Prevalence of Diabetes and Its Risk Factors in China, 1994

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OBJECTIVE — To determine the prevalence of diabetes and impaired glucose tolerance (IGT) and its risk factors in the Chinese population.

RESEARCH DESIGN AND METHODS — This study was a population-based cross-sectional study of 224,251 residents aged 25–64 years in 19 provinces and areas, including cities and rural areas of the north, south, east, and middle part of China.

RESULTS — Using the 1985 World Health Organization criteria, the prevalence of diabetes and IGT was 2.5 and 3.2%, respectively, in 213,515 subjects aged 25–64 years. Two thirds (70.3%) of the cases had newly recognized diabetes. The prevalence of diabetes in China is about three times higher than it was 10 years ago. On average, subjects with diabetes are older, have higher personal annual incomes, and more often have a family history of diabetes. They also have higher mean BMI, waist-to-hip ratio (WHR), systolic blood pressure, diastolic blood pressure, and a greater prevalence of hypertension. They perform less physical activity and have less education than people with normal oral glucose tolerance test results. Multiple logistic stepwise regression analysis shows that age, BMI (or WHR), family history of diabetes, hypertension, less physical activity, and higher annual income are independent risk factors of NIDDM, and that low education is also an independent risk factor of NIDDM in people with higher personal annual income.

CONCLUSIONS — The prevalence of diabetes in China is increasing with economic development and changes from traditional to modernized lifestyle, especially where people had lower level of education and socioeconomic development. Therefore, Chinese people should attempt to retain certain features of their traditional lifestyle (physical activity, healthy food, moderate body weight). Increased knowledge of risk factors for diabetes may help to prevent a further rapid increase in the prevalence of diabetes in China.

In recent years, the number of diabetic patients in China has been increasing, but the prevalence of diabetes had been uncertain. China has not had a national diabetes survey since 1980 (1). Knowledge of the prevalence of diabetes and its risk factors is important for evaluating the potential social and economic costs associated with diabetes and for designing rational prevention programs to reduce the prevalence of this disease. We also hope to extend and perform a national impaired glucose tolerance (IGT) prospective intervention study after discovering more subjects with IGT in different areas of the country. The recently completed Da Qing IGT 6-Year Prospective Study (1986–1992) indicated that diet, exercise, and diet-plus-exercise interventions were associated with 35% ($P < 0.03$), 46% ($P < 0.0005$), and 42.1% ($P < 0.005$) reduction in risk of developing diabetes in 530 subjects with IGT (2). We have surveyed a population of about 250,000 people aged ≥25 years in 19 areas, including cities and rural areas of the north, south, east, west, and middle part of China in 1994.

RESEARCH DESIGN AND METHODS

— China has 31 administrative provinces, cities, and autonomous areas with a total population of 1.2 billion. The selection of the study population depended on the willingness of local doctors to volunteer time and effort to conduct the local surveys and whether it could be supported by the local administrative office. Populations in 19 provinces and areas were surveyed, including cities and rural areas, in the north, south, east, west, and middle parts of China. The underlying population in each area surveyed was identified by the local administrative office. In April 1994, a workshop was held to discuss the protocol of the survey. We then held a training course for 3 days in each location before starting the survey in order to standardize the protocol and methodology of the survey.

There were about 250,000 people aged 25 years and over in all of the surveyed areas. In each locality, we held a meeting for people who should be surveyed or we went out to their home if they did not come to the meeting. The initial survey, provided by local investigators, determined capillary finger blood glucose concentration using One Touch II glucose meters 2 h after a breakfast containing at least 80 g carbohydrate and after fasting 12 h overnight. A total of 224,251 subjects aged 25 and over participated in the study (~89% of study population), of whom 213,515 subjects (men 113,002; women 100,513) were in the age range 25–64 years. Of these subjects, 21,851 (10.3%) had a 2-h finger blood glucose level ≥6.67 mmol/l (120 mg/dl) after breakfast, and each subject was given an appointment to receive an oral glucose tolerance test (OGTT). Individuals currently taking either insulin or oral hypoglycemic treatment did not undergo an OGTT. Subjects with previously diagnosed diabetes and not on pharmacological treatment, however, did receive a 2-h plasma glucose determination after breakfast. If this value was ≥11.1 mmol/l, the diagnosis of diabetes was accepted and the individuals were not subjected to an OGTT. If the value was <11.1 mmol/l, they received an OGTT. A total of 10,736 people aged 65 and over were surveyed. At first survey, 2,092 of them had the 2-h capillary finger blood

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Abbreviations: dBP, diastolic blood pressure; IGT, impaired glucose tolerance; OGTT, oral glucose tolerance test; sBP, systolic blood pressure; WHO, World Health Organization; WHR, waist-to-hip ratio.

Table 1—*Prevalence of diabetes, previously and newly diagnosed, in 213,515 people aged 25–64 years*

	Male				Female				Total			
	Sample	With diabetes			Sample	With diabetes			Sample	With diabetes		
Age (years)	population	Previous	New	Prevalence	population	Previous	New	Prevalence	population	Previous	New	Prevalence
25–34	36,446	15	89	0.29	36,114	12	102	0.32	72,560	27	190	0.30
35–44	33,610	114	392	1.51	34,404	95	361	1.33	68,014	209	760	1.41
45–54	24,932	257	639	3.59	19,243	248	496	3.87	44,175	505	1,134	3.71
55–64	18,014	417	771	6.59	10,752	285	571	7.96	28,766	701	1,342	7.11
Total	113,002	803	1,891	2.38	100,513	640	1,530	2.16	213,515	1,443	3,421	2.28
Standardized rate (95% CI)	—	—	—	2.21 (2.12–2.30)	—	—	—	2.40 (2.31–2.49)	—	—	—	2.28 (2.22–2.34)

Data are *n* or %. Standardized rate is rate after age standardization to 1990 Chinese population.

glucose concentration ≥6.67 mmol/l (120 mg/dl) after a breakfast. However, the response rate of the OGTT in these older people was <70% for those who should have an OGTT in most of the areas. The response rate ranged from 26 to 67%; thus, these results were not analyzed, since we considered that the prevalence of diabetes and IGT was unreliable.

Examination

The survey was conducted during a 6-month period between July 1994 and January 1995. Nineteen teams worked in nineteen provinces, cities, and rural areas. Physicians completed questionnaires and blood pressure measurements, and trained nurses measured height, weight, and circumference of waist and hip. The waist circumference was measured at the middle point between the rib cage and iliac crests, and the hip circumference was measured at the level of the greater femoral trochanter. OGTTs were performed after a 10- to 12-h overnight fast. After a fasting blood specimen had been obtained, each subject ingested 75 g of glucose dissolved in 300 ml of water over 2 min. Venous blood was drawn for determining fasting and 2-h plasma glucose and insulin concentrations after the glucose load. Biochemical measurements included fasting total cholesterol and triglyceride. The questionnaire included questions for past medical history, family history of diabetes, and diet and physical activity. Labor was divided into mild, moderate, and heavy (as standardized by the government according to different kinds of work) and average personal annual income was assessed in each area. The methods for determining blood pressure, height, weight, resting 12-lead electrocardiogram, and plasma glucose, insulin, cholesterol, and triglyceride concentrations were similar to those used in the Da Qing IGT and Diabetes study (3).

Statistics

In this cross-sectional analysis, means ± SD are presented and compared using Student's *t* test for continuous variables or χ^2 tests for categorical variables. Forward stepwise multiple logistic regression analysis was used to test several models for the association of prevalence of diabetes and other variables; results of the parsimonious models are presented. All analyses were performed with the SAS system.

RESULTS

Prevalence of diabetes and IGT

We analyzed the prevalence of diabetes and IGT for 213,515 subjects within the age range 25–64 years, in whom the response rate was 89.7%. Of these 213,515 subjects, 21,851 (10.3%) had 2-h capillary blood glucose concentration ≥6.67 mmol/l (120 mg/dl) and were therefore eligible for the OGTT. Of these subjects, 15,918 (73%) received OGTT. The number of people with newly diagnosed diabetes and IGT was calculated by correcting for the response rate in each area. The prevalence of diabetes according to the 1985 World Health Organization (WHO) criteria (4) (3,421 newly diagnosed and 1,443 previously diagnosed diabetic subjects) and IGT (4,526 subjects) in this population was 2.28% (95% CI 2.22–2.34) and 2.09% (95% CI 2.03–2.15), respectively, standardized to the 1990 Chinese population (Tables 1 and 2). We suspected that this prevalence of diabetes and IGT might be underestimated to some extent, because subjects with 2-h capillary blood glucose concentrations 6.1–6.6 mmol/l (110–119 mg/dl) after breakfast might include a small number with diabetes

Table 2—*Prevalence of IGT in 213,515 people aged 25-64 years*

	Male			Female			Total		
Age (years)	Sample population	With IGT	Prevalence	Sample population	With IGT	Prevalence	Sample population	With IGT	Prevalence
25–34	36,446	184	0.50	36,114	208	0.56	72,560	395	0.54
35–44	33,610	643	1.91	34,404	623	1.81	68,014	1,273	1.87
45–54	24,932	815	3.27	19,243	624	3.24	44,175	1,455	3.29
55–64	18,014	855	4.75	10,752	522	4.85	28,766	1,403	4.88
Total	113,002	2,497	2.21	100,513	1,977	1.97	213,515	4,526	2.12
Standardized rate (95% CI)	—	—	2.07 1.99–2.15	—	—	2.07 1.98–2.16	—	—	2.09 (2.03–2.15)

Data are *n* or %. Standardized rate is rate after age standardization to 1990 Chinese population.

Table 3—*Prevalence of diabetes and IGT in 34,604 subjects aged 25–64 years with 2-h capillary blood glucose concentration after breakfast of 6.1–6.6 mmol/l (110–119 mg/dl) in five areas*

Age (years)	Diabetes prevalence	IGT prevalence
25–34	0.018	0.426
35–44	0.244	1.360
45–54	0.351	2.570
55–64	0.576	3.140
Total	0.243	1.101
Standardized rate (95% CI)	0.23 (0.18–0.28)	1.11 (1.04–1.16)

Data are %.

and a greater number with IGT. A subsample of 34,604 subjects in five areas aged 25–64 years received the OGTT if their 2-h capillary blood glucose concentration was ≥6.1 mmol/l. Among them, there were 2,403 subjects with 2-h capillary blood glucose concentrations 6.1–6.6 mmol/l, of whom 1,626 (67.7%) subjects received the OGTT. In this subgroup there were 57 (3.5%) subjects with diabetes and 256 (15.7%) subjects with IGT. The prevalences of diabetes and IGT in the subjects who initially had capillary screening blood glucose concentrations of 6.1–6.6 mmol/l were 0.23 and 1.11%, respectively, as standardized to the 1990 Chinese population (Table 3). Data from this subsample were used to estimate the proportion of subjects in the population who would have had diabetes or IGT if all subjects with an initial capillary glucose concentration ≥6.1 mmol/l had received an OGTT. Thus, the overall prevalence of diabetes and IGT is estimated to be 2.51% (2.28 + 0.23%) and 3.23% (2.12 + 1.11%) in the Chinese population aged 25–64 years.

Comparisons of diabetes prevalence in groups with different average personal annual incomes showed that the prevalence of diabetes increased with age and average personal annual income ($P < 0.05$) (Fig. 1).

Characteristics of diabetes and risk factors of diabetic prevalence

We analyzed the characteristics of people with diabetes using the available data of 16,102 subjects who had 2-h capillary blood glucose concentration ≥6.1 mmol/l after breakfast, received the OGTT, and had complete data. Among them, there were 9,633 subjects with normal OGTT, 3,206 subjects with IGT, and 3,263 people with diabetes, according to WHO criteria in 1985. The data showed that subjects with diabetes have higher age, income, BMI, WHR, family history of diabetes, sBP, dBP, and hypertension, and lower education and less physical activity, compared with subjects with normal OGTT (Table 4). Stepwise multiple logistic regression analysis showed that hypertension, family history of diabetes, less physical activity (mild compared to heavy), and higher income are related to the prevalence of diabetes after adjusting for age, sex, and BMI. The analysis also confirmed that age, female sex, BMI, family history of diabetes, lower physical activity, higher income, and hypertension are independent risk factors of diabetes (Table 5). Multiple logistic regression with stepwise analysis also showed that age, female sex, BMI, hypertension, family history, and low education (illiterate compared with college educated) are independent risk factors for diabetes in people with a higher annual income (≥5,000 yuan) (Table 6).

CONCLUSIONS — The results of the present study may be compared with those of other large population surveys of diabetes conducted in China during 1980 (1) and 1986 (Table 7). The present prevalence of diabetes and IGT in China is about three times higher than that observed in 1980 (0.9%) (1) and the present prevalence of diabetes in Da Qing (3.51%) is 3.4 times that found in 1986 (1.04%) (3,5).

Our experience is that for a survey of diabetes and IGT in a large population like China, it is easier and simpler to determine 2-h capillary blood glucose concentration by portable glucose meters and strips after a breakfast containing at least 80 g carbohydrate. If only subjects with 2-h capillary blood glucose concentration ≥6.67 mmol/l (120 mg/dl) receive an OGTT, this strategy may underestimate diabetes by 9.2% (0.23% divided by 2.51%) and prevalence of IGT by 34.4% (1.11% divided by 3.23%), but it would be necessary to increase the proportion undergoing the OGTT from 10.3 to 17.2% (10.3 plus 6.9%) of the population to test all subjects with 2-h capillary blood glucose concentration ≥6.1 mmol/l. However, this was not practical in most of the areas that participated in the survey. Furthermore, even among those with 2-h capillary blood glucose levels ≥6.67 mmol/l, only 73% received the OGTT .

The data presented from a national diabetes survey of 19 provinces, cities, and areas in 1994 have shown that the overall prevalence of diabetes and IGT was 2.51 and 3.23%, respectively, in the population aged 25–64 years. The present prevalence of dia-

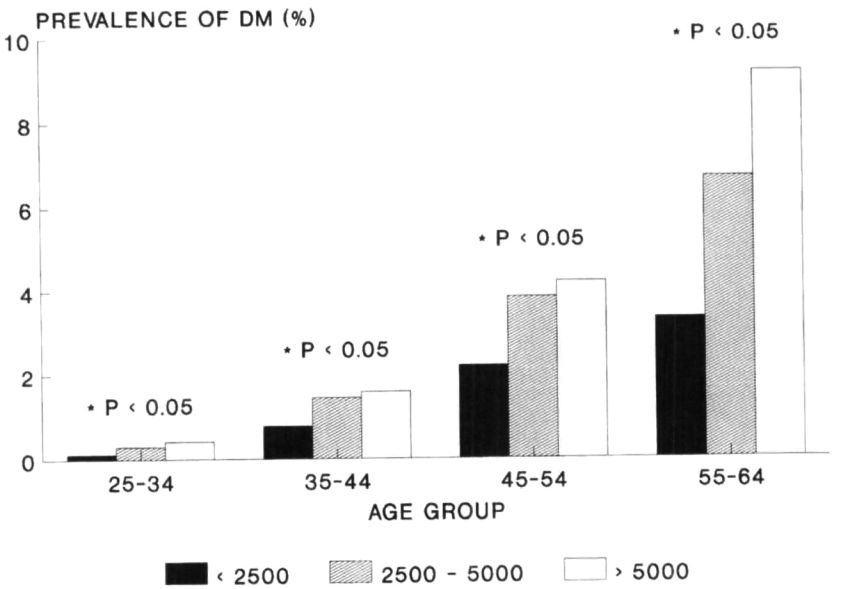

Figure 1—*Prevalence of diabetes in China in 1994 increased significantly ($P < 0.05$) with increasing age and personal income (yuan/year).*

Table 4—*Comparison of clinical characteristics between subjects with NGT and diabetes*

	NGT	Diabetes	*P* value
n	9,633	3,263	—
Continuous variables			
Age (years)	9,633 (47.11 ± 11.43)	3,263 (53.45 ± 10.32)	0.0001
BMI	9,434 (23.77 ± 3.36)	3,232 (25.20 ± 3.55)	0.0001
WHR	7,277 (0.87 ± 0.08)	2,947 (0.90 ± 0.08)	0.0001
sBP (mmHg)	9,417 (123.23 ± 20.93)	3,202 (134.86 ± 23.86)	0.0001
dBP (mmHg)	9,408 (78.90 ± 12.05)	3,201 (83.44 ± 12.59)	0.0001
FPG (mg/dl)	9,585 (95.07 ± 15.54)	3,198 (159.27 ± 57.96)	0.0001
PG2 (mg/dl)	9,519 (104.54 ± 19.93)	3,071 (263.52 ± 79.81)	0.0001
Categorical variables			
Sex (male)	5,671 (58.94)	1,807 (55.40)	<0.001
Smoking	3,155 (39.27)	918 (33.37)	<0.001
Education			
Illiteracy	553 (5.91)	359 (11.29)	<0.001
Middle school	6,873 (73.43)	2,214 (69.60)	
College	1,934 (20.66)	608 (19.11)	
Labor			
Mild	5,826 (60.54)	2,361 (72.62)	<0.001
Moderate	3,122 (32.50)	766 (23.56)	
Heavy	659 (6.86)	124 (3.81)	
Family history	650 (7.49)	388 (13.94)	<0.001
Hypertension	3,209 (34.97)	1,778 (55.20)	<0.001
Income (RMB yuan/year)			
<2,500	1,189 (12.34)	323 (9.90)	<0.001
2,500–5,000	5345 (55.49)	1,468 (44.99)	
>5,000	3,099 (32.17)	1,472 (45.11)	

Data are *n* (means ± SD) or *n* (%). Hypertension = sBP ≥140 mmHg and/or dBP ≥90 mmHg, having history of hypertension, or taking antihypertensive drugs. NGT, normal glucose tolerance; FPG, fasting plasma glucose; PG2, 2-h plasma glucose after glucose load.

betes and IGT in China is still low compared with developed countries (5). But China has the largest population (~1.2 billion people) of any country in the world, and the estimated number of people with diabetes aged 25–64 is about 15 million (2.5% of 0.6 billion population aged 25–64). Thus the total number of diabetic subjects in the population may be the largest in the world.

There were 1,443 (29.6%) previously diagnosed diabetic individuals aged 25–64 years in the surveyed population in 1994. The proportion with newly diagnosed diabetes (70.3%) is similar to that found in the population survey of diabetes in 1986 (76.8% newly diagnosed and 23.2% previously diagnosed diabetic individuals) (3), but the proportion of newly diagnosed diabetes in China is higher than that of newly diagnosed diabetes (48%) in the U.S. (6). Therefore, it is important to perform diabetes screening in high-risk individuals and groups in order to provide earlier diagnosis and treatment of diabetes and IGT to prevent diabetic complications in China.

The prevalence of diabetes in China increases with age and personal annual income and is about three times higher than 10 years ago. This rate of increase is faster than that of Singaporean Chinese, whose prevalence increased from 4 to 8% between 1984 and 1992. The results show that in China, a population with very low rates of NIDDM in the past may in the future exhibit prevalences that are higher than in most developed countries (7). The prevalence of NIDDM in China is changing very rapidly. This change represents a tremendous increase in the number of people with diabetes in China and worldwide.

The annual incidence of NIDDM in Da Qing among 36,471 subjects from 1986 to 1990 was 130/100,000, as standardized to the 1982 Chinese population (8). We estimate that there are >700,000 new diabetic subjects per year in 25- to 74-year-old Chinese people. However, the prevalence of diabetes was 1.3% in 1986. We believe now that the annual incidence of diabetes in China is probably even higher than 130/100,000 in Da Qing from 1986 to 1990, and we estimate that there may be more than 1 million new diabetic individuals per year in the Chinese population aged 25 and over. There will be about 20 million people with diabetes (from the current 15 million) in the year 2000, and 63 million people with diabetes in the year 2010 if the Chinese population is 1.4 billion and the prevalence of diabetes increases threefold.

The present data show that the characteristics of diabetic subjects are higher age, BMI, income, family history of diabetes, WHR, sBP, dBP, and hypertension, and lower education and less physical labor, compared with people with normal OGTT. These results are consistent with other reports (9–12). However, it may be especially important for Chinese people that higher income and lower education appear

Table 5—*Relationship between prevalence of diabetes and variables*

	β	SE	*P* value	Standardized estimate
Age	0.0470	0.0024	0.0001	0.2953
Sex	0.3030	0.0475	0.0001	0.0826
BMI	0.0839	0.0070	0.0001	0.1598
Hypertension	0.4244	0.0499	0.0001	0.1144
Family history	0.7627	0.0744	0.0001	0.1213
Labor2	0.1657	0.0529	0.0017	0.0441
Income2	0.3920	0.0486	0.0001	0.1026

NGT, *n* = 8,297; diabetic patients, *n* = 2,731; missing number, *n* = 1,868. Stepwise multiple logistic regression analysis including age, sex, BMI, hypertension, family history, labor1, labor2, income1 and income2, education1, and education2; only significant variables selected were shown, except age and BMI; others are categorical variables. Sex: female compared with male. Hypertension, sBP ≥ 140 mmHg or dBP ≥ 90 mmHg, or normal blood pressure with history of hypertension or taking antihypertensive drugs. Family history: yes compared with no. Labor: labor1, mild compared with moderate; labor2, mild compared with heavy. Income: yuan/year/person. Income1, 2,500–5,000 yuan compared with <2,500 yuan; income2, 5,000 yuan compared with <2,500 yuan. WHR instead of BMI gave similar results.

Table 6—*Relationship of prevalence of diabetes to variables in subjects with income >5,000 yuan/year/person*

	β	SE	*P* value	Standardized estimate
Age	0.0465	0.0035	0.0001	0.3001
Sex	0.1524	0.0756	0.0437	0.0418
BMI	0.0648	0.0108	0.0001	0.1247
Hypertension	0.3734	0.0781	0.0001	0.1022
Family history	0.6750	0.1049	0.0001	0.1277
Education2	−0.2415	0.0927	0.0091	−0.0556

Subjects with NGT, *n* = 2,593; diabetic patients, *n* = 1,185; missing number, *n* = 793. Stepwise multiple logistic regression analysis including age, sex, BMI, hypertension, family history, labor1, labor2, education1, and education2; only significant variables selected were shown. Sex, hypertension, family history, labor as noted in Table 5. Education1, illiteracy compared with primary or middle school; education2, illiteracy compared with college. WHR instead of BMI gave a similar result.

to be independent risk factors of NIDDM. We can predict that the prevalence of diabetes will increase even more rapidly with economic development, rising standards of living, and increased longevity, especially in people with currently low educational levels in the countryside, where 80% of the Chinese population live, if we do not take active action to prevent diabetes. More attention to primary prevention and early diagnosis and treatment of diabetes may help to reduce the impact of the disease in future China.

It is also very important to note that the prevalence of diabetes could be moderated even in the face of rapid economic development if more physical activity occurred. Therefore, Chinese people should keep their traditional lifestyle (more physical activity, healthy food, moderate body weight). Knowledge of risk factors for diabetes may help to prevent a further rapid increase of diabetes prevalence in China and in the world.

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Table 7—*Comparison of prevalence of diabetes in 1986 and 1994 in China*

Year	Area	*n*	Age (years)	Prevalence		
				Diabetes (%)	IGT (%)	Diabetes + IGT (%)
1980	14 provinces	107,954	≥30	0.9	0.8	1.7
1986	Da Qing	109,629	25–64	1.04	0.68	1.72
		110,660	>25	1.3	0.8	2.13
1994	19 provinces	213,515	25–64	2.51	3.23	5.66
		224,251	>25	3.09	4.01	6.65

The prevalence of diabetes in Da Qing in 1994 was 3.51%, which was 3.4 times that in 1986.

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Hebei Province
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Shandong Province
Yue-Xing Zhang and Shu-Liang Wang.

Anhui Province
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Sichuan Province
Shu Chen, Yue-Chan Lu, Xiu-Jun Li, and Min Lin.

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