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ARTICLE

The Danish National Diabetes Register: trends in incidence, prevalence and mortality

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Abstract
Aims/hypothesis The aim of the study was to describe trends in the incidence rate, prevalence and mortality rate for diabetes in Denmark.
Methods Healthcare registers at the National Board of Health were used to compile a register of diabetic patients in the Danish population (5.4 million people). Age- and sex-specific prevalence, incidence rates, mortality rates and standardised mortality ratios relative to the non-diabetic part of the population were calculated.
Results The register contains records for about 360,000 persons with diabetes; 230,000 were alive at 1 January 2007, corresponding to an overall prevalence of 4.2%. The prevalence increased by 6% per year. In 2004 the incidence rates were 1.8 per 100,000 at age 40 years and 10.0 per 100,000 at age 70 years. The incidence rate increased 5% per year before 2004 and then stabilised. The mortality rate in the diabetic population decreased 4% per year, compared with 2% per year in the non-diabetic part of the population. The mortality rate decreased 40% during the first 3 years after inclusion in the register. The standardised mortality ratio decreased with age, from 4.0 at age 50 years to 2.5 at age 70 years and just under 2 at age 85 years, identically for men and women. The standardised mortality ratio decreased 1% per calendar year. The lifetime risk of diabetes was 30%.
Conclusions/interpretation The prevalence of diabetes in Denmark rose in 1995–2006, but the mortality rate in diabetic patients decreased faster than that of the non-diabetic population. The mortality rate decreased markedly just after inclusion in the register. Incidence rates have shown a tendency to decrease during the last few years, but this finding should be viewed with caution.

Keywords Demography of diabetes · Epidemiology · Incidence · Lifetime risk · Mortality · Prevalence · Relative mortality · Registers · SMR

Abbreviations

GDM	gestational diabetes mellitus
NDR	National Diabetes Register
NHISR	National Health Insurance Service Registry
NPR	National Patient Register
RMPS	Register of Medicinal Product Statistics
SMR	standardised mortality ratio

Introduction

Epidemiological surveys in Denmark have documented an increasing prevalence of diabetes over the last decades (see [1] for a brief overview), but the true burden of diabetes remains unknown. To solve this, and in order to establish an accurate monitoring of diabetes in the Danish population, in 2006 it was decided to establish a register of diabetes cases in Denmark. The register is based on existing administrative records in the Danish healthcare system and is maintained at the National Board of Health.

The register serves several purposes: first, it provides a tool to describe and monitor the occurrence of diabetes in

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the Danish population; second, it monitors the prognosis by providing data on mortality and morbidity rates; third, it contributes data to a system for continuous monitoring of quality of care; and finally it is a resource for epidemiological research in the area of diabetes.

This paper reports the incidence rates, prevalence and mortality rates for diabetes and trends in these variables over the period from 1 January 1995 to 31 December 2006.

Methods

Denmark has a universal healthcare system that covers all citizens. Visits to general practitioners and specialists are free of charge. All Danish residents have a unique personal identification number kept in the Danish Civil Registration System. All medical, social and other public administrative records use this number for identification of citizens.

The National Patient Register (NPR), established in 1977, contains electronic records of all patient-discharges from hospitals, and since 1994 also of all treatments in outpatient clinics. Each contact is recorded with one or more diagnosis codes in ICD-10 (http://www.who.int/classifications/icd/en/) (ICD-8 before 1999). The coverage is 100% as reporting is compulsory.

The National Health Insurance Service Registry (NHISR), established in 1973, contains information on all services provided by general and specialist practitioners to patients in Denmark, including provision for institutionalised persons. The main purpose of the register is administration of reimbursements. Hence the register is precise for service provision, but does not contain any information about diagnoses or test results.

The Register of Medicinal Product Statistics (RMPS [prescription register]), established in 1993, contains information on all prescriptions dispensed at Danish pharmacies. Each prescription is identified by date, type and amount (ATC-DDD codes), as well as the personal identification number.

Inclusion criteria for the diabetes register The National Diabetes Register (NDR) was established by linking information from these three registers (NPR, NHSIR and RPMS). Individuals were classified as having diabetes with a date of inclusion equal to the earliest of the dates where one of the following criteria were met:

- Diagnosis of diabetes in the NPR, defined as ICD10: DE10-14, DH36.0, DO24 (excluding DO24.4), or ICD8 (prior to 1999): 249, 250.
- Chiropody for diabetic patients recorded in NHISR.
- The date of the fifth blood glucose measurement within 1 year recorded in NHISR.
- Two blood glucose measurements per year in five consecutive years recorded in NHISR. The date of the last measurement in the last year is taken as inclusion date.
- Second purchase of oral glucose-lowering drugs recorded in RMPS within 6 months (except for women aged 20–39 years prescribed metformin alone, since this is also used as medication for polycystic ovarian syndrome).
- Second purchase of prescribed insulin recorded in RMPS.

Women diagnosed with gestational diabetes (GDM) were excluded; specifically, if a diagnosis of GDM is found in NPR, all criteria are disregarded for a period of 1 year from the date of GDM. This is repeated for each new diagnosis of GDM considered to emerge from a new pregnancy.

The choice of criteria for inclusion was based on a pilot study from Aarhus county (600,000 people, about 12% of the Danish population) [2] showing that these criteria have a sensitivity and positive predictive value above 85% compared with using complete laboratory databases and surveys among general practitioners.

A complete classification of cases in type 1 and type 2 diabetes is not possible based on the information available in registers; hence the type of diabetes is not considered further in this report.

The data are linked to mortality data from the Civil Registration System using the unique personal identification number for all persons in Denmark. Cause of death is not used.

As the register is based on administrative records, the date of inclusion can only be taken as a proxy for the date of diagnosis—a formal clinical diagnosis will probably be made some time before date of inclusion in the register. Because of the different dates of initiation of the underlying registers and accumulation of prevalent cases, we only considered date of inclusion reliable as of 1 January 1995, even though inclusion of cases started at 1 January 1990. Therefore, analyses of the effect of time since inclusion ('diabetes duration') is restricted to patients included after 1995.

Population data and register follow-up From 1995 to 2007 the Danish population increased from 5.2 million to 5.4 million. From Statistics Denmark's data bank we obtained data on population size from 1 January 1995 to 1 January 2007 by sex and age, as well as the number of deaths in the Danish population subdivided by sex, age and date of death [3]. The data on population size were used to compute risk time for the population subdivided by sex, age, calendar time and date of birth [4].

Persons in the register were classified by sex, age and date of diagnosis, and date of birth for analysis of incidence rates. They were followed up for death, and the number of deaths and the risk time were tabulated by sex and age, calendar time, date of birth and time since inclusion ('duration'). Follow-up was truncated at age 100 years.

The risk time among the diabetic patients was subtracted from that of the population to form the risk time among non-diabetic persons in the population. Likewise, the deaths among the diabetic patients were subtracted from the population deaths, and the mortality rate in the non-diabetic part of the population was calculated. Expected numbers of deaths were computed by multiplying the risk time among diabetic patients by the mortality rates among non-diabetic persons.

All classifications of age and dates were in 1 year classes. All tabulations were done using the SAS system (version 9.1; SAS Institute, Cary, NC, USA), including a macro for classification of follow-up time [5].

Statistical methods All analyses were done separately for men and women. Rates were analysed by Poisson models for the number of counts (diabetes cases or deaths) with the log-person-years as offset (in the case of standardised mortality ratio [SMR] with the log-expected cases as offset). The midpoints of age, period and duration categories were used as continuous covariates, and the effect of these were taken as smooth parametric functions, implemented as natural splines [6, 7].

Incidence rates were modelled by age and calendar time. Date of birth (cohort) was not included in the model, since the short period (12 years) compared with the long age-span (100 years) would render this variable almost perfectly correlated with age.

Mortality rates among diabetic patients were modelled by age and calendar time ('date') and time since inclusion in the register ('duration of diabetes'). Since the date of inclusion is only well-defined for persons entering after 1 January 1995, the analysis of mortality rate was restricted to these persons. The SMR (the mortality rate ratio in the diabetic vs the non-diabetic population) was modelled similarly. Mortality rates in the non-diabetic population were modelled by age and current date.

Prevalences were modelled separately for each year and sex, using a binomial model with log-link, and a smooth function of age.

We used the estimated incidence and mortality rates in 2004 to derive estimates of lifetime risk of diabetes. Details of the calculations are given in the Appendix 1.

All confidence intervals are 95% confidence intervals. *p* values are not given since they are meaningless in a study based on an entire population. All analyses and graphs were generated with *R* [8].

Results

Inclusion criteria Of the persons included, 30% were included based on the criterion of five blood glucose measurements within a 1 year period, 30% based on NPR diagnosis, 21% based on RPMS (prescriptions) and 9% based on chiropody. The criterion of two blood glucose measurements in five consecutive years only contributed 0.04% of all cases. At least two inclusion criteria were met by 60% of all cases and 47% met at least three criteria. Among those included based on blood glucose measurements, 54% met this one criterion only; among those included on the other criteria this was between 27% and 42%. The fraction of included patients that only met one criterion was 26% in 1995, increasing to 72% in 2006.

Incidence rates The total number of persons included in the National Danish Diabetes Register was 358,729, of whom 233,137 (121,160 men and 111,977 women) were included after 1 January 1995. The latter formed the basis for the analysis of incidence rates. Table 1 shows the number of new (incident) cases by calendar year. The number of new cases stabilised within the period 1990–1994, indicating that incidence values from 1995 onward are reliable.

Figure 1 shows the age-specific incidence rates in 2004 and the rate ratio relative to this date. Incidence rates were higher among women aged 20–35 years, and from age 35 years onward higher for men, about 20% higher than for women from age 45 years. From age 70 years the rates were roughly constant at about 12 per 1,000 person-years for men and 10 per 1,000 person-years for women (in 2004).

Table 1 Number of cases in the Danish NDR by year of first inclusion to the register ('date of diagnosis')

Year of inclusion	Men	Women	All
≤1989	1,480	1,310	2,790
1990	21,347	24,738	46,085
1991	10,681	9,987	20,668
1992	8,554	7,855	16,409
1993	9,165	7,639	16,804
1994	12,103	10,733	22,836
1995	7,745	7,148	14,893
1996	8,015	7,388	15,403
1997	7,923	7,528	15,451
1998	8,800	8,039	16,839
1999	9,295	8,537	17,832
2000	9,614	8,881	18,495
2001	10,181	9,468	19,649
2002	11,123	10,745	21,868
2003	12,385	11,378	23,763
2004	12,465	11,465	23,930
2005	11,607	10,535	22,142
2006	12,007	10,865	22,872
1995–2006	121,160	111,977	233,137
Total	184,490	174,239	358,729

The register is only considered valid for incidence of diabetes as of 1995

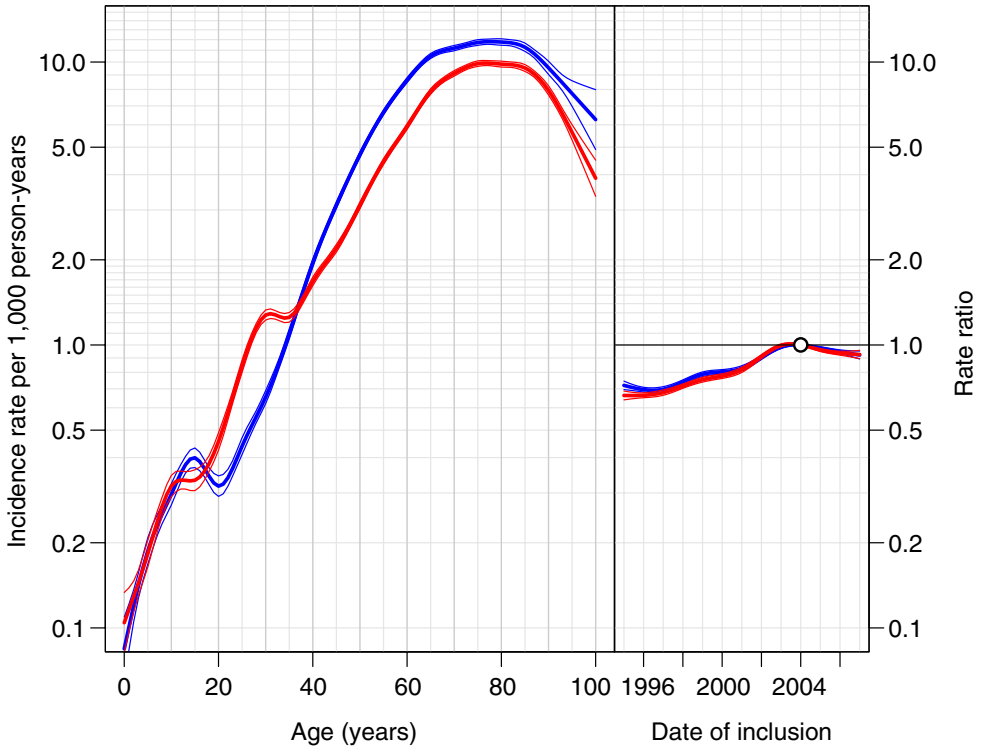


Fig. 1 Age-specific incidence rates and rate ratios by period for diabetes in Denmark 1995–2006. Separate models for men and women. The age-specific rates are cross-sectional, referring to 1 January 2004. Red curves, women; blue curves, men

Incidence rates increased over the period 1995–2004 and showed a tendency to decline after this. A model with separate linear trends before and after 1 January 2004 showed an average increase of 5.3% per year (95% CI 5.1–5.4) before 2004, and an average decline of 3.1% per year (95% CI 2.5–3.6) after this.

Prevalence The number of patients in Denmark with diabetes as of 1 January 2007 was 228,959 (117,096 men and 111,863 women, corresponding to 4.3% and 4.1% of the population, respectively).

The prevalence of diabetes more than doubled from 1995 to 2007. The total number of prevalent cases is given in Table 2, and Fig. 2 shows the age-specific prevalences at 1 January 1995 to 1 January 2007. The average annual increase in prevalence was 6.3% among men and 6.6% among women (Table 2). The annual increase was largely constant across age classes, except for the youngest

Table 2 Number of prevalent diabetes cases in Denmark and overall prevalence

Date[a]	No. persons			Percentage of population		
	Men	Women	All	Men	Women	All
1995	49,427	49,140	98,567	1.92	1.86	1.89
1996	53,408	52,628	106,036	2.06	1.98	2.02
1997	57,700	56,532	114,232	2.21	2.12	2.17
1998	61,793	60,522	122,315	2.36	2.26	2.31
1999	66,691	64,962	131,653	2.54	2.42	2.48
2000	71,730	69,658	141,388	2.72	2.58	2.65
2001	77,034	74,528	151,562	2.91	2.76	2.83
2002	82,808	79,860	162,668	3.12	2.94	3.03
2003	89,130	86,287	175,417	3.35	3.17	3.26
2004	96,567	93,137	189,704	3.62	3.41	3.51
2005	103,980	100,150	204,130	3.88	3.66	3.77
2006	110,422	105,935	216,357	4.11	3.86	3.99
2007	117,096	111,863	228,959	4.34	4.07	4.20

[a] 1 January

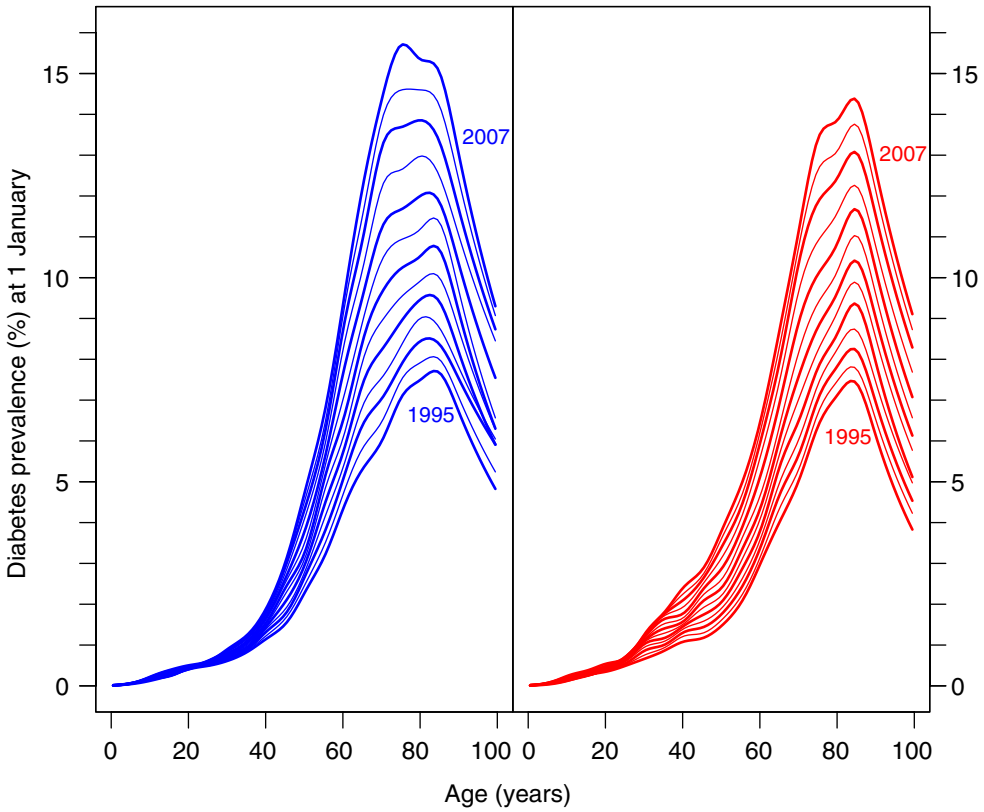


Fig. 2 Age-specific prevalences for diabetes in Denmark at 1 January 1995–2007. Thick lines, odd years; thin lines, even years. Red curves, women; blue curves, men

(<30 years), where it was only 2.7% for men and 3.7% for women (Table 3).

By 1 January 2007 the peak prevalence in men was at age 75 years (15.5%) and in women at age 85 years (14.3%).

The marked increase in the prevalence of diabetes is primarily attributable to the fact that incidence contribute more cases than mortality removes (Table 4). This is partly a product of the reproductive pattern in the Danish population 50–60 years ago, where the annual number of births rose to over 90,000 per year in the years 1944–1948 and then fluctuated between 70,000 and 80,000 per year in the period 1949–1975. Figure 3 shows the age distribution of the population that emerged from this; the 'baby boom' generations born in the late 1940s are now entering the high-incidence ages and therefore an increase in prevalence is to be expected alone on this account over the next 20 years. The surplus number of cases, i.e. the difference between the number of new cases and deaths among diabetes patients, has shown a weak tendency to decline, but this is not likely to continue given the age distribution of the population as of 2007 (also seen from Fig. 3).

Table 3 Annual change (%) in prevalence of diabetes in Denmark in the period 1995–2006

Age (years)	Men	Women
<30	2.7	3.7
30–50	5.1	7.0
50–60	6.2	7.6
60–70	7.1	6.9
70–80	7.2	6.7
>80	6.0	5.9
All	6.3	6.6

Mortality rates In the period 1995–2006 a total of 102,248 deaths (53,324 men, 48,924 women) were recorded in the register during 1.88 million person-years of follow-up. Among those included after 1 January 1995, 49,982 deaths

Table 4 Number of new cases and deaths in the Danish NDR and the annual surplus of cases

Year	New cases	Deaths	Surplus
1995	14,893	7,430	7,463
1996	15,403	7,155	8,248
1997	15,451	7,342	8,109
1998	16,839	7,474	9,365
1999	17,832	8,090	9,742
2000	18,495	8,277	10,218
2001	19,649	8,506	11,143
2002	21,868	9,082	12,786
2003	23,763	9,480	14,283
2004	23,930	9,436	14,494
2005	22,142	9,892	12,250
2006	22,872	10,199	12,673

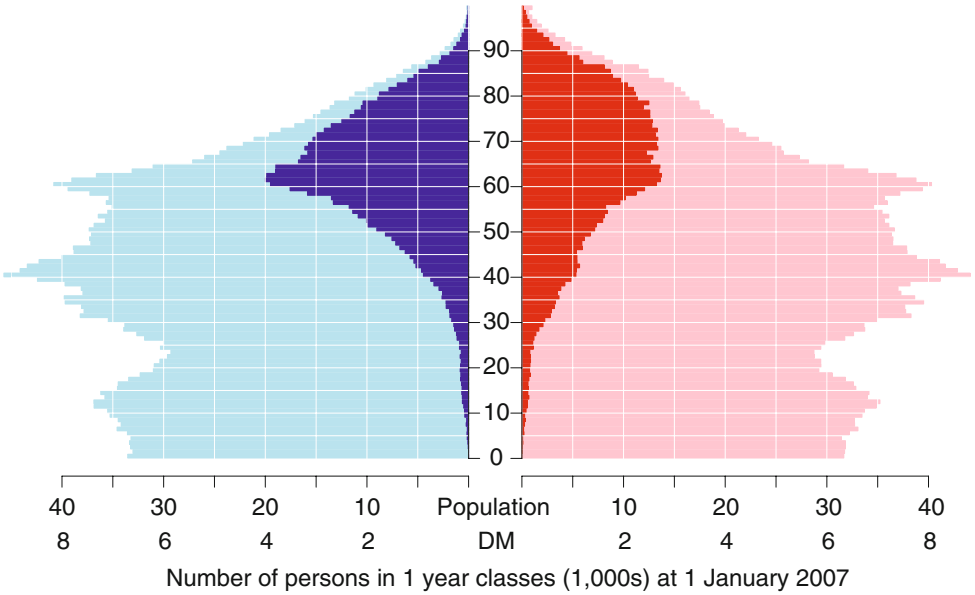


Fig. 3 Age-distribution of the Danish population (pink and pale blue shading) and the diabetic population (blue and red shading). Note the different scales for population and patients. DM, diabetes mellitus. Red/pink, women; blue/light blue, men

(27,013 men, 22,969 women) were seen during 1.06 million person-years. The mortality rate by age, date and time since inclusion in the register is shown in Fig. 4. The mortality rate increased roughly exponentially with age (linearly on a log-scale). It was higher than the mortality rate in the non-diabetic population, but the increase by age was less.

The mortality rate decreased by calendar time (4.6% per year [95% CI 4.2–5.0] in men, 3.7% per year [95% CI 3.3–4.1] in women); controlling for time since inclusion ('duration of diabetes') reduced these values to 3.9% per year for men and 2.6% per year for women. This was substantially more than the decrease in mortality rate in the non-diabetic part of the population, where the annual decrease was 2.5% for men and 1.8% for women.

The mortality rate among diabetes patients declined by about 40% during the first 3 years relative to the mortality rate, as it otherwise would have increased with age. Since the mortality rate among diabetes patients by age increased

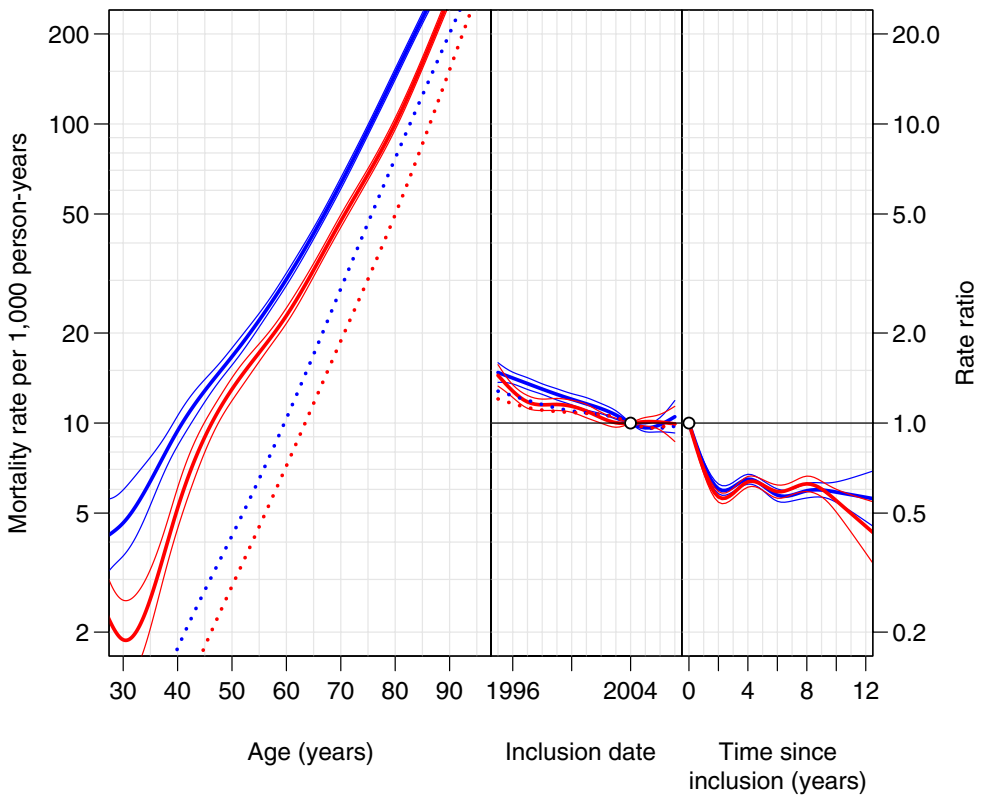


Fig. 4 Mortality rates of diabetes patients (continuous lines with 95% CI) and the non-diabetic population (dotted lines). Red curves, women; blue curves, men

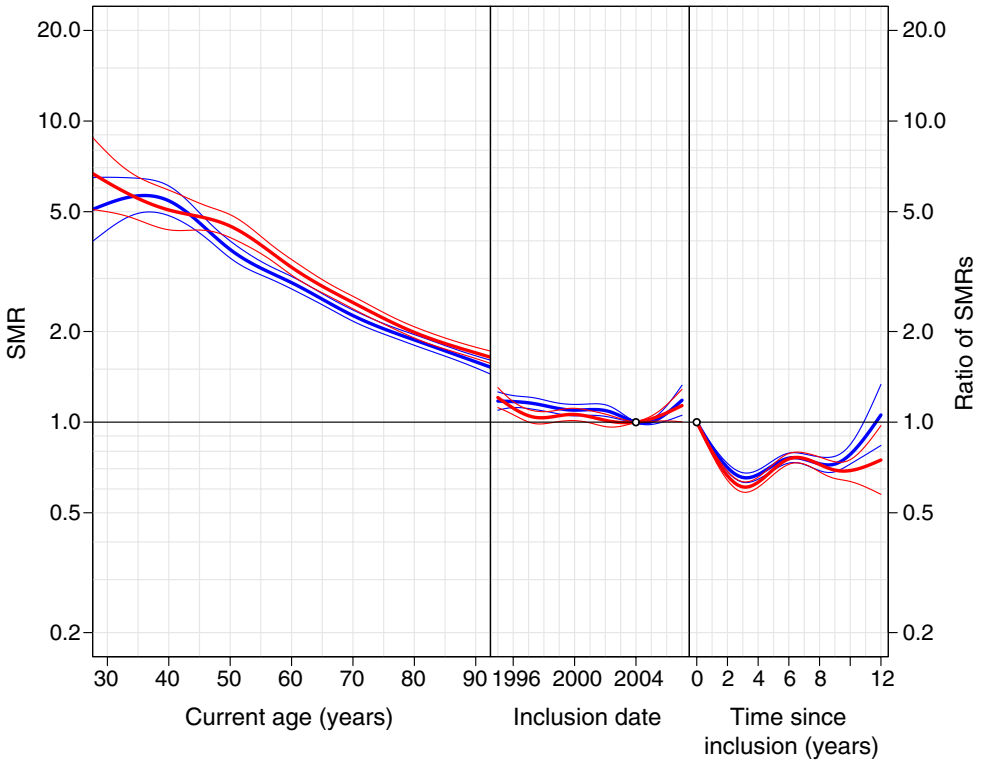


Fig. 5 SMR of diabetic patients relative to the non-diabetic part of the population. Red curves, women; blue curves, men

27% per 3 years, this relative decline translates to a decline of 13% in mortality rate in the first 3 years after inclusion, after which the age-determined increase in mortality rate increases again.

SMRs The mortality rate among diabetes patients increased less by age and decreased more by calendar time than the mortality rate among non-diabetic persons. Therefore, the SMR decreased by age and calendar time (Fig. 5). We found that the SMRs for men and women were virtually identical, and decreased by age from about 4.0 at age 50 years to just under 2 at age 85 years. The average annual decrease in SMR was 1.4% (95% CI 0.9–1.8) in men and 0.7% (95% CI 0.2–1.2) in women.

Lifetime risk of diabetes Using the estimated age-specific incidence and mortality rates from 2004, we found that the fraction of a future population that will have a diagnosis of diabetes before age 70 years is 22% for men and 18% for women, whereas some 30% of a birth cohort will get diabetes at some point during their life (see Fig. 6).

Discussion

This is the first report of a nationwide register of diabetes cases. The register is based on administrative records, i.e. we do not have a definite diagnosis of the persons included, but the advantage is that the entire population is covered by uniform inclusion criteria and the dropout rate is 0. The disadvantage is that no formal information on clinical measurements used at diagnosis of the persons included are used, as they are not available at population level. The register is based on criteria developed in a study where more detailed information on patients was available [2], so we believe that the misclassification is small. The register

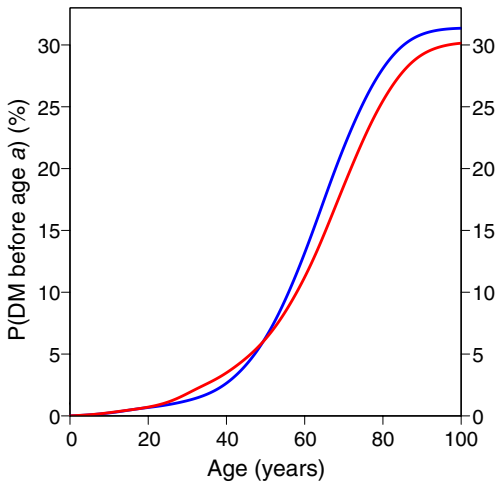


Fig. 6 Risk of developing diabetes before a given age in a future cohort. Estimates are based on the estimated incidence rates and mortality rates for 2004. DM, diabetes mellitus; P, probability. Red curves, women; blue curves, men

does not contain information on whether the patients have type 1 or type 2 diabetes; this distinction has no consequence for the management of the patients that can be seen in the administrative records.

The increase in the number of cases that met only one of the inclusion criteria (26% to 72% over the period 1995–2006) reflects disease progression by time since inclusion. The blood glucose measurement criterion is the most frequently met (40%), indicating that persons included in the register for the first time are mild cases.

The increase in prevalence is primarily attributable to the imbalance between the incidence and the mortality rates, resulting in an annual surplus of some 10,000 patients. The increasing incidence rate and decreasing mortality rate among diabetic patients in the period 1995–2006 contribute further to this.

The increase in the incidence rate of diabetes until 2004 may be attributed to a real increase in the disease incidence, but also to an increase in diagnostic intensity. This notion is supported by the observed decrease after 2004, which may be taken as an indication that the pool of 'prevalent undiagnosed' cases is diminishing. Studies in the Danish population [9, 10] have shown an increase in the incidences of overweight and obesity (although the increases were not dramatic), but have also shown that the increase is smaller in later-born cohorts, so this may be a further contributing factor. Because of the short time span after 2004, and since the break-point is chosen by examination of the data, the estimates for the two trends are those with maximally achievable difference (+5% before and −3% after), so the observed decrease should be viewed with caution. However, it is unlikely that incidence rates will increase substantially over the next few years.

The increase in incidence rate of about 5% per year corresponds to a 65% increase over a 10 year period, which is a great deal to attribute to increasing diagnostic activity alone; at the least it would require a large pool of undiagnosed cases. Therefore, we suggest that there has been a real increase in the occurrence of diabetes; the decrease over the last 3 years may be attributed to success of diagnostic activity exhausting the pool of undiagnosed individuals, but no firm data on this are available.

The incidence rate for women of fertile age (20–35 years old) is about twice as large as the rate for men of the same age. GDM when registered in the NPR was not included and a woman could not enter the register for a period of 1 year after a diagnosis of GDM. The registration of GDM is believed to be fairly accurate, as the diagnosis is mostly made in hospital or maternity clinics that report to the NPR. The higher rates may reflect the possibility that as women with GDM are known to be at increased risk of developing diabetes, they are likely to be followed more closely by their general practitioner, and therefore have a diagnosis of diabetes earlier in the course of the disease. It is not possible to see from these data whether there is also a diabetogenic effect of pregnancy per se.

The decreasing mortality rate in the general population may lead to increasing numbers of persons at risk of diabetes, but it is not likely to contribute substantially to the increase in the incidence rate of diabetes. The decrease in the mortality rate among diabetes patients would further contribute to the continuing rise in prevalence. Increased diagnostic activity would also result in a healthier patient population and hence decreasing mortality rate among diabetes patients, as seen. Moving patients from the non-diabetes to the diabetes pool would also increase the (average) health in the non-diabetes group, and hence lead to a decreasing mortality rate, albeit with considerably smaller effect.

The decrease in mortality rate among diabetes patients may also be attributed to earlier and more rigorous pharmacological treatment, and to screening activities leading to earlier diagnosis and hence a better prognosis for the patients. With our data we cannot quantify the relative contributions of these two factors to the increasing incidence and decreasing mortality rates.

The decrease in mortality rate and SMR during the first years after inclusion may be a reflection of initial treatment benefits, i.e. mortality rate is reduced (relative to what it otherwise would have been) as treatment is started, but it may also be a selection effect as persons diagnosed with diabetes because of emerging complications die in the first short period after diagnosis.

The 2004 level of diabetes incidence rate and mortality rate will lead to a 30% lifetime risk of diabetes in a hypothetical future cohort. The calculation is speculative in the sense that it assumes that incidence rates and mortality rates remain constant for the next 100 years, but it gives a convenient summary measure of the state of affairs in the current population.

The inclusion criteria for the persons in the register are not based on clinical measurements, but on registrations in administrative registers, i.e. persons in touch with the healthcare system as part of routine visits to their general practioners. Hence, the number of patients in the register is probably an underestimate of the actual number of (diagnosed) diabetic patients. A pilot study in Aarhus county, Denmark [1], which validated register-identified patients with their general practitioners, indicated that the sensitivity of the register algorithm used here is 86% and the positive predictive value close to 90%.

Many population surveys have been done internationally, but these invariably have a massive, most likely non-random, non-responder rate (e.g. Inter99 [11] 47.5% non-response, AusDiab [12], 61% non-response). The Danish NDR includes persons on the basis of their registered

contacts with the healthcare system, whereas population surveys normally define diabetic patients as persons who confirm that they have been told by a physician to have diabetes.

The prevalence estimates in this study confirm the findings in the Inter99 study [11]; the prevalence at ages 55 and 60 years were: men 4.0 and 5.8%, women 3.2 and 5.9%, respectively; and the corresponding values from this register were: men 4.4 and 5.8%, women 2.8 and 3.8%, respectively.

In the Tayside region (population about 400,000) of Scotland there is a registry operating [13] that is based on record linkage from more sources than the Danish register. This has shown [14] a similar prevalence of diabetes in 1996 (1.94% compared with 1.89% in Denmark) and similar increase in prevalence (6.7% per year compared with 6.3% per year [men] and 6.6% per year [women] in Denmark). In the Skaraborg region (population about 300,000) of Sweden, a registry based on clinical recordings from patients [15] showed a prevalence of 3.2% in 1995, somewhat higher than found in Denmark. None of these studies have published the age distribution of the underlying population, and hence it is impossible to judge whether the crude rates reported are comparable to the Danish ones.

To our knowledge there is no nationwide diabetes register anywhere else in the world that is continually able to monitor prevalence, incidence rate and mortality rate. The state of Alberta in Canada runs the Alberta Diabetes Surveillance System (ADSS) [16], which is similar to the Danish Register and comparable as far as demographic capabilities are concerned. In Alberta the prevalence of diabetes in 2005 at age 70 years was 17% among men and 13% among women (abstracted from Fig. 2.4 in [16]), and in Denmark 13.0% and 10.5%, respectively. However, the ADSS does not have the same potential as a research resource via record linkage as the Danish register has, because of the unique personal identifier used throughout administrative systems in Denmark.

Studies of the diabetes population in various geographical areas in Denmark have shown similar results to this study. The incidence rates in the younger age group in this study show a similar pattern to those reported in studies from the Danish Childhood Diabetes Register (DSBD), with a peak among girls about age 12 years and about 15 years for boys [17]. Furthermore, a study using pharmacological data to identify the diabetes population in the county of Fyn has also found an increased prevalence and decreased mortality rates in the same period [18].

As in all epidemiological surveys of diabetes, there is a degree of underreporting, primarily because of lack of clinical diagnosis. The size of this fraction of patients is unknown, and it is probably not constant over time. Therefore, some of the increase in the prevalence may be attributable to increased diagnostic awareness both among patients and among physicians. It is likely that the increased awareness of diabetes as a lifestyle disease in recent years has contributed to the apparent rise in incidence rates, but the effect of the inclusion of the undiagnosed patients should diminish in the future, as the recent decrease in incidence rates suggests. Thus, the observed trends in diabetes rates would to a larger extent reflect the actual disease pattern in the population and not changes in diagnostic behaviour in the healthcare system.

The NDR is a tool for epidemiological monitoring of the entire (known) population of diabetes patients in Denmark. Clinical databases have recently been established to monitor the quality of diabetes care and will have national coverage in a few years time. Together with the NDR, this will constitute a unique tool for administrators, health economists and physicians to monitor, plan and organise optimal diabetes care.

Summary

Statistical analysis of the Danish NDR showed that the:

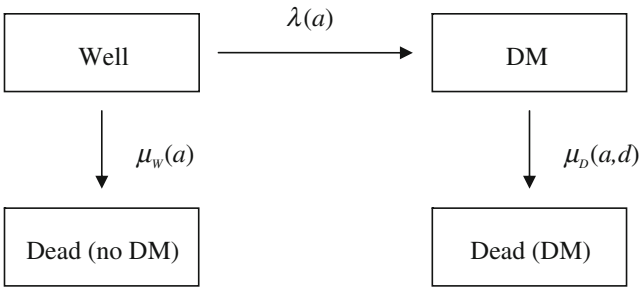
- Prevalence of diabetes in Denmark increased 6% per year
- Incidence rate of diabetes increased 5% per year until 2004, but was constant thereafter
- Mortality rate among diabetic patients decreased 4% per year
- Mortality rate decreased 40% during the first 3 years after inclusion
- SMR was 4 in age 50 and 2 at age 85, and identical for men and women
- SMR decreased 1% per year
- Lifetime risk of diabetes is 30%.

Duality of interest The authors declare that there is no duality of interest associated with this manuscript.

Appendix 1

Cumulative risk of diabetes

Computations are based on a four-state model for a hypothetical cohort (DM, diabetes mellitus):



Note that we in accordance with normal clinical sense assume that the mortality rate among diabetes patients depends both on age and duration of diabetes (represented here by time since inclusion).

Standard probability theory leads to the following expressions for being in each of the four states:

$$\mathrm{P}\{\text{Well at } a\} = \exp\left(-\int_0^a \lambda(s) + \mu_W(s)\,\mathrm{d}s\right)$$

$$\mathrm{P}\{\text{Dead (no DM) at } a\} = \int_0^a \mu_W(s)\exp\left(-\int_0^s \lambda(u) + \mu_W(u)\,\mathrm{d}u\right)\mathrm{d}s$$

$$\begin{aligned}\mathrm{P}\{\text{DM at } a\} &= \int_0^a \mathrm{P}\{\text{DM diagnosis at } s\} \\ &\quad \times \mathrm{P}\{\text{survive with DM from } s \text{ to } a\}\,\mathrm{d}s \\ &= \int_0^a \lambda(s)\exp\left(-\int_0^s \lambda(u) + \mu_W(u)\,\mathrm{d}u\right) \\ &\quad \times \exp\left(-\int_s^a \mu_D(u, u-s)\,\mathrm{d}u\right)\mathrm{d}s\end{aligned}$$

$$\begin{aligned}\mathrm{P}\{\text{Dead (DM) at } a\} &= 1 - \mathrm{P}\{\text{Well at } a\} \\ &\quad - \mathrm{P}\{\text{Dead (no DM) at } a\} \\ &\quad - \mathrm{P}\{\text{DM at } a\}\end{aligned}$$

We used the estimates for the rates from the statistical models to calculate these quantities. We approximated the integrals by sums over 3 month periods, and used the age range 0–100 years, so we used 400 intervals for the calculations. Calculations were done separately for men and women.

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