INTRODUCTION:
Diabetes is one of the most common chronic diseases the world over, and the number of people with diabetes has risen sharply in recent years and has reached epidemic proportions particularly in developing countries like India. Indeed, India with 40 million people with diabetes leads the world with the maximum number in any country and this number is set to increase to 70 million by the year 2025 [1]. This is of particular significance considering that diabetes is frequently not diagnosed until complications appear, and approximately half of all subjects with diabetes remain undiagnosed [2,3]. Diabetes, if left undiagnosed or untreated, may lead to serious long-term consequences and hence it is important to detect diabetes early by screening in order to prevent its micro and macro vascular complications. By early detection of the disorder, we would be able to take therapeutic measures, which will allow us to prevent or at least to delay the complications of diabetes.

This underscores the need for mass awareness and screening programmes to detect undiagnosed diabetes and thus reduce the burden of diabetes in India. Mass screening programmes using blood sugar estimations to cover the whole population are not feasible in a large country like ours with a population of over 1 billion people due to logistic, socio-economic and other constraints. Hence, cost effective tools to selectively screen ‘high risk groups’ for diabetes are urgently needed in order to make diabetes screening cost effective in India. This article focuses on how to detect the millions of people with undiagnosed diabetes in India cost effectively based on research work done by us at the Madras Diabetes Research Foundation, Chennai.

SCREENING FOR DIABETES:
As diabetes particularly its complications affects the public health and health care budgets, early detection of subjects with undiagnosed diabetes is important in reducing the burden of diabetic complications. Apart from the direct costs due to diabetes and its associated complications, the indirect, social and personal costs are incalculable. Unless effective prevention strategies are put into place, the incidence of diabetes will continue to rise adding to the already strained health budgets of nations, particularly developing countries like India.

Screening for type 2 diabetes can be carried out in various ways. Universal screening refers to screening an entire population. Performing universal screening for type 2 diabetes using blood sugar estimations to cover the whole population is neither feasible nor cost effective. Selective or targeted screening is directed at individuals with a high prevalence of risk factors. Opportunistic screening consists of screening people during their visits to, for example, the general practitioner’s clinic.

Cost effective tools to selectively screen ‘high risk groups’ for diabetes are urgently needed in order to make diabetes screening cost effective. Targeted screening with a noninvasive test for initial selection of subjects followed by glucose testing in high-risk individuals only is a more efficient approach. Assessment of risk of undiagnosed type 2 diabetes is commonly used to identify individuals who should be recommended for further biochemical testing. Several risk assessment tools called as ‘diabetes risk scores’ have been developed for this purpose using a combination of demographic, clinical, and sometimes biochemical information [4-7]. The applicability of these risk scores to populations of different ethnic background with different risk factor distribution is uncertain given the differences in ethnic susceptibility, different genetic predispositions, varying degrees of obesity and other cultural differences. There are attempts to develop simple, fast, and noninvasive scoring systems for identification of high-risk subjects. Such an attempt by us lead to the development of a risk score specific to Indian population, called as the Indian Diabetes Risk Score [IDRS].

STEPWISE APPROACH IN THE COST EFFECTIVE SCREENING OF DIABETES:
To cost effectively screen for diabetes at the community level, there are two steps involved. Use of IDRS is the first step to identify individuals at high risk for undiagnosed diabetes to undergo diagnostic testing. Step two involves use of blood test, such as random capillary blood glucose [RCBG] to further narrow
Table 1: Indian Diabetes Risk Score [IDRS] Developed by Dr.V.Mohan & Colleagues, Madras Diabetes Research Foundation, Chennai

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age [years]</strong></td>
<td></td>
</tr>
<tr>
<td>&lt; 35 years</td>
<td>0</td>
</tr>
<tr>
<td>35 - 49</td>
<td>20</td>
</tr>
<tr>
<td>≥ 50</td>
<td>30</td>
</tr>
<tr>
<td><strong>Waist Circumference [Pant size]</strong></td>
<td></td>
</tr>
<tr>
<td>Waist &lt;80 cm [32” female], &lt;90 [36” male]</td>
<td>0</td>
</tr>
<tr>
<td>Waist ≥80 - 89 cm [32”-35”] [female], ≥90 – 99 [36”-39”] [male]</td>
<td>10</td>
</tr>
<tr>
<td>Waist ≥90 cm [36” female], ≥100 cm [40” male]</td>
<td>20</td>
</tr>
<tr>
<td><strong>Physical activity</strong></td>
<td></td>
</tr>
<tr>
<td>Vigorous exercise [regular] or strenuous [manual] labour at home/ work</td>
<td>0</td>
</tr>
<tr>
<td>Moderate exercise [regular] or moderate physical activity at home/ work</td>
<td>10</td>
</tr>
<tr>
<td>Mild exercise [regular] or mild physical activity at home/ work</td>
<td>20</td>
</tr>
<tr>
<td>No exercise and sedentary activities at home/work</td>
<td>30</td>
</tr>
<tr>
<td><strong>Family history</strong></td>
<td></td>
</tr>
<tr>
<td>No family history</td>
<td>0</td>
</tr>
<tr>
<td>Either parent</td>
<td>10</td>
</tr>
<tr>
<td>Both parents</td>
<td>20</td>
</tr>
</tbody>
</table>

| Score: ≥60- Very high risk; 30-50- Moderate risk; < 30 – Low risk |

The validated IDRS has been successfully implemented as a practical screening tool to assess the diabetes risk and to detect undiagnosed type 2 diabetes [9]. Moreover, it also proved suitable in prediction of metabolic syndrome and cardiovascular disease in the South Indian population [10].

**Step 2 - Blood test using Random Capillary Blood Glucose:**

The most scientific tests for screening for diabetes are Fasting Plasma Glucose [FPG] and 2 hour Oral Glucose Tolerance Test [OGTT] [11,12]. However, while these tests are useful for epidemiological studies, they are difficult to do in a community setting on a mass scale. Recently we have reported that the most convenient way to screen large numbers of people is by measuring the Random Capillary Blood Glucose [RCBG]. This has an advantage, that it can be undertaken at any time of the day, does not require a venipuncture, and can even be performed by lay people. We reported that those with RCBG ≥140 mg/dl are most likely to have diabetes while those above 113 mg/dl are likely to have prediabetes i.e., impaired glucose tolerance (IGT) or impaired fasting glucose (IFG). We therefore recommend that all those with RCBG ≥110 mg/dl at initial screening can be recommended to undergo definitive testing by OGTT as this will help to pick up everyone with any glucose intolerance, i.e., diabetes, IGT or IFG [13]. If funds are restricted and we only want to pick up those with diabetes anyone with RCBG ≥ 140 mg/dl can be tested further.

**COST EFFECTIVENESS SCREENING OF DIABETES:**

Compared with the elaborate and expensive standard procedure using standard laboratory tests, the IDRS represents a simple and cost-efficient tool with a good predictive value to detect undiagnosed diabetes, which can be used in large scale epidemiological studies, community health camps and opportunistic screening camps. Of these, opportunistic targeted screening might be a valuable cost effective screening method for diabetes. The pragmatic nature of opportunistic targeted screening enables initiation of further diagnostic testing and treatment of newly diagnosed diabetes.

The stepwise screening approach, i.e., adopting IDRS to identify high risk individuals and thereafter screening for diabetes using random capillary blood glucose could be adopted to screen cost effectively in millions of people. It would thus help to do selective screening instead of universal screening. When in opportunistic screening studies, all those with RCBG ≥110 mg/dl receive more definitive tests for diabetes, this could not only help limit the number of individuals who must arrive for screening in a fasting state but also reduce the costs of screening, as only 60% of those screened would have RCBG ≥110 mg/dl. This could make screening programmes more cost effective as it can reduce the cost by over 50%.

Figure 1 depicts proposed model for cost effective screening of diabetes in India. For example, if we were to screen one lakh population which consists of approximately 50,000 adults in a city using an Oral Glucose Tolerance Test (OGTT), assuming the cost of one glucose estimation including blood collection to be
How to Detect the Millions of People in India with Undiagnosed Diabetes Cost Effectively

IDRS = 60

Information to IDRS (n = 50,000 @ Rs.1.50/IDRS), Rs.4,30,000 for performing OGTT (n = 12,900 @ Rs.200/OGTT), which add up to Rs.30,85,000. Thus there would be a cost saving of almost Rs.69,15,000.

RCBG ≥ 110 mg/dl (which is 60% of the population). If the IDRS is used for screening of diabetes, i.e. use IDRS first and then do a RCBG only on those with score ≥ 60 (which is 43% of the population) and then finally perform an OGTT on those with RCBG ≥ 110 mg/dl (which is 60% of the population). If the IDRS is used in all and screening test is carried out following the step approach, the cost would work out to Rs.75,000 for collecting information on IDRS (n = 50,000 @ Rs.1.50/IDRS), Rs.4,30,000 for performing RCBG (n = 21,500 @ Rs.20/RCBG) and Rs.25,80,000 for performing OGTT (n = 12,900 @ Rs.200/OGTT), which add up to Rs.30,85,000. Thus there would be a cost saving of almost 70%, which in this case is Rs.69,15,000.

A recent programme [14] which was a major break through in screening for diabetes and creating awareness in Chennai, south India, is the PACE [Prevention Awareness Counselling Evaluation] diabetes project. This was one of the largest and most successful community based awareness and screening diabetes programs ever conducted in India and reached nearly 2 million people in Chennai. PACE used the stepwise approach to screen for diabetes and found it to be cost effective. These programmes were organized in schools, colleges, youth organizations, factories and work places, cinema halls, temples, churches, mosques, bus stands, railway station, airport, fairs, shopping complex, banks, training centres and so on to reach out target million of people [15]. The impact and reach of the PACE Diabetes Project is quite substantial and several organizations and institutions have already adopted the “PACE Diabetes Model” and replicated this program.

CONCLUSION:

Stepwise screening approach – the IDRS scoring system and the RCBG testing in high risk individuals could prove to be a cost effective tool for screening of diabetes. Further, use of such a risk score would be of great help in developing countries like India where there is a marked explosion of diabetes and over half of the cases remain undiagnosed. An increasing number of people in their working age are affected by diabetes, increasing the economic burden of the health care system due to an earlier onset of complications, and subsequently, a longer and more intensive medical treatment period. Demographic and epidemiological evidence indicates that unless an effective preventive strategy is developed, there will be a sharp increase in the global prevalence of diabetes. Hence significant efforts should be made to stop or at least show the rise in diabetes. If not health care services across the world will soon be crippled by the costs of treating the disease and its complications. Primary prevention programs aimed at lifestyle modifications have been shown to be successful in delaying or preventing diabetes. The first step in prevention of diabetes is to identify and screen the high risk groups using simple screening tools as described in this article. We hope this would be a suitable model for the Govt. of India’s National Program for Prevention and Control of Diabetes / Cardiovascular Disease and Stroke [16].

REFERENCES


Fig. 1 : Proposed model for cost effective screening of diabetes in India

Whole population 
(N = 1,00,000)

Perform IDRS 
in adults aged > 20 years 
(n = 50,000)

IDRS = 30

IDRS 40 - 50

Lower risk

Moderate risk

High risk

IDRS = 60 
(43% of the population) 
(n = 21,500)

Check random 
capillary blood 
glucose 
(RCBG)

RCBG < 110 mg/dl

No further testing

RCBG ≥ 110 mg/dl 
(50% of the population) 
(n = 12,900)

Recommend to perform Oral Glucose Tolerance Test 
[OGTT] to rule out diabetes or glucose intolerance

CONCLUSION:

Stepwise screening approach – the IDRS scoring system and the RCBG testing in high risk individuals could prove to be a cost effective tool for screening of diabetes. Further, use of such a risk score would be of great help in developing countries like India where there is a marked explosion of diabetes and over half of the cases remain undiagnosed. An increasing number of people in their working age are affected by diabetes, increasing the economic burden of the health care system due to an earlier onset of complications, and subsequently, a longer and more intensive medical treatment period. Demographic and epidemiological evidence indicates that unless an effective preventive strategy is developed, there will be a sharp increase in the global prevalence of diabetes. Hence significant efforts should be made to stop or at least show the rise in diabetes. If not health care services across the world will soon be crippled by the costs of treating the disease and its complications. Primary prevention programs aimed at lifestyle modifications have been shown to be successful in delaying or preventing diabetes. The first step in prevention of diabetes is to identify and screen the high risk groups using simple screening tools as described in this article. We hope this would be a suitable model for the Govt. of India’s National Program for Prevention and Control of Diabetes / Cardiovascular Disease and Stroke [16].

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