

The Prevalence of Diabetes in a Swedish Population of 280,411 Inhabitants

A report from the Skaraborg Diabetes Registry

BO BERGER, MD
GUNNAR STENSTRÖM, MD, PHD

YUE-FANG CHANG, PHD
GÖRAN SUNDKVIST, MD, PHD

OBJECTIVE — To estimate the prevalence of known diabetes in a Swedish county (Skaraborg) and to evaluate capture-recapture methods for validation of the diabetes prevalence.

RESEARCH DESIGN AND METHODS — Four sources were used to find known diabetic patients: 1) the Skaraborg Diabetes Registry (SDR), a case-finding inventory, 2) an administrative hospital registry, 3) a registry for the retinopathy screening program, and 4) a pharmacy prescription inventory. The capture-recapture method was applied to various combinations of sources to determine the prevalence of diabetes.

RESULTS — The completeness of the SDR was $88.4 \pm 1.3\%$, indicating a diabetes prevalence of $3.20 \pm 0.08\%$. When the SDR was not used as one of the sources, the estimated prevalence varied between 2.2 and 4.5%.

CONCLUSIONS — A case-finding registry is important in reliably estimating the prevalence of diabetes.

The prevalence of diabetes in the Scandinavian countries has been estimated from studies of relatively small populations (1–5). Therefore, in 1991, we established a diabetes registry in a large population that included subjects of all ages: the complete population of Skaraborg county, Sweden. Because of the difficulty in classifying the type of diabetes without determination of autoimmune markers (6,7), the first objective of the Skaraborg Diabetes Registry (SDR) has been to ascertain the prevalence of diagnosed diabetes without considering type of diabetes. The aims of this report were to estimate the prevalence of known diabetes and to validate the SDR by capture-recapture methods.

RESEARCH DESIGN AND METHODS — The county of Skaraborg

is a rural district in southern Sweden with a population of 280,411 inhabitants (1 January 1995). The age and gender distribution, morbidity, and BMI of the population in Skaraborg are statistically similar to those of the general Swedish population (8,9).

On 1 January 1991, the SDR was established, and prevalent cases on that day, and all incident cases diagnosed thereafter (according to World Health Organization criteria) (10), have been prospectively registered on special record forms completed by all physicians and nurses caring for diabetic patients in the county. The registry was approved by the Ethics Committee of Sahlgren's Hospital, Gothenburg, Sweden, and the Swedish Data Inspection Board.

To determine the capture rate, the SDR was compared with the administrative registry at the Department of Medicine, Skövde

Central Hospital, Skövde, Sweden (HOSP) during 1994, the Skaraborg Retinopathy Screening Program (RSP) during 1994 (includes patients who were <60 years of age when they were diagnosed and who had a diabetes duration of ≥ 5 years), and a prescription inventory (PIN) conducted during a 3-month period during 1992–1994 at 10 of 21 pharmacies in Skaraborg.

Statistical analysis

A conventional formula for capture-recapture calculations was used (11,12). Data are presented as estimation $\pm 95\%$ CI. The 95% CIs were estimated as prevalence $\pm 1.96 \times$ standard error of prevalence (SE [P]).

RESULTS — During the period 1992–1994, a total of 9,374 patients with diagnosed diabetes were found in the four registries (SDR, HOSP, RSP, PIN); 9,141 (97.5%) of them were registered in the SDR. Estimations of the total diabetic population varied considerably when different pairs of sources were used (Fig. 1). When the SDR was used as one source versus the others, however, the estimations varied less. A diabetic population of $9,664 \pm 51$ was obtained when the SDR was used as one source versus a combination of the other three registries (HOSP, RSP, PIN).

The fact that the estimated diabetic population varied with the sources indicated heterogenic populations of diabetic patients with variable capture rates in the four registries. To overcome this problem, we stratified the patients according to age and treatment. Among pharmacologically treated patients, only 25 patients <60 years of age and 48 patients ≥ 60 years of age were found outside the SDR; these 73 cases were all found in the PIN. Hence, for estimation of pharmacologically treated patients, only the SDR and the PIN had to be considered. Among patients not treated pharmacologically, 109 unique cases of diabetes were found in the HOSP and 49 were found in the RSP, whereas no unique cases were identified by the PIN. Therefore, for estimation of patients not treated pharmacologically, the SDR in combination with the HOSP and the RSP were used. Table 1 shows capture-

From the Department of Medicine (B.B.), Skövde Central Hospital, Skövde; the Department of Medicine (G.St.), Lidköping Hospital, Lidköping; the Department of Endocrinology (G.Su.), Malmö University Hospital, Malmö, Sweden; and the Department of Epidemiology (Y.-F.C.), University of Pittsburgh, Pittsburgh, Pennsylvania.

Address correspondence and reprint requests to Bo Berger, MD, Department of Medicine, KSS, S-541 85 Skövde, Sweden.

Received for publication 16 May 1997 and accepted in revised form 1 December 1997.

Abbreviations: HOSP, the administrative registry at the Department of Medicine, Skövde Central Hospital; PIN, prescription inventory performed 1992–1994 in Skaraborg; RSP, Retinopathy Screening Program; SDR, Skaraborg Diabetes Registry; SE (P), standard error of prevalence.

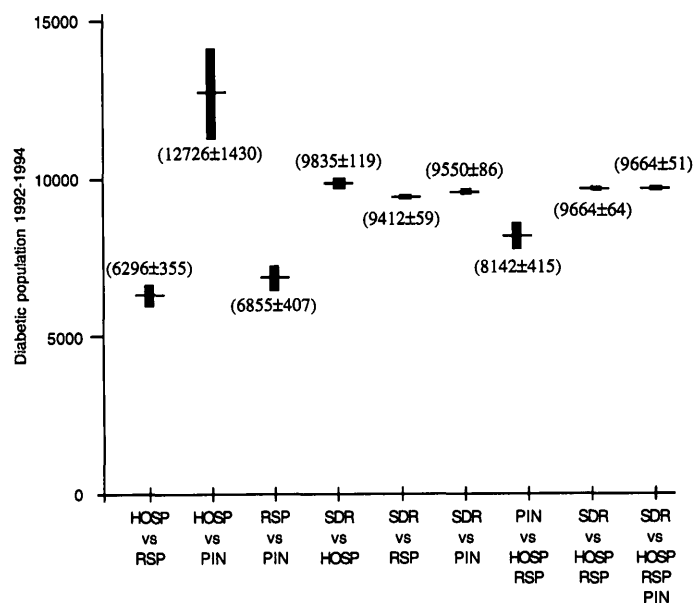


Figure 1—The diabetes population during 1992–1994 estimated by applying the capture-recapture method to six possible combinations of pairs of registries, and to the combined registries after they are fused with high positive bias. Estimation (horizontal line) \pm 95% CIs (vertical bar), which are estimated as prevalence \pm 1.96 \times SE (P).

recapture estimations and diabetic population for the four subgroups of patients. After the estimations of each subgroup were added, the total population of diabetic patients during the period 1992–1994 was estimated to be 10,335 \pm 158, i.e., 7.1% higher than without stratification.

The number of registered cases of diabetes in the SDR (9,141) divided by the number of estimated cases (10,335) indicated that 88.4 \pm 1.3% of the diabetic population was captured by SDR. SDR captured 96.8 \pm 1.4% of those <60 years of age who were receiving pharmacological treatment, 96.9 \pm 1.0% of those \geq 60 years of age receiving pharmacological treatment, 82.6 \pm 5.6% of those <60 years of age not receiving pharmacological treatment, and 79.3 \pm 3.5% of those \geq 60 years of age not receiving pharmacological treatment.

By dividing patients in the SDR on 1 January 1995 ($n = 7,925$) by capture rate (88.4 \pm 1.3%), the diabetes population in Skaraborg on 1 January 1995 was esti-

Table 1—Estimation of the diabetes population in Skaraborg (1992–94) based on information from four registries, stratified according to age and treatment

With/without pharmacological treatment	Age (years)	Found in SDR	Found in PIN	Found in HOSP/RSP	n	N(est)	95% CI	n	Found %
With	<60	Yes	Yes	—	543	2,059	31	1,993	96.1 \pm 1.4
		Yes	No	—	1,425				
		No	Yes	—	25				
		No	No	—	?				
					1,968				
With	\geq 60	Yes	Yes	—	1,105	4,495	47	4,356	96.9 \pm 1.0
		Yes	No	—	3,203				
		No	Yes	—	48				
		No	No	—	?				
					4,308				
Without	<60	Yes	—	Yes	122	770	56	636	82.6 \pm 5.6
		Yes	—	No	480				
		No	—	Yes	34				
		No	—	No	?				
					602				
Without	\geq 60	Yes	—	Yes	381	3,011	137	2,389	79.3 \pm 3.5
		Yes	—	No	1,882				
		No	—	Yes	126				
		No	—	No	?				
					2,263				
Summary	N(est)				10,355				
	95% CI					158			
	Found in SDR							9,141	
	Completeness of SDR								88.4 \pm 1.3%
	Found in all registries								90.7 \pm 1.5%

Data are n or %. N(est), estimated population. Estimation \pm 95% CI, estimated as prevalence \pm 1.96 \times SE (P).

mated to be $8,960 \pm 133$, indicating a diabetes prevalence of $3.20 \pm 0.08\%$.

CONCLUSIONS — This report shows that the SDR is a valid tool for following the prevalence of diagnosed diabetes in a large population. Considering that 97% of pharmacologically treated patients were found in the SDR, our registry appears as reliable as the Diabetes Incidence Study in Sweden (DISS) registry (adults 15–34 years of age, 86.5% of IDDM cases captured) (13) and the Swedish Childhood Diabetes Registry (99% of IDDM cases captured) (14). Although not as high as values reported from two small geographic areas in Sweden (3.3 and 4.3%) (1,2) or from ethnic minorities (Nauruans 41%, Pima Indians 50%) in other countries (15), the prevalence of diabetes in Skaraborg (3.20%) was higher than that reported in other populations, both in (2.0–3.1%) (3–5) and outside (1.17%–2.82%) (16–24) Sweden. Preexisting health care registries are often positively biased; patients with complications tend to appear in different registries, whereas patients without complications are captured with low probability. This study indicates that SDR has a high rate of capture, and this may contribute to the higher prevalence of diabetes found in Skaraborg county.

In conclusion, SDR provides a more reliable estimate of the prevalence of clinically known diabetes in an exclusively Scandinavian population. In other ethnic groups—Mexican-Americans, Pima Indians, Nauruans—the prevalence of diabetes (mostly NIDDM) is remarkably high (50–80%) (20). Studies of our population in comparison with others may provide important clues to the etiology and pathogenesis of diabetes.

Acknowledgments — This study was supported by grants from Research Funds Skaraborg (SkaraborgsInstitutets Forskinings- och Utvecklingsfond), The Child Diabetes Fund, Lundström Foundation, Malmö Diabetes Association, Novo-Nordic Foundation, and Research Funds Malmö University Hospital, Swedish Diabetes Association, Swedish Medical Research Council (7507), and Funds, Lund University and Malmö University Hospital.

We thank all diabetes nurses, general practitioners, and internists in Skaraborg for their

thorough and enthusiastic reporting of patients to the registry.

References

- Andersson DKG, Svärdsudd K, Tibblin G: Prevalence and incidence of diabetes in a Swedish community 1972–1987. *Diabet Med* 8:428–434, 1991
- Falkenberg MGK: Diabetes mellitus: prevalence and local risk factors in a primary health care district. *Scand J Soc Med* 15:139–144, 1987
- Santor G: Prevalence of type 2 diabetes in Sweden. *Acta Endocrinol* 262 (Suppl.): 27–29, 1984
- Bitzén P-O: *On the Early Detection and Treatment of Non-Insulin-Dependent Diabetes Mellitus in Primary Health Care*. Dissertation. Lund, Sweden, University of Lund, 1988
- Forrest RD: Diabetes mellitus in North Sweden: prevalence assessed from prescriptions for anti-diabetic drugs. *J Intern Med* 228:267–273, 1990
- Tuomi T, Groop L, Zimmet P, Rowley M, Knowles W, Mackay I: Antibodies to glutamic acid decarboxylase reveal latent autoimmune diabetes mellitus in adults with a non-insulin-dependent onset of disease. *Diabetes* 42:359–362, 1993
- Arnqvist HJ, Littorin B, Nyström L, Scherstén B, Östman J, Blohmé G, Lithner F, Wibell L: Difficulties classifying diabetes at presentation in young adults. *Diabet Med* 10:606–613, 1993
- Pellmer K for Skaraborgsinstitutet, sektionen för allmänmedicin och länsstyrelsen Skaraborg: *Pusslet om Skaraborgarnas hälsa och levnadsförhållanden: resultat från Skaraborgsenkäten 1992*. Mariestad, Sweden, Länsstyrelsen Skaraborg, 1994
- Spek JE, Himmelman L for Västsvenska planeringsnämnden: *Västsvensk dödsorsaksanalys*. Göteborg, Sweden, Göteborgs länsstryckeri, 1994
- World Health Organization: *Diabetes Mellitus: Report of a WHO Study Group*. Geneva, World Health Org., 1985 (Tech. Rep. Ser., no. 727)
- Wittes J, Sidel V: A generalisation of the simple capture-recapture model with applications to epidemiological research. *J Chronic Dis* 20:287–301, 1968
- LaPorte RE, McCarty D, Bruno G, Naoko T, Shigeaki B: Counting diabetes in the next millennium: application of capture-recapture technology. *Diabetes Care* 16:528–534, 1993
- Littorin B, Sundkvist G, Scherstén B, Nyström L, Arnqvist H, Blohmé G, Lithner F, Wibell L, Östman J: Patient administrative system as a tool to validate the ascertainment in the Diabetes Incidence Study in Sweden (DISS). *Diabetes Res Clin Pract* 33:129–133, 1996
- Nyström L, Dahlquist G, Rewers M, Wall S: The Swedish Childhood Diabetes Study: an analysis of the temporal variation in diabetes incidence 1978–1987. *Int J Epidemiol* 19:141–146, 1990
- King H, Rewers M, for the World Health Organization Diabetes Reporting Group: Global estimates for prevalence of diabetes mellitus and impaired glucose tolerance in adults. *Diabetes Care* 16:157–177, 1993
- Bruno G, LaPorte R, Merletti F, Biggeri A, McCarty D, Pagano G: National diabetes programs: application of capture-recapture to count diabetes? *Diabetes Care* 17:548–556, 1994
- Di Cianni G, Benzi L, Giannarelli R, Orsini P, Villani G, Ciccarone A, Cecchetti P, Fedele O, Navalesi R: A prevalence study of known diabetes mellitus in Tuscany assessed from pharmaceutical prescriptions and other independent sources. *Acta Diabetol* 31:87–90, 1994
- D'Allesandro A, Damato A, De Pergola G, Lollini G, Giorgino R: Combining three different sources as a valid tool to identify known diabetic patients: use in a prevalence study in an Italian local health unit. *Diabete Metab* 20:265–270, 1994
- Garancini MP, Sergi A, Lazzari P, Gallus G: Epidemiology of known diabetes in Lombardy, north Italy: clinical characteristics and methodological aspects. *Acta Diabetol* 32:268–272, 1995
- Warram JH, Kocpozynski J, Janka HU, Krolewski AS: Epidemiology of non-insulin-dependent diabetes mellitus and its macrovascular complications. *Endocrinol Metab Clin North Am* 26:165–188, 1997
- Papoz L, and the EURODIAB Subarea C Study Group: Utilization of drug sales data for epidemiology of chronic diseases: the example of diabetes. *Epidemiology* 4:421–427, 1993
- Tan M-H, MacLean DR: Epidemiology of diabetes mellitus in Canada. *Clin Invest Med* 18:240–246, 1995
- Vilbergsson S, Sigurdsson G, Sigvaldson H, Hreidarsson ÁB, Sigfusson N: Prevalence and incidence of NIDDM in Iceland: evidence for stable incidence among males and females 1967–1991: The Reykjavik Study. *Diabet Med* 14:491–498, 1997
- Mølbak A, Christau B, Marnar B, Borch-Johnsen K, Nerup J: Incidence of insulin-dependent diabetes mellitus in age groups over 30 years in Denmark. *Diabet Med* 11:650–655, 1994