Epidemic obesity and type 2 diabetes in Asia

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The proportions of people with type 2 diabetes and obesity have increased throughout Asia, and the rate of increase shows no sign of slowing. People in Asia tend to develop diabetes with a lesser degree of obesity at younger ages, suffer longer with complications of diabetes, and die sooner than people in other regions. Childhood obesity has increased substantially and the prevalence of type 2 diabetes has now reached epidemic levels in Asia. The health consequences of this epidemic threaten to overwhelm health-care systems in the region. Urgent action is needed, and advocacy for lifestyle changes is the first step. Countries should review and implement interventions, and take a comprehensive and integrated public-health approach. At the level of primary prevention, such programmes can be linked to other non-communicable disease prevention programmes that target lifestyle-related issues. The cost of inaction is clear and unacceptable.

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Introduction

The proportions of people with type 2 diabetes and obesity have increased throughout Asia, and the rates of increase show no signs of slowing. The International Diabetes Federation estimates that in 2003, 194 million people had diabetes, and that by 2025, 333 million people will have this disease.[1] Some argue that Asia is emerging as the epicentre of this epidemic.[2] This region contains some of the most populous countries in the world, and has undergone pronounced demographic, epidemiologic, and socioeconomic change in recent decades. Within the region is the world's most populous country, China, which contains 20% of the world's population, followed by India, with a population of more than one billion. India and China have the greatest numbers of people with diabetes, and are likely to remain in this position in 2025, by which time they could each have 20 million affected individuals.[3] The economic burden from type 2 diabetes associated with obesity has also probably been underestimated in this region, which has delayed appropriate prevention and management strategies by national governments and regional agencies. We review the specific clinical characteristics of obesity and type 2 diabetes in Asia, and discuss the effects of environmental changes, such as urbanisation, in the distinct ethnic groups in the region.

Search strategy and selection criteria

The data in this review article are based on MEDLINE and PubMed searches with the search term "diabetes mellitus", "obesity", or both, in combination with the keywords "prevalence", "Asia", and selected Asian countries. A search of MEDLINE and PubMed was also done with search terms "diabetes", "Asian", or both, together with the terms "β-cell defect", "lean body mass", "abdominal adipose tissue", "nutrition transit", and "sedentary lifestyle".

We selected papers that were published between Jan 1970 and July 2006, but also included frequently referenced and highly regarded older papers. Some review articles and book chapters were included because they provide comprehensive overviews that are beyond the scope of this article.

Clinical characteristics of the epidemics

The increase in type 2 diabetes in Asia differs from that reported in other parts of the world: it has developed in a much shorter time, in a younger age group, and in people with much lower body-mass index (BMI).[4,5] Substantial differences in the prevalence of obesity and type 2 diabetes have been noted between the different countries in Asia, and between different locations in the same countries. Evidence also shows that the epidemics of obesity and type 2 diabetes can happen at different stages of urbanisation.[6] Although environmental factors such as urbanisation are important, they cannot account for all the characteristics of the epidemic in Asia, and genetic influences probably have an important role. The pronounced differences in the Asian population include the high proportion of body fat and prominent abdominal obesity in Asian people

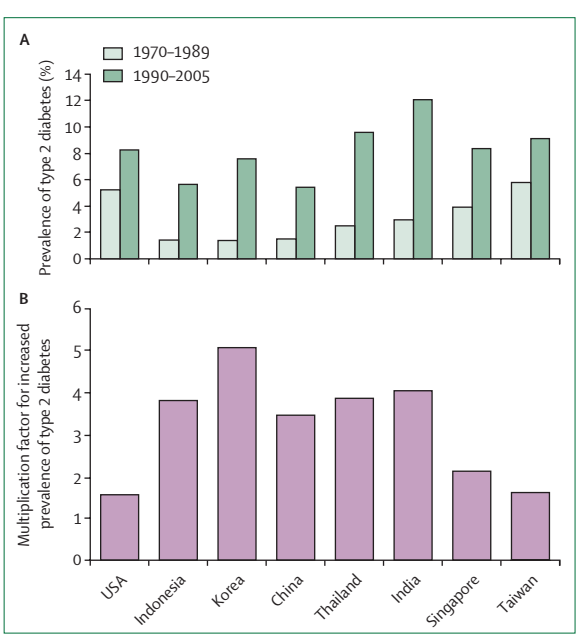

Figure 1: **Comparison of prevalence rates of diabetes in selected countries between 1970–1989 and 1990–2005**
(A) Prevalence of diabetes in selected nations. (B) Multiplication factor for change in prevalence of diabetes in selected nations between 1970–1989 and 1990–2005.

	Year	Sample	Age distribution	Method of diagnosis	Classification of diabetes	Adjustment for age
USA[33]	1976–80	Nationwide	20–74	FBS	‡§	US 2000 census population
	1999–2000	Nationwide	20–74	FBS	‡§	US 2000 census population
Indonesia[25]	1982	Jakarta	Not known	Not known	Not known	Not adjusted
	1995	Jakarta	Not known	Not known	Not known	Not adjusted
Korea	1971[23]	Rural	≥30	UG+50 g OGTT¶	UG	Not adjusted
	2001[24]	Nationwide	>20	FBS	‡§	2001 standard Korean population
China	1986[28]	Da Qing	25–74	OGTT	*§	Segi standard world population[38]
	2000[29]	Nationwide	35–74	FBS	‡§	Not adjusted
Thailand	1971[26]	Urban	Not known	Not known	Not known	Not adjusted
	2000[27]	Nationwide	≥35	FBS	‡§	Not adjusted
India	1979[30]	Urban	Not known	Not known	Not known	Not adjusted
	2000[21]	National urban study (six major city)	≥20	OGTT	†§	Urban population of India using the 1991 census population
Singapore	1984[31]	Nationwide	18–69	OGTT	†§	1990 Singapore resident population
	1992[32]	Nationwide	18–69	OGTT	†§	1990 Singapore resident population
Taiwan	1985[33]	Taipei city	≥40	FBS or 2 h PG	*§	Segi standard world population[38]
	1996[34]	Tainan city	≥20	OGTT	*§	Segi standard world population[38]

UG=urinary glucose. FBS=fasting blood sugar. PG=plasma glucose. OGTT=oral glucose tolerance test; *WHO, 1985 classification:[35] fasting plasma glucose (FPG) ≥7·8 mmol/L or 2 h PG ≥11·1 mmol/L. †WHO, 1999 classification:[36] FPG ≥7·0 mmol/L or 2 h PG ≥11·1 mmol/L. ‡American Diabetes Association, 1997 classification:[37] FPG ≥7·0 mmol/L. §Previously diagnosed diabetes. ¶1 h PG≥8·9 mmol/L or 2 h PG≥6·1 mmol/L.

Table 1: **Description of survey data used for figure 1**

compared with those of European origin with similar BMI values.[7,8] These characteristics mean that Asian people have a higher predisposition to insulin resistance at a lesser degree of obesity than people of European descent.[7,8] Another factor that predisposes Asian people to type 2 diabetes is the pronounced dysfunction in early insulin secretion that has been reported in various populations in Asia.[9–12]

In the USA, the prevalence of type 2 diabetes has doubled—from 4% to 8% during the past 40 years.[13] But although this is dramatic, increases in newly developed and developing countries in Asia have been even greater.[1,14] In Chinese adults, the prevalence tripled between 1980 and 1996, from about 1·0% to 3·2%.[15,16] The data from the Indian subcontinent are equally disconcerting,[17–22] and the same trend can be seen in other countries in the region. For example, the prevalence rates of type 2 diabetes in Korea, Indonesia, and Thailand have also increased three-fold to five-fold during the past 30 years.[23–27] Thus, although the prevalence of type 2 diabetes in Asian countries is currently similar to (or only slightly higher than) that in the USA, the rate at which diabetes has increased during the past three decades (figure 1; table 1) and the likelihood that it will continue to increase at this rate, provide substantial grounds for concern.

In developed countries in which most people are of European descent, diabetes affects mainly those who are older than 65 years.[39] But in developing countries, most people with diabetes are aged between 45 and

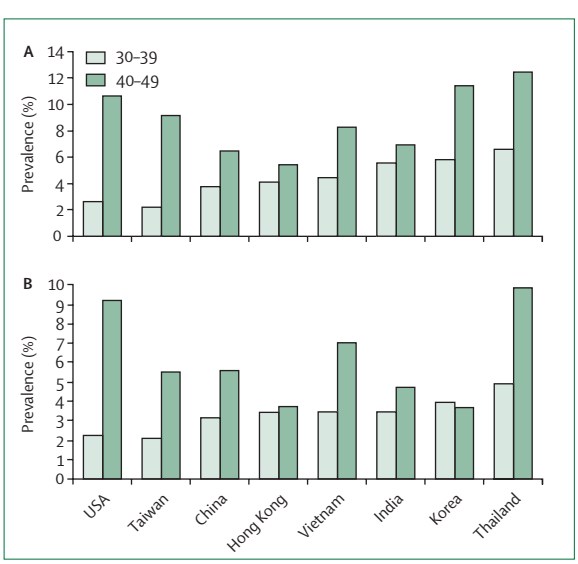

Figure 2: **Comparison of prevalence of diabetes between 30 and 40 year-old age-groups in male and female populations**
(A) Male. (B) Female.

64 years.[39] The prevalence of type 2 diabetes in those aged between 30 and 50 years in developing countries is also high in comparison with other countries.[24,34,40,41] Figure 2 shows the prevalence of diabetes in the 30–39 and 40–49 year age-groups in Asian populations. The prevalence of diabetes in people aged 30–39 years in Asia is generally high—eg, 5·6% of Korean men aged 30–39 years have diabetes (figure 2, table 2). From 1980 to 1996, the prevalence of obesity in children and young adolescents in Taiwan grew steadily, from 4% to 12%.[45] Moreover, in China, the proportion of children aged 7 to 18 years who were obese and overweight increased 28-fold between 1985 and 2000.[46] The age at which type 2 diabetes develops has also decreased, and the prevalence of the disease in children and adolescents has risen.[47] Cases of type 2 diabetes now greatly outnumber cases of type 1 diabetes in children and adolescents.[39] Type 2 diabetes mellitus in children has been examined in more detail in Japan than elsewhere in Asia. About 80% of Japanese children with diabetes have the type 2 form.[48] The incidence rate of type 2 diabetes for 1981 to 1990 was reported to be 4·1 per 100 000 person-years, which was about twice as high as the rate of type 1 diabetes in Japanese children.[49] Although the prevalence of type 2 diabetes in adolescents in Hong Kong is not as high as in Japan, it is becoming more common.[50] Thus, a problem that currently affects only a minority of youth worldwide is threatening the majority in Asia.[39]

The onset of type 2 diabetes in younger age-groups is likely to result in major economic burdens for countries in Asia due to premature ill health and death. Already, the proportions of patients in Asia who need haemodialysis because of diabetes are similar to those in developed countries.[51] Furthermore, most patients in this region who have end-stage renal disease have type 2 diabetes[51] (figure 3). WHO argues that chronic diseases are the major cause of death in almost all countries, including those in Asia.[52] Only 30% of deaths from chronic disease happen in upper middle-income and high-income countries, whereas 70% of such deaths happen in low-income and lower middle-income countries, such as China, India, Pakistan, Cambodia, and Vietnam.[52]

Evidence from several national health surveys in Asia suggests that the prevalence of overweight and obese individuals has increased, but that it varies between countries (figure 4; table 3).[63–65] The prevalence of adult obesity (BMI ≥30 kg/m²) in most Asian countries is quite low compared with developed countries such as the USA.[53–55,57,58,60–62] The highest rate of obesity in Asia is in Thailand, where 6·8% of adults are reported to be obese.[62] The lowest obesity rates in the region are in the less developed parts of Asia: 2·2% in India and 3·3% in the Philippines.[54,55] The prevalence of overweight individuals (who have a BMI of more than 25 kg/m² but less than 30 kg/m²) ranges from 10·0% in India to 28·3% in Thailand.[53–55,57,58,60–62] Since the prevalence of diabetes ranges from 5·1% to 12·1%, this feature does not seem to correspond with the prevalence of obesity.[13,21,24,29,32,34,39,56,59] For example, the prevalence of obesity in India is the lowest of this group, at 2·2%, but the prevalence of diabetes is the highest, at 12%.[21,54]

Evidence from some prospective studies in Asia suggests that obesity is directly related to the incidence of diseases such as hypertension, type 2 diabetes, and hypercholesterolaemia.[64,66,67] Such diseases have been reported

	Year	Sample	Age groups	Method of diagnosis	Classification of diabetes
USA[42]	1999–2000	Nationwide	20–39 and 40–59	FBS	‡§
Taiwan[34]	1996	Tainan City	30–39 and 40–49	OGTT	*§
China[29]	2000–01	Nationwide	35–44 and 45–54	FBS	‡§
Hong Kong[40]	1990	Hospital data	30–39 and 40–49	OGTT	*§
Vietnam[43]	2001	Urban	35–44 and 45–54	FBS	‡§
India[44]	1999–2002	Nationwide	30–39 and 40–49	OGTT	†§
Korea[24]	2001	Nationwide	30–39 and 40–49	FBS	‡§
Thailand[27]	2000	Nationwide	34–44 and 45–54	FBS	‡§

FBS=fasting blood sugar. OGTT=oral glucose tolerance test. *WHO, 1985 classification:[35] fasting plasma glucose (FPG) ≥7·8 mmol/L or 2 h PG ≥11·1 mmol/L. † WHO, 1999 classification:[36] FPG ≥7·0 mmol/L or 2 h PG ≥11·1 mmol/L. ‡American Diabetes Association, 1997 classification:[37] FPG ≥7·0 mmol/L. §Previously diagnosed diabetes.

Table 2: **Survey data used for figure 2**

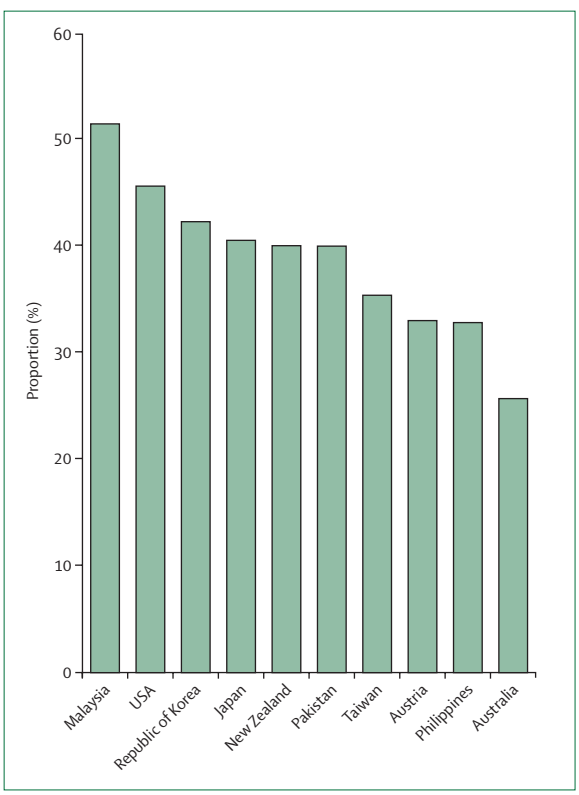

Figure 3: **International comparisons of proportion of end stage renal disease patients with diabetes, 2003**

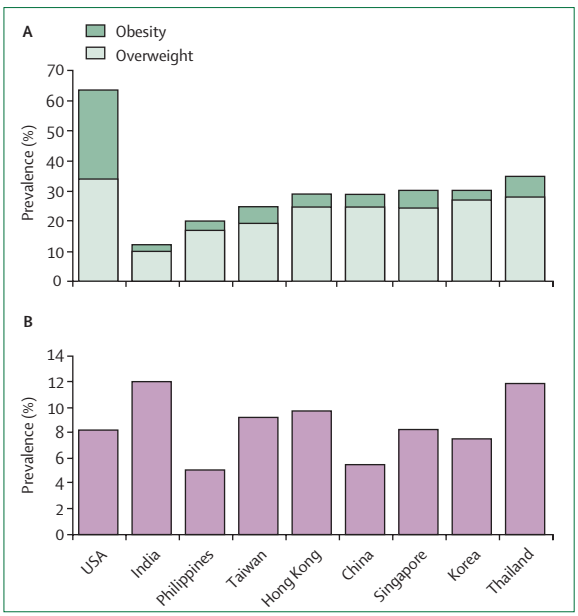

Figure 4: **International comparison of prevalence of adult obesity and diabetes**
(A) Proportion of overweight and obese adults. (B) Prevalence of diabetes.

	Survey year	Prevalence of overweight adults (%)*	Prevalence of obese adults (%)†	Prevalence of diabetes (%)
USA	1999–2000[53]	34·0	30·0	
	1999–2000[43]			8·2
India	1998–99[54]	10·0	2·2	
	2000[21]			12·1
Philippines	1998[55]	16·9	3·3	
	1996[56]			5·1
Taiwan	1993–96[57]	21·1	4·0	
	1996[34]			9·2
Hong Kong	1996–97[58]	25·1	3·8	
	1995–96[59]			9·8
China	1999–2000[51]	25·0	4·0	
	2000–2001[29]			5·5
Singapore	1998[60]	24·4	6·0	
	1992[32]			8·4
Korea	2001[61]	27·4	3·2	
	2001[24]			7·6
Thailand	1998[62]	28·3	6·8	
	1995[39]			11·9

*25 kg/m²≤BMI<30 kg/m². †BMI≥30 kg/m².

Table 3: **Survey data used for figure 4**

in individuals with lower BMI (≥25 kg/m²) than people with the same diseases in developed countries.[64,66,67] Thus, in general, although Asians have lower BMI levels than people of European descent, they have a higher prevalence of type 2 diabetes (figure 4). However, waist circumference or waist-to-hip ratio might be more appropriate indices of obesity for Asian people.[68]

Environmental factors and genetic predisposition

If environmental factors have a major role in triggering development of diabetes, one would expect lower prevalence of diabetes in rural areas, where people follow a traditional lifestyle. This urban–rural difference has been reported in several countries.[17,18,27,29,44,69] In India, two populations with different socioeconomic status showed wide differences in the prevalence of diabetes: 8·2% in the urban group and 2·4% in the rural group,[70] and much the same trends have been reported in studies from the Philippines[71] and Cambodia.[6] However, the prevalence of diabetes in the rural population in Thailand[26] and Korea[72] was not low compared with the urban population (figure 5). These results suggest that the rate of diabetes might increase in rural communities as they become urbanised.

Rapid economic developments have improved the availability of nutrients, together with socioeconomic and health conditions, in many countries.[73] These improvements have led to lower morbidity and mortality and to a pronounced decrease in nutritional deficiencies. However, high nutrient availability, and specifically an energy dense diet, can predispose people to both obesity and type 2 diabetes.[74,75] Unlike the gradual transition in nutrient availability that happened in the USA and most European countries, this change has happened rapidly in many lower-income countries. In Asia, economic factors have had especially apparent effects on the nutrition transition.[76,77] For example, a rapid shift in dietary structures was reported during Japan's accelerated economic growth from 1950 to 1970.[78] An even more rapid shift in diet can be seen in China, especially in urban residents.[79–83] Obesity has increased concurrently with these nutritional transitions in most Asian countries.[84] South Korea experienced earlier economic change than did most Asian countries and its gross national product increased more than 17 times between 1962 and 1996.[85] During this period, the proportion of plant-food in the diet decreased from 97% in 1969 to 79% in 1995.[86] By contrast, the animal-food intake increased seven times during that period. Carbohydrate intake

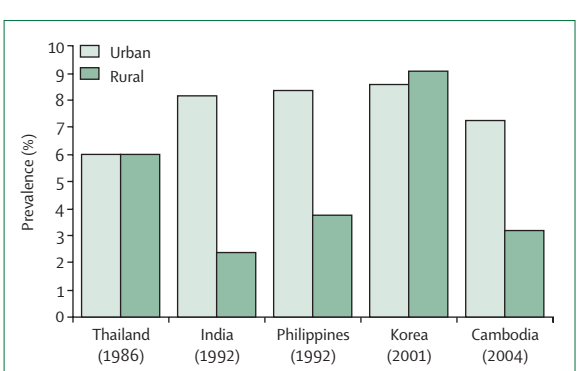

Figure 5: **Comparison of the prevalence of diabetes in urban and rural areas**

decreased gradually after 1940, from 81% of total energy intake to 64% in 1995. Total protein intake remained nearly constant throughout that period, whereas fat-derived energy intake increased gradually, from 6·2% to 18·8%.[86] Similar data have been reported from Japan. Thus, for 5 year-old boys in the Tokyo metropolitan area, the intake of fat as a proportion of total energy intake grew from 12·6% in 1952 to 33·2% in 1994.[87]

The behavioural patterns of the very young have been rapidly altered. Fast foods are readily available and lifestyles have become more sedentary due to internet communications, computer games, televised entertainment, academic study and private lessons, poor urban planning, and transportation by motor car.[88] The health consequences threaten to become the epidemic of this millennium.[88] Furthermore, with rapid shifts in income, changes in occupation linked with reduced physical activity have happened in most developing countries, including Asian countries. Thus, in South Korea in 1960, the urban population was only 27·7%; by 1996 it was 82·3%.[86] A shift from energy-intensive occupations in the rural primary product sectors of agriculture, forestry, and fisheries to occupations in services and manufacturing led to the growth in South Korea's gross national product.

In people of European origin, a BMI of 30 correlates with about 25% body fat in men and 30% body fat in women.[89] However, for the same age, sex, and BMI, African Americans have a lower fat percentage and Asians have a higher fat percentage.[89] One study showed 32% body fat in Chinese females with a BMI of only 21·2 kg/m², and 25% body fat content in Chinese males with a BMI of 23·7 kg/m². BMI values ranging between 23 and 26 kg/m² have been reported consistently in studies of Chinese people with diabetes for both sexes.[90] Thus, Asians have higher body fat content and are at higher risk for diabetes, high blood pressure, and heart disease than other people with the same BMI.[91] This difference has been termed the Yudkin-Yajnik paradox.[92] Furthermore, at an early stage in the increment of visceral fatness in some Asian people, the risk of dysglycaemia is greater than for Europeans of the same age.[93,94] Park and co-workers have also reported that Asian ethnicity is an independent variable for the determinant of visceral obesity in Asian-American populations.[7] These observations prompted WHO to establish an Asia-Pacific guideline for the diagnostic criteria of obesity. WHO concluded that a substantial proportion of Asian people with BMI values lower than 25 kg/m² (and thus not classified as overweight under the existing WHO definition) are at high risk of type 2 diabetes and cardiovascular disease.[95] Although understanding of the specific features of obesity in Asia is increasing, little is known about the underlying pathogenesis of increased body fat content and central obesity. Low birthweight has been associated with subsequent risks of non-communicable disease. Strong arguments suggest that the environment does not exclusively determine the health outcomes, but that the so-called thrifty genotype plays a substantial role.[96]

Both a high proportion of body fat and a predominance of central obesity are associated with insulin resistance. A high proportion of Asian people have both these characteristics, and might also have pancreatic β-cell secretory defects. Several studies have reported the importance of early-phase insulin secretory defects in relation to insulin resistance in the development of glucose intolerance in Asian people.[9,10] Some investigators have reported a slight impairment in insulin secretion that begins in subjects with normal glucose tolerance.[11,12] Impaired insulin secretion might be induced by insufficient β-cell mass, by functional defects within the β cells themselves, or both. Although a good linear correlation between β-cell mass and BMI has been reported in normal and type 2 diabetic patients,[97] measurements of β-cell mass in non-obese diabetes patients were lower than those in other patients and were not related to the duration of diabetes or to the glycosylated haemoglobin (HbA_{1c}) levels of patients.[97] These results suggest that maximal β-cell mass and the regenerative capacity of β cells of an individual patient's response to insulin resistance could be established at an early stage of life, either by the intrauterine environment or by genetically determined factors, or both. Other investigators have reported similar findings.[98,99]

Leiter has clearly summarised factors that can induce β-cell apoptosis in diabetic patients: so-called gluco-lipotoxicity (toxic effects of high concentrations of glucose and free fatty acids); low-grade chronic inflammation and amylin deposition with fibrotic islet destruction;[100–102] and a reduction of β-cell mass.[99,103,104] Pancreatic stellate cells and angiotensin receptors exist in the islets[105] and long-term treatment with the angiotensin converting enzyme (ACE) inhibitor, ramipril, in an animal model of type 2 diabetes showed much improved glucose tolerance tests and reduced islet fibrosis.[106,107] Significant activation of pancreatic stellate cells in the islets of diabetic patients has also been noted. All these results suggest that islet fibrosis and β-cell loss advance over time, and that protection of islet fibrosis might be a strategy to halt the progression of type 2 diabetes.

Interventions and strategies for prevention

The global emergence of obesity and diabetes is an economic issue as much as a health issue.[108] Asia faces especially serious difficulties. Studies such as the Diabetes Prevention Programme,[109] Da-qing study,[110] Finnish Diabetes Prevention Study,[111] Japan lifestyle study,[112] and Indian Diabetes Prevention Programme[113] have shown that lifestyle changes and some medications are effective in prevention of type 2 diabetes in individuals at risk, such as those with impaired glucose tolerance. In particular, lifestyle modification is likely to affect the morbidity and mortality of diabetes, and should be recommended for all people at high risk.

Public health strategies aimed at prevention of weight gain and obesity will probably be more cost effective than treatment of consequences such as diabetes. Therefore, WHO has emphasised that the prevention of obesity and type 2 diabetes should be regarded as of high priority.[73]

In conclusion, people in Asia develop diabetes at a lower degree of obesity and at younger ages, suffer longer with chronic diabetic complications, and die sooner than those in developed countries. More children are becoming overweight and obese at the same time as Asia undergoes rapid urbanisation, and the incidence of type 2 diabetes reaches epidemic levels in the region. Asian people have different associations between BMI, percentage of body fat and health risks compared with European people. Thus, people in Asia have a strong genetic susceptibility to type 2 diabetes, characterised by early β-cell failure and prominent central obesity. Preventive action should begin urgently, and lifestyle changes such as weight control and exercise are the first step. However, lifestyle is notoriously resistant to change, and public health measures that have been taken so far have been indecisive and insufficiently systematic. Improvement of public health remains an urgent need, since the looming epidemic of diabetes and its complications threatens to drain finite health care resources. Therefore, strong public actions, supported by well-targeted government policies and very clear action plans, will be crucial. As the late Jong-Wook Lee, former Director-General of the WHO, commented, "Until recently, the impact and profile of chronic disease has generally been insufficiently appreciated. It is vital that countries review and implement the interventions described, taking a comprehensive and integrated public health approach. The cost of inaction is clear and unacceptable. Through investing in vigorous and well targeted prevention and control now, there is a real opportunity to make significant progress and improve the lives of populations across the globe."[52]

Contributors

K H Yoon conceived of the article and suggested its structure. J H Lee, Y H Choi and J H Cho gathered and reviewed literature about the epidemiological issue of obesity and type 2 diabetes, and drafted the manuscript. J W Kim and S H Ko gathered and reviewed literature on the manifestations of type 2 diabetes, and contributed to the manuscript, which was edited by P Zimmet, H Y Son and K H Yoon. The final version was approved by all authors.

Conflict of interest statement

We declare that we have no conflict of interest.

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