Global Prevalence of Diabetes

Estimates for the year 2000 and projections for 2030

SARAH WILD, MB BCHIR, PHD[1]
GOJKA ROGLIC, MD[2]
ANDERS GREEN, MD, PHD, DR MED SCI[3]
RICHARD SICREE, MBBS, MPH[4]
HILARY KING, MD, DSC[2]

OBJECTIVE — The goal of this study was to estimate the prevalence of diabetes and the number of people of all ages with diabetes for years 2000 and 2030.

RESEARCH DESIGN AND METHODS — Data on diabetes prevalence by age and sex from a limited number of countries were extrapolated to all 191 World Health Organization member states and applied to United Nations' population estimates for 2000 and 2030. Urban and rural populations were considered separately for developing countries.

RESULTS — The prevalence of diabetes for all age-groups worldwide was estimated to be 2.8% in 2000 and 4.4% in 2030. The total number of people with diabetes is projected to rise from 171 million in 2000 to 366 million in 2030. The prevalence of diabetes is higher in men than women, but there are more women with diabetes than men. The urban population in developing countries is projected to double between 2000 and 2030. The most important demographic change to diabetes prevalence across the world appears to be the increase in the proportion of people >65 years of age.

CONCLUSIONS — These findings indicate that the "diabetes epidemic" will continue even if levels of obesity remain constant. Given the increasing prevalence of obesity, it is likely that these figures provide an underestimate of future diabetes prevalence.

Diabetes Care 27:1047–1053, 2004

The number of people with diabetes is increasing due to population growth, aging, urbanization, and increasing prevalence of obesity and physical inactivity. Quantifying the prevalence of diabetes and the number of people affected by diabetes, now and in the future, is important to allow rational planning and allocation of resources.

Estimates of current and future diabetes prevalence have been published previously (1–3). Since these reports appeared, further epidemiological data have become available for several countries in Africa and the Middle East and for India. The sources of these data are identified in Table 1.

This report provides estimates of the global prevalence of diabetes in the year 2000 (as used in the World Health Organization [WHO] Global Burden of Disease Study) and projections for 2030. It provides a sequel to the report describing estimates of the global burden of diabetes in 1990 (2) using newer data and different methods for estimating age-specific prevalence. As before, the estimates are based on demographic changes alone with the conservative assumption that other risk factor levels such as obesity and physical activity remain constant (in developed countries) or are accounted for by urbanization (in less developed countries). The current estimates include all age-groups, and age-specific data are presented (online appendix [available at http://care.diabetesjournals.org]) to allow comparison with previous estimates that were for adults only (2). As most data sources do not distinguish between type 1 and type 2 diabetes in adults, it is not possible to present data separately for subtypes of diabetes.

RESEARCH DESIGN AND METHODS

Diabetes prevalence data for adults (≥20 years of age) were derived from studies meeting the following criteria: a defined, population-based sample and diagnosis of diabetes based on optimal WHO criteria (a venous plasma glucose concentration of >11.1 mmol/l 2 h after a 75-g glucose tolerance test). The exceptions to the latter criterion were the study in China, for which a test meal was used (4), and the study in Tanzania (5), in which fasting glucose alone gave a higher prevalence of diabetes than a previous study that used the optimal WHO criteria.

Prevalence estimates for type 1 diabetes for people <20 years of age for individual countries were estimated from available incidence data using methods described in the International Diabetes Federation (IDF) Diabetes Atlas 2000 (6). Population-based data are not available for type 2 diabetes in people <20 years of age, and this group has been excluded from these estimates.

Age- and sex-specific estimates for diabetes prevalence were extrapolated to other countries using a combination of criteria including geographical proximity, ethnic, and socioeconomic similarities applied by the authors with the advice of the WHO regional officer and other

From the [1]Public Health Sciences, University of Edinburgh, Edinburgh, Scotland; the [2]Department of Non-Communicable Diseases, World Health Organization, Geneva, Switzerland; the [3]Department of Epidemiology and Social Medicine, University of Aarhus, Aarhus, Denmark; and the [4]International Diabetes Institute, Caulfield, Victoria, Australia.

Address correspondence and reprint requests to Dr. Sarah Wild, Public Health Sciences, University of Edinburgh, Teviot Place, Edinburgh, EH8 9AG, Scotland. E-mail: sarah.wild@ed.ac.uk.

Received for publication 18 October 2003 and accepted in revised form 26 January 2004.

S.W. received honoraria for speaking engagements from Bayer Corporation. A.G. is a paid consultant of Novo Nordisk.

Additional information for this article can be found in an online appendix at http://care.diabetesjournals.org.

Abbreviations: IDF, International Diabetes Federation; WHO, World Health Organization.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1 —*List of diabetes prevalence studies by country of study giving sample size, age-group, and the countries to which the data were extrapolated*

Country of study, year, and reference*	Sample size	Age-group (years)	Additional countries that estimates were applied to
Australia, 2000 (21)†	11,247	≥25	New Zealand
Bolivia, 1998 (22)†	2,948	≥20	Ecuador, Peru
Brazil, 1988/1989 (23)†	2,051	30–69	Argentina, Chile, Cuba, Mexico, Uruguay, Venezuela
Cameroon, published 1997 (24)†	1,767	24–74	Angola, Central African Republic, Congo, Gabon, Guinea, Sao Tome, and Principe
China, 1994 (4)†‡	224,251	25–64	North Korea/Democratic People's Republic of Korea‡
Colombia, 1988/1989 (25)	670	≥30	Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama
Fiji, 1980 (26)‡	1,709	≥20	Kiribati‡, Marshall Islands‡, Micronesia (Federated States)‡, Palau‡, Papua New Guinea‡, Solomon Islands‡, Vanuatu‡
Ghana, 1998 (27)†	4,733	≥25	Benin, Burkina Faso, Cape Verde, Chad, Cote d'Ivoire, Equatorial Guinea, Guinea Bissau, Gambia, Liberia, Nigeria, Senegal, Sierra Leone, Togo
India, 2000 (28)†	11,216	≥20	Bangladesh, Bhutan, Sri Lanka, Maldives, Nepal
Iran, 1999/2000 (29)†	9,229	≥20	Azerbaijan, Iraq, Yemen
Israel (30)†‡	1,502	25–64	
Japan Funagata, 1990–1992 (31)†	2,624	≥40	
Jordan (32)†	2,836	≥25	Syria, urban Egypt
Lebanon†§	2,518	≥30	
Malta (33)†	2,149	≥15	
Mauritius (34)†‡	4,929	25–74	Seychelles
Mongolia (35)†‡	2,449	≥35	
Nauru (36)†‡	1,546	≥20	
Netherlands, 1989–1992 (37)†	2,484	50–74	Austria, Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Norway, Sweden, Switzerland, U.K.
Oman, 1991 (38)	2,963	≥20	Qatar
Pakistan: rural Baluchistan (39)†	570	≥25	Afghanistan
Pakistan: Sindh, 1994 (40)	967	≥25	
Paraguay, 1991/1992 (41)†	1,606 urban white Hispanic	20–74	Suriname
Poland¶	2,523	25–74	Bosnia, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Serbia, Slovakia, Slovenia, the Former Yugoslav Republic of Macedonia, Ukraine
Russia‖	1,602	25–64	
Samoa (42)†‡	1,772	25–74	Cook Islands‡, Niue‡, Tonga‡, Tuvalu‡
Saudi Arabia (43)†‡	25,337	2–77	Bahrain‡, Kuwait‡
Singapore (44)†‡	3,568	18–69	Brunei‡, Indonesia, Malaysia, Philippines, Thailand
South Africa (45)†	729	≥30	Botswana, Lesotho, Namibia, Swaziland, Zimbabwe
South Korea/Republic of Korea (46)†	2,520	≥30	
Spain (47)†	2,214	30–89	Andorra, Italy, Monaco, San Marino, Portugal
Sudan (48)†	1,284	≥25	Eritrea, Ethiopia, Mali, Mauritania, Niger
Tanzania, 1996/1997 (5)†	1,698	≥15	Burundi, Comoros, Democratic Republic of the Congo, Djibouti, Kenya, Madagascar, Malawi, Mozambique, Rwanda, Somalia, Uganda, Zambia
Trinidad, 1977–1981 (49)	2,315	35–69	Antigua and Barbuda‡, Bahamas‡, Barbados, Belize, Dominica, Dominican Republic, Grenada‡, Guyana, Haiti, Jamaica, St. Kitts and Nevis‡, St. Lucia‡, St. Vincent and the Grenadines‡
Tunisia, 1976/1977, 1980/1981 (50)	3,826 urban 1,787 rural	≥20	Algeria, Libya, Morocco
Turkey (51)†	24,788	≥20	Albania, Belarus, Bulgaria, Cyprus, Greece, Moldova, Romania
United Arab Emirates, 2000†‡#	5,844	≥19	
U.S., 1988–1994 (52)†	2,844	40–74	Canada
Uzbekistan, 1996 (53)‡	1,956	≥35	Armenia‡, Georgia‡, Kazakhstan‡, Kyrgyzstan‡, Tajikistan‡, Turkmenistan‡
Vietnam†**	1,121	≥25	Cambodia, Laos, Myanmar

*Year indicates year of study, if given, or year of publication. †Indicates data that were not used in estimates for 1990. ‡Indicates same diabetes prevalence data used for urban and rural populations. §I. Salti, M. Khogali, S. Alam, N. Nassar, A. Masri, personal communication. ‖E. Shubnikov, personal communication. ¶Z. Szybinski, W. Zukowski, R. Rita, J. Sieradzki, I. Turska-Karbowska, M. Gizler, personal communication. #M. Malik, A. Bakir, B. Abi Saab, G.R., H.K., personal communication. **P. Khi, personal communication.

Table 2—*Estimated numbers of people with diabetes by region for 2000 and 2030 and summary of population changes*

	2000	2030	2000–2030			
Region (all ages)	Number of people with diabetes	Number of people with diabetes	Percentage of change in number of people with diabetes*	Percentage of change in total population*	Percentage of change in population >65 years of age*	Percentage of change in urban population*
Established market economies	44,268	68,156	54	9	80	N/A
Former socialist economies	11,665	13,960	20	−14	42	N/A
India	31,705	79,441	151	40	168	101
China	20,757	42,321	104	16	168	115
Other Asia and Islands	22,328	58,109	148	42	198	91
Sub-Saharan Africa	7,146	18,645	161	97	147	192
Latin America and the Caribbean	13,307	32,959	148	40	194	56
Middle Eastern Crescent	20,051	52,794	163	67	194	94
World	171,228	366,212	114	37	134	61

*A positive value indicates an increase, a negative value indicates a decrease.

experts. Table 1 shows the studies used and the countries to which data were extrapolated.

Surveys were generally performed on middle-aged populations, and data are more limited at younger and older ages. Data on diabetes prevalence are usually presented in broad age bands, which suggest a biologically implausible step-like increase in diabetes prevalence with increasing age. DISMOD II software (available from http://www3.who.int/whosis) was used to produce smoothed, age-specific estimates of diabetes prevalence from the available data from each study. Further details on DISMOD II have been published elsewhere (7). In summary, age- and sex-specific diabetes prevalence (derived from the studies listed in Table 1), remission (assumed to be zero), and estimates of relative risk of mortality among people with diabetes (see below) were entered into models. The model output provides estimates of prevalence, incidence, and mortality that are consistent with one another (7).

Estimates of relative risk of all-cause mortality among people with diabetes, by age and sex, were derived from the limited number of cohort studies that provide this information (8–10). Estimated relative risks for all-cause mortality ranged between 1 (for the oldest age-group, ≥80 years of age) and 4.1 (for 20–39 years of age) for men and between 1 (for ≥80 years of age) and 6.7 (for 20–39 years of age) for women. Further information on the estimation of age-specific relative risks is available in the draft Global Burden of Disease 2000 documentation (11). Mortality data were derived from developed countries (U.K., Sweden, and U.S.). As no information was available for developing countries, the same relative risks were assumed to apply. Data are required to test the validity of this assumption. Survival is unlikely to be better in developing countries than developed countries, and any bias in the approach we have taken would lead to conservative estimates of incidence of diabetes in developing countries but would not affect estimates of prevalence. Estimates of incidence and mortality are not presented in this report but are available from the authors and from the draft Global Burden of Disease 2000 documentation (11).

The prevalence estimates were applied to population estimates for individual countries for 2000 and 2030, which were produced by the United Nations Population Division (12). Conventional, albeit simplistic, definitions of developed countries (Europe including former socialist economies, North America, Japan, Australia, and New Zealand) and less developed countries (all other countries) were used. In keeping with previous estimates, prevalence of diabetes was assumed to be similar in urban and rural areas of developed countries (2). For developing countries, urbanization was used as a proxy measure of the increased risk of diabetes associated with altered diet, obesity, decreased physical activity, and other factors such as stress, which are assumed to differ between urban and rural populations. For most developing countries, the prevalence of diabetes in

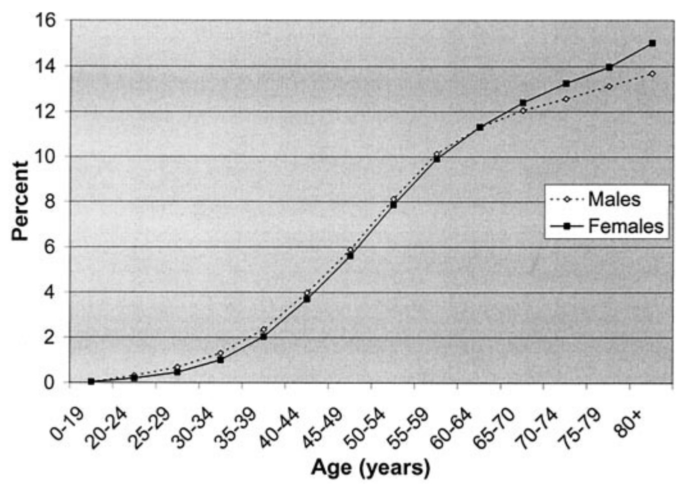

Figure 1—*Global diabetes prevalence by age and sex for 2000.*

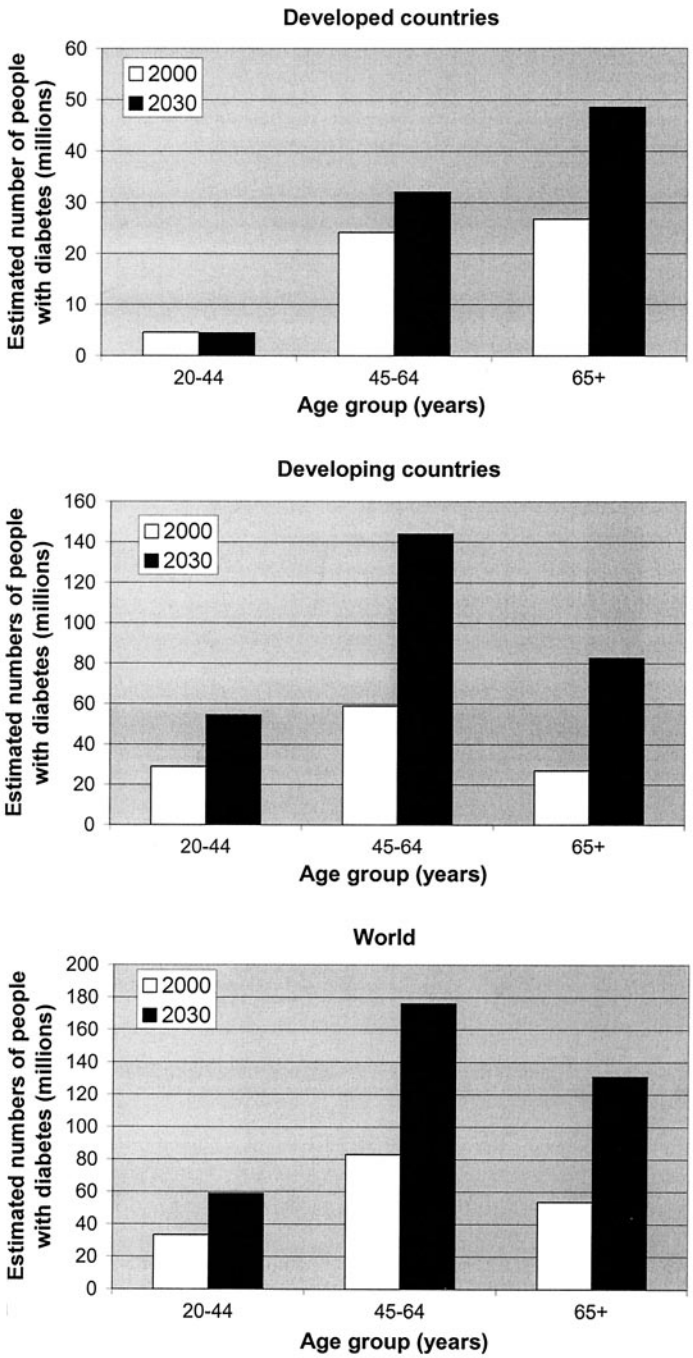

Figure 2—*Estimated number of adults with diabetes by age-group, year, and countries for the developed and developing categories and for the world.*

rural areas was assumed to be one-half that of urban areas, based on the ratio observed in a number of population studies and as used in previous estimates (1). For some populations in developing countries (small islands and populations for which prevalence data were derived from studies combining urban and rural populations), a single estimate of diabetes prevalence was used. In the current estimates, on the advice of local experts, the prevalence of diabetes in rural areas was assumed to be one-quarter that of urban areas for Bangladesh, Bhutan, India, the Maldives, Nepal, and Sri Lanka (13).

To facilitate comparisons with previous estimates, the regional grouping of countries originally used in the World Development Report 1993 (14) and the Global Burden of Disease 1990 study was retained. Data on population size and estimated numbers of people with diabetes for individual countries were combined to give regional estimates of diabetes prevalence.

RESULTS — Detailed information on the estimated number of people with diabetes, population size, and prevalence for individual countries is given in the online appendix. The regional summaries are shown in Table 2.

Assuming that age-specific prevalence remains constant, the number of people with diabetes in the world is expected to approximately double between 2000 and 2030, based solely upon demographic changes. The greatest relative increases will occur in the Middle Eastern Crescent, sub-Saharan Africa, and India. The greatest absolute increase in the number of people with diabetes will be in India. Most of the expected population growth between 2000 and 2030 will be concentrated in the urban areas of the world (15). The most striking demographic change in global terms will be the increase in the proportion of the population >65 years of age (see Table 2).

The importance of age on the prevalence of diabetes is illustrated in Fig. 1, which shows sex-specific estimates of diabetes prevalence by age. Globally, diabetes prevalence is similar in men and women but it is slightly higher in men <60 years of age and in women at older ages. Overall, diabetes prevalence is higher in men, but there are more women with diabetes than men (data available from the authors). The combined effect of a greater number of elderly women than men in most populations and the increasing prevalence of diabetes with age is the most likely explanation for this observation.

In developing countries, the majority of people with diabetes are in the 45- to 64-year age range, similar to the finding reported previously (2). In contrast, the majority of people with diabetes in developed countries are >64 years of age. By 2030, it is estimated that the number of people with diabetes >64 years of age will be >82 million in developing countries and >48 million in developed countries. The age distribution of the number of people with diabetes in developed

Table 3 —*List of countries with the highest numbers of estimated cases of diabetes for 2000 and 2030*

	2000		2030	
Ranking	Country	People with diabetes (millions)	Country	People with diabetes (millions)
1	India	31.7	India	79.4
2	China	20.8	China	42.3
3	U.S.	17.7	U.S.	30.3
4	Indonesia	8.4	Indonesia	21.3
5	Japan	6.8	Pakistan	13.9
6	Pakistan	5.2	Brazil	11.3
7	Russian Federation	4.6	Bangladesh	11.1
8	Brazil	4.6	Japan	8.9
9	Italy	4.3	Philippines	7.8
10	Bangladesh	3.2	Egypt	6.7

and developing countries is illustrated in Fig. 2.

The 10 countries estimated to have the highest numbers of people with diabetes in 2000 and 2030 are listed in Table 3. The "top three" countries are the same as those identified for 1995 (2) (India, China, and U.S.). Bangladesh, Brazil, Indonesia, Japan, and Pakistan also appear in the lists for both 2000 and 2030. The Russian Federation and Italy appear in the list for 2000 but are replaced by the Philippines and Egypt for 2030, reflecting anticipated changes in the population size and structure in these countries between the two time periods.

CONCLUSIONS— The number of cases of diabetes worldwide in 2000 among adults ≥20 years of age is estimated to be ~171 million. This figure is 11% higher than the previous estimate of 154 million (2). Estimates of total population size and proportion of people >64 years of age in 2000 used in the previous report were higher than those used in this report, and therefore demographic changes cannot account for the discrepancy. The higher prevalence is more likely to be explained by a combination of the inclusion of surveys reporting higher prevalence of diabetes than was assumed previously and different data sources for some countries. The IDF Diabetes Atlas 2000 used different and less stringent criteria for the inclusion of studies to estimate prevalence of diabetes for 20- to 79-year-old individuals in the 172 IDF member countries (~90% of the population of the world) (6). It was estimated that there were 151 million people with diabetes in this subpopulation in 2000. Despite methodological differences, this was similar to the present estimate for a comparable population of 147 million. The IDF has subsequently released estimates of the numbers of people with diabetes for 2003 and forecasts for 2025 of 194 million and 334 million, respectively (16).

Even if the prevalence of obesity remains stable until 2030, which seems unlikely, it is anticipated that the number of people with diabetes will more than double as a consequence of population aging and urbanization. In the light of the observed increase in prevalence of obesity in many countries of the world and the importance of obesity as a risk factor for diabetes, the number of cases of diabetes in 2030 may be considerably higher than stated here. Increasing evidence of effective interventions, including changes in diet and physical activity or pharmacological treatment to reduce prevalence of diabetes, provides an impetus for wider introduction of preventive approaches (17–19). Furthermore, improved survival may contribute to increasing prevalence of diabetes in the future especially in developed countries (20).

As with previous similar studies, these estimates are limited by a paucity of data, particularly for Eastern Europe and Southeast Asia, and by the assumptions required to generate the estimates. It is possible that individual studies are not representative of the whole country in which they were performed, and it is likely that extrapolation of results to neighboring countries may give inaccurate estimates of diabetes prevalence. A new approach to estimating age-specific prevalence of diabetes was used for the present estimates. For the estimates prepared for the Global Burden of Disease Study 1990, logistic regression models with a linear factor for age were used when data for all age-groups were not available (2). The IDF estimates for 2000 included a quadratic regression model for diabetes with age (6), which can result in a marked reduction in diabetes prevalence at the oldest ages. DISMOD II models showed a flattening or modest reduction of diabetes prevalence in the oldest ages, which appears to be more consistent with the pattern observed in the limited number of studies giving information on diabetes prevalence in the oldest age-groups.

A conservative approach to calculating estimates was taken throughout this study. Given that several of the surveys were performed more than a decade ago, it is probable that this has generated underestimates of diabetes prevalence. Until more modern and nationally representative data are available, this approach provides a guide to the lower limits of the extent of the diabetes epidemic. It is anticipated that estimates will be updated periodically as new information becomes available.

In summary, these data provide an updated quantification of the growing public health burden of diabetes across the world. The human and economic costs of this epidemic are enormous. Mortality from communicable diseases and infant and maternal mortality in less-developed countries are declining. In association with increasing diabetes prevalence, this will inevitably result in increasing proportions of deaths from cardiovascular disease in these countries, as well as increased prevalence and associated consequences of other complications of diabetes. A concerted, global initiative is required to address the diabetes epidemic.

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