Diabetes Register(s)
Register collaboration

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Danish Registers, University of Copenhagen, December 2019

Background for a diabetes register

Population surveillance

- Monitor and describe:
  - Prevalence (no. and %)
  - Incidence (no. and rates)
  - Mortality and SMR

Health care surveillance

- Keep track of diabetes patients
- Predictions of likely future developments
- Match patients to treatment indicators (GPs)
- . . . improve accuracy of treatment information

Results up to 31.12.2006 reported in:

Carstensen *et al.*: The Danish National Diabetes Register: Trends in incidence, prevalence and mortality. Diabetologia, 2008

Danish Diabetes Registers - short history

- **NDR** — established 2006, last year of update 2012
  no T1D/T2D distinction
- **RUKS** — Started 2015, initially not available for linkage
  has T1D/T2D distinction, based **only** on NPR & RMPS
- **DMreg** — established 2018 by SDCC Clinical Epidemiology
  using Statistics Denmark, has T1D/T2D distinction, based on
  DADD, NPR, NHSR, DiaBase & RMPS.
  Covers **1996–2016** incl.

DADD:	Danish Adult Diabetes Database - quality register updated annually
NPR:	Nation Patient Register
NHSR:	National Health Services Register
RMPS:	Register of Medicinal Products Statistics - Prescription register
DiaBase:	Quality database for eye-screening of diabetes patients

Construction of the NDR

- Based on existing registers in Denmark:
  - National Patient Register
    — all hospital and outpatient clinic contacts.
  - National Health Insurance Service Registry
    — all services provided in the NHS.
  - Register of Medicinal Product Statistics
    — all prescriptions taken out at pharmacies.
- Linked to mortality and migration data from the Central Person Register.
- All records are CPR-identified, for linkage purposes.
- Inclusion start at 1.1.1990.

Inclusion criteria for the register

- Diagnosis of DM in NPR.
- Gestational diabetes excluded. A diagnosis of GDM precludes inclusion for a period of 1 year.
- Foot-therapy for diabetics recorded in NHISR.
- 5 blood-glucose measurements within 1 year recorded in Register of Medicinal Product Statistics.
- 2 blood-glucose measurements per year in 5 consecutive years recorded in NHISR.
- Prescription on insulin or oral antidiabetic medicine. Metformin alone in women aged 20–39 excluded (PCOS).

Variables in the NDR (scrambeled)

- D_FODDTO - date of birth
- C_SEX - sex
- D_INKLDTO - date of inclusion
- C_INKLAARSAG - criterion first met
- D_DODSDTO - date of death
- D_LPR - first DM diagnosis in LPR
- D_FODT - first date of chiropody
- D_BLOD2I5 - first date of 2 BG / 5y
- D_BLOD5I1 - first date of 5 BG / 1y
- D_OAD - date of 2nd OAD purchase
- D_INS - date of 2nd insulin purchase
- V_PID - person-id

Random sample from NDR

D_FODDTO	C_SEX	D_INKLDTO	C_INKLAAR	D_DODSDTO	D_LPR	D_FODT	D_BLOD2I5	D_BLOD5I1	D_OAD
09NOV1935	K	12OCT2009	oad	.	.	.	.	.	12OCT2009
11SEP1919	M	19APR1990	lpr	22MAY1992	19APR1990	.	.	04JUL1990	.
12JUN1923	K	03JUN1998	blod5i1	22FEB2008	.	.	.	03JUN1998	.
18MAR1936	M	18APR2001	blod5i1	.	06JUN2007	23MAY2007	.	18APR2001	01JUN2001
12AUG1959	K	08OCT2008	blod5i1	.	.	.	.	08OCT2008	.
24DEC1941	M	16MAR2005	blod5i1	24FEB2007	.	.	.	16MAR2005	.
03JUL1944	M	09JAN2003	oad	.	.	.	.	12DEC2007	09JAN2003
22JAN1964	K	22JAN1997	blod5i1	.	.	.	.	22JAN1997	.
29MAR1941	K	01OCT2009	lpr	.	01OCT2009	.	.	.	22OCT2009
01JUN1949	M	06OCT2005	oad	.	.	.	.	11JAN2006	06OCT2005
15AUG1962	M	29SEP2009	oad	.	.	.	.	.	29SEP2009
02APR1949	K	18AUG2004	blod5i1	.	21JAN2009	19MAR2008	23APR2008	18AUG2004	08SEP2007
21JUL1931	K	14MAY2003	blod5i1	.	.	.	.	14MAY2003	.
08OCT1901	K	08AUG1992	lpr	20DEC1993	08AUG1992	.	.	.	.
19APR1913	K	23JAN1991	fodt	29AUG1992	.	23JAN1991	.	.	.
09MAR1913	K	03APR1998	oad	20MAY1999	.	.	.	.	03APR1998
15APR1947	M	24APR2001	oad	.	21MAY2001	.	.	.	24APR2001
12DEC1940	K	16JUL2002	lpr	.	16JUL2002	.	.	.	13JAN2006
31DEC1916	M	24MAY1991	lpr	28JUN1991	24MAY1991	.	.	.	.
21JUN1919	K	16FEB1992	lpr	15NOV1993	16FEB1992	20JAN1993	.	17JUN1992	.
31DEC1944	K	05OCT1993	lpr	.	05OCT1993	21APR2004	.	.	05NOV1994
30JUN1916	K	01FEB2006	blod5i1	18MAR2009	.	.	.	01FEB2006	.
16OCT1971	K	08DEC2004	blod5i1	.	.	.	.	08DEC2004	.
16MAY1965	K	25MAY2005	blod5i1	.	22MAY2006	.	.	25MAY2005	23NOV2005
06AUG1923	K	28OCT1998	blod5i1	01APR2004	.	.	.	28OCT1998	.
26JAN1932	M	20FEB2008	blod5i1	.	.	21MAY2008	.	20FEB2008	05MAR2008
16JUN1932	M	25FEB1998	lpr	24APR2006	25FEB1998	18NOV1998	04AUG2004	27SEP2000	03MAR2000
15FEB1914	M	22JUL1992	blod5i1	17FEB1993	.	.	.	22JUL1992	.

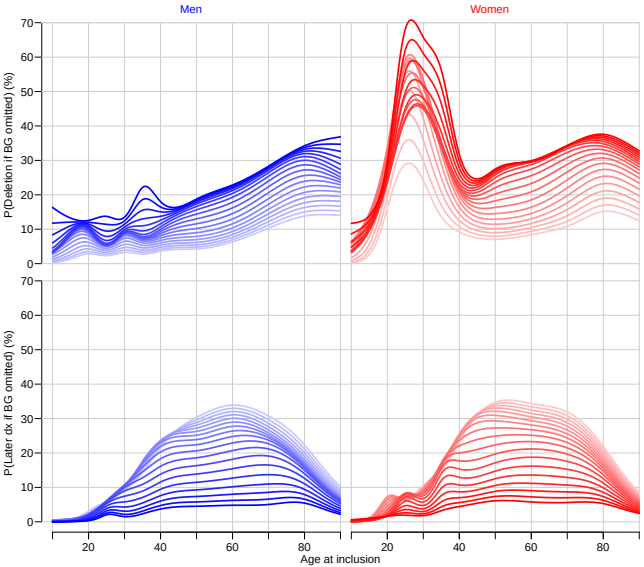
Random sample from NDR

D_INKLDTO	C_INKLAAR	D_LPR	D_FODT	D_BLOD2I5	D_BLOD5I1	D_OAD	D_INS	V_PID
12OCT2009	oad	.	.	.	.	12OCT2009	.	0C25D
19APR1990	lpr	19APR1990	.	.	04JUL1990	.	.	0CEC1
03JUN1998	blod5i1	.	.	.	03JUN1998	.	.	0CAF5
18APR2001	blod5i1	06JUN2007	23MAY2007	.	18APR2001	01JUN2001	.	0CCE3
08OCT2008	blod5i1	.	.	.	08OCT2008	.	.	0C2CD
16MAR2005	blod5i1	.	.	.	16MAR2005	.	.	0C47B
09JAN2003	oad	.	.	.	12DEC2007	09JAN2003	.	0C619
22JAN1997	blod5i1	.	.	.	22JAN1997	.	.	0C6F9
01OCT2009	lpr	01OCT2009	.	.	.	22OCT2009	.	0CD42
06OCT2005	oad	.	.	.	11JAN2006	06OCT2005	.	0C42B
29SEP2009	oad	.	.	.	.	29SEP2009	.	0CBE4
18AUG2004	blod5i1	21JAN2009	19MAR2008	23APR2008	18AUG2004	08SEP2007	.	0C2ED
14MAY2003	blod5i1	.	.	.	14MAY2003	.	.	0C2CD
08AUG1992	lpr	08AUG1992	.	.	.	.	.	0C5FA
23JAN1991	fodt	.	23JAN1991	.	.	.	.	0CFB0
03APR1998	oad	.	.	.	.	03APR1998	.	0C976
24APR2001	oad	21MAY2001	.	.	.	24APR2001	.	0CB64
16JUL2002	lpr	16JUL2002	.	.	.	13JAN2006	17JAN2006	0CEE1
24MAY1991	lpr	24MAY1991	.	.	.	.	.	0CB84
16FEB1992	lpr	16FEB1992	20JAN1993	.	17JUN1992	.	.	0CF20
05OCT1993	lpr	05OCT1993	21APR2004	.	.	05NOV1994	.	0CCB3
01FEB2006	blod5i1	.	.	.	01FEB2006	.	.	0C867
08DEC2004	blod5i1	.	.	.	08DEC2004	.	.	0CB44
25MAY2005	blod5i1	22MAY2006	.	.	25MAY2005	23NOV2005	.	0C52A
28OCT1998	blod5i1	.	.	.	28OCT1998	.	.	0CE21
20FEB2008	blod5i1	.	21MAY2008	.	20FEB2008	05MAR2008	.	0C758
25FEB1998	lpr	25FEB1998	18NOV1998	04AUG2004	27SEP2000	03MAR2000	30JUL2002	0CBB4
22JUL1992	blod5i1	.	.	.	22JUL1992	.	.	0C709

Glucose criteria in NDR

- Women who have a glucose tolerance test triggesrs typically 6 blood glucose measuremnts.
- Omitting the glucose criteria:
  - Some are removed from the register
  - Some have a later diagnosis (meeting a different criterion).
- The new diagnostic criteria based on HbA1c makes the blood glucose criteria even more uncertaing.
- No consensus on how to proceed.

Excluded if BG criteria omitted



RUKS — Register for Udvalgte Kroniske Sygdomme

- NDR only updated until 2012 — discontinued
- RUKS comprises:
  - Asthma
  - Dementia
  - COPD
  - Arthritis
  - Osteoporosis
  - Schizophrenia
  - Diabetes, type 1
  - Diabetes, type 2

RUKS definition of T2 DM

- Two purchases of OAD (A10B)
- Latest NPR diagnosis is E11
- Women with NPR diagnosis of PCOS excluded
- Date of T2D debut is the first of:
  - date of first (!) insulin/OAD purchase
  - date of first NPR recording with diabetes

RUKS definition of T1 DM

- Two purchases of insulin (A10A)
- NPR diagnosis E10
- Purchase of insulin ± 280 days from GDM diagnosis not counted
- Persons classified as T2D excluded
- Date of T1D debut is the first of:
  - date of first (!) insulin purchase
  - date of first NPR recording

RUKS definition of T1/T2 DM

- If a person have no recording of insulin/OAD purchase or diagnosis E10 / E11 in NPR, in a period of 10 years, the person is excluded from RUKS.
- Not specified whether the person is excluded from registrations earlier than the 10 year limit.

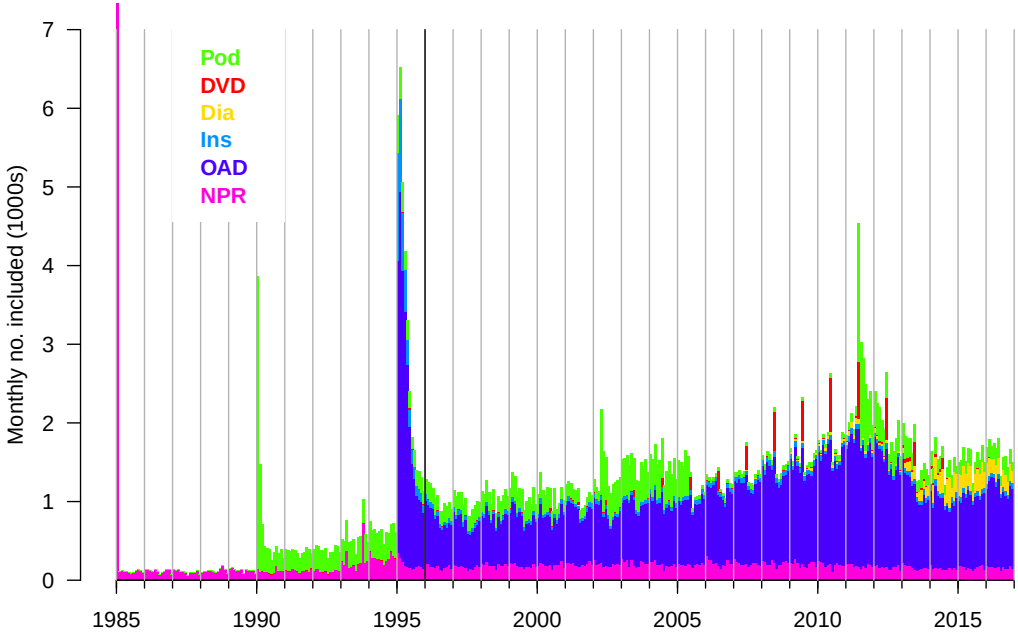
Reconstructed Diabetes Register — sources

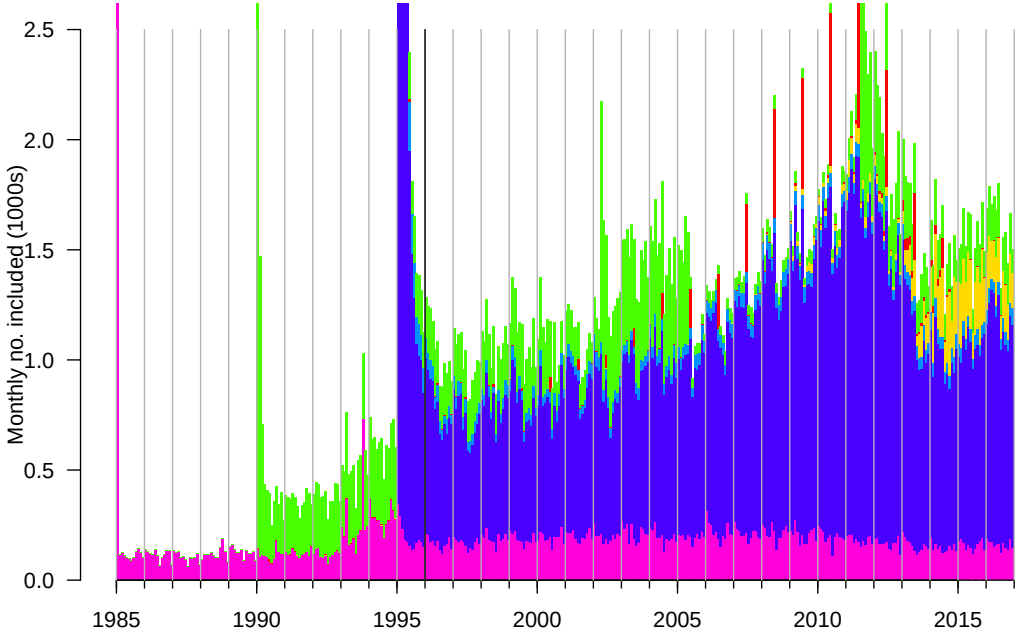
A side effect of a project at Statistics Denmark (DST), available inside the project at DST — Clinical Epidemiology at SDCC

- NPR, National Patient Register
- RMPS, Register of Medicinal Product Statistics (prescription reg.)
- NHSR, National Health Services Register
- DADD, Danish Adult Diabetes Database
  — annual clinical status since 2005
  — complete for T1D, not for T2D
- DiaBase, Eyescreening database
- Inclusion data is the first occurrence in any of these as a diabetes patient

Reconstructed Diabetes Register

- No blood glucose criteria used
- Podiatry (foot therapy) for DM patients (NHSR)
- GDM window -30 to 365 days
- PCOS: -30 days from NPR diagnosis or only metformin in the age-range 20–40 years — excluded
- T1/T2 classification:
  - Based on DVDD (Danish Adult Diabetes Database)
  - Subsequently on NPR
  - Any OAD before age 15 $\rightarrow$ T1D
  - Any insulin before age 30 $\rightarrow$ T1D
  - Non-classifiable coded as T2D


Pod
DVD
Dia
Ins
OAD
NPR
Monthly no. included (1000s)
0
1
2
3
4
5
6
7
1985
1990
1995
2000
2005
2010
2015


Monthly no. included (1000s)
0.0
0.5
1.0
1.5
2.0
2.5
1985
1990
1995
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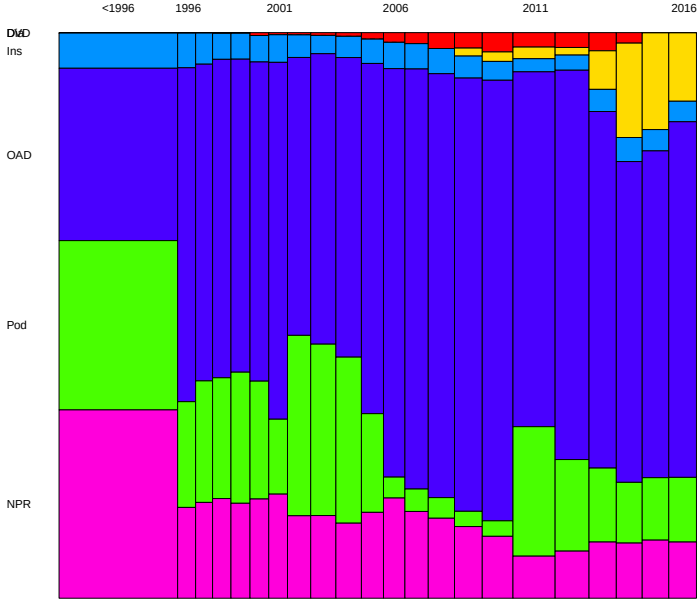
2010
2015


<1996
1996
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2016
DVD
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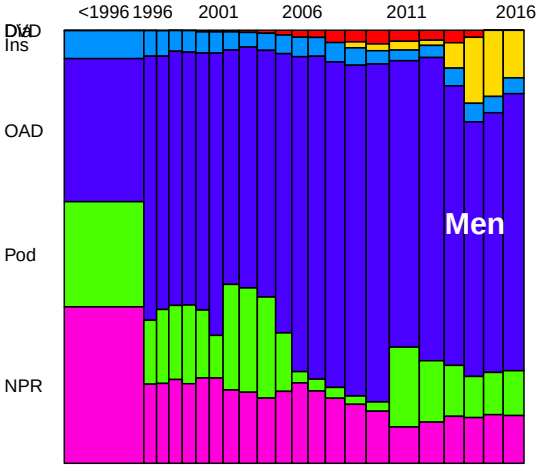
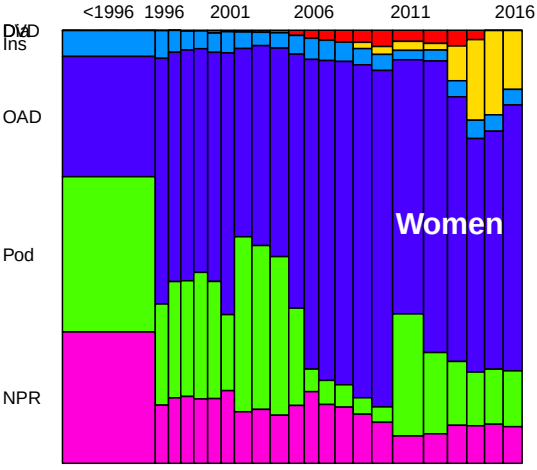
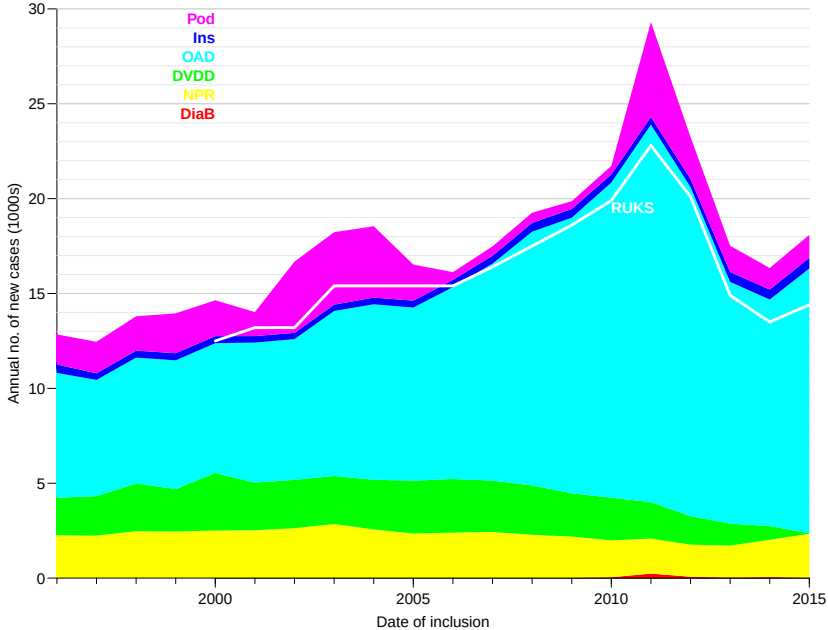
OAD
Pod
NPR


DVD
Ins
OAD
Pod
NPR
Men

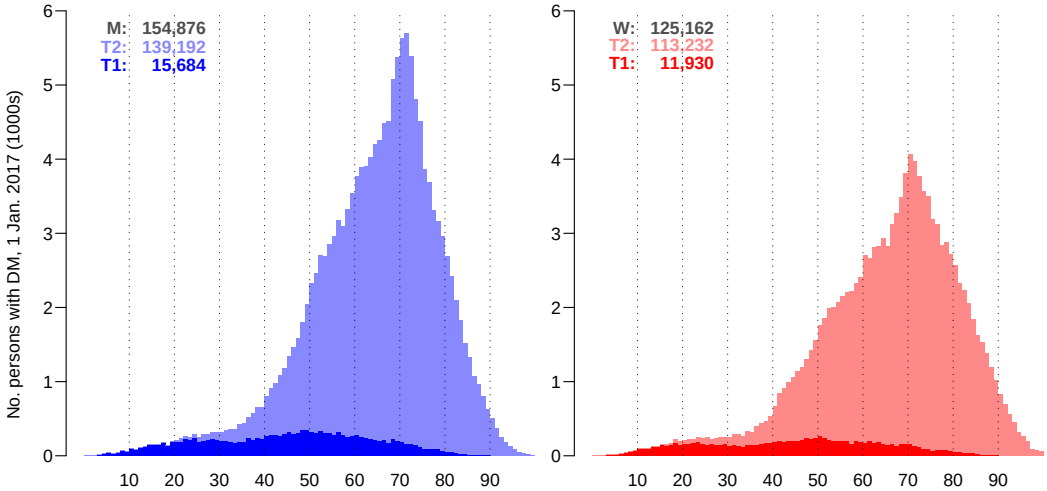

DVD
Ins
OAD
Pod
NPR
Women

Annual number of cases by the reconstructed algorithm, according to first criterion met.

White line is the RUKS annual number included



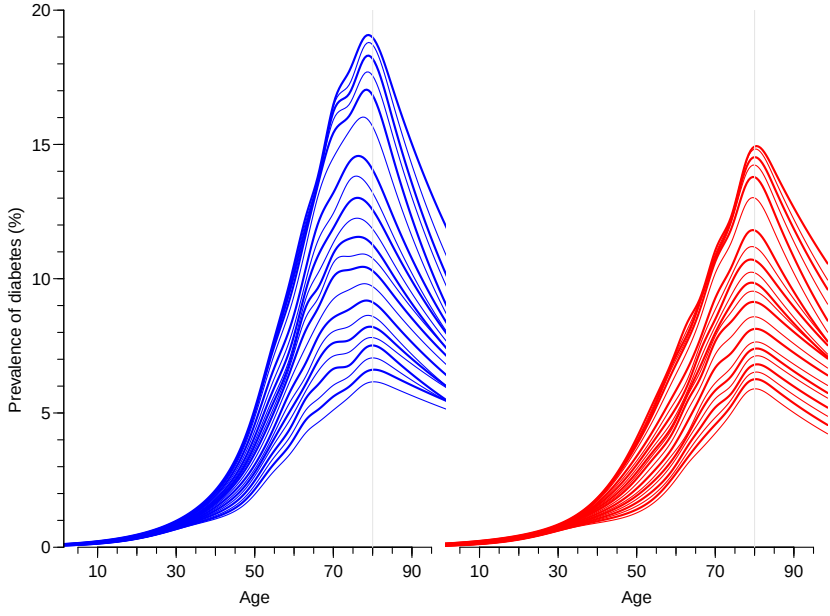
Number of diabetes patients 2017-01-01



Prevalence: Methods

- Prevalent cases by 1 Jan 1995,. . . ,2017 tabulated by sex and 1-year age.
- Corresponding population figures from Statistics Denmark.
- Prevalence analysed by a binomial model with log-link and the population size as denominator.
- Separate parametric terms used for each sex and date.
- One age-specific prevalence curve for each sex and year.

Age-specific prevalences of DM according to the reconstructed register.

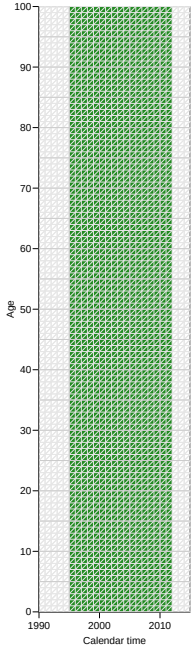


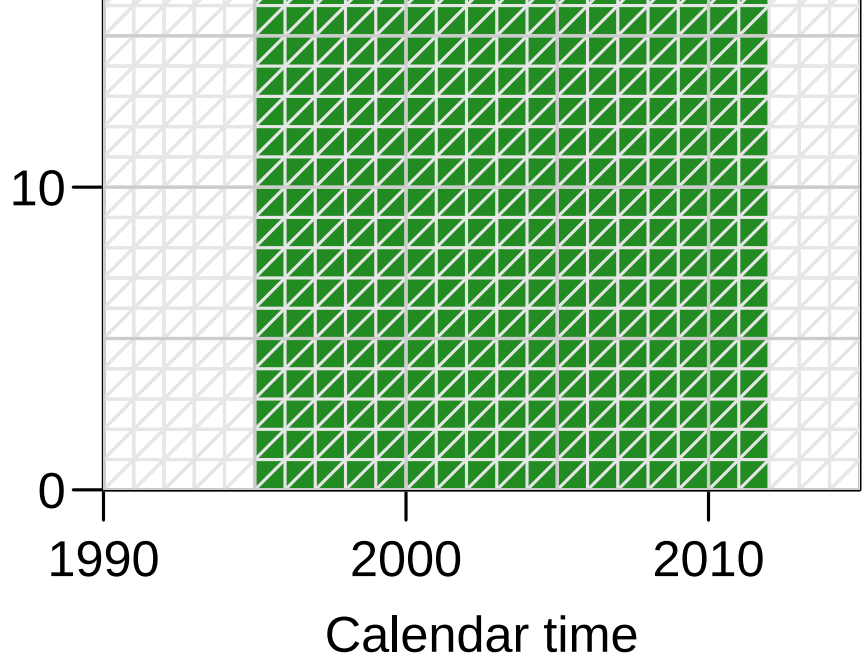
Incidence: New cases included

	T1D		T2D		All DM		
Period	M	W	M	W	M	W	M+W
1996	725	527	6,269	5,345	6,994	5,872	12,866
1997	649	528	6,192	5,264	6,841	5,792	12,633
1998	714	503	7,019	5,844	7,733	6,347	14,080
1999	654	451	7,415	6,203	8,069	6,654	14,723
2000	692	479	8,450	7,005	9,142	7,484	16,626
2001	655	455	7,391	6,090	8,046	6,545	14,591
2002	621	423	8,410	7,474	9,031	7,897	16,928
2003	588	412	9,468	8,140	10,056	8,552	18,608
2004	583	453	9,782	8,288	10,365	8,741	19,106
2005	585	427	9,163	7,621	9,748	8,048	17,796
2006	584	440	9,050	7,193	9,634	7,633	17,267
2007	585	450	9,636	7,966	10,221	8,416	18,637
2008	603	438	10,831	8,792	11,434	9,230	20,664
2009	596	392	10,962	8,509	11,558	8,901	20,459
2010	587	405	11,876	9,333	12,463	9,738	22,201
2011	537	401	13,363	11,084	13,900	11,485	25,385
2012	517	347	10,981	9,013	11,498	9,360	20,858
2013	495	398	8,650	6,829	9,145	7,227	16,372
2014	495	398	8,637	6,443	9,132	6,841	15,973
2015	520	406	9,569	7,354	10,089	7,760	17,849
2016	518	363	10,404	7,819	10,922	8,182	19,104
Sum	12,503	9,096	193,518	157,609	206,021	166,705	372,726

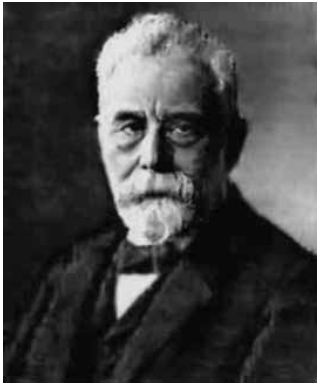
Incidence: Methods

- New cases tabulated by age and date of diagnosis (1996-2016) and date of birth, in 1-year classes.
- Corresponding person-years figures from Statistics Denmark — person-years in the diabetes register subtracted.
- Incidence rates analysed by Poisson-regression with smooth parametric terms in age and date of diagnosis and date of birth, using log-person-years as offset.

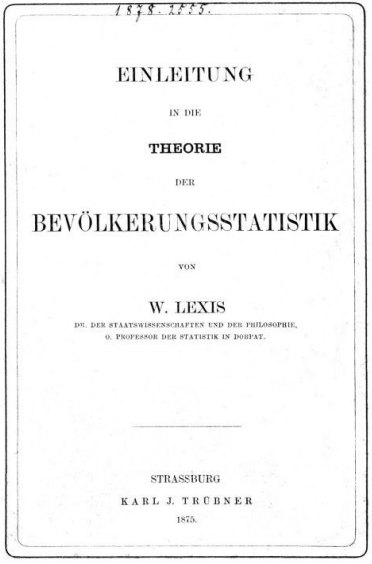



10
0
1990
2000
2010
Calendar time

Digression: Lexis diagram



Wilhelm Lexis (1837–1914)
German demographer, statistician and economist.



1878. 2275.

EINLEITUNG

IN DIE

THEORIE

DER

BEVÖLKERUNGSSTATISTIK

VON

W. LEXIS

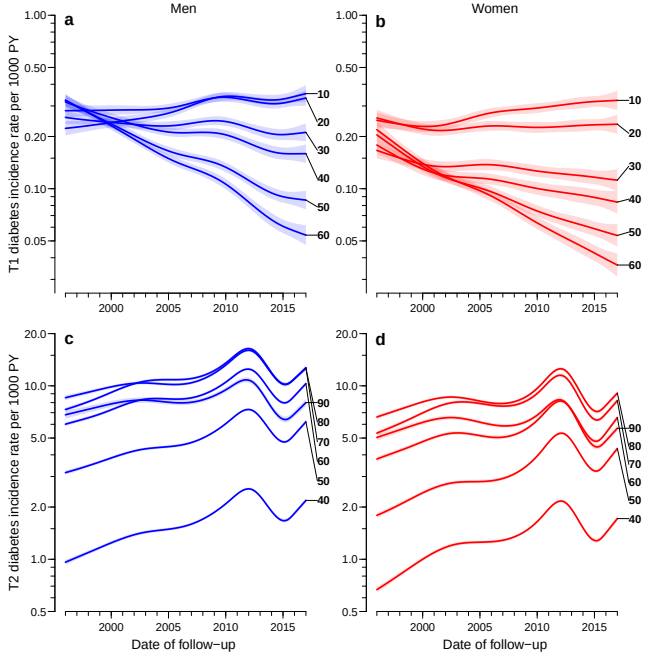
DR. DER STAATSWISSENSCHAFTEN UND DER PHILOSOPHIE,
O. PROFESSOR DER STATISTIK IN DORPAT.

STRASSBURG
KARL J. TRÜBNER
1875.

Incidence rates in different ages.

Note the different y-axes for T1D and T2D.

T2D is 10 times more common than T1D.



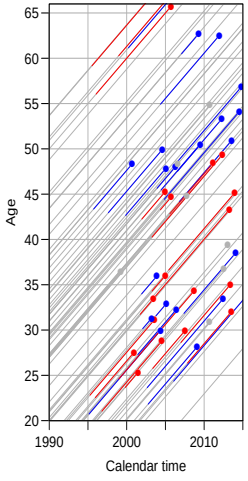
Methods: Mortality and SMR

- Deaths and person-years of follow-up among diabetics tabulated by age and period at follow-up in 1-year classes.
- Corresponding mortality figures from Statistics Denmark. Deaths and person-years from the diabetes cohort subtracted.
- Mortality analysed by Poisson-regression of deaths with smooth parametric terms for current age, current date and current disease duration, using log-person-years as offset.
- SMR analysed using dataset amended by mortality among non-DM persons, using interaction between DM / non-DM and age / duration.

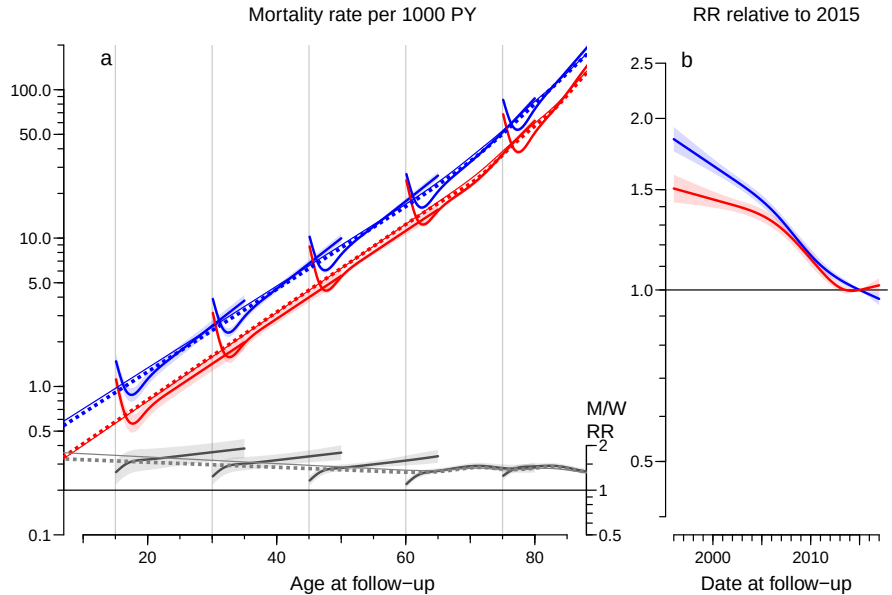
Number of deaths — imbalance

Year	New cases	Deaths	Surplus
1996	12,866	6,116	6,750
1997	12,633	6,306	6,327
1998	14,080	6,397	7,683
1999	14,723	6,841	7,882
2000	16,626	6,947	9,679
2001	14,591	7,054	7,537
2002	16,928	7,406	9,522
2003	18,608	7,747	10,861
2004	19,106	7,609	11,497
2005	17,796	7,902	9,894
2006	17,267	8,000	9,267
2007	18,637	8,158	10,479
2008	20,664	8,034	12,630
2009	20,459	8,716	11,743
2010	22,201	8,808	13,393
2011	25,385	8,839	16,546
2012	20,858	9,158	11,700
2013	16,372	9,431	6,941
2014	15,973	9,746	6,227
2015	17,849	10,079	7,770
2016	19,104	10,259	8,845

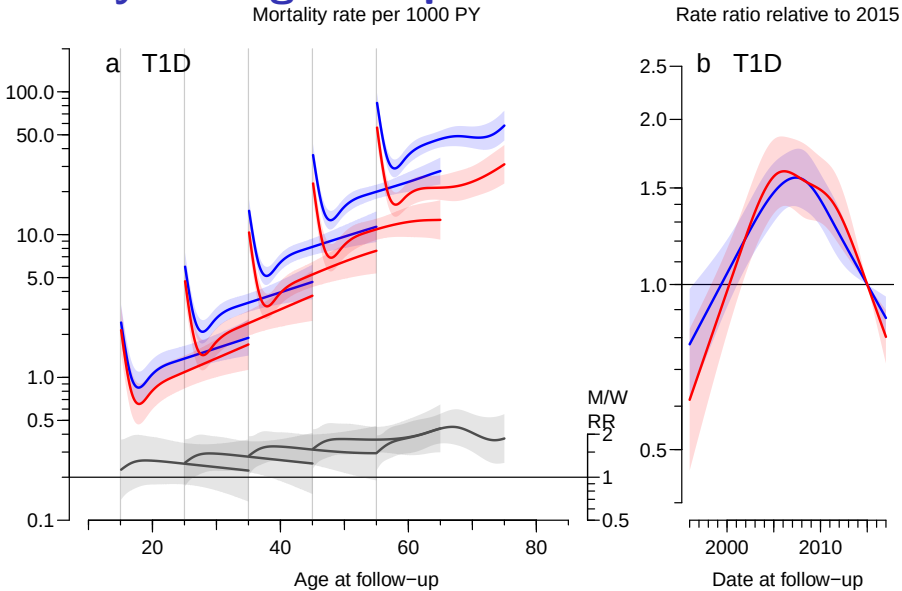
Incident cases Mortality



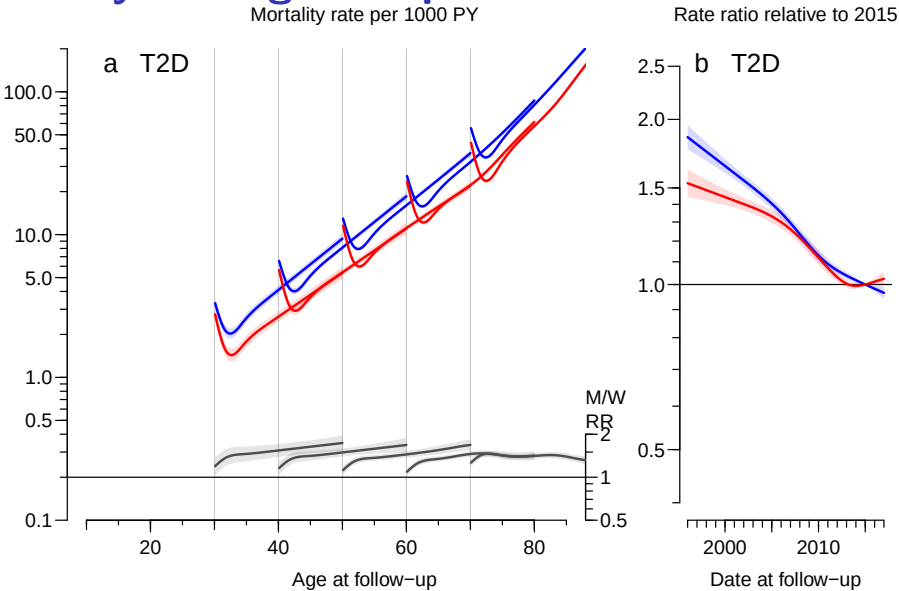
Mortality among DM patients



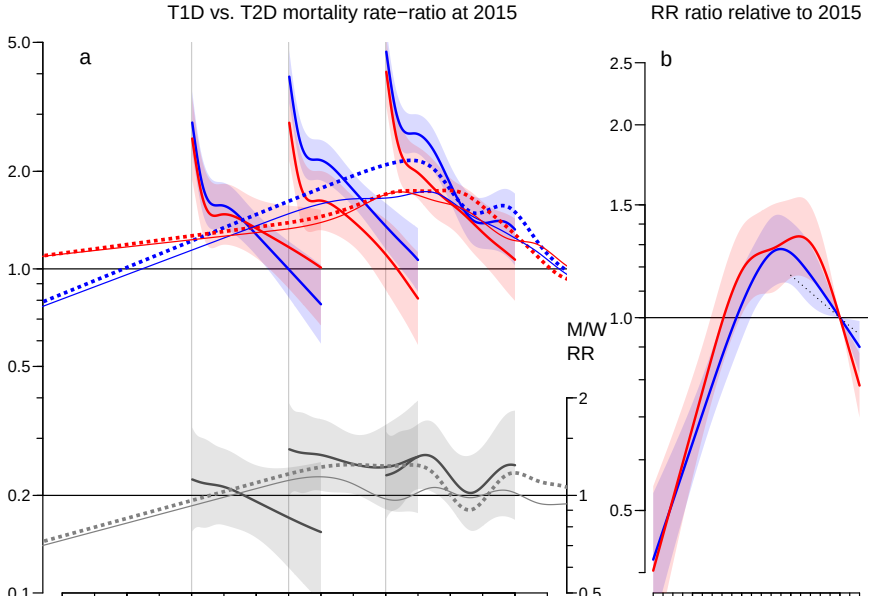
Mortality among T1D patients



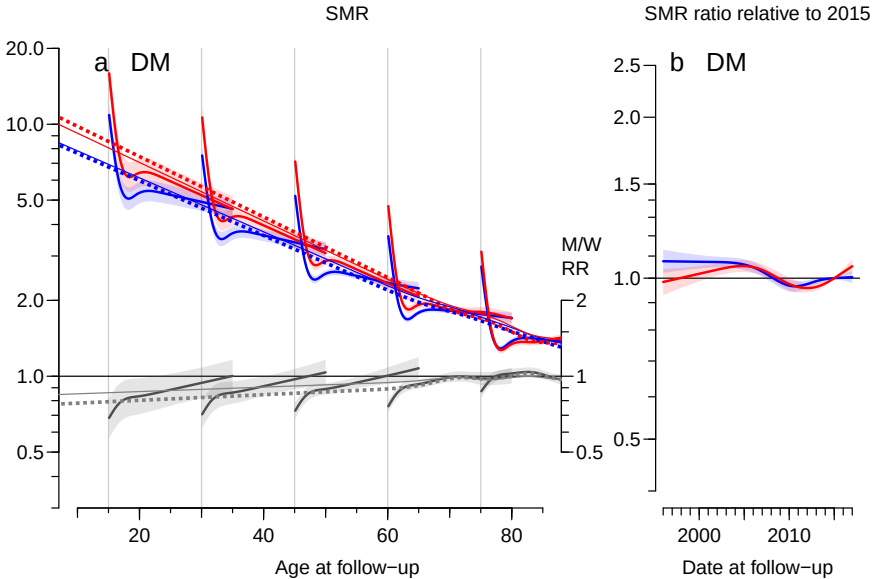
Mortality among T2D patients



Mortality RR between T1D/T2D



SMR relative to persons without DM



Mortality summary

- Mortality in DM patients increases exponentially by age.
- Decreasing by time: 4.0/3.8%/year
  (non-DM: 2.8/2.4)
- Duration effects differs between T1D and T2D:
  - T1D: smaller mortality for longer duration
  - T2D: larger mortality for longer duration
- SMR is (almost) the same for men and women.
- SMR is 3 at age 45, 1.5 at 80

Cancer among diabetes patients

- Merge the Diabetes Register with the Danish Cancer Register.
- Compute the RR of cancer between persons with and without diabetes.
- 25 cancer sites, 2 sexes, age-interaction, duration.

Aims

- Describe cancer incidence rates among diabetes patients in Denmark.
- and how rates vary relative to the non-DM population with:
  - duration of diabetes
  - duration of insulin use
- for all types of cancer
- and for specific sites of cancer

Diabetologia (2012) 55:948–958
DOI 10.1007/s00125-011-2381-4

ARTICLE

Cancer occurrence in Danish diabetic patients: duration and insulin effects

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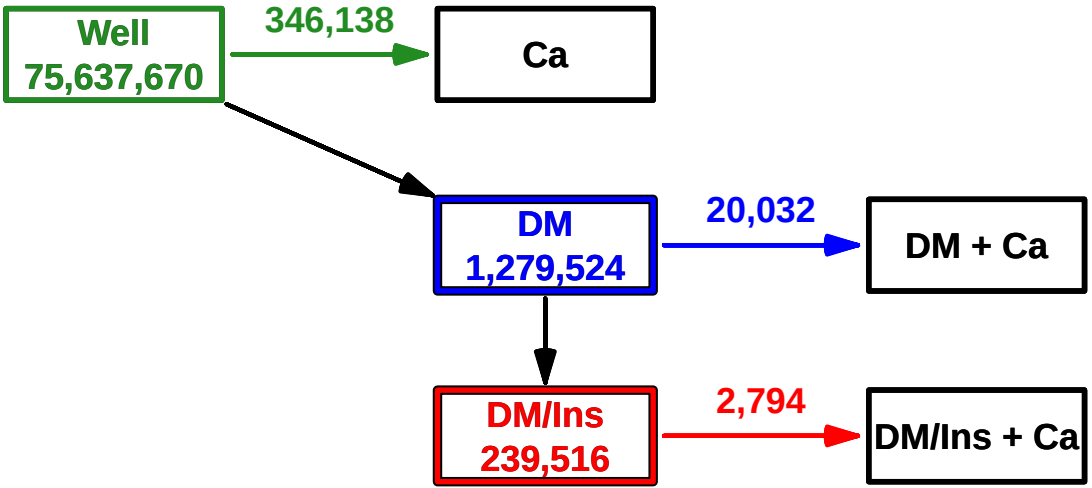
Abstract
Aims/hypothesis Cancer is more frequent among diabetes

population decreased from over 2 at diagnosis to 1.15 after 2 years of diabetes duration. The cancer incidence rate ratio

Follow-up of the Danish population

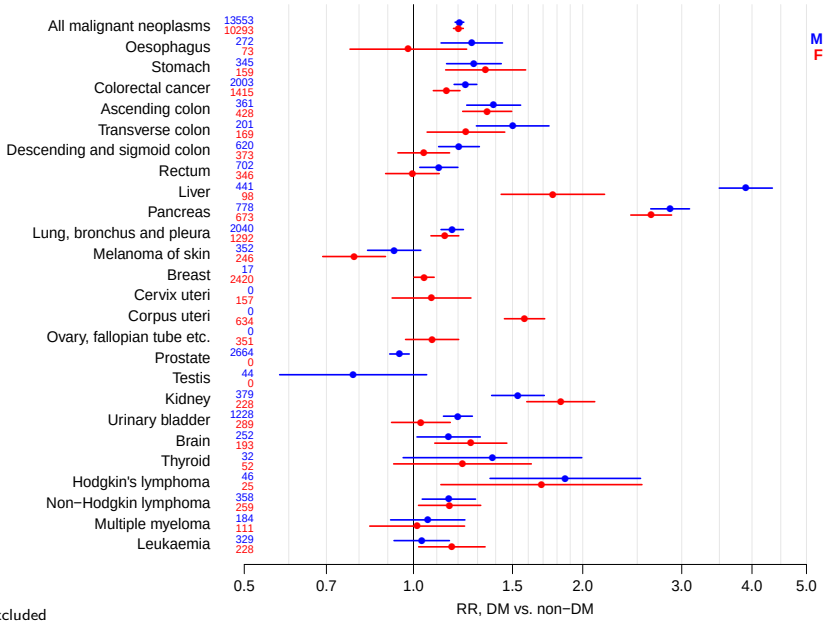


Follow-up in the population

Persons are followed 1 Jan 1995 to:

event: first primary cancer of a given type

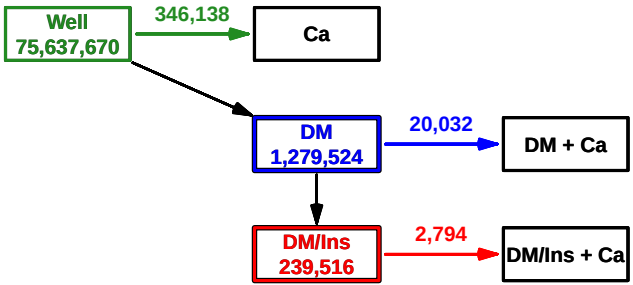
censoring:
- diagnosis of any other primary cancer
- death
- 31 Dec 2009

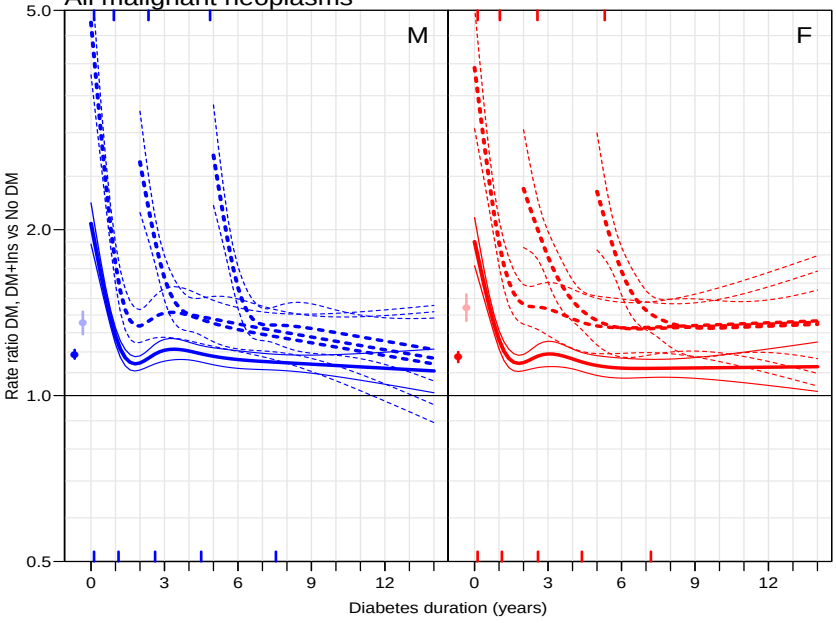


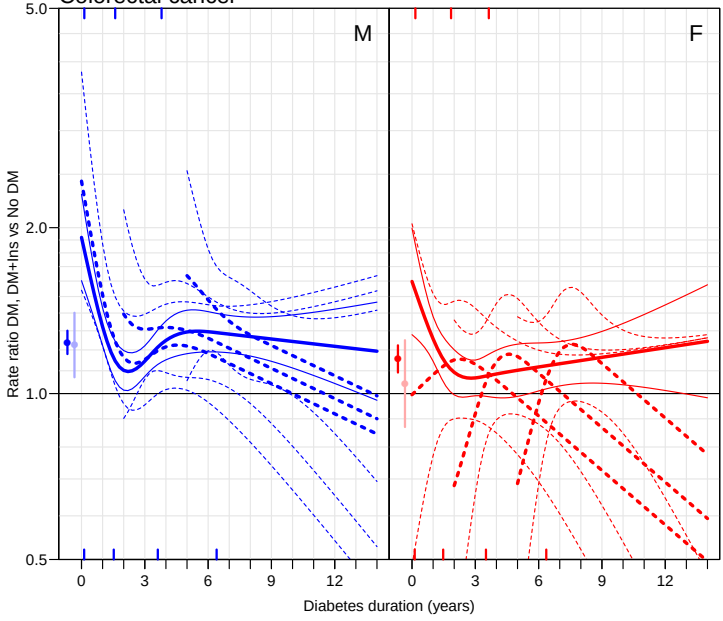
DM prevalent at 1.1.1995 excluded

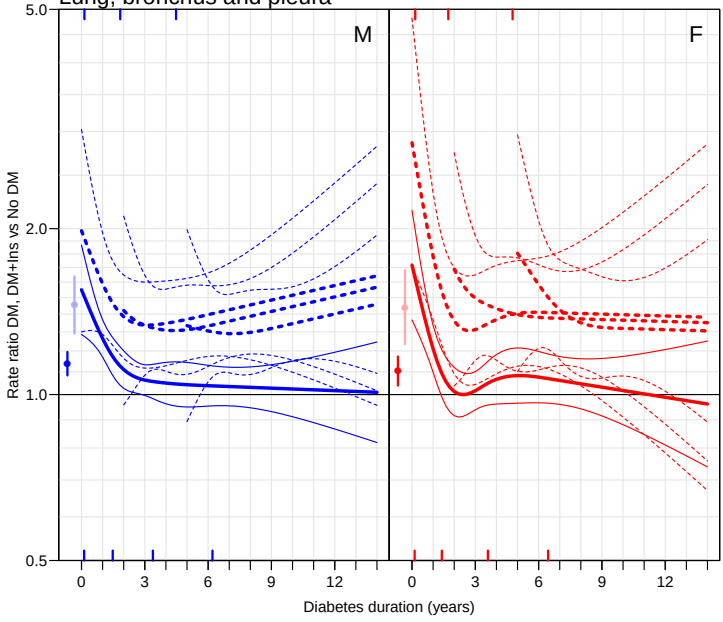
Duration model

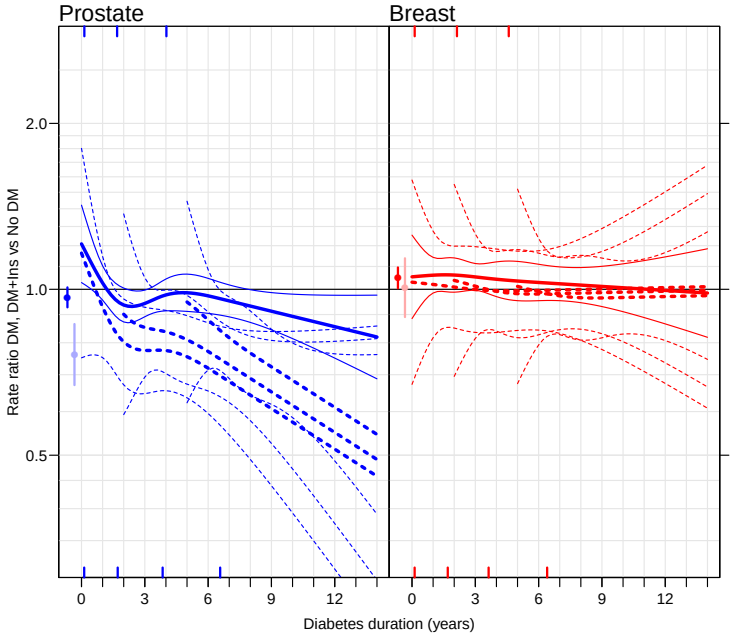
$$\text{rate} = f(\text{age}) \times g(\text{date of FU}) \times h(\text{date of birth}) \times t(\text{DM-duration}) \times s(\text{Ins-duration})$$




All malignant neoplasms
M
F
Rate ratio DM, DM+Ins vs No DM
5.0
2.0
1.0
0.5
0
3
6
9
12
Diabetes duration (years)


Colorectal cancer
M
F
5.0
2.0
1.0
0.5
Rate ratio DM, DM+Ins vs No DM
0
3
6
9
12
Diabetes duration (years)


Lung, bronchus and pleura
M
F
5.0
2.0
1.0
0.5
Rate ratio DM, DM+Ins vs No DM
0
3
6
9
12
Diabetes duration (years)


Prostate
Breast
Rate ratio DM, DM+Ins vs No DM
2.0
1.0
0.5
0
3
6
9
12
Diabetes duration (years)

Curr Diab Rep (2014) 14:535
DOI 10.1007/s11892-014-0535-8

DIABETES AND OTHER DISEASES-EMERGING ASSOCIATIONS (JJ NOLAN, SECTION EDITOR)

The Epidemiology of Diabetes and Cancer

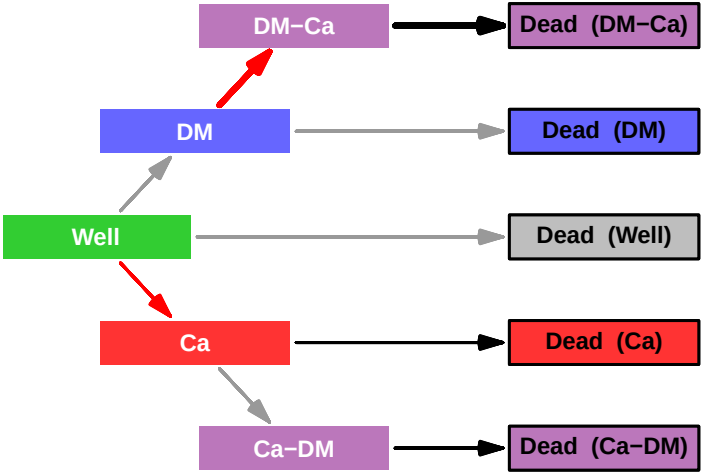
Bendix Carstensen · Marit Eika Jørgensen · Søren Friis

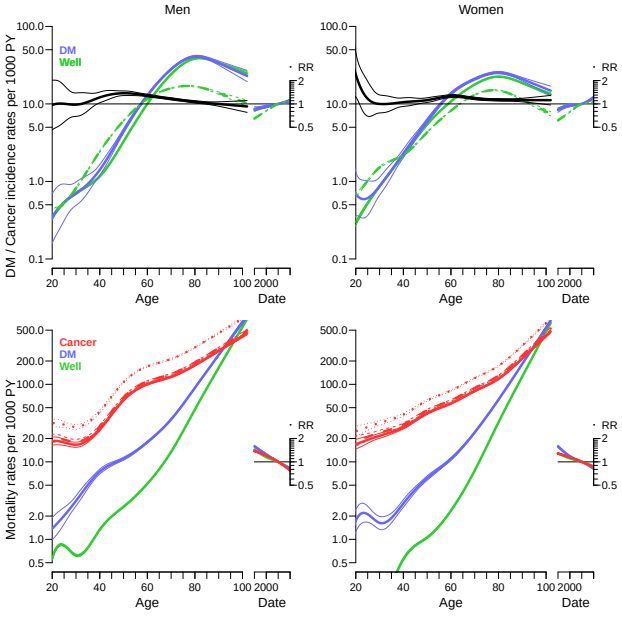
Abstract The literature on cancer occurrence in persons with diabetes has almost invariably been concerned with relative measures. In this paper, we briefly review this, but the aim is to quantify the absolute occurrence of diabetes and cancer in the population in order to give a fuller picture, which also

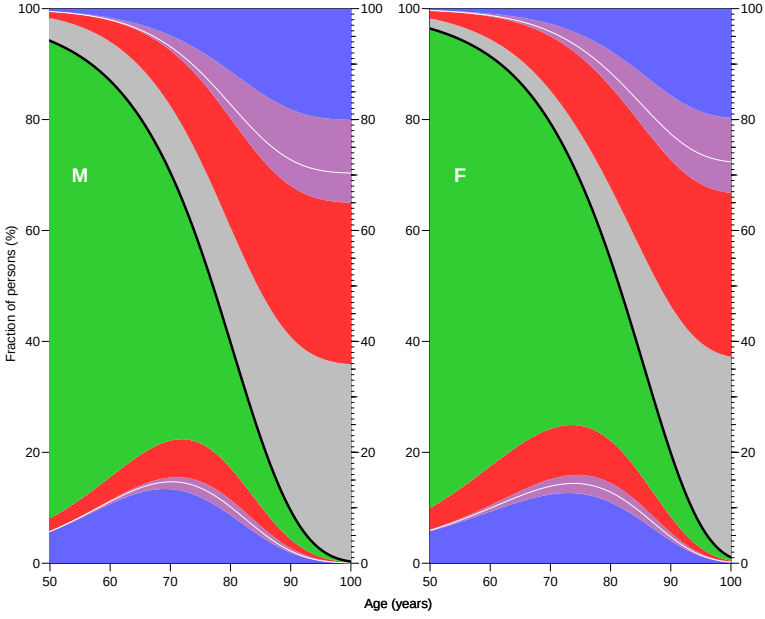
Introduction

The link between diabetes and cancer occurrence is well established, and comprehensive population-based studies have demonstrated that the association relates to both cancer

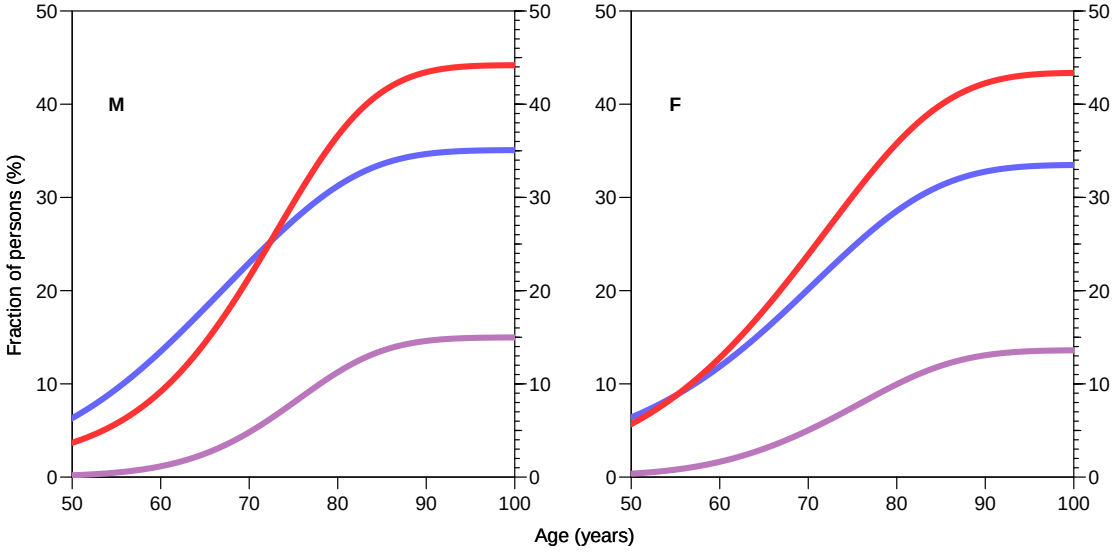
Demography: Life time risk

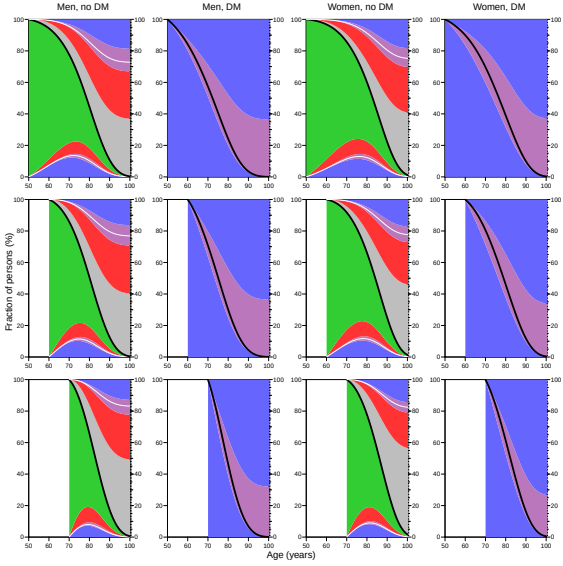



Men
Women
DM
Well
DM / Cancer incidence rates per 1000 PY
Mortality rates per 1000 PY
Cancer
RR
Age
Date


M
F
Fraction of persons (%)
Age (years)
0
20
40
60
80
100
50
60
70
80
90
100

Demography: Cumulative risk




Men, no DM
Men, DM
Women, no DM
Women, DM
Fraction of persons (%)
Age (years)