Three Patterns of Rising type 2 Diabetes Prevalence in the World: Need to Widen the Concept of Prevention in Individuals into Control in the Community

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ABSTRACT

This paper analyses the patterns of rising type 2 diabetes prevalence in the world with their plausible reasons focusing on control measures. It shows existence of combinations of three patterns of rises, viz. gradual, rapid and accelerated, leading to prevalence of 4–9% now in Europids, 14–20% in migrant or urbanized Asian Indians, Arabs, Chinese, Africans, and Hispanics and above 30–50% in indigenous peoples of Canada, USA, Australia and Pacific regions. It demonstrates that though ageing, sedentary life and obesity of people explain gradual rise in Europids, effects of rapid transition in nutritional status of population and of maternal hyperglycaemia on the risk of offspring developing glucose intolerance further add to rapid and accelerated rises respectively. It recommends that current approach of primary prevention of diabetes in people, particularly with impaired glucose tolerance, advocating modest loss of excess weight and moderate-intensity exercise, be widen into concept of control in community covering rapid and accelerated rises. The control programmes essentially are vigorous educational campaign and planning to improve nutritional status of women of childbearing age in rural and poorer sectors of society and to keep weight of adults within recommended body mass index (BMI) range, like 18.5–22.9 kg/m^2 for Asian and other similar populations. The population-based approaches with examples, considering developing countries, are outlined. The paper emphasizes the importance of keeping prepregnancy weight optimum, preferably below the middle of recommended BMI range, to avoid even sub-clinical maternal hyperglycemia, for prevention and control of accelerated rise in any population.

Key Words: *diabetes, diabetes control, diabetes epidemiology, diabetes prevention, prepregnancy weight*

INTRODUCTION

Current literature indicates that diabetes (type 2 diabetes) is increasing – and increasing rapidly – all over the world.[1] Ethnicity is considered to be an important factor in diabetes development with higher rates being reported in Asians, Hispanics, African Americans and indigenous peoples of the USA, Canada, Australia and Pacific regions.[1]

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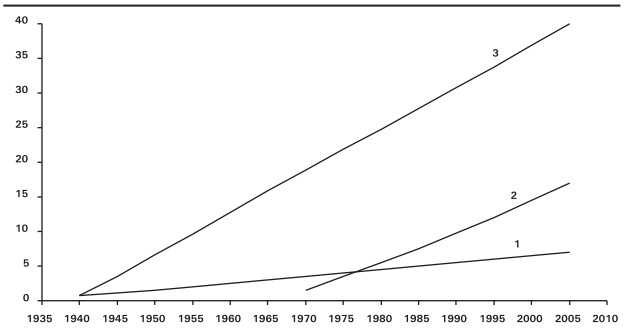
However the term ethnicity appears to carry the notion of predominant genetic element, which we cannot change. Diabetes has risen dramatically in the world from an estimated 30 million cases in 1985 to 177 million in 2000,[2] which is further expected to increase to some 380 million by 2025.[1] Genetic factors alone can not explain such rapid rise in diabetes prevalence in the world. Further diabetes prevalence is similar in different migrant or urbanized ethnic groups like Asian Indians, Arabs, Chinese, Africans, and Hispanics.[1,3-6] The heterogeneity in diabetes prevalence in the world is no doubt rooted in more recent environmental events rather than genetic factors.[5,7] Effects of environmental factors right from the conception to adult life need to be considered. This paper analyses the patterns of rising diabetes prevalence in the world correlating with the most likely environmental factors focusing on the required control approaches.

OBESITY, SEDENTARY LIFE AND AGEING AND GRADUAL RISE OF DIABETES PREVALENCE

Prevalence of diabetes in rural areas in many parts in the world now or in the past has generally been below 1–3%.[1,3-5] This is the background or rural prevalence of diabetes. With increasing obesity, decreasing physical activity, and rising life expectancy of population, prevalence of diabetes increases. Accordingly modest loss of excess weight and moderate-intensity exercise has been recommended as primary prevention interventions in people, especially with impaired glucose tolerance.[8] Prevalence of 'diagnosed' diabetes in the USA increased progressively from 0.9% in 1958 to 5.9% in 2006.[9] Prevalence of diabetes in the USA in 1976-80 was 6.6% and about half the people with diabetes did not know their condition.[10] In Canada age-adjusted increase in prevalence was from 4.4% in 1986 to 6.6% in 1991.[11] Similarly in Iceland the prevalence in males was 2.8% in 1970-1972, 4.5% in 1979-1984 and 5.0% in 1985-1990.[12] The comparative diabetes prevalence estimates for 2007 in North America and Europe are about 4-9%.[1] Considering the trend, the increase in diabetes prevalence in Europids is represented diagrammatically in Figure 1.

In the USA there is progressive increase in obesity and an estimated 66% of adults were overweight or obese in 2003-2004.[13] Similar rise in obesity was seen in Europe.[14] The adult mean body mass index (BMI) levels of 20–23 kg/m^2 were found among the general population in Africa and Asia, while levels were 25–27 kg/m^2 across North America and Europe in 2002.[15] In the USA prevalence of diabetes has increased in accord with the increasing prevalence of obesity,[16] and 80% of individuals with diabetes are obese, others particularly the elderly are lean.[2] Prevalence of diabetes in Europe, Canada and the USA is also, to a large degree, a consequence of the relatively old population, such that currently about a third of their population is over 50 years of age.[1] The proportion of total estimated number of people with diabetes in 2007 in 20–39, 40–59 and 60–79 age groups are 7–10%, 36–45%, and 46–57% in European and North American regions and 23–33%, 42–52% and 25–30% in African, South-East Asian and Eastern Mediterranean and Middle East regions respectively.[1]

Thus the gradual rise (Figure 1) in diabetes prevalence in Europids over many decades is mostly associated with ageing of the population and much increased obesity. Such gradual rise can occur in all populations.



1–Europids

2–Migrant or urbanized Asian Indians, Arabs, Africans, Chinese and Hispanics

3–Indigenous peoples of the USA, Canada, Australia and Pacific region

Figure 1. Diagrammatic representation of increase in diabetes prevalence in different populations of the world

RAPID AND ACCELERATED RISES OF DIABETES PREVALENCE

Contrary to the expectation of gradual rise from background level, prevalence of diabetes have reached within a few decades to around 14–20% in migrant or urbanized Asian Indians, Arabs, Africans, Chinese and Hispanics.[1,3-6] Prevalence of diabetes among adults above 20 years in urban India was around 1% in 1960 which increased steeply reaching to about 12% by 2005.[5] Similarly, analysis of previous trends of age-adjusted prevalence rates of diabetes in different urban areas reveals 7.7% in 1990 and 8.9% in 1995 in Hong Kong, 8.1% in 1993 in Singapore and 11% in 1995 in Taiwan;[4] 5% in 1994 in urban Sri Lanka, 9.7% in 2004 in urban Cambodia and 4.5% in 1997 and 8.1% in 2005 in Dhaka;[3] 9.5% in Latinos and 13.3% in Africans in 2005 in the USA;[2] and 15.2% in Bahrain and Qatar and 19.4% in the United Arab Emirates in 2007.[1] Accordingly the secular trend in diabetes prevalence in the urbanized or migrant Asian Indians, Arabs, Africans, Chinese and Hispanics is diagrammatically represented

in Figure 1. However the countries of origin of these populations have overall prevalence relatively lower at present due to the larger rural proportions there. But with increasing urbanization and migration the likelihood of the people from rural populations in such countries to develop similar rapid rise in diabetes prevalence reflect the magnitude of the potential problem.

Further in indigenous peoples of the USA, Canada, Australia and Pacific regions diabetes occurs in more than 30–50% of adults.[1] Previous age-standardized prevalence of diabetes were 21.1% in 1978 in Pima Indians[17] and 19% in 1970 in Aboriginals in Davenport.[18] Similarly, the first case of diabetes in Naurans was not noted until 1925 and after 1954 prevalence of diabetes rose steeply,[19] reaching to 24.7% in 1982 in Nauru.[20] Considering the trend, the increase in diabetes prevalence in these populations is represented diagrammatically in Figure 1. These populations, being either part of or in close proximity with industrialized countries like the USA, Canada and Australia, mostly received the modern technology benefits of lifestyle and food earlier than rest of the developing countries. Per capita income of Naurans started rising considerably from 1930s from royalties from mining of phosphate reaching to US $ 22,500 annually in 1968.[19]

Sedentary life, obesity and ageing of the population, which are expected to cause gradual rise in prevalence as in Europids, cannot alone account for the above high prevalence that are much more and have occurred over a relatively shorter time period in the other two groups. Rapid transition in nutritional status of population is considered for such initial rapid rises of diabetes prevalence in the two groups of the urbanized or migrant and indigenous populations with effects of maternal hyperglycaemia on the risk of offspring developing glucose intolerance further adding to the continued accelerated rise seen in the indigenous and other populations with high prevalence of diabetes.

RAPID TRANSITION IN NUTRITIONAL STATUS OF POPULATION AND RAPID RISE OF DIABETES PREVALENCE

The Europids have been developing increasing improvements in agricultural and industrial technologies, over about 300 years, and have undergone more gradual adaptation over generations, whereas other evolving urban populations have received these technologies ready developed over a much shorter period of some decades and have not experienced a protracted period of change.[5,19] The rapid transition in the nutritional status of population leads to dissociation in metabolic states of foetal life, associated with nutritional want, and adult life, with nutritional surfeit, of people. The relative malnutrition during fetal life is associated with increased risk of insulin resistance, impaired pancreatic islet cell development, and diabetes in people who are underweight at birth but become overweight or obese in later life,[1,21-23] helping to explain the greatly increased frequency of diabetes in the populations which move rapidly from nutritional want to adequacy or surfeit.[24,25] The rapid transition in the nutritional status of population in this way appears related to the initial rapid rises of diabetes prevalence seen in different evolving urban and indigenous populations.

A World Health Organization (WHO) expert consultation concluded that Asians generally have a higher percentage of body fat than white people of the same age, sex and BMI and that the proportion of Asian people with a high risk of diabetes and cardiovascular disease is substantial at BMIs lower than the existing WHO international cut-off point for overweight (>24.9 kg/m^2).[26] BMI is strongly correlated with total body fat in the general population, though it overestimates body fat in persons who are very muscular, such as athletes and sportsmen, and underestimates body fat in those who have lost muscle mass without significant change in weight such as elderly persons. It is calculated as weight in kilograms divided by height in meters squared. The WHO Western Pacific Region Office has recommended the BMI of 18.5–22.9 kg/m^2 as normal in people of Asian origin.[27] This is in contrast to the range of 18.5–24.9 kg/m^2 proposed by the WHO 1998 Consultation on Obesity based on classifications used in a number of past studies on Europids.[14,27] Similarly the Consensus Statement from India also indicated BMI of 18–22.9 kg/m^2 as normal for Asian Indians.[28] Risk of insulin resistance and diabetes in adult increases progressively upwards of a BMI of 20–22 kg/m^2.[15,29] More than 80% of the people with diabetes live in low- and middle-income countries[1] and nearly two thirds of diabetes globally are attributable to BMI above 21 kg/m^2.[15] One study reported the mean BMI to define obesity associated with development of adverse glucose and lipid metabolic profile to be 21 kg/m^2 among South Asians.[30] Thus in general the risk of insulin resistance and glucose intolerance appears to increase once BMI starts rising above the middle of the recommended BMI for the population. The normal BMI range for the population may gradually rise later to higher level with continuous prosperity of the people improving the growth and metabolic states during foetal life.

Implications and programmes

There are implications of the rapid transition in nutritional status of population for both foetal and adult lives of the people. Given the relatively poor nutritional status of mothers in rural areas in developing countries, an obvious approach would be to improve the nutritional status of girls and women of childbearing age in rural

and poorer sectors of society for the possible betterment of nutritional and metabolic status of the foetus during the pregnancy occurring later. For example, nutritional supplementation with balanced diet in school, workplace and community for girls and women of childbearing age in rural and poorer sectors of society would not only help to improve their nutrition but also provide enlightening health education to the local community to follow. The Global Strategy on Diet, Physical Activity and Health recognized the importance of maternal health and nutrition before and during pregnancy in the prevention of noncommunicable diseases throughout the life course.[31]

The other implication considering the rapid transition in nutritional status of the population is to make population-based plans and programmes to prevent excess weight gain by the people. Educational campaign about the body weight ranges as per different heights based on the recommended BMI ranges, e.g. of 18.5–24.9 kg/m^2 for Europids and of 18.5–22.9 kg/m^2 for Asians and other similar populations, among both the public and health workers is important, as even doctors may not know about the BMI ranges recommended for their population.[32] Similarly, environments must be created that are conductive to achieving and maintaining an active lifestyle and healthy eating habits.[33] Healthy cooking campaigning with guidelines and examples, considering the habit and culture of the population, and encouragement of formation of healthy cooking training societies could get the attention of the people, involve the housewives and generate discussion, including of innovative local ideas and food recipes. Regulation to provide the healthy snacks of fruits, vegetables and salads in school would also help to cultivate the habit from childhood and adolescent. The food and drink industry is a key partner for reducing energy density and fat content,[33] and portion size of food and drink. There is a need for statutory food labeling with simple and understandable displays of the composition and energy density in all eating establishments,[33] including in the menus.

Pedestrians, cyclists and public transport passengers are the top three hierarchy groups recommended while developing transport strategies,[34] with due attention given to factors like frequency and reliability of public transportation, walking and biking paths, and adequate facilities for securing bicycles in cities and public areas.[14] Legislations to keep at least one standard indoor swimming pool in shopping malls flourishing in urban areas and public swimming, games and sports, and dance and music facilities in each ward by Municipalities appear relevant in developing countries. Change in school curriculum is also required to encourage children to participate in sports and physical,[33] and dance and musical activities.

MATERNAL HYPERGLYCAEMIA AND ACCELERATED RISE OF DIABETES PREVALENCE

The relation of exposure of foetus to maternal hyperglycaemia and increased risk of offspring developing diabetes in later life – independently of genetic influences[35-38] is the major factor to consider in regards to the accelerated rise, which is evident in indigenous and other populations with high prevalence of diabetes. Intrauterine exposure to hyperglycaemia and hyperinsulinemia may affect development of adipose tissue and pancreatic beta cells leading to future obesity and altered glucose metabolism.[38] The babies of mothers who have diabetes during pregnancy were reported to have up to 45% risk of developing diabetes, compared with 8.6% in babies of mothers who develop diabetes after pregnancy, or 1.4% in babies of mothers without diabetes, as seen in Pima Indians.[35] Offspring of mothers with type 1 diabetes have also increased risk of type 2 diabetes development due to the exposure to maternal hyperglycaemia.[37] Youths with type 2 diabetes were diagnosed at younger ages among those exposed to hyperglycaemia in utero.[36,39] In the US in 10–19 years aged children with all types of diabetes, type 2 diabetes accounted for 6% in non-Hispanic white and 76% in Native American.[40] The prevalence of type 2 diabetes was 2.2% in 10-14 years old and 5.1% in 15-19 years old in 1992-1996 in Pima Indians.[41] Further the prevalence of glucose intolerance in the children of mothers with a diabetic pregnancy increases with time, for example from 1.2% at less than five years of age to 19.3% at 10-16 years of age.[39] As the women of childbearing age start having glucose intolerance, whether due to gradual or rapid rise of prevalence or increased weight or age of women at the time of pregnancy, a vicious circle of increased risk of diabetes leading to the accelerated rise of prevalence may occur in any population (Figure 2).

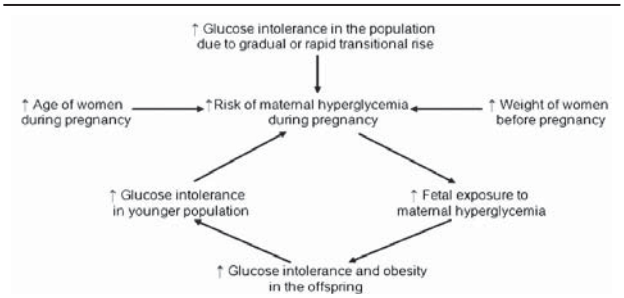


Figure 2. A vicious circle of glucose intolerance in younger population and maternal hyperglycemia during pregnancy

The safe level of maternal blood glucose during pregnancy

Chances of having macrosomia, birth weight greater than the 90th percentile, are five times higher as fasting

blood glucose concentration increases above 75 mg/dL (4.2 mmol/L) though remaining below the values required to diagnose diabetes.[42] The continuous relationship between increasing glucose concentration and foetal growth and adverse foetal outcome is significant with fasting blood value above 90 mg/dL (5 mmol/L), even in women who did not meet the criteria for diagnosis of diabetes.[42-44] Weeks 3 to 8 encompass organogenesis and major malformations in infants of diabetic mother occur during these periods.[45] So to protect the foetus from any possible effect of maternal hyperglycemia, blood glucose during the whole duration, including the early stage, of pregnancy has to be within the safe normal level. Considering the risks of the macrosomia development,[42-44] the safe normal level of fasting plasma glucose appears to be at least below 90 mg/dL (5 mmol/L).

Optimum prepregnancy weight of women to decrease the risk of hyperglycemia during pregnancy

Normal pregnancy itself without glucose intolerance is characterized by hyperplasia of insulin-secreting pancreatic beta cells, increased insulin secretion, and progressive insulin resistance.[46] Gestational diabetes or sub-clinical hyperglycemia sufficient to cause foetal programming towards the development of glucose intolerance in adult life may occur during pregnancy when a woman's pancreatic function is not sufficient to overcome the insulin resistance occurring during pregnancy. Risk of insulin resistance and glucose intolerance even in non-pregnant adult appears to increase once the BMI starts rising more than the middle of the recommended BMI, as discussed earlier. Thus to decrease the risk of even sub-clinical hyperglycaemia during pregnancy leading to foetal programming, the prepregnancy weight of women should be optimum, preferably below the middle of the recommended BMI for the population. In Finland with predominant Europid population the mean prepregnancy BMI of women was 21.9 kg/m^2 in 1960s.[47]

Women who had a child gains more weight than women who remained nulliparous and the pregnancy-associated weight gain is considered one of the major contributors to lifetime weight gain among women, particularly in ethnic groups like African-American.[48,49] A study from one Asian community has shown that such pregnancy-associated weight gain is related to the culture of excessive feeding after delivery or abortion.[50] The second and the subsequent children are, thus, more likely to get exposure to the maternal clinical or sub-clinical hyperglycaemia due to the increased weight of mothers. The population which is following one child policy may have lesser risk of such problem in the second or subsequent pregnancy.

Implications and programmes

Programmes and educational campaign regarding diet and physical activity, as discussed earlier, to keep prepregnancy weight of women optimum, preferably below the middle of the recommended BMI range, is the top priority in any population. The people and couples have also the right to learn about the matter concerning the health of future offspring and the knowledge about the importance of prepregnancy weight itself would motivate women. The culture of excessive feeding after delivery or abortion, if present, needs to be discouraged. Antenatal and postnatal visits to the health care setting can be effectively utilized for such programmes to avoid excess weight gain during and after pregnancy.

CONCLUSION

Diabetes is increasing rapidly in the world with the combinations of gradual, rapid, and accelerated rising patterns in different populations. With its tendency to have accelerated rise once glucose intolerance starts affecting women of childbearing age, diabetes, unlike any other disease, can have very high prevalence in any general population almost becoming its part with difficult to control it later. Thus, considering the rising and potentially self-perpetuating situation of diabetes prevalence, the approach of primary prevention of diabetes, focusing on modest loss of excess weight and moderate-intensity exercise, in people, particularly with impaired glucose tolerance, has to be widened into the concept of control in the community covering the rapid and accelerated rises. There may be many other factors, and controversies, to consider, but the need and possible programmes for the control of diabetes epidemic, particularly in developing countries, are clear.

To achieve the challenging measures the world resources need to be mobilized involving international agencies, like WHO, International Diabetes Federation, United Nations Development Programme (UNDP), United Nations Children's Fund (UNICEF), Food and Agricultural Organization, World Food Programme, World Bank, and other international and national diabetes and obesity associations.[14] Cardiovascular disease alone also accounts for nearly 30% of all deaths worldwide and 27% in low-income and middle-income countries.[51,52] Glucose intolerance is one of the major predisposing factors for deaths due to cardiovascular disease and is rapidly emerging as a global health care problem that threatens to reach pandemic levels by 2030.[6] Any reduction in the prevalence of glucose intolerance will save the much resources required later not only to supply insulin but also to manage the complications like coronary heart disease, stroke, heart failure, kidney failure, blindness, amputation and others reaping the rewards, in the direct and indirect ways, of the international and national resources and efforts mobilized.

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