] and New Zealand [5]. The estimated prevalence in these studies (from 2.8% to 3.7%) was lower, as compared with data collected in Switzerland. However, Cameron et al. [5] in New Zealand chose a population from 15 years of age, whereas the Italian studies included the entire population. Those studies are rather out-of-date or were questioned because of the mutual dependence of the chosen data sources [17, 18]. In addition, these studies included considerable numbers of persons less than 18 years old. This clearly reduced the estimated total prevalence.

As the prevalence in adults, determined in large-sized studies performed in China [3] and the United States [4], was 9.9% to 11.6%, it must be assumed that variances are explained by geographical differences. In comparison, the prevalence estimated in a national Swedish study [19] was significantly lower, at 4.3%.

Data sources

The goal of our approach was to meet the conditions proposed by Bishop and Feinberg et al. [16], namely the independence of data sources and an equal probability of being listed in a databank for each individual.

Table 1: Relevant values concerning the estimation of the prevalence of diabetes mellitus by capture-recapture 2010–2014.

Year	2010	2011	2012	2013	2014	Average
Population	324,193	326,514	330,266	333,708	336,780	330,292
Outpatients Inselspital	599	653	687	813	928	736
Patients Helsana	3022	2830	2780	2799	2844	2855
Overlap	140	141	134	175	214	161
Total patients	12,862	13,037	14,171	12,949	12,292	13,063
Prevalence (%)	3.97	3.99	4.29	3.88	3.65	3.96
Var (N)	849,903	884,027	1,129,530	695,934	497,074	811,293
95% confidence interval	3.41–4.53	3.43–4.55	3.66–4.92	3.39–4.37	3.24–4.06	3.43–4.49
Direct detection (%)	27.1	25.6	23.5	26.5	29.0	26.3

An equal probability for all patients with diabetes mellitus in the greater Bern area to appear as a patient in the diabetes consultation at Inselspital and thus be included in our patient lists can be assumed. As health insurance is mandatory in Switzerland and as Helsana offers their insurance to the general population, an important selection bias is unlikely. Still, Helsana Group tends to insure slightly older people [10]. Thus, the prevalence may be somewhat overestimated. The collection of data from outpatient lists in combination with insured persons has never been described before. There is no reason to assume that a mutual dependence would exist.

The identification of patients with diabetes mellitus by means of the WHO ATC classification system allows the number of treated patients with diabetes mellitus to be quantified directly. According to previous studies, the prescription of at least one drug used in diabetes mellitus can be used for the precise identification of patients with diabetes in a population [20]. The reason is the highly specific use of these drugs in diabetes mellitus, since they are not indicated for other diseases or off-label use. On the other hand, the disadvantage of the use of the ATC system is that patients in remission after successful treatment with antidiabetic drugs are considered to still have diabetes. Patients with prediabetes who are treated (e.g., with metformin) without qualifying for the diagnosis of diabetes mellitus may be included. Untreated patients with diabetes mellitus or patients who are treated by diet and lifestyle changes only are missing.

A further biasing factor is the incomplete documentation of diabetes mellitus in hospitals. This could be a reason for a low estimate when capture-recapture uses badly documented patient data in hospitals [20]. Incomplete documentation of diabetes mellitus should not be a problem in our study, as data were collected from diabetes consultations only.

Statistics

The validity of the capture-recapture method is a subject of controversy. Verlato et al. [18], for example, argued, that independence of data sources most often cannot be achieved. Moreover, they queried the existence of a population that cannot be found in any data source, but only be assumed from capture-recapture. Otherwise, capture-recapture seems to be well-established according to Cameron et al. [5] or Bruno et al. [17], but should be applied with caution. Especially in medical science, different sources of data are not mutually independent. That is why they recommend including more than two data sources. By using different statistical models (such as log-linear models), mutual dependence can be excluded, which increases the probability of the validity of estimated prevalence. If independence is not a given, an underestimate of prevalence can be assumed [17].

The accuracy of the method is dependent on the overlap of patients found in both data sources. The smaller the overlap, the bigger the undetected population and the more fictional cases need to be estimated [17]. Compared with the studies of Cameron et al. [5] and Bruno et al. [17], the number of undetected cases (74%) in our study is much higher. Cameron et al. estimated a value for undetected cases of 15%, and Bruno et al. 20%. Both used more than two data sources. As simplicity is one important requirement for effective monitoring of diabetes mellitus, it could be claimed that it is an advantage to define only two data sources, whereby a large proportion will be estimated instead of being detected.

Further investigations

As mentioned before, many authors have reported that the prevalence of diabetes mellitus is increasing [2–4, 11]. In contrast, this study showed a decreasing tendency (−0.7%/year), albeit only over a 5-year period. To make a significant statement about the trend in the greater Bern region, a long-term study would be needed.

Using questionnaires, the Swiss Health Observatory [21] recorded a slight and steady increase in the prevalence of diabetes mellitus in Switzerland, from 3.3% in 1997 to 4.6% in 2017,. Results in the canton of Bern showed a comparable trend, but from 2012 to 2017 a decrease of 1.6% (from 5.5% to 3.9%) was described. As there were only a few respondents (58–92 in Bern, 423–1104 in the whole country), wide confidence intervals put the significance of this finding in perspective.

In any case, to check efficiency in treatment and prevention of diabetes mellitus, there is a need for robust epidemiological data.

Categorisation of the population according to age, gender or ethnicity was not possible, to preserve data privacy. If data on a patient were recorded more precisely, it could no longer be considered a simple anonymous case in a patient list. Then the procedure of evaluation of data becomes more complex, which makes the surveillance of chronic disease more difficult.

Conclusion

As population-based studies using diagnostic tests such as fasting glucose, oral glucose tolerance tests or glycated haemoglobin are cumbersome and expensive, there is a need for simpler ways to monitor diabetes prevalence more frequently. Routine data collected by clinics and insurance companies can provide data sources for epidemiological studies. Using the capture-recapture method, we have estimated the prevalence of diabetes mellitus in a specified region of Switzerland. This method entails comparatively low effort and costs, and therefore might be used to extend the current available data on diabetes mellitus.

Acknowledgements

We thank Helsana Insurance Group, as well as Miryam Abebe at Inselspital, who provided data for this study.

Disclosure statement

No financial support and no other potential conflict of interest relevant to this article was reported.

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