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Review Article

Diabetes in South Asians

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Abstract

Economic, dietary and other lifestyle transitions have been occurring rapidly in most South Asian countries, making their populations more vulnerable to developing Type 2 diabetes and cardiovascular diseases. Recent data show an increasing prevalence of Type 2 diabetes in urban areas as well as in semi-urban and rural areas, inclusive of people belonging to middle and low socio-economic strata. Prime determinants for Type 2 diabetes in South Asians include physical inactivity, imbalanced diets, abdominal obesity, excess hepatic fat and, possibly, adverse perinatal and early life nutrition and intra-country migration. It is reported that Type 2 diabetes affects South Asians a decade earlier and some complications, for example nephropathy, are more prevalent and progressive than in other races. Further, prevalence of pre-diabetes is high, and so is conversion to diabetes, while more than 50% of those who are affected remain undiagnosed. Attitudes, cultural differences and religious and social beliefs pose barriers in effective prevention and management of Type 2 diabetes in South Asians. Inadequate resources, insufficient healthcare budgets, lack of medical reimbursement and socio-economic factors contribute to the cost of diabetes management. The challenge is to develop new translational strategies, which are pragmatic, cost-effective and scalable and can be adopted by the South Asian countries with limited resources. The key areas that need focus are: generation of awareness, prioritizing health care for vulnerable subgroups (children, women, pregnant women and the underprivileged), screening of high-risk groups, maximum coverage of the population with essential medicines, and strengthening primary care. An effective national diabetes control programme in each South Asian country should be formulated, with these issues in mind.

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Introduction

South Asia constitutes one fifth of the world's population and includes residents of India, Pakistan, Bangladesh, Sri Lanka, Nepal, Bhutan and the Maldives. South Asians are multicultural, multi-ethnic and follow distinctive socio-cultural norms and dietary practices. A few decades earlier, their lives were labour intensive and most people consumed frugal diets. Recent economic, dietary and other lifestyle transitions have made them more vulnerable to developing Type 2 diabetes mellitus and cardiovascular diseases. Migration to developed countries has been substantial and continuing, constituting a 'South Asian diaspora' in many countries, including South Africa, Singapore, the UK, Canada and the USA. Some of the first reports, wherein a high predisposition of South Asians to insulin resistance, abdominal obesity, diabetes and premature mortality were reported, were based on research on the South Asian diaspora in the UK [1].

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In this review, we summarize the epidemiology, characteristics, determinants and ethnic-specific key issues in the prevention and management of Type 2 diabetes in South Asians.

Search strategy

PubMed (National Library of Medicine, Bethesda, MD, USA) and Google Scholar search engines were used for a literature search using the keywords 'South Asians', 'Asian Indians', 'Type 2 diabetes', 'impaired glucose tolerance', 'epidemiological trends', 'obesity', 'dietary factors', 'physical activity', 'genetic factors', 'migration', 'management', 'complications', 'diabetic retinopathy', 'nephropathy', 'neuropathy', 'peripheral vascular disease', 'cardiovascular disease', 'cost of care' and 'prevention' from 1970 to March 2014. All the authors independently reviewed the studies. AM and US searched studies on introductory overview and management of Type 2 diabetes; AR and CS conducted the search on epidemiology and prevention. Determinants and

complications were searched by RJ and setting of the diabetes control programme by US. Subsequently, AM and US reviewed and edited all written material and articles.

Epidemiological trends

Native South Asians

The number of people with diabetes in South Asia is estimated to increase to 120.9 million (10.2% of the adult population) by 2030. India has nearly 65.1 million cases of diabetes and occupies the second position, next to China, in the global list of countries with the highest number of persons with diabetes, while Pakistan and Bangladesh are in 12th and 13th position, respectively. National prevalence exceeds 4.9% in all South Asian countries except Nepal (Table 1) [2].

Prevalence data vary according to the country, area of residence (urban vs. rural) and socio-economic status. Between 1989 and 2005, prevalence of diabetes increased significantly from 8.3% to 18.6% in the urban population and from 2.2% to 9.2% in the rural population in South India [3]. A systematic analysis of secular trends over a period of 15 years (1994–2009) revealed an increase in diabetes prevalence among the rural population at a rate of 2.02 per 1000 population per year. Further, the rate of increase was higher in men (3.33 per 1000 per year) compared with women (0.88 per 1000 per year) [4]. Two national health surveys in Mauritius showed an increase in prevalence of diabetes from 13% in 1987 to 21.3% in 2009—a 64% increase since 1987 [5]. In Sri Lanka, between 1990 and 2000, the prevalence increased from 5.3% to 6.5% in the urban population and from 2.5% to 8.5% in the rural population [6]. Secular trends in the prevalence of diabetes for Bangladesh, India and Sri Lanka have been reviewed recently [6].

South Asian populations have a high prevalence of pre-diabetes, impaired fasting glucose, impaired glucose tolerance and a more rapid progression to diabetes [7]. Recent data from India [3] and a systematic review of published data from 1987 to 2009 from South Asians worldwide indicated an increase in diabetes prevalence [8]. Based on studies published between 1980 and 2011, the prevalence of pre-diabetes varied from 3.0% in the Maldives and rural Pakistan to 19.5% in urban Nepal [6]. Interestingly, recent studies from Tamil Nadu, India and Mauritius have shown a decrease in prevalence rates of impaired glucose tolerance [8]. A rise in the prevalence of Type 2 diabetes with a concomitant decline in the prevalence of impaired glucose tolerance could be as a result of a rapid conversion of impaired glucose tolerance to diabetes because of major changes in lifestyle over the last decade or improved maternal and infant nutrition.

South Asian diaspora

A higher prevalence of Type 2 diabetes in the South Asian diaspora has been shown compared with other ethnic populations in many western countries [1]. South Asians in the UK comprise over 4% of the country's total population, but have nearly a fivefold higher risk of Type 2 diabetes. In addition to insulin resistance, central obesity and susceptibility for Type 2 diabetes at lower BMI levels, South Asians show higher levels of pro-inflammatory and pro-thrombotic factors, and more endothelial dysfunction than White Europeans [1,9]. In the USA, Asian Indians had the highest odds of prevalent diabetes, followed by other Asian populations. A large population-based cross-sectional survey in Oslo, Norway in 30- to 60-year-olds showed that the age-standardized prevalence rate of diabetes among Pakistanis (men 26.4% and women 20.0%) and Sri Lankans (men 22.5% and women 20.7%) were significantly higher than among the Norwegians (men and women 2.7% and 6.4%, respectively) at all levels of adiposity [10]. Several reports from Fiji, Singapore, Mauritius, Tanzania and South Africa have also shown a higher prevalence of diabetes among migrant Asian Indians than in the native population and other migrant ethnic groups residing in the country.

Table 1 Estimates for diabetes and impaired glucose tolerance for 2012 for people of 20–79 years in South Asia

Country	Cases of diabetes (in thousands)	Diabetes national prevalence (%)	Number with diabetes (in thousands)		Number with undiagnosed diabetes (in thousands)	Impaired glucose tolerance national prevalence (%)
			Rural setting	Urban setting		
Afghanistan	849.09	5.95	603.15	245.94	424.55	5.97
Bangladesh	5521.41	6.14	1614.48	3906.93	2760.71	2.50
Bhutan	22.36	4.89	10.55	11.81	11.42	2.69
India	63 013.87	8.37	34 433.22	28 580.65	32 184.34	2.79
Maldives	15.91	7.74	6.56	9.34	8.13	4.28
Mauritius	141.64	15.53	68.40	73.25	72.34	10.66
Nepal	506.73	3.05	191.01	315.71	253.36	2.0
Pakistan	6550.18	6.74	3710.76	2839.41	3650.74	7.63
Sri Lanka	1100.21	7.84	793.45	306.76	561.93	5.54

Adapted from the International Diabetes Federation (2013) with permission.

Diabetes in South Asians: some distinctive features and trends

More than 50% of people affected with Type 2 diabetes remain undiagnosed, thus exposing them to a high risk of complications. Moreover, many are unaware of diabetes and its causes, and of strategies to prevent it. Type 2 diabetes occurs almost a decade earlier and at lower BMI levels in South Asians than in other ethnic groups [11]. Higher rates of insulin resistance, postprandial glycaemia, abdominal adiposity, the metabolic syndrome and non-alcoholic fatty liver disease have been reported in South Asians than in people of other ethnicities [12]. South Asians are predisposed to develop diabetic nephropathy [13] and cardiovascular disease (see below) [9]. Finally, the coexistence of tuberculosis, which continues in an epidemic form in South Asian countries, and diabetes needs to be further researched in this region.

It is interesting to note the changing epidemiological trends in Type 2 diabetes in South Asian countries. An increasing prevalence has been reported in rural areas, in middle-income groups and among underprivileged persons. Data from India, Pakistan and Sri Lanka show a further lowering of the age at onset in recent years (Fig. 1, panel 3) [3]. The rising trend in the prevalence of obesity [14] and gestational diabetes among Asian women may also contribute to the escalating prevalence of Type 2 diabetes in young persons. It is possible that better awareness and increasing use of periodic screening may unmask Type 2 diabetes at a younger age. Some of those who develop diabetes in youth may have maturity-onset diabetes of the young (MODY) or late-onset autoimmune diabetes (LADA).

Determinants

Dietary factors

It is believed that dietary habits play an important role in the epidemic of diabetes among South Asians; however, the published data from this region are limited. Previous studies either did not measure diet or did not use accurately validated instruments. Further, nutritional transition is rapid, particularly in children, causing adverse effects of imbalanced diets.

Carbohydrates

South Asian diets are predominantly based on starchy foods, typically consisting of over 60% or more of carbohydrates. High intake of carbohydrates may lead to hyperinsulinaemia, high serum triglycerides and low HDL cholesterol levels associated with insulin resistance [15]. In a study on South

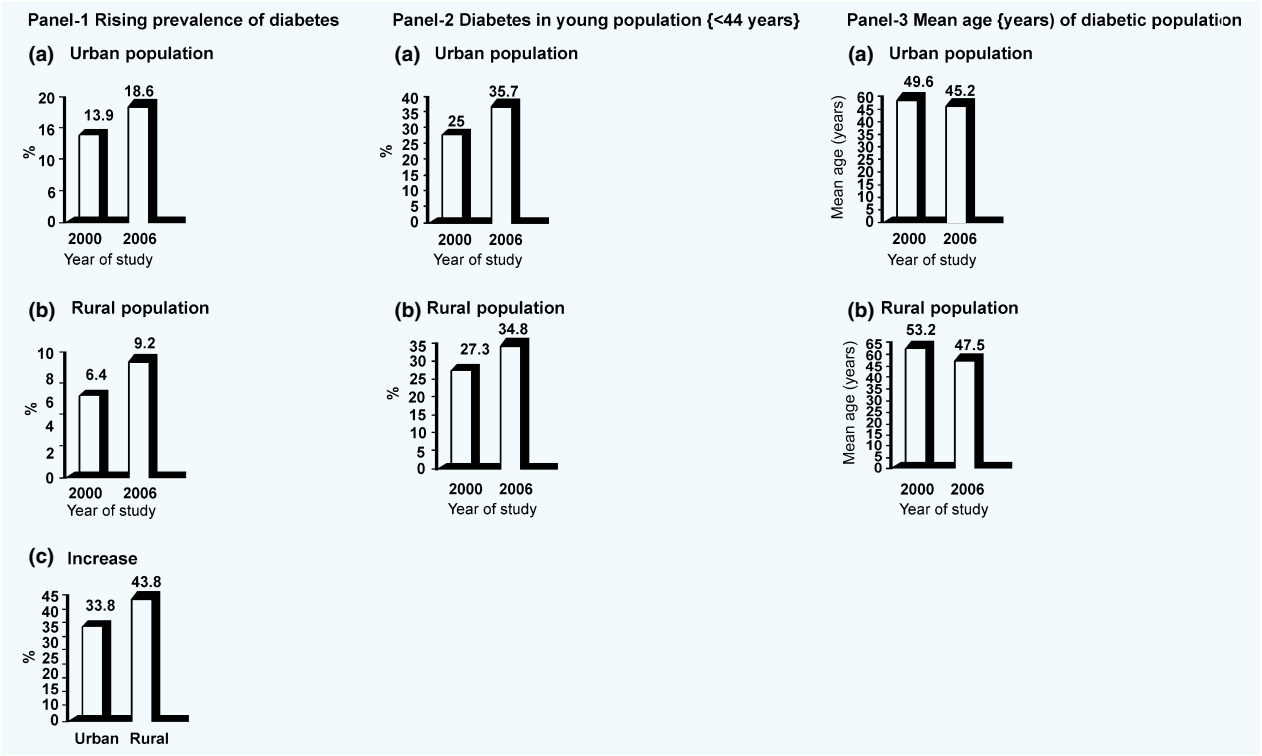

FIGURE 1 Values are given in percentages. Panel 1 (a and b) shows the rising trend in prevalence of diabetes in urban and rural Tamilnadu, India, respectively. Panel 1c shows the percentage of increase in urban and rural areas. Panel 2 (a and b) show the rising trend in prevalence of diabetes among young populations. Panel 3 (a and b) illustrate the reduction in mean age of newly diagnosed people with diabetes in urban and rural areas, respectively.

Asians in the UK, a 'typical' Asian Indian vegetarian diet as compared with a 'typical' European diet induced a higher and more prolonged rise in mean plasma glucose levels and higher 2-h postprandial insulin levels [16].

Fats

South Asians have a higher intake of saturated fatty acids, n-6 polyunsaturated fatty acids and trans-fatty acids and lower intakes of n-3 polyunsaturated fatty acids compared with other populations [15]. In India and other South Asian countries, ghee (clarified butter), vegetable ghee (partially hydrogenated vegetable oil, popularly known as 'Vanaspati') and coconut oil, containing high levels of saturated fatty acids and trans-fatty acids are used for cooking and may contribute to a dysmetabolic state.

Fruit, vegetables, vitamins and minerals

Although fruit and vegetables are widely available in South Asian countries, the INTERHEART study showed that South Asians had a lower daily intake of fruits and vegetables than people from 47 non-South-Asian countries [17]. Several other country-specific reports have shown that < 4% of the South Asian population consume the minimum daily recommendation for fruit and vegetables, probably because of cost constraints [6]. Although dietary guidelines in other countries remain to be formulated, those from India recommend 3–5 servings of fruit and vegetables [18].

A high prevalence of hypo-vitaminosis D and low dietary calcium levels have been reported among Asian Indians. There is some evidence, from a short-term study, that supplementation of vitamin D improves insulin sensitivity in Asian Indians.

Physical activity

It is reported that South Asians are physically inactive compared with other ethnic groups (Table 2) [9,21–25]. Moreover, South Asians have lower cardio-respiratory fitness and capacity for fat oxidation during exercise compared with matched White Caucasians, and these factors may be associated with their lower insulin sensitivity. Physical inactivity was significantly associated with Type 2 diabetes (odds ratio 1.6) in Sri Lankans. Adaptation of a Western lifestyle, sedentary occupations, increased mechanization in the workplace and in household work, indoor entertainment and increasing use of automobiles are important contributory factors to physical inactivity (Table 2) [9]. Barriers to physical activity among South Asians have been sparsely researched, but include lack of awareness of the benefits of physical activity and social restrictions for outdoor physical activity in women. Although resistance exercise has been shown to decrease insulin resistance and glycaemia in Asian Indians with Type 2 diabetes [19], it has rarely been included in the exercise programmes. In the physical activity guidelines for Asian Indians, daily physical activity of 60 min duration, including 10–15 min of resistance exercise and work-related activity has been recommended [20].

Obesity

Although South Asia has the highest number of patients with diabetes, prevalence of obesity defined by BMI $\geq$ 30 kg/m^2 is the lowest compared with other regions in the world. Despite this, morbidities such as Type 2 diabetes are substantial: age-adjusted prevalence of diabetes is 10.3% among Sri Lankan adults, but the prevalence of obesity (BMI $\geq$ 30 kg/m^2) is 3.7% in the same population. Such data suggest that other adverse features of body composition (see below) may contribute to hyperglycaemia and dyslipidemia [14]. Nonetheless, the increasing prevalence of obesity and the metabolic syndrome in general, and in urban women and children, is of particular concern [14,19].

Using BMI, it is often not possible to distinguish between fat and fat-free mass and fat distribution. First, for a given BMI value, South Asians have a higher fat percentage; second, they have greater total abdominal, subcutaneous and intra-abdominal adipose tissue and fat deposition in ectopic sites (liver and skeletal muscle); and, third, they have lesser skeletal muscle mass than other ethnic groups [11,14]. South Asians also have a lower waist circumference than White Caucasians. A World Health Organization subcommittee suggested lower BMI values than prevalent WHO guidelines as public health action points for Asian populations. Subsequently, the Indian consensus statement [26] has suggested a BMI of $\geq$ 23 kg/m^2 and $\geq$ 25 kg/m^2 as the diagnostic cut-offs for overweight and obesity (Table 3) [14,28–30], respectively, and these guidelines have now been endorsed for South Asians in UK [27]. Cut-offs of waist circumference for defining abdominal obesity in Asian Indians are lower than conventional criteria [26] and this has also been widely endorsed [27]. Waist-to-height ratio as a risk factor for Type 2 diabetes and cardiovascular disease requires more research. Despite a consistent concern about obesity and abdominal obesity in this population, weight perception related weight loss practices are extremely low. Moreover, obesity, specifically childhood obesity, is not considered a harbinger of any disease, but of health, by mothers.

Genetic factors

In a meta-analysis on cross-sectional studies on diabetes in South Asia, family history was significantly associated with diabetes (odds ratio 2.75; $P < 0.001$). To date, genome-wide association studies have identified over 40 genes to be associated with Type 2 diabetes [6]. Many of these genes implicated for diabetes are common among White Caucasians and Asians; however, location and frequency of those

Table 2 Differences in physical activity patterns in South Asians/Asian Indians vs. White Cacuasians/Europeans

Study	*n*	Physical activity criteria/variable	South Asians/Asian Indians	White Caucasians/ Europeans
Mohanty *et al.* [21]	555 Asian Indians and 87 846non-Hispanic White Caucasians	Per cent reporting vigorous activity	33.0%	40.7%*
Hayes *et al.* [22]	684 South Asians† (259 Indian, 305 Pakistani, 120 Bangladeshi) and 825 Europeans†	Never active or active less than once a week30-min moderate activity most weekdaysGuidelines of physical activity index not met by:	67.0%Indians: M, 29%; F, 17%Pakistanis: M, 12%; F, 19% Bangladeshis: M, 13%; F, 9% Indians, 71%;Pakistanis, 88%; Bangladeshis, 87%	59.3%*M, 48%; F, 37%52%
Lean *et al.* [23]	63 South Asian migrants, 56 South Asians born in the UK, and 50 Europeans‡	Participated in sport or other recreational exercise	23%§§, 17%¶¶	50%
Shaukat *et al.* [24]	89 Asian Indians and 82 Caucasians§	Physical activity index** Daily distance (km) walked for 1 week††	8.5 1.78	13.7 2.39
Rudat [25]	1017 Asian Indians, 935 Pakistanis and 667 Bangladeshis¶	Reported general physical activity‡‡ Reported sporting activity	Indian: M, 12%; F, 5%Pakistani: M, 8%; F, 8%Bangladeshi: M, 4%; F, 4%Indians: M, 36%; F, 15%Pakistanis: M, 26%; F, 10%Bangladeshis:, 18%; F, 2%	M, 17%; F, 19% M, 43%; F, 37%

F, female; M, male; *n*, number of sample study population.
*$P = 0.004$.
†Aged 25–70 years.
‡Women aged 20–42 years.
§Sons of patients with coronary heart disease aged 15–30 years.
¶Aged 16–74 years.
**Developed by authors.
††Measured by pedometer.
‡‡Activities undertaken to maintain or improve health.
§§South Asians born in UK.
¶¶Migrant South Asians.
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Table 3 Cut-offs of obesity and abdominal obesity for Asian Indians vs. International criteria

Variable	Consensus Guidelines for Asian Indians*	International Criteria
Generalized obesity BMI cut-offs (kg/m^2) Abdominal obesity—waist circumference cut-offs (cm)	Normal: 18.0–22.9 kg/m^2 Overweight:23.0–24.9 kg/m^2;Obesity: ≥ 25 kg/m^2 Men: ≥ 90 cm‡Women: ≥ 80 cm‡	Normal: 18.5–24.9 kg/m^{2†} Overweight: 25.0–29.9 kg/m^{2†}Obesity: ≥ 30 kg/m^{2†} Men: ≥ 102 cm§Women: ≥ 88 cm§

*From Consensus guidelines for Asian Indians [26].
†According to World Health Organization guidelines [28].
‡Both as per Consensus Guidelines for Asian Indians [26] and the International Diabetes Federation [29].
§According to the Modified National Cholesterol Education Program, Adult Treatment Panel III guidelines [NCEP) [30].
Adapted from Misra & Khurana (2011) with permission from Nature Publishing Group.

alleles vary among ethnic groups Moreover, a recent genome-wide association study reported six newly associated loci associated with South Asian patients with diabetes [31]. Interestingly, a gene, *myostatin*, which has been shown to influence body fat and lean body mass in Asian Indians, could be investigated in future studies [32]. Importantly, the several-fold increase in the prevalence of Type 2 diabetes among South Asians during the last two decades cannot be explained by the genetic factors alone; an increasingly adverse interaction with multiple lifestyle factors is more likely.

Fetal and post-natal factors

Hales and Barker [33] hypothesized that poor fetal and early post-natal nutrition may increase the risk of diabetes. Yajnik [34] reported that, compared with White Caucasians babies, Indian newborns have a lower birthweight and lean mass, but higher subcutaneous adiposity. It is possible that the mismatch between early life and adult environment may be associated with risk of diabetes. This effect may be mediated by the gene expression rather than changes in genotypes. This hypothesis, although attractive as an explanation of the high

prevalence of diabetes in several developing countries, requires further research.

Migration

Migrant South Asians living in developed countries showed a higher prevalence of Type 2 diabetes and associated complications than their native counterparts [35]. Some recent data show that rural–urban migrants in India have a higher prevalence of Type 2 diabetes and obesity than rural dwellers.

Complications

South Asians are at a higher risk for complications atributable to multiple factors: early onset of diabetes, delayed diagnosis, suboptimal control, non-compliance to treatment, and genetic predisposition A cross-sectional study in Sri Lanka showed that the prevalence of retinopathy, neuropathy and nephropathy was 6.8%, 11% and 18.8% in newly diagnosed patients and, in those with 16–20 years of diabetes duration, the prevalence rose to 52.6%, 54.3% and 23.8%, respectively [36].

Diabetic retinopathy

Diabetic retinopathy is the leading cause of blindness among working adults in India and other countries [37]. The prevalence of diabetic retinopathy, including sight-threatening retinopathy, is significantly higher among South Asian patients compared with White Europeans [37].

Nephropathy

The UK Asian Diabetes Study (UKADS) showed the prevalence of microalbuminuria was significantly higher in South Asian patients (31%) compared with White European patients (20%) ($P = 0.007$) [38]. Importantly, Shaw *et al.* [13] reported that Indo-Asian patients with Type 2 diabetes had a nearly 40-fold increase in the risk for end-stage nephropathy, compared with the native Dutch population. Nephropathy is reported to occur with shorter duration of diabetes (< 10 years) [39] and showed faster progression in South Asians than in White Caucasians (Fig. 2) [9].

Neuropathy and peripheral vascular disease

A community-based study in Sri Lanka reported that the prevalence of diabetic neuropathy in men and women was 20.0% and 26.4%, respectively [40]. Diabetic neuropathy and peripheral vascular disease is of specific clinical importance among South Asians, as rural-based people especially walk with bare feet, resulting in foot infection and associated complications [41]. The reason for the significantly lower prevalence of peripheral vascular disease and foot amputation among South Asians than White Europeans is unclear.

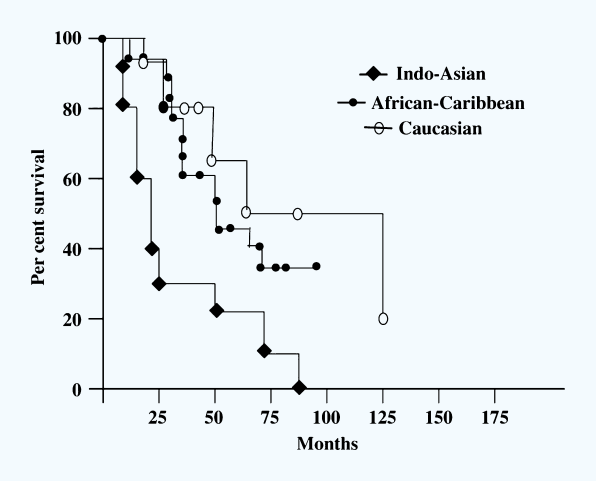

FIGURE 2 Kaplan–Meier survival plots of Indo-Asian, African-Caribbean and white patients with Type 2 diabetes showing doubling of serum creatinine (as endpoint) on the *y*-axis and follow-up (months) on the *x*-axis. All Indo-Asian patients experienced doubling of their creatinine compared with only 45% and 50% of African-Caribbean and White Caucasian, respectively (log-rank test $\chi^2 = 7.36$; $P = 0.025$). Reproduced from Earle *et al.* (2001) with permission from Oxford Medical Journals.

Cardiovascular risk

South Asians have a higher risk of cardiovascular disease as compared with Europeans, contributed by multiple risk factors such as abdominal obesity, low HDL and high triglycerides ('atherogenic dyslipidemia'), insulin resistance, hyperglycaemia and a procoagulant tendency [9]. Importantly, South Asians living in the UK have more diffuse, aggressive and premature cardiovascular disease and are more likely to develop acute cardiac events than White Caucasians [42]. Further, as compared with UK White people, South Asians with myocardial infarction had a lesser survival rate, both at 30 days and at 6 months, respectively, which is likely to be contributed by diabetes, in spite of a greater proportion of South Asians receiving thrombolytic drugs [42]. Similarly, mortality from stroke is higher among South Asians compared with White Europeans.

Cost of diabetes care

Inadequate resources, an insufficient healthcare budget, lack of medical reimbursement and socio-economic barriers contribute to the cost of diabetes management in South Asian countries. The cost of diabetes care increases manyfold when complications occur or when insulin treatment, admission to hospital, or surgery is/are required. Annual median expenditure by patients on diabetes care is Indian National Rupees (INR) 10 000 ($227) in urban areas and INR 6260 ($142) in rural areas. Importantly, the low-income group spends nearly 25–35% of their annual income on diabetes care. Annual direct and indirect cost of diabetes care

were estimated to be 1541.4 billion INR ($31.9 billion) in 2010 for India [41]. Because of the high economic burden on the patients and their families, people tend to neglect health care, causing severe morbidities and early mortality.

Management

Major hurdles in implementing effective preventive and management modalities in South Asians exist because of attitudes, cultural differences, and religious and social beliefs [9].

Early detection

This is a major challenge in South Asia because of apprehensions about blood tests, mainly in rural people, a fatalistic attitude and fear of lifelong medication if diagnosed. A number of social habits and attitudes act as major barriers in effective management of diabetes in South Asians: the culture of eating calorie dense sweets during festivals; not to refuse offered sweets as a part of social etiquette; and to hide illness, as it may prove to be hindrance for marriage or employment.

Lifestyle management

Non-compliance with lifestyle management is a frequent issue. Lack of open spaces in urban areas poses a major challenge for outdoor physical activities. A traditional mindset, often incorrect, about 'good' and 'bad' diets, for themselves and for their children, is common in mothers. Further, consistent application of diet and physical activity is often interrupted because of religious fasting, festivals and social occasions.

Access to health care and pharmacological management

Specific barriers in management include: delayed diagnosis, insufficient clinical evaluation and advice and lack of access to affordable and specialized health care [43].

Glycaemic control is often significantly worse in South Asians than in White Caucasians, in spite of their being younger and having lower BMI. In general, the control of blood cholesterol levels and blood pressure were also lesser than those observed in White Caucasians. The popular anti-hyperglycaemic drug remains sulphonylurea, largely because of the cost factor, closely followed by metformin. Dipeptidyl-peptidase-4 (DPP-4) inhibitors are increasingly being used; however, cost may be prohibitive in developing populations [43]. The response to drugs used in treatment of diabetes has not been adequately investigated, but it is suspected to be different in South Asians than in White Caucasians. Asian Indians respond more favourably to pioglitazone, with significant improvements in insulin sensitivity (glucose disposal was improved by 32%). Further, use of pioglitazone resulted in a > 50% decrease in high-sensitivity C-reactive protein (hs-CRP) and plasminogen activator inhibitor-1 (PAI-1) levels in Asian Indians compared with White Caucasians [44]. One report has suggested that metformin may be more effective in South Asians than in White Caucasians. However, potential problems with metformin use in Asian Indians could be more gastrointestinal upsets attributable to widespread gastrointestinal infestations and infections and exacerbation of vitamin B_{12} deficiency in an already vitamin B_{12}-deficient population. The apparent differential response to insulin sensitizers in South Asians and White Caucasians and its possible determinants need to be further studied. Because of fewer tendencies to cause hypoglycaemia, DPP-4 inhibitors may be better suited when people fast during Ramadan or other religious festivals [45]. Some studies have suggested that caution should be exercised in prescribing statins in South Asians. In a study conducted on the use of rosuvastatin in Asian Indians, it was suggested that a lower dose (5 mg once daily) should be used and can be increased to 40 mg per day (if required), but this should be carried out with caution.

Management of diabetes during intermittent or prolonged fasting, as is the practice in many religious groups, poses a challenge, particularly in those on multiple drug therapy and/or insulin. Drug therapy inappropriate to meals, or reluctance to take drugs because of religious beliefs, may cause hypoglycaemia, hyperglycaemia with or without ketoacidosis or dehydration. Patients should undergo pre-Ramadan assessment and receive appropriate education and instructions related to physical activity, meal planning, glucose monitoring, and dosage and timing of medications. The management plan must be highly individualized. Close follow-up is essential to reduce the risk of development of complications. Appropriate treatment guidelines for such patients are available in recent reviews.

Country-specific guidelines for the management of diabetes have been developed by the Indian Council of Medical Research in India [46]; however, these need to be constantly updated and, also, adapted or developed by other South Asian countries.

Prevention

Prevention of Type 2 diabetes with diverse interventions has been shown in different populations. In the US-based Diabetes Prevention Program, a small cohort (4%) of Asian subjects was included. In this study, lifestyle management as well as metformin was effective in preventing diabetes in this cohort as well as in the white population [47]. The Indian Diabetes Prevention Program-1 (IDPP) [7] conducted in subjects with impaired glucose tolerance in South India (n = 531) showed that persistent lifestyle management of moderate intensity and/or small doses of metformin (250 mg twice a day) were equally effective, with a risk reduction of 29% compared with standard care over a period of 3 years, independent of significant weight reduction. Improvement in insulin sensitivity and sustained preservation of β-cell function were found to be the key mechanisms responsible

for the beneficial outcomes [7]. It is important to note that combining either metformin or pioglitazone with lifestyle management did not further improve the efficacy of lifestyle management in Asian Indians [48]. In a 6-month lifestyle management intervention on 15 to 17 year-old Asian Indian children, with better lifestyle practices (less television viewing, eating more fruit, etc.), a significant decrease in waist–hip ratio, better insulin sensitivity and significantly lower hs-CRP values were seen in the intervention group vs. control group [49].

The challenge is to develop newer translational strategies that are pragmatic, cost-effective, and scalable and can be adopted by resource-constrained South Asian countries. The recent prospective clinical trial from Chennai, India, showed that mobile phone messaging is an alternative means of delivery of educational and motivational messages. The cumulative incidence of diabetes in years was lower among the intervention group who received frequent messages on healthy lifestyle factors (18%) than among the control group on standard care (27%) [hazard ratio 0.64, 95% CI (0.45–0.92, $P = 0.015$)] [50]. One recent study from India has estimated that sustained taxing of sugar-sweetened beverages at a high tax rate could mitigate rising obesity and Type 2 diabetes among both urban and rural sub-populations [51].

Primordial prevention strategies instituted in potential mothers, prevention of malnutrition *in utero* and in childhood, healthy diets, adequate physical activity and a stress-free environment ('life course approach') are requisites for the prevention of Type 2 diabetes in South Asians. Translating the research findings to a real-world environment poses a considerable challenge, especially in South Asian countries with limited economic and healthcare resources. Finally, more intervention studies are required to establish culturally, locally specific and cost-effective strategies, particularly focusing on diet, physical activity and low-cost drugs, for prevention and management of Type 2 diabetes in South Asians.

Setting up national guidelines and national diabetes control programmes

Guidelines are available in India for cut-offs of obesity and abdominal obesity appropriate to Asian Indians [26], for physical activity [20] and diet [18] for prevention of obesity and diabetes. These guidelines stress lower limits of obesity and more stringent physical exercise and diet for Asian Indians. These guidelines need to be adapted, or similar guidelines should be developed for other South Asian countries.

National disease control programmes in South Asian countries are needed to evolve key and locally effective strategies for the prevention and management of diabetes. The principal areas that need focus are: generation of awareness, prioritizing health care for vulnerable subgroups (children, women, pregnant women and the underprivileged), screening of high-risk groups, maximum coverage of the population with essential medicines, and strengthening primary care. In India, a pilot phase of the National Program for Control of Cancer, Diabetes, Cardiovascular Disease and Stroke (NPCDCS) was launched in 100 districts in 2008, with strong screening and monitoring components, and was subsequently strengthened in 2013–2014. Other countries are in the process of launching or strengthening these efforts: the Pakistan Diabetes Prevention Programme (PDPP), The Diabetes Prevention Intervention Study in Bangladesh and community efforts in Sri Lanka and Nepal.

Financial sources

None.

Competing interests

None declared.

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