

Global burden of diabetes mellitus in the year 2000

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1. Introduction

Diabetes mellitus is defined as a group of metabolic diseases whose common feature is an elevated blood glucose level (hyperglycaemia). Chronic hyperglycaemia is associated with the long-term consequences of diabetes that include damage and dysfunction of the cardiovascular system, eyes, kidneys and nerves. The complications of diabetes are often divided into two groups: microvascular (retinopathy, nephropathy, neuropathy) and macrovascular (ischaemic heart disease, stroke, peripheral vascular disease). These estimates relate to the direct burden of diabetes as a proximate cause and do not include the attributable burden of diabetes to renal failure and cardiovascular disease. Separate estimates of the total attributable burden of diabetes are being produced.

Diabetes mellitus (DM) was estimated to be the 29th leading cause of burden of disease in the world in 1990, accounting for 1.1% of total years lived with disability (YLD), around the same percentage as respiratory infections or malignant neoplasms (1). In the Version 1 estimates for the Global Burden of Disease (GBD) 2000 study, published in the World Health Report 2001 (2), DM is the 20th leading cause of YLDs at global level, accounting for 1.4% of total global YLDs. This draft paper summarises the data and methods used to produce the Version 2 estimates of DM burden for the year 2000.

2. Case and sequelae definitions

Criteria for the diagnosis and classification of diabetes have been revised several times and can differ between countries. The current WHO classification of disorders of glycaemia (3) is as follows:

- type 1 (pancreatic beta-cell destruction leading to absolute insulin deficiency),
- type 2 (insulin resistance and relative insulin deficiency)
- other specific types of diabetes
- gestational diabetes

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The onset of type 1 diabetes is most common in children or young adults and accounts for around 10% or less of the total number of people with diabetes. Type 2 diabetes accounts for almost all of the remaining cases of diabetes as the other forms are rare. Type 2 diabetes is a condition that predominantly affects middle-aged and older people but prevalence is increasing among children and young adults in countries with a high prevalence of obesity.

Glucose levels are distributed in a continuous manner in most populations but an approximate threshold at which markedly increased risk of microvascular complications arise has been used to define diabetes mellitus. The World Health Organization (WHO) Expert Committee on Diabetes in 1980 (4) defined diabetes using the criteria given in Table 2.1 and these criteria have been used for the diagnosis of diabetes in the majority of epidemiological studies of diabetes prevalence to date.

Revised diagnostic criteria for diabetes based on a fasting plasma glucose of ≥ 7.0 mmol/l have recently been adopted in the United States (5). WHO recognises the 2 hour glucose level as the gold standard for diagnosis of diabetes but the 1999 WHO criteria (3) indicate that a fasting plasma glucose of ≥ 7.0 mmol/l can be accepted as a satisfactory alternative in epidemiological studies (see Table 2.1).

A variety of studies have compared prevalence of diabetes using the different criteria and the majority indicate that prevalence of diabetes is lower using the fasting level alone rather than the fasting and/or 2 hour level, with the most marked relative under-ascertainment in older people and women (6;7). The Japanese Diabetes Society criteria include HbA1c $\geq 6.1\%$ as a criterion for diagnosis of diabetes among Japanese populations but this criterion has not been widely evaluated in other populations. At present this criterion is of limited value in global terms as there is not a uniform standard for measurement (8).

For these estimates of global burden of diabetes we aimed to identify representative population-based studies that used oral glucose tolerance tests and 1980 WHO criteria to define diabetes prevalence by age and sex. The exceptions to this rule were to use:

1. a study of diabetes prevalence based on fasting plasma glucose that gave higher prevalence than that determined from an earlier study in the same population based on fasting and/or 2 hour glucose levels (for Tanzania)
2. a large population based study performed using an 80g carbohydrate load (for China). Several studies that met the above criteria but that had implausible age distributions of diabetes prevalence due to small numbers of cases were excluded. Where more than one study was available for regions of the world where diabetes prevalence estimates were assumed to be similar then a conservative approach was taken and the study with the lowest prevalence estimates was used.

Table 2.1 WHO criteria for diagnosis of diabetes in venous plasma

Year of criteria	1980	1999
Fasting plasma glucose	≥ 7.8 mmol/l (140 mg/dl)	≥ 7.0 mmol/l (126 mg/dl)
OR		
2 hour post 75g glucose load plasma glucose	≥ 11.1 mmol/l (200mg/dl)	≥ 11.1 mmol/l (200mg/dl)

The prevalence of complications was estimated for the same complications as for the 1990 burden of disease study (blindness due to retinopathy, diabetic foot, neuropathy and amputation).

Table 2.2 GBD 2000 case and sequelae definitions for diabetes mellitus

Cause category	GBD 2000 Code	ICD 9 codes	ICD 10 codes
Diabetes mellitus	W079	250	E10-E14

Sequela	Definition
Cases	See above
Blindness due to retinopathy	Inability to distinguish the fingers of a hand at the distance of 3 meters, visual acuity of less than 3/60, or corresponding visual field loss in the better eye with best possible correction, due to diabetic retinopathy
Diabetic foot	Foot ulcer(s) associated with diabetes
Neuropathy	Loss of reflexes and of vibration; damage and dysfunction of sensory, motor or autonomic nerves attributable to diabetes
Amputation	Surgical removal of the lower extremity or part of it because of gangrene

3. Population prevalence and incidence studies

Estimates of prevalence of diabetes among people under 20 years of age were provided by Dr Anders Green and were estimated from incidence data derived from published studies. Further details of the methods used are given in the Diabetes Atlas 2000 (9).

Appropriate surveys for adults were identified by a MEDLINE search using the words diabetes mellitus, incidence, prevalence, occurrence and epidemiology and from unpublished studies known to the diabetes programme team at WHO or the International Diabetes Institute. Where more than one survey for a country was identified that met the eligibility criteria defined above, preference was given to more recent studies. For countries for which eligible data were not available, data from a proxy country believed to have similar diabetes prevalence were used (see Table 3.1). The majority of studies of diabetes prevalence do not indicate the type of diabetes and consequently the estimates refer to all diabetes.

Estimates of diabetes prevalence in developing countries where data were only available for urban areas were halved to derive estimates for rural areas and where data were only available for rural areas these were doubled to derive urban estimates, consistent with the approach used in previous estimates (10). An exception was made for India and the countries for which Indian prevalence of diabetes was used as a proxy. On the advice of regional experts (Prof. Ramachandran and Mr Jerzy Leowski) a factor of 4 was used to divide urban estimates of diabetes prevalence to derive estimates of diabetes prevalence in rural areas. These separate estimates were then applied to the appropriate urban:rural population divisions of countries for which prevalence data were not directly available to obtain estimates of numbers of cases of diabetes and country-specific estimates of diabetes prevalence.

3.1 Prevalence

Table 3.1. Prevalence studies for diabetes mellitus

Country of study, year and reference	Sample size	Age group	Additional countries that estimates were applied to
Australia 2000 (11)	11,247	25+	New Zealand
Bolivia 1998 (12)	2,948	20+	Ecuador, Peru
Brazil 1988/89 (13)	2,051	30-69	Argentina, Chile, Cuba, Mexico, Uruguay, Venezuela
Cameroon pre-1996 (14)	1,767	24-74	Angola, Central African Republic, Congo, Gabon, Guinea, Sao Tome and Principe
China 1994 (15)	224,251	25-64	North Korea
Colombia 1988/9 (16)	670	30+	Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama
Fiji 1980 (17)	1,709	20+	
Ghana 1998 (18)	4,733	25+	Benin, Burkina Faso, Cape Verde, Chad, Cote d'Ivoire, Guinea, Guinea Bissau, Gambia, Liberia, Nigeria, Senegal, Sierra Leone, Togo
India 2000 (19)	11,216	20+	Bangladesh, Bhutan, Sri Lanka, Maldives, Nepal
Iran 1999/2000 (20)	9,229	20+	Azerbaijan, Iraq, Yemen
Israel (21)	1,502	25-64	
Japan Funagata 1990-2 (22)	2,624	40+	
Jordan (23)	2,836	25+	Syria
Korea (24)	2,520	30+	South Korea
Lebanon (25)	2,518	30+	
Malta (26)	2,149	15+	
Mauritius (27)	4,929	25-74	
Mongolia (28)	2,449	35+	
Nauru (29)	1,546	20+	
Netherlands 1989-1992 (30)	2,484	50-74	Austria, Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Norway, Sweden, Switzerland, UK
Oman 1991 (31)	2,963	20+	Qatar
Pakistan: rural Baluchistan (32)	570	25+	Afghanistan

Pakistan: Sindh 1994 (33)	967	25+	
Paraguay 1991/2 (34)	1606 Urban white Hispanic	20-74	Suriname
Poland (35)	2,523	25-74	Bosnia, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Slovakia, Slovenia, TFYR Macedonia, Yugoslavia
Russia (36)	1,602	25-64	
Samoa (37)	1,772	25-74	Cook Islands, Niue, Samoa, Tonga, Tuvalu
Saudi Arabia (38)	25,337	2-77	Bahrain, Kuwait
Singapore (39)	3,568	18-69	Brunei, Indonesia, Malaysia, Philippines, Thailand
South Africa (40)	729	30+	Botswana, Lesotho, Namibia, Swaziland, Zimbabwe
South Korea (24)	2,520	30+	
Spain (41)	2,214	30-89	Andorra, Italy, Monaco, San Marino, Portugal
Sudan (42)	1,284	25+	Eritrea, Ethiopia, Mali, Mauritania, Niger
Tanzania 1996/7 (43)	1,698	15+	Burundi, Comoros, Congo, Djibouti, Kenya, Madagascar, Malawi, Mozambique, Rwanda, Somalia, Uganda, Zambia
Trinidad 1977-1981 (44)	2,315	35-69	Antigua, Bahamas, Barbados, Belize, Dominica, Dominican Republic, Grenada, Guyana, Haiti, Jamaica, St Kitts and Nevis, St Lucia, St Vincent And The Grenadines
Tunisia 1976/7 1980/1(45)	3826 urban 1787 rural	20+	Algeria, Libya, Morocco
Turkey (46)	24,788	20+	Albania, Belarus, Bulgaria, Greece, Moldova, Romania
United Arab Emirates 2000 (47)	5,844	19+	
U.S. 1988-1994 (48)	6,587 fpg 2844 ogtt	20+ 40-74	Canada
Uzbekistan 1996 (49)	1,956	35+	Armenia, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan
VietNam (50)	1121	25+	Cambodia, Laos, Myanmar,

3.2 Incidence

Available data on diabetes mellitus incidence are much less widely available than for prevalence and tend to be available only for selected populations. Age-specific incidence patterns from published

studies were applied within Dismod in order to derive plausible and internally consistent estimates of incidence and prevalence (51-53).

3.3 Time trends in diabetes mellitus

Prevalence of known diabetes appears to be increasing in most countries, presumably due to increasing prevalence of risk factors (see below) and improved diagnosis. A previous study giving predictions of diabetes prevalence in 2000 was based on demographic changes and urban to rural population ratios. Comparisons of the methods and results of current estimates and previous estimates and predictions are given in the discussion.

3.4 Risk factors for the development of diabetes mellitus

Risk factors for type 2 diabetes include obesity, physical inactivity, ageing and genetic predisposition. A proxy measure for the first two factors is urbanisation and prevalence of diabetes is generally higher in urban than rural areas in developing countries. At present, data on prevalence of risk factors for diabetes other than ageing and urbanisation have not been incorporated into current or predicted future estimates of diabetes prevalence.

4. Mortality

Estimates of relative risk of all-cause mortality among people with diabetes by age and sex were derived from cohort studies that provided this information (54-57). Data from the various studies were combined using a weight of the total number of deaths in each study. The estimates are given in Table 4.1 with the figures used in the 1990 GBD study given in Table 4.2. All of these studies were in developed countries (Britain, Sweden and the United States) and as no information was available for developing countries the same relative risks were assumed to apply. Further details of the methods used to estimate the relative risks are available from the authors. Relative risks of mortality among people with blindness due to retinopathy and/or among people with diabetic neuropathy were assumed to be 1.76 times higher than those of uncomplicated diabetes cases (58).

Table 4.1 Relative risk of mortality for Diabetes mellitus (DM) cases for GBD 2000

Age group (years)	Males	Females
0-19	1.8	3.1
20-39	4.1	6.7
40-59	2.9	3.5
60-79	1.5	2.3
80+	1	1

Table 4.2 Relative risk of mortality for Diabetes mellitus (DM) cases for GBD 1990

Age group (years)	Males	Females
0-4	1.007	1.007
5-14	1.021	1.023
15-29	1.028	1.045
30-44	1.176	1.127

45-59	1.371	1.24
60-69	1.456	1.385
70+	1.544	1.616

5. Estimates of remission and duration of DM and prevalence, remission and duration of sequelae

Remission was assumed to be zero for diabetes cases, blindness due to diabetic retinopathy, neuropathy and amputation. Duration of diabetic foot ulcers was assumed to be 6 months. Estimates of prevalence of complications of diabetes were based upon a proportion of people with diabetes having the complication (with the exception of estimates of blindness due to retinopathy where such data were not available and estimates were generated by attributing a proportion of blindness prevalence to diabetes). The proportions were derived from literature reviews and are summarised in Tables 5.1 to 5.4. Comparisons with estimates for 1990 are given in Table 5.5.

Age and sex distribution of prevalence of complications has not been well documented in the literature. Estimating the pattern of complications of diabetes is made more difficult by the association with duration of diabetes, the adequacy of control of diabetes and the prevalence of other risk factors, none of which are directly taken in to account in these estimates. Age and sex distributions of diabetes sequelae for these estimates of burden of diabetes were generated using the following assumptions:

- For blindness due to diabetic retinopathy, prevalence was assumed to be zero below 15 years of age and prevalence as a proportion of people with diabetes was assumed to be equal for both sexes. The age distribution was generated from a single estimate for all ages for 15-44, 45-64 and 65+ year olds using the same age pattern as in the 1990 burden of disease estimates.
- For neuropathy and diabetic foot prevalence was assumed to be zero below 20 years of age. Prevalence as a proportion of people with diabetes was assumed to be equal for both sexes for neuropathy and diabetic foot based on evidence for an absence of difference in prevalence of neuropathy by sex in the United States (59). The age pattern of percentage of people with diabetes with neuropathy and diabetic foot were obtained from 1990 data from the United States and were assumed to apply to all regions (60).
- Prevalence and incidence of amputation was assumed to be zero below 20 years of age. Estimates of the proportions of people with diabetes with amputation were derived from an epidemiological study of incidence based in centres in Europe, the U.S. and Japan (61) with extrapolation to other regions. Incidence was assumed to be equal to prevalence based on the assumption that average survival after amputation is one year.

Table 5.1 Estimates of prevalence of diabetic retinopathy for GBD 2000

Region	Prevalence of blindness %	Proportion of blindness due to diabetic retinopathy (%)	Proportion of people with diabetes blind due to diabetic retinopathy (%)	Prevalence of blindness due to diabetic retinopathy per 100,000 population	Source of data
AfrD	1	1		10	Blindness prevalence from Lewallen review (62) assuming 1% due to DR
AfrE	1	1		10	As above
AmrA			0.53	43	Wisconsin data: 1.6% of DM blind, 33% due to DR (63)
AmrB	1.7*	1.4*	0.52§	24* 24§	*Barbados (64) § QUALIDIAB 2.6% blind (65), guess 20% due to DM
AmrD	1.7*	1.4*	0.52§	24* 22§	As above
EmrB	0.6	2.5		15	Lebanon (66)
EmrD			0.6	15	Egypt: 5.9% of diabetics blind, 4.2% of non-diabetics blind (67). Assume 33% blind DM due to DR
EurA			0.5	26	Assume blindness prevalence 1.5% of DM (cf 1.2% (68), 1.3% (69), 1.6% (70) + 33% due to DR (63)), (cf 32% (71), 25% (69), 43% (72))
EurB1			0.5	28	As above
EurB2			0.5	16	As above
EurC			0.5	29	As above
SearB			0.09 (and round to 0.1)	3.9	See below
SearD			0.09 (and round to 0.1)	3.9	S. India clinic data 0.2% blind and 45% of VI due to DM (73)
WprA	1.4	10	0.33	14	Australian blindness registry (74) 2.9% Japanese diabetics blind in one or both eyes (75) – assume 1% blind in both eyes and 33% due to DR
WprB1	0.4	2		8	China blindness prevalence (76) and guess 2% due to DR
WprB2	0.4	2		8	As above

WprB3	0.6	2.5		15	Tonga data (77) and assuming 2.5% blindness due to DR
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Table 5.1b Estimates of prevalence of blindness due to diabetic retinopathy for GBD 2000 per 100,000 by age and sex

Region	Men			Women		
	15-44	45-59	60+	15-44	45-59	60+
Age (years)						
Afro D & E	4.73	28.24	72.31	4.64	38.57	112.5
Amro A	11.78	59.3	185.28	10.15	51.08	159.61
Amro B	7.5	46.03	127.26	12.43	76.24	210.8
Amro D	9.81	60.17	166.36	10.98	67.33	186.15
Emro B & D	7.63	50.26	122.76	7.63	50.26	122.76
Euro A	8.76	44.11	137.82	7.51	37.79	118.08
Euro B1	7.99	45.36	109.83	5.78	32.83	79.5
Euro B2	5.79	32.86	79.57	5.71	32.4	78.45
Euro C	7.93	45.02	109.01	7.93	45.02	109.01
Searo B	17.78	102.95	244.36	15.57	93.03	238.19
Searo D	12.93	78.46	195.69	12.56	78.31	201.04
Wpro A	8.82	44.41	138.76	7.27	36.58	114.29
Wpro B1 & B2	3.03	17.73	49.3	2.93	16.39	49.56
Wpro B3	5.68	33.24	92.43	5.49	30.73	92.93

Table 5.2a Estimates of prevalence of diabetic neuropathy for GBD 2000 per 100,000
 (* includes asymptomatic neuropathy)

Region	Country	N (people with DM)	Diabetic neuropathy (% of DM)
EME	US (59)	2405	38
	Japan (78)	6472	40
	Portugal (79)	93	32
	UK (80)	6487	29
	UK (81)	811	42
	Italy (82)	374	32
	Italy (83)	8757	32
	Spain (84)	2644	23
	Australia (85)	173	48*
FSE	Ukraine (86)	4123	27.9
India	India (87)	3010	27.5
China	China (88)	626	46.5
OAI	Sri Lanka (89)	500	31
	Taiwan (90)	219	32
	Mauritius (91)	847	8.3
	Philippines (92)	2708	42
SSA	Sudan (93)	413	32
	Ethiopia (94)	1386	10.5
	Zambia (95)	600	31.2
	South Africa (96)	133	21.7
	South Africa (97)	300	27.6
	Tanzania (98)	153	27.1
	Tanzania (99)	139	32.4
Ivory Coast (100)	587	27	
LAC	QUALIDIAB(65)	13513	28
MEC	Saudi Arabia(101)	375	26
	Saudi Arabia (102)	689	36
	Turkey (103)	297	31
	Egypt (67)		22
	Libya (104)	428	12.6
	Yemen (105)	1074	40.7

Table 5.2b Regional age-specific estimates of prevalence of diabetic neuropathy for GBD 2000 as percentage of people with diabetes (Wtd. av. = weighted average)

Region	Original estimate and country	Age group (years)		
		15-44	45-59	60+
EME	Average of all studies 32%	18	27	41
FSE	Ukraine 28%	16	24	36
India	India 28%	16	24	36
China	Wtd. av. China and Taiwan 43%	25	37	55
OAI – Sri Lanka and Indo-China	Wtd. av. Sri Lanka and Philippines 40%	23	34	51
OAI Mauritius	Mauritius 8.3%	5	7	11
SSA	Wtd. av. of all studies 22%	13	19	28
LAC	QUALIDIAB 28%	16	24	36
MEC	Wtd. av. of all studies 32%	18	27	41

5.3 Estimates of prevalence of diabetic foot for GBD 2000 per 100,000 (T1 indicates type 1 diabetes, T2 indicates type 2 diabetes, § indicates study population was of people with foot ulcers rather than people with diabetes, * indicates current and past prevalence of foot ulcer)

Region	Country	N	Diabetic foot (% of people with diabetes)
EME	Flanders (106)	1653	8.7
	US Medicare (107)	400000§	7.3
	Amsterdam (108)	609	1.8
	Japan (75)	6472	2
	UK (109)	1077	7.4
	UK (81)	811	5.3*
	Wisconsin (110)	1780	3.3*
	Umea (111)	298T1,77T2	9.5, 9
	Stockholm (112)	617	4.4
	Medelpad, Sw (113)	446 T1, 358T2	0.7, 1.4
	New Zealand (114)	331 Europeans	1.7
FSE	Czech R (115)	624086	6.4
India	No data – use Sri Lanka		
China	No data – use Taiwan		
OAI	Sri Lanka (89)	500	5.4
	Taiwan(116)	234	3.3
	Philippines (92)	2708	2
SSA	Tanzania (99)	139	2.2
LAC	No data – use US		
MEC	Saudi Arabia (101)	375	2.3
	Saudi Arabia (102)	1000*	10.5
	Egypt (67)	?	1.0
	Libya (104)	428	3.5

Table 5.4 Estimates of prevalence of amputation for GBD 2000 as a percentage of people with diabetes by age and sex (major and minor amputation combined)

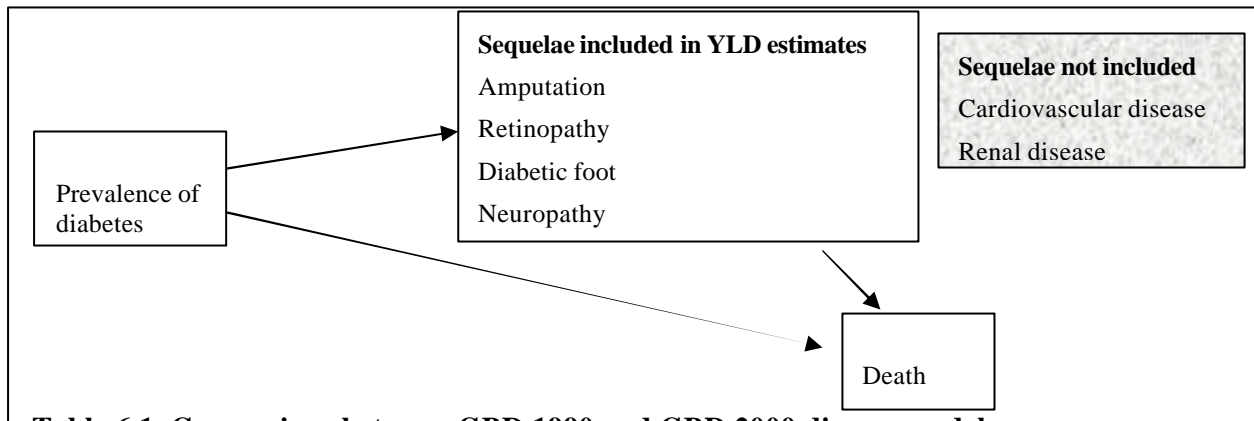
Region	Country data derived from	Men				Women				
		Age (years)	20-39	40-59	60-79	80+	20-39	40-59	60-79	80+
Amro A,B, D	US		0.188	0.236	0.397	0.366	0	0.146	0.204	0.462
Wpro A, B, Searo	Japan		0.04	0.022	0.034	0.073	0	0.011	0.018	0.026
Afro D, E Emro B, D Euro A, B, C	European average		0.014	0.089	0.39	0.575	0.009	0.04	0.192	0.338

Table 5.5 Comparison of percentages of people with diabetes with each sequela in 1990 and 2000

Region	Blindness due to diabetic retinopathy		Neuropathy		Diabetic foot		Amputation	
	1990	2000	1990	2000	1990	2000	1990	2000
EME	5.18	Amro A 0.53 Euro A 0.5 Wpro A 0.5	19.58	32	0.80	Amro A 7.3 Euro A 6.2 Wpro A 2	5.99	Amro A 0.26 Euro A 0.24 Wpro A 0.02
FSE	3.26	0.5	18.35	28	0.76	6.2	4.73	Euro B1 0.18 Euro B2 0.16 Euro C 0.18
India	4.45	Searo D 0.5	21.35	28	0.90	5	5.05	0.02
China	4.31	WproB1 0.49	19.98	43	0.84	3.3	5.15	0.02
OAI	4.48	Searo B 0.5	21.40	40 (8.3 for Mauritius)	0.89	Searo B 2 Wpro B2 3.3 Wpro B3 3.3	5.06	Searo B 0.02 Wpro B2 0.018 Wpro B3 0.015
SSA	3.77	Afro D 0.46 Afro E 0.9	21.40	22	0.87	2.2	4.84	0.12
LAC	4.75	0.52	21.63	28	0.90	7.3	5.44	0.22
MEC	4.41	Emro B 0.33 Emro D 0.48	21.31	32	0.88	2.9	5.25	Emro B 0.11 Emro D 0.13

6. Disease model for diabetes mellitus

A disease model was developed for diabetes mellitus. As for the estimates produced for the 1990 estimates, no attempt was made to allow for the presence of multiple complications and an additive approach to disability-adjusted life years was taken. Disability weights and proportions treated were the same as for GBD 1990.

Figure 6.1 Diabetes mellitus disease model.**Table 6.1. Comparison between GBD 1990 and GBD 2000 disease models**

	GBD 1990	GBD 2000
Stages/Sequelae	WHO criteria for cases and sequelae as above	WHO criteria for cases and sequelae as above
Incidence rates	DISMOD 1 used to estimate from prevalence rates	DISMOD 2 used to estimate from prevalence rates
Duration	Diabetic foot = 2 months. Otherwise as derived from models.	Diabetic foot = 6 months. Otherwise as derived from models.
Case fatality	See Table 4.2	See Table 4.1
Severity distribution for 1990 and 2000	See Table 6.2	See Table 6.2

Table 6.2 Disability weights by treatment status for GBD 1990 and GBD 2000 disease models

	Untreated	Treated
Cases	0.0116	0.0327
Blindness due to retinopathy	0.6	0.489
Neuropathy	0.078	0.064
Diabetic foot	0.136875	0.12871
Amputation	0.155	0.068

7. Regional incidence, prevalence and mortality estimates

Table 7.1 summarises the data used to estimate country-specific prevalence rates. The raw prevalence data for each country providing prevalence estimates as listed below were entered into

Dismod 2, with a remission of zero and age and sex specific relative risks of mortality as given in Table 2.1. Smoothed prevalence and incidence curves were generated within the model. Prevalence outputs from the 40 studies were applied to population data by age and sex (and proportion urban for developing countries) to generate country specific estimates of diabetes prevalence by sex and 5 year age group. Regional estimates of diabetes prevalence were obtained by combining country specific data on cases of diabetes and population.

Table 7.1 Country specific data used to estimate regional prevalence rates of diabetes mellitus for adults (20+ years of age)

AFRO	Cameroon, Ghana, Mauritius, South Africa, Sudan, Tanzania, Tunisia
AMRO A	United States
AMRO B and D	Bolivia, Brazil, Colombia, Paraguay, Trinidad
EMRO	Iran, Jordan, Lebanon, Oman, Saudi Arabia, Turkey, Tunisia
EURO A	Israel, Malta, Netherlands, Poland, Spain
EURO B	Iran, Poland, Turkey, Uzbekistan
EURO C	Poland, Siberia, Turkey, Uzbekistan
SEARO B	India, Singapore
SEARO D	India, Pakistan
WPRO A	Australia, Japan
WPRO B1	China, Republic of Korea, Mongolia
WPRO B2	VietNam
WPRO B3	Fiji, Nauru, Samoa

Figure 7.1. Diabetes mellitus prevalence rates, age group and sex, broad regions, 2000.

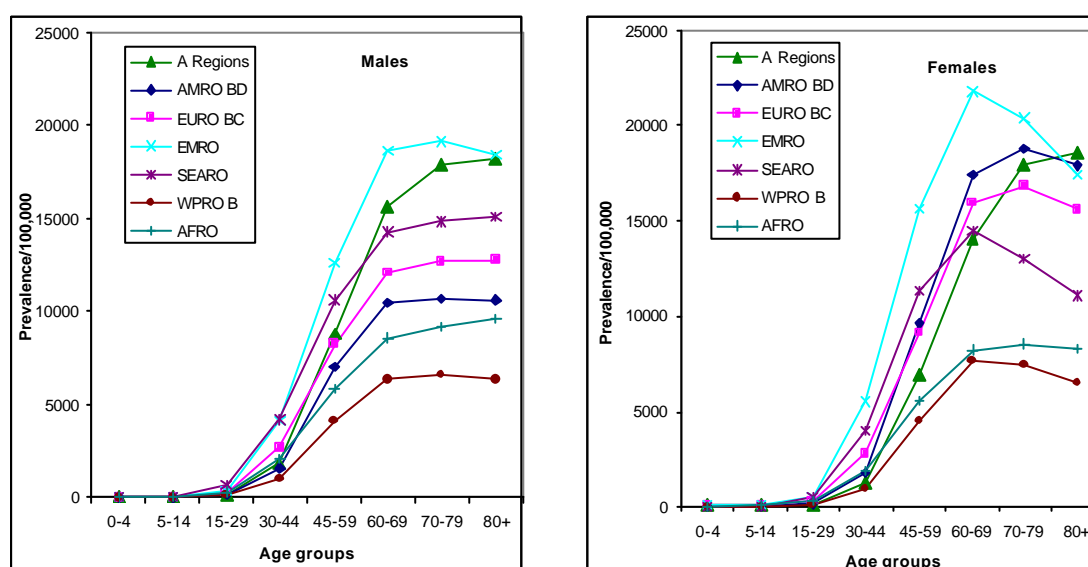


Table 7.2 Diabetes mellitus: age-standardized (to the UN world standard population) incidence per year, prevalence and mortality rate estimates for WHO epidemiological subregions, 2000.

Subregion	Age-std. Incidence/100,000		Age-std. prevalence/100,000		Age-std. mortality/100,000	
	Males	Females	Males	Females	Males	Females
AFRO D	232.4	281.7	3258.9	3258.9	12.2	17.9
AFRO E	144.2	136.2	1767.4	1454.1	19.6	31.6
AMRO A	309.1	286.2	5348.3	4834.3	17.4	14.3
AMRO B	156.6	264.6	2651.3	4115.5	37.3	40.4
AMRO D	209.7	249.5	3539.5	3921.4	52.5	65.1
EMRO B	313.1	447.8	5652.1	8245.7	14.4	17.4
EMRO D	273.9	265.1	4809.5	4507.0	18.2	20.7
EURO A	181.1	169.0	2907.9	2349.0	10.9	9.7
EURO B1	209.5	254.0	3530.6	4222.7	9.4	10.7
EURO B2	206.6	208.5	3146.6	3367.1	21.0	22.0
EURO C	169.0	180.4	2223.6	2655.7	6.0	7.8
SEARO B	303.1	302.6	5297.3	4937.3	24.9	26.0
SEARO D	253.3	255.0	4289.8	4214.1	19.1	23.8
WPRO A	198.6	176.8	3632.3	3046.9	7.5	4.7
WPRO B1	99.4	113.6	1686.2	1841.6	8.5	9.2
WPRO B2	82.0	97.6	1369.0	1653.0	15.9	16.4
WPRO B3	449.0	452.8	7679.3	6303.7	31.3	36.2
World	196.0	213.6	3269.4	3347.6	15.2	16.4

8. Global burden of diabetes mellitus in 2000

General methods used for estimation of the global burden of disease and definitions of the terms YLD (years of life lived with disability), YLL (years of life lost) and DALY (disability adjusted life years) are given elsewhere (26). The tables and graphs below summarise the global burden of diabetes mellitus estimates for GBD 2000 and compare them with the diabetes mellitus estimates from GBD 1990 (27).

Table 8.1 Diabetes mellitus: global total YLD, YLL and DALY estimates, 1990 and 2000.

	Males	Females	Persons
YLD('000)			
GBD1990	2,548	2,786	5,333
GBD2000	3,460	3,814	7,274
YLL('000)			
GBD1990	2,650	3,119	5,769

GBD2000	3,340	4,147	7,487
DALY('000)			
GBD1990	5,198	5,905	11,103
GBD2000	6,800	7,961	14,761

Table 8.2 DM: YLD, YLL and DALY estimates for WHO epidemiological subregions, 2000.

Subregion	YLD/100,000		YLL/100,000		YLD ('000)	YLL ('000)	DALY ('000)
	Males	Females	Males	Females			
AFRO D	53.4	56.2	48.8	86.8	183	227	410
AFRO E	32.2	33.2	77.9	135.2	110	360	471
AMRO A	265.5	257.4	166.3	158.9	809	503	1,312
AMRO B	88.6	147.6	225.9	275.6	524	1,111	1,634
AMRO D	100.3	119.4	234.6	350.3	78	209	287
EMRO B	151.3	213.5	69.2	90.3	253	111	364
EMRO D	130.5	134.2	98.0	119.7	183	150	333
EURO A	156.1	153.4	102.4	107.4	636	431	1,067
EURO B1	138.5	160.8	86.0	113.3	249	166	414
EURO B2	85.9	105.2	155.7	182.7	49	86	135
EURO C	98.4	143.8	77.4	123.0	301	250	551
SEARO B	185.5	192.9	139.8	163.7	746	599	1,345
SEARO D	124.3	131.1	131.6	175.2	1,720	2,059	3,779
WPRO A	174.9	160.7	85.2	56.3	251	105	356
WPRO B1	74.7	86.8	62.6	75.1	1,095	933	2,028
WPRO B2	45.7	60.5	110.4	138.4	76	177	252
WPRO B3	190.8	166.1	144.1	189.5	12	11	24

Figure 8.1. Diabetes mellitus YLD rates, by sex, broad regions, 1990 and 2000.

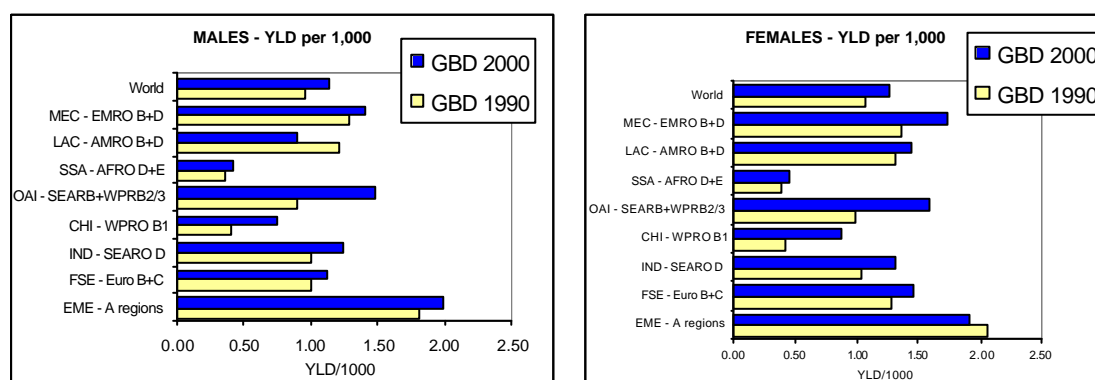
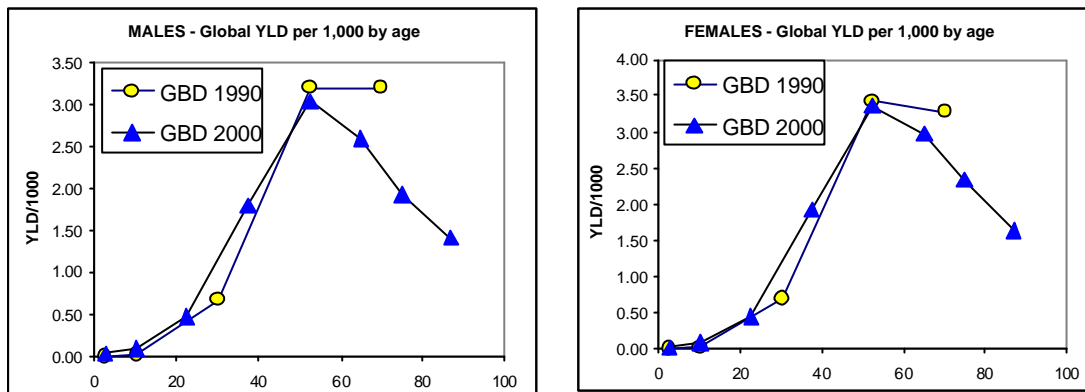


Figure 8.2. Global Diabetes mellitus YLD rates, by age and sex, 1990 and 2000.



9. Uncertainty analysis

General methods for uncertainty analysis of estimates for the Global Burden of Disease 2000 are outlined elsewhere (28). Uncertainty analysis for diabetes mellitus has not yet been completed. Future possible sensitivity analyses may include an assessment of the possible effect of selection bias due to poor response rates.

10. Conclusions

The estimates of global prevalence of diabetes for 2000 presented here differ from other estimates of global diabetes prevalence and the following Table gives a summary of the major differences (differences in the use of population estimates are minor).

Comparison	Age group	Cases (000s)	GBD 2000 estimates (000s)	Differences in methods
King et al, 1998 (10)	20+	154,392	179,533	<ul style="list-style-type: none"> • fewer studies • logistic regression model used to develop age-specific estimates
IDF 2000 (selected)	20-79	150,916	145,750	<ul style="list-style-type: none"> • more studies • range of diagnostic criteria

member countries)(9)				<ul style="list-style-type: none"> • logistic regression model with quadratic assumption used to develop age-specific estimates • urban:rural distinction maintained for FSE countries
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The major limitation of all global estimates of diabetes prevalence is the paucity of country specific data and the need for extrapolation from existing data. Even for countries with eligible survey data the results may not be representative of the whole country. In addition data are limited for older age groups and consequently further assumptions are required to produce estimates among older people. Many studies suggest that diabetes prevalence falls with age in the oldest age groups but it is not clear whether this is a consequence of selection bias, survival bias, a cohort effect or a combination. Many studies of diabetes prevalence have relatively low response rates thereby introducing a risk of selection bias.

Limitations specific to the GBD estimates in addition to those relevant to prevalence include assumptions made about the age distribution of diabetes incidence, the relative risk estimates and the extrapolation of relative risk estimates to countries outside Europe and North America. Estimates of mortality due to diabetes are difficult to make as a consequence of:

- death certificate data are available for only a minority of countries
- diabetes is under-reported on death certificates
- in developed countries most people with diabetes die of cardiovascular disease

Further limitations of the GBD estimates of the burden of diabetes relate to the estimates of prevalence of complications. These use a further set of assumptions in addition to those used to estimate diabetes prevalence. The definition and classification of complications is much less precise and data on prevalence of complications of diabetes are scarce, based on selected populations and are rarely available by age and sex.

These are version 2 estimates for the GBD 2000. Apart from the uncertainty analysis, updating estimates to reflect revisions of mortality estimates and any new or revised epidemiological data or evidence, it is not intended to undertake any major addition revision of these estimates.

We welcome comments and criticisms of these estimates, and information on additional sources of data and evidence that can be used for future estimates. Please contact the diabetes programme at WHO Geneva by email to kingh@who.int or roglic@who.int

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