The epidemiology of diabetes mellitus in the Asia-Pacific region

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The Asia-Pacific region is at the forefront of the current epidemic of diabetes. There are currently more than 30 million people with diabetes in the Western Pacific region alone. The World Health Organization predicts that this number will rise dramatically by the year 2025, by which time India and China may each face the problem of dealing with 50 million affected individuals. The problem in the region results from a combination of large population size with rapidly rising prevalence rates, particularly of type 2 diabetes mellitus. Although much heterogeneity exists, rising prevalence rates are being seen throughout the region and appear to be closely associated with westernisation, urbanisation, and mechanisation. The risk for diabetes appears to result from a combination of genetic predisposition and lifestyle change. The most important lifestyle changes relate to changes in dietary habits and physical activity and diabetes risk, particularly in younger individuals, is associated with the development of obesity and particularly central obesity. In some populations, for example Chinese, the relationship between diabetes and weight gain begins to appear at levels of body weight that would not be conventionally regarded as representing obesity. The increasing trend for type 2 diabetes to develop in young people is of particular concern. In children and adolescents in some parts of the region, type 2 diabetes now outnumbers type 1 diabetes by a ratio of 4:1. In view of the severity of the long-term complications of diabetes, the health consequences of this epidemic will become increasingly devastating and threaten to overwhelm the health care systems in the most vulnerable countries. There is an urgent need for prioritisation of diabetes as a key issue by governments throughout the region. Diabetes prevention programmes can be justified on economic, as well as humanitarian grounds. At the level of primary prevention, such programmes can be linked to other non-communicable disease prevention programmes which also target lifestyle-related issues.

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Introduction

The Asia-Pacific region contains some of the most populous countries in the world. The largest country, China, contains 20% of the world's population (1.2 billion). Asia also contains the world's second largest country, India, with a population of 1 billion and fourth largest country, Indonesia, with a population of about 200 million. Thus, the Asia-Pacific region is of prime importance to the epidemiology of diabetes. The region combines a high proportion of the world's population with rapidly rising diabetes prevalence rates. The Western Pacific region, along with the Indian subcontinent, is at the forefront of the current epidemic of type 2 diabetes mellitus. In 1998 it was estimated that, globally, there were already 140 million people with diabetes. Predictions compiled by Dr Hilary King of the World Health Organization (WHO) indicate that this figure will rise to 300 million by the year 2025. Of these, more than 150 million will be in Asia. The figures for India are predicted to rise from an estimated 15 million in 1995 to 57 million in 2025. For China, current estimates are 15 to 20 million, with a predicted rise to 50 million by 2025. Thus, more than 30% of the global number of people with diabetes in 2025 will be in these two countries alone.[1]

In some countries, much epidemiological information is available, while in others, data are scarce or

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non-existent. Prevalence rates of diabetes vary greatly, and generally parallel the level of affluence and degree of industrialisation of individual countries. Geographically, Australia and New Zealand belong to the Asia-Pacific region. With their predominantly Caucasian populations, patterns of diabetes in Australia and New Zealand generally resemble those of Caucasian populations in Europe and North America. However, even these countries demonstrate diversity as a result of the presence of the Aboriginal population in Australia, and the Maori and Pacific Island populations in New Zealand. Both countries also have significant immigrant populations from other parts of Asia, living mainly in urban areas.

Comparison and interpretation of prevalence studies are also sometimes rendered difficult by differences in methodology, diagnostic criteria, or age of subjects studied. This is particularly true of older studies. Prevalence figures for diabetes require age-standardisation to allow meaningful comparisons to be made. Where possible age-standardised data will be given, unless otherwise stated.

General epidemiological points

Despite the diversity within the region, a number of common themes can be found with regard to patterns of diabetes and prevalence rates.[2] With the exception of Australia and New Zealand, type 1 diabetes is relatively less common throughout the region than in European populations, with some of the lowest incidence rates in the world (1-2 per 100 000 person-years). As a result, type 1 diabetes accounts for less than 3% of the total burden imposed by diabetes.

Type 2 diabetes prevalence rates show marked differences throughout the region, according to lifestyle, affluence, mechanisation, and urbanisation. They remain low in traditional societies but are rising rapidly in association with urbanisation and modernisation, to rates which are among the highest reported anywhere (in excess of 30% of the adult population). Type 2 diabetes is also becoming increasingly common in younger people and (except in Australia and New Zealand) outnumbers type 1 diabetes, even in the very young. Teenagers and children with type 2 diabetes are emerging with increasing frequency. In those developed countries with predominantly Caucasian populations, most people with diabetes are older than 65 years. In developing countries, however, the majority are aged between 45 and 64 years. Epidemiological studies consistently demonstrate that more than 50% (up to 85%) of identified cases had not been previously diagnosed and are therefore not receiving treatment.

Commonality of environmental risk factors is also invariably observed: notably changing nutrition, obesity and central obesity, decreasing physical activity levels, and urbanisation. However, as discussed later, the quantitative details may vary between different populations and ethnic groups—for example, quantitative definitions of obesity risk among Chinese and Pacific Island populations. Prevalence rates of impaired glucose tolerance (IGT), with few exceptions, generally mirror those of diabetes, and in many countries the IGT prevalence rates are higher than those of diabetes. High rates of IGT can be taken to indicate that a future rise in diabetes prevalence is likely.

Changing lifestyles, human history, and diabetes prevalence

Homo sapiens, and his probable direct ancestors within the genus Homo, have a lengthy history dating back at least 2 million years. For the vast majority of this time, a hunter-gatherer lifestyle was pursued. In some parts of the region, this either continues or has continued until within the last few generations—for example, in Papua New Guinea and Australia. Palaeoanthropological evidence indicates that this lifestyle has involved a mixed carnivorous-herbivorous diet. Regional dietary variations would have existed according to habitat, but overall fat intakes consistently below 25% of total energy intake seem probable. The hunter-gatherer lifestyle is characterised also by very high levels of physical activity and by periodic shortages of food.

The development of agriculture in certain parts of the Asia-Pacific region may date back 10 000 years, but is still very recent in terms of evolutionary time. Agriculture probably had little or no impact on the risk of metabolic disorders such as obesity and diabetes. Physical activity levels remained high and dietary patterns shifted towards a greater herbivorous food intake and an even lower fat intake. There would also have been an increased risk of famine as a result of crop failure and dependence upon relatively few crops. The main change which agriculture allowed was an increase in population density.

Thus, there is strong and lengthy evolutionary pressure for adaptation to a hunter-gatherer lifestyle. More recent selective evolutionary pressures may have operated in a specific manner in response to adaptation to different environments and habitats, and such pressures may explain, for example, the different body builds of the slender Chinese and Japanese compared to the heavily built Polynesians. The stocky build of the Polynesians, with high muscle and fat mass, may be a specific adaptation to a harsh oceanic environment, combined with geographical isolation, cultural acceptance of relative obesity, and an abundant supply of high-quality food staples and seafood. This 'baseline' physique of Polynesians has been described as 'healthy obesity'.

In general terms, metabolic adaptations during human evolution have developed in response to the principal environmental stressor: food shortage and weight loss. This is in keeping with the 'thrifty gene' hypothesis proposed by Neel in 1962 which basically states that individuals with a genotype which is favourable in terms of metabolic economy in times of famine, may be most at risk when exposed to overnutrition and physical inactivity.[3] It is also in keeping with recent suggestions that infants with low birthweight (reflecting intrauterine poor nutrition) may also be more prone to obesity, diabetes, and hypertension in adult life.[4] The advent of industrialisation, modernisation, and urbanisation is associated throughout the region with rapidly rising prevalence rates of both diabetes and obesity. It is significant that particularly high diabetes prevalence rates are being seen in Papua New Guinea and in Australian Aborigines who have moved directly from a hunter-gatherer lifestyle to an urbanised setting within only one to two generations.

The difference in baseline body builds—for example, between Chinese and Pacific Island populations—makes correlation between diabetes and obesity difficult to quantify. However, within all populations studied, diabetes prevalence rates rise rapidly with increasing obesity, particularly central obesity. In the slender Chinese and Japanese, the presence of such obesity may only be recognised by careful examination and conventional criteria cannot be applied. By contrast, in Nauru, massive obesity is associated with a diabetes prevalence exceeding 40% of the population.[5] At present, the extreme circumstances of Nauru, Papua New Guinea, and Australian Aboriginals are associated with extremes in diabetes prevalence (35%-40%).[5] It remains to be seen whether other populations in the region carry the same potential degree of risk or whether diabetes prevalence rates will stabilise at lower levels.

Since prevalence rates of type 2 diabetes are generally lower in Caucasian populations, it has been suggested that, in Caucasians, the risk may have become attenuated by a more lengthy exposure to the lifestyle changes of the modern era.

The epidemiological transition

The rising prevalence of diabetes in the region reflects overall changes in disease patterns. Improvements in nutrition, hygiene, and control of infectious diseases have led to increases in life expectancy and to the emergence of non-communicable diseases as the foremost health problems. This shift in disease patterns has been termed the 'epidemiological transition', and is seen in its completed form in developed countries. Many newly industrialised nations in Asia have undergone, or are undergoing, this transition at a very rapid rate and may be caught by a double burden from both ends of the spectrum if development is patchy, heterogeneous or very rapid. China is a good example of this. The WHO estimates that in China, 15% of the population remains traditional, the emphasis remaining on infectious disease while 25% have already undergone transition, the emphasis being non-communicable diseases. The remaining 60% are in the transition phase and are threatened by a double burden.

The concept of epidemiological transition can also be applied within diabetes. In those countries which have not yet undergone epidemiological transition (eg Cambodia) diabetes prevalence rates remain low, but the problems are still considerable. Such countries experience particular problems with infectious complications of diabetes, notably severe foot sepsis, pneumonia, and tuberculosis. Diabetic ketoacidosis also poses problems, due to combinations of chronically poor glycaemic control, superimposed infections, and lack of adequate treatment facilities. Medical care and availability of supplies may also be patchy and erratic, and drugs and insulin may not always be available. As epidemiological transition occurs, prevalence rates of diabetes rise and the familiar pattern of chronic diabetic complications becomes increasingly apparent. However, at the same time, improved delivery of health care helps to reduce the burden imposed by infections and their associated problems. Countries undergoing rapid transition may again show a double burden, reflecting the legacy of the immediate past together with the consequences of rapid change. All three situations may coexist within one country (eg Indonesia and the Philippines), particularly where there is marked maldistribution of wealth and resources.

South East Asian Peninsula and 'ASEAN'

The countries forming the Association of South-East Asian Nations (ASEAN) are Thailand, Malaysia, Indonesia, Singapore, the Philippines, Myanmar, and Vietnam. Cambodia and Laos also fall naturally into

Table 1. Prevalence of diabetes mellitus in the South-East Asian Peninsula[2]

Country	Prevalence **(%)**	Year	Comment
Vietnam	1.4%*†	1990	Hanoi
	2.5%†	1992	Ho Chi Minh City (urban)
Indonesia	5.7%	1992	Jakarta (urban)
Malaysia	>8.0%*	1997	National survey
Singapore	8.1%*	1992	Ethnic Chinese; higher in Indians and Malays
Thailand	11.9%	1995	North-East Thailand (rural); age 30-74 years

* Age-adjusted figure
† Screening test used

this region. Economic diversity is considerable as reflected, for example, by the affluence of Singapore compared with Cambodia. No reliable epidemiological data are available from Cambodia, Laos, or Myanmar and the magnitude of the problem of diabetes is unknown. Since these countries are, at best, in the early stages of epidemiological transition, it seems probable that diabetes prevalence rates remain relatively low. In Cambodia, there are no trained diabetologists, 50% of people with diabetes use traditional remedies, and the main problems encountered are tuberculosis, other infections and lack of supplies. One vial of U40 insulin (40 U/mL) costs US$7 compared with an average monthly income of less than US$10 (S Hel, written communication, 1999). Recent prevalence rates reported from this part of the region are summarised in Table 1.

Vietnam

Epidemiological data available from Vietnam indicate that the diabetes prevalence rates are still relatively low. A survey conducted in Hanoi in 1990 shows an age-adjusted prevalence rate of 1.4%.[6] In this study, the prevalence rate may be underestimated since an initial screening test (capillary glucose, $\geq$5.8 mmol/L before dinner) was performed, but the effect of this is likely to be small. The results are supported by findings in Ho Chi Minh City in 1992, again using an initial screening test (fasting plasma glucose, $\geq$5.7 mmol/L), prior to an oral glucose tolerance test (OGTT), which indicates a crude prevalence rate of 2.5%. In the Hanoi survey, only 15% of the diabetic subjects identified had been previously diagnosed. Of 63 diabetic subjects identified only one had features of typical type 1 diabetes and only one had a body mass index (BMI) greater than 27 kg/m^2. However, two of the subjects showed features of fibrocalculous pancreatic diabetes. The apparent higher prevalence rate in Ho Chi Minh City compared to Hanoi may reflect a number of factors including differences in study design and different age distributions, or it may reflect a genuine difference between the two cities, perhaps related to their degree of economic development.

Singapore and Malaysia

A National Survey in Malaysia conducted in 1997 indicates that the prevalence of diabetes exceeds 8% of the adult population. In Singapore, the prevalence rate in the majority ethnic Chinese population had reached 8.1% in 1992 and was even higher in Malays and Indians.[2] Both Malaysia and Singapore have demonstrated very rapid rises within one to two decades. Sequential studies from Singapore since the mid-1970s have indicated on approximate doubling in prevalence during each decade. The age-standardised prevalence of diabetes in Malays in Singapore is approximately 20%, which is almost double the rate seen among the Malay population of Malaysia.[5,7] Studies from Singapore also indicate a higher prevalence among males compared to females for both diabetes and IGT, although the gap between the sexes has narrowed between 1984 and 1992.[7]

Indonesia

Only limited epidemiological data are available from Indonesia. However, two studies from Jakarta, conducted a decade apart, further demonstrate the potential for diabetes prevalence rates to rise rapidly, in urban populations, within a short period of time.[8] These studies were performed in 1982 and 1992 in different districts of Jakarta, and showed crude prevalence rates of 1.7% and 5.7% respectively, indicating a three-fold rise within a decade. Age distribution details were lacking, which make the prevalence rates difficult to compare with other studies. However, the two surveys are internally comparable since the age distributions were similar. The two surveys also indicated a rise in obesity and in dietary fat and protein intake. Dietary fat intake rose from 19% of total dietary intake in 1982 to 28% by 1992.[8]

The Philippines and Thailand

Epidemiological data from the Philippines, another of the region's more populous countries, are also scarce. It is probable that overall prevalence rates in the Philippines are similar to Indonesia and are now approximately 8%, at least in Metro-Manila and other major urban centres. The situation in Thailand also appears broadly similar.

Australia

In Australia, type 1 diabetes has a high prevalence among Caucasians but a lower prevalence in other ethnic groups. Reported incidence figures for Caucasians range from 12 to 15 per 100 000 person-years and appear to have remained relatively stable since 1983.[9] Type 2 diabetes among Australian Caucasians appears to show prevalence rates which are comparable to those reported for Caucasians elsewhere, with an age-standardised prevalence of approximately 5% to 6%. However, much higher prevalence rates are seen in non-Caucasian ethnic groups. Long-acculturated Australian Aboriginal people have prevalence rates of diabetes exceeded only by the Pima Indians, Nauruans, and Koki people of Papua New Guinea. Age-adjusted prevalence rates in urban Aborigines now exceed 20%[5,9] and approach 25% in Aborigines with a long history of acculturation.[10] Very high rates of infection, renal disease, and macrovascular disease are also reported in Aborigines.

New Zealand

The New Zealand population in 1991 was 80% Caucasian and 18% Polynesian (either Maori or other Polynesian). The epidemiology of diabetes mellitus in New Zealand has been reviewed recently by Simmons.[11] The incidence of type 1 diabetes is approximately 10 to 12 per 100 000 person-years, although a higher incidence (19.5 per 100 000 person-years) has been reported from Canterbury in the South Island. Type 1 diabetes is less common in Polynesians than in Europeans. Type 2 diabetes accounts for 89% of diabetes mellitus in Europeans but more than 95% in Polynesians. Type 2 diabetes among Polynesians consistently shows two- to four-fold higher prevalence rates compared with Caucasians, and more rapid rises among Polynesians are anticipated in future. Prevalence rates among Caucasians are similar to those reported for other Caucasian populations. Polynesians are diagnosed, on average, at an age 5 to 10 years lower than Caucasians and have a higher BMI. Polynesians also have a higher prevalence of diabetic nephropathy than Caucasians, the proportion of patients with end-stage renal failure being four- to eight-fold higher.

Pacific Islands

The Melanesian, Micronesian, and Polynesian populations of the Pacific Islands show great differences in diabetes prevalence rates which again reflect differing degrees of urbanisation, industrialisation, and westernisation of diet. Some of the highest reported prevalence rates come from the Pacific Islands. Examples from Nauru, Papua New Guinea, Fiji, and Western Samoa can be used to demonstrate these issues.

Nauru, Micronesia

The Micronesian population of Nauru exhibit an age-standardised diabetes prevalence of more than 40%, which is exceeded only by the Pima Indians of Arizona, United States. Nauru, enriched by bauxite mining, has a longer history of westernisation than other Pacific Island populations. Sequential studies by Zimmet's group have consistently shown high prevalence rates since the late 1970s.[12] The more recent studies, however, indicate that prevalence rates may now have stabilised.[12] Obesity rates are also very high in Nauru and relate strongly related to diabetes risk. The situation in Nauru demonstrates the potential magnitude of the effect of modernisation, high energy intake, and reduced physical activity in a susceptible population, and indicates the scale of the problem that can potentially be reached if preventive countermeasures are not taken.

Fiji, Melanesia

Fiji is unique in having a biethnic population consisting largely of native Fijians of Melanesian ancestry and migrants from India. Recent surveys of diabetes prevalence in Fiji are lacking but a large survey conducted in 1980 by Zimmet's group is of interest.[13] This study, conducted in adults older than 20 years showed, at that time, higher prevalence rates of diabetes in Indians compared with Melanesians. Crude prevalence rates among the Indian population were 13%, with no significant urban-rural gradient (13.1% urban versus 12.8% rural). When age-standardised, this rate rises to almost 20%. At that time, the comparable prevalence rate among urban Melanesians was 6.6% and among rural Melanesians, 1.7%.

In view of the trend elsewhere in the region, towards a rise in prevalence with time, taken together with the situation in urbanised Melanesians in Papua New Guinea, it seems probable that prevalence rates, at least among Fijian Melanesians, are now significantly greater. The Melanesian people of Fiji share with other Island populations a notable propensity for foot sepsis. Foot sepsis is the most common single cause for the presentation and diagnosis of diabetes in Fiji and this mirrors the situation elsewhere in the Pacific—for example, Tonga and the Solomon Islands. Foot sepsis has now become a specific programmed target for diabetes prevention in Fiji.

Papua New Guinea

The situation in Papua New Guinea provides a classic example of the effect of rapid urbanisation on the prevalence of diabetes, and the extreme urban-rural gradients which can result. Reports by King et al[14] demonstrate prevalence rates close to 0% in highland populations. However, in the urbanised Koki people, the age-standardised rate exceeds 40%, approaching that of Nauru,[15] Intermediate rates are seen in Austronesians of coastal ancestry and in other rural and semi-rural communities. A similar situation also appears to exist in the Solomon Islands. In the Solomon Islands, diabetes is being seen with increasing frequency in urbanised Melanesians and in Micronesian and Polynesian minority communities. Again, foot sepsis is the most common single presenting feature, often resulting from rat bites to a neuropathic foot.

Western Samoa, Polynesia

The population of Western Samoa is Polynesian. The prevalence of both diabetes and its microvascular complications has been more thoroughly examined in Western Samoa than elsewhere in Polynesia, as a result of two studies, conducted in 1978 and 1991, by Zimmet's group.[16] Other Polynesian populations (from Wallis Island, Tonga, and the Cook Islands) show broadly similar prevalence rates when set against the changes with time seen in Western Samoa. Interestingly, an earlier study from New Caledonia (in 1985, also by Zimmet's group) showed a crude diabetes prevalence of 11.9% in a population aged 20 to 64 years, higher than other reports from Polynesia at that time. In Western Samoa, a baseline survey was performed in 1978 and was repeated in 1991, in a population of similar age distribution (>20 years). In 1978, the crude prevalence rates were 3.4% and 8.7% in rural and urban populations, respectively. By 1991, these rates had risen to 6.5% and 9% in two rural communities and to 16% in the urban setting of Apia.[16]

Western Samoans, in keeping with other Polynesian populations, demonstrate very high rates of obesity, particularly among females. In most Polynesian Island populations diabetes rates are higher in females than males, often markedly so. For example, the author observed, in Tonga in 1991, a female to male ratio of 4:1 among known diabetes in both a hospital-based clinic and a general practice setting, reflecting the very high obesity rates among females.

The 1991 survey in Western Samoa also examined microvascular complications.[17] Diabetic retinopathy was present in 43% of subjects with known diabetes, 15% of newly diagnosed subjects, and 7% of subjects with IGT. Proliferative diabetic retinopathy was present in 4.5% of subjects with known diabetes. Abnormal albuminuria was present in 15%. Duration of diabetes and degree of glycaemia were the most important risk factors for microvascular complications. Details with regard to foot sepsis and neuropathy are not available from Western Samoa. The author's observations in nearby Tonga, in 1991, indicated that more than 50% of people with diabetes presented with foot sepsis or ulceration as the initial clinical presentation. These findings suggest that the prevalence of microvascular complications in Polynesians with type 2 diabetes is higher than that seen in Caucasian populations.

Japan

Earlier prevalence studies of type 2 diabetes conducted in Japan from the early 1960s, showed adult prevalence rates of 2% to 5%.[18] However due to differences in methodology, these are not directly comparable to more recent studies using WHO (1985) criteria. Recent surveys report prevalence rates approaching 10% for type 2 diabetes and more than 20% for IGT.[19] It is probable that approximately 7 million people in total have diabetes, of whom only 45% are currently receiving medical care.[20] Incidence rate estimates for type 2 diabetes range from 5 to 7 per 1000 person-years.[21,22]

The increasing problem of type 2 diabetes in children has also been examined in more detail in Japan than elsewhere in Asia. A 1.5-fold increase in type 2 diabetes in children younger than 18 years has been observed in the past two decades and is closely associated with the increasing prevalence of obesity.[23] Approximately 80% of Japanese children with diabetes have type 2 diabetes.[24] The incidence rate for 1981 to 1990 is reported to be 4.1 per 100 000 person-years compared with 1.5 to 2.0 per 100 000 person-years for type 1 diabetes.[23,25] Children with type 2 diabetes tend to be diagnosed after 9 years of age with an increasing frequency with advancing age.[20] Approximately 50% are more than 140% of their ideal body weight (IBW) and 80% are above 120% of IBW. A high percentage have a positive family history of type 2 diabetes. Obesity and hyperinsulinaemia are more characteristic of type 2 diabetes in Japanese children than in adults.[20]

Slowly progressive type 1 diabetes is also well recognised in Japan, as in many other Asian countries. In Japan, this form of diabetes accounts for approximately half of all type 1 cases, and is also seen, not uncommonly in children.[23,26] Affected individuals are characterised by diagnosis at a later age, a low prevalence of islet cell antibodies at diagnosis and high frequency of a family history of type 1 diabetes. Some have mitochondrial gene mutations at nucleotide pair 3243. As elsewhere in Asia, other candidate gene mutations are also being reported with increasing frequency, and overlap between the clinical phenotypes of type 1 and type 2 diabetes is not uncommon in patients in whom these mutations are identified.

China, Hong Kong, and Taiwan

During the past two decades a considerable amount of information has been obtained from the People's Republic of China, Hong Kong and Taiwan. Studies conducted in China between 1980 and 1990 consistently show low diabetes prevalence rates of approximately 1.5% or less, even in urban populations such as Shanghai in 1980.[27-31] The prevalence of diabetes in Shanghai in 1980 was close to 1%. In rural Guangdong Province it was 0.33%.[28] More recent studies from the present decade indicate sharply rising prevalence rates, especially in urban areas, although they remain below the rates reported from Hong Kong, Taiwan and Singapore. Prevalence data from recent studies are summarised in Table 2.

A very large study, involving 19 provinces and more than 200 000 subjects (aged between 25 and 64 years) was conducted in 1994.[32] The crude prevalence rates of diabetes and IGT in this study were 2.5% and 3.2%, respectively. The age-standardised rates were 2.3% for diabetes and 2.1% for IGT. Data obtained from the Da Qing area in North-East China, when analysed separately, showed a prevalence rate for diabetes of 3.51%, which is 3.4 times greater than the rate (1.04%) found in a survey conducted in Da Qing province in 1986—only 8 years earlier.[30,31]

Studies conducted in Beijing in 1992[33] and in Zhejiang Province in 1993[34] confirm the rising trend. The age-adjusted prevalence rate for diabetes in Zhejiang was 3.2% while that in Beijing was 3.6% (prevalence of IGT, 4.2%). Recent data from Shanghai suggest a prevalence in that city which may now be close to 6% of the adult population (KGMM Alberti, written communication, 1999).

In Hong Kong, studies conducted in 1990[35] and 1995[36] showed age-adjusted prevalence rates of 7.8% and 7.3%, respectively. These remain lower than the rates in Singapore (1992) of 10.4% among the 80% majority ethnic Chinese population.[5] Studies in elderly subjects in Hong Kong show rates exceeding 10% to 15%.[37,38] Studies from Taiwan also indicate prevalence rates which are higher than the People's Republic of China and broadly similar to those of Hong Kong and Singapore.[39-41] However, results of studies from Taiwan show greater variation reflecting heterogeneity, particularly of diagnostic procedures and age distributions, which make direct comparison more difficult. In Hualien County, East Taiwan, a 1995 study demonstrated an age-adjusted prevalence of diabetes of 11% (12% in women, 10% in men) in Han Chinese villagers, most of whom were farmers or manual workers.[40] These results, using WHO (1985) criteria, are higher than those of earlier studies in Taiwan.[39] This study also examined two groups of Taiwanese aborigines, the Ami and the Ayatal who are interesting since they are probably descendants of the ancestral forerunners of the Malayo-Polynesian population migration which expanded through South-East Asia and into the Pacific Islands, starting approximately 30 000 years ago. The prevalence rates were slightly lower among the Aborigines, compared with the Han Chinese, with a combined age-adjusted prevalence of 9.9% (Ami 9.1%; Ayatal, 10.8%).[40]

Thus, while prevalence rates of diabetes remain lower in the People's Republic of China compared to Chinese populations in Hong Kong, Singapore, and Taiwan, there is considerable cause for concern as rates rise sharply within a short period of time. This is emphasised by the massive population size involved. Of the current 15 to 20 million people with diabetes

Table 2. Prevalence of diabetes mellitus among Chinese populations in East Asia, since 1990[2]

Country/region	Year	Prevalence (%)	Age (years)
China	1993	1.6	30-64
China*	1994	2.5	25-64
Zhejiang, China	1993	3.2	30-64
Beijing, China	1992	3.63	30-64
Hong Kong	1990	7.7	Age-standardised
Hong Kong	1995	8.9	Age-standardised
Taiwan	1994	9.0	>40
Taiwan	1995	11.0	Age-standardised
Singapore	1992	8.1	Age-standardised

* 19 provinces; n=213, 515

in China, only one third have been diagnosed. If prevalence rates rise to levels seen in other Chinese populations this number will increase two- to three-fold within one or two decades. One study in Taiwan, commenced in 1990, estimates the incidence of type 2 diabetes in subjects aged 35 to 74 years.[42] The age-standardised incidence rates were 8.9 per 1000 person-years in both males and females. This can be compared with incidence rates of 1.37 per 1000 person-years in males and 1.25 per 1000 person-years, obtained from the Da Qing study in China.[32]

In China, with 20% of the world population, the direct and indirect health costs, and the socio-economic implications of the rising prevalence rates are enormous. Estimates of the direct costs alone, attributable to diabetes in 1996, were US$3.5 billion based on a diabetic population of 15 million (XR Pan, written communication, 1996). Predictive factors for type 2 diabetes in Chinese populations are now quite well described and appear similar to those described for other populations, particularly non-Caucasian populations. These factors have been described in studies reported from China, [30,32,33] Taiwan, [39-42] and the Chinese population of Mauritius,[43] as well as from the Hong Kong Special Administrative Region.[35] A positive family history of diabetes, obesity, central obesity, and increasing age are all major factors. Physical inactivity has been less thoroughly examined but has been shown to be important in Mauritius and Taiwan. The study from Da Qing province has also emphasised the preventative effect of increasing physical activity in reducing the progression rate of IGT to diabetes.[44]

In Hong Kong, the effect of ageing is clearly demonstrated by the reported surveys of the elderly.[37,38] More than 30% of diabetic subjects give a positive family history of diabetes in a first-degree relative, and this proportion increases to more than 50% in subjects with a young onset (<35 years of age) of disease.[45] In subjects with a positive family history in a first-degree relative, the prevalence of type 2 diabetes reaches almost 10% by the age of 30 years. Additional independent risk factors that have been identified in some studies are high annual income (especially in subjects with low educational attainment)[44] and the postmenopausal state.[46]

Obesity

All studies consistently demonstrate a strong relationship between obesity and type 2 diabetes. The importance of obesity has been examined by the application of structural equation modelling to the epidemiological data obtained in Hong Kong in 1990.[35] The results indicated the central importance of both obesity and ageing in terms of a direct causal relationship to diabetes. Body mass index contributed more greatly than waist to hip ratio (WHR) to diabetes, although WHR appeared of greater significance with regard to hypertriglyceridaemia.[47] A gender difference also exists, however, with WHR being relatively more important in men than women, while BMI and WHR both exert important effects in women, particularly in premenopausal women.[41,48] Central obesity (as indicated indirectly by WHR) becomes more prominent in women following the menopause, coincident with a sharp rise in the prevalence of glucose intolerance.

The quantitative definitions of obesity appear to differ from those of most other ethnic groups, both Caucasian and non-Caucasian. The Chinese people, as a general rule, are of slender build and 'conventional' definitions of obesity may not apply. The role of obesity as a risk factor needs to be judged against the lower baseline values seen in Chinese. One study, which compared Chinese values to Caucasian standards demonstrates the lower BMI values that correspond to a given body fat percentage.[49] In this study, 32% body fat in Chinese females corresponded to a BMI of only 21.2 kg/m^2. Similarly, in Chinese males, 25% body fat content coincided with a BMI of 23.7 kg/m^2. Mean BMI values ranging between 23 and 26 kg/m^2 have been reported consistently in studies of diabetic Chinese subjects, appear similar in both sexes, and are consistently higher than those found in matched non-diabetic populations. The BMI values in subjects with IGT are closer to those of the diabetic population than to the non-diabetic population. The point is emphasised further by reports that Chinese and Caucasians living in the United Kingdom have similar diabetes prevalence rates despite lower BMI values among the Chinese population.[50]

Visceral (central or abdominal) obesity is an important and independent risk factor, particularly among males and postmenopausal females, but again quantitative details differ from Caucasians. In Hong Kong, the mean WHR values in subjects with normoglycaemia have been reported as 0.87 in males and 0.79 in females,[35] compared with 0.92 and 0.86, respectively, in diabetic males and females. Very similar values are reported from Taiwan.[41] In females, diabetes risk accelerates steeply when waist circumference exceeds 75 cm, while in males the equivalent figure is 80 cm.[48] Visceral fat area in subjects with type 2 diabetes, measured using magnetic resonance imaging, is associated with dyslipidaemia, hypertension, insulin resistance, and albuminuria.[51]

Type 1 diabetes mellitus in the Chinese population

As in Japan and elsewhere in Asia, type 1 diabetes demonstrates low prevalence rates in Chinese populations. For example, in Hong Kong, the annual incidence of type 1 diabetes in children is approximately 1.8 per 100 000.[52] In an adult specialised diabetes clinic, only 3% of attending patients have classical type 1 diabetes, using strict clinical criteria.[45] This figure increases, but to only 10% in subjects who had been diagnosed before the age of 35 years. However, as in Japan, the situation is complicated by clinical and aetiological overlap both between type 1 and type 2 diabetes, and within the group categorised as type 1 diabetes. Assigning the disease type is hence sometimes difficult.[53]

Conclusion

It is clear from the information presented that the WHO estimates of 150 million people with diabetes in the region by 2025 are by no means unrealistic and that the situations in India and China are particularly alarming. In China, the massive population size, together with particularly rapid rates of urbanisation and industrialisation in the large conurbations close to the Eastern coastline, combine to produce a major threat for the future.

Points of particular importance, apart from rising prevalence rates, are the falling ages at which the disease develops and the rising prevalence of type 2 diabetes in children, adolescents, and young adults to the extent that type 2 diabetes now greatly outnumbers type 1 diabetes in the young. It seems clear that the rising prevalence rates mirror changes in lifestyle, notably overnutrition, physical inactivity, and urbanisation. The new, urbanised, affluent young from the more prosperous parts of the region are under particular threat. Readily available fast foods, sedentary lifestyles (academic study, home computers, televisions, and the motor car) have rapidly altered the behavioural patterns of the very young, and the health consequences threaten to become the epidemic of the new millennium.

Obesity, as a risk factor for diabetes, needs to be judged according to criteria developed specifically for use in individual populations. For example, in Chinese people, a BMI in excess of 23 kg/m^2 could be regarded as indicating overweight.

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