Developing a framework for community based screening, risk profiling and assessing the true diabetes burden in South Indian Rural Populations by linking Casual Plasma Glucose and Body Mass Index

Zeena Johar

IKP Centre for Technologies in Public Health (ICTPH)

Chennai, India

Co Authors:

Sunayana Sen

IKP Centre for Technologies in Public Health

Chennai, India

Rajaratnam Abel

IKP Centre for Technologies in Public Health

Chennai, India

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Abstract:

Background:

Worldwide the prevalence of diabetes amongst other chronic diseases is increasing. To facilitate diabetes management in a community setting for rural Indian populations, IKP Centre for Technologies in Public health (ICTPH) conducted a baseline survey, leading to the emergence of their diabetes risk profile.

Methods:

A cross-sectional census survey across three villages in rural Tamil Nadu with a total of 3600 individuals aged above 18 years with Casual Plasma Glucose (CPG) and Body Mass Index (BMI) were made available for analysis. Percentages were used in risk profiling the samples and estimating diabetes prevalence. Using a scatter plot a framework was developed to categorise the samples into nine categories.

Results:

The prevalence of diabetes with CPG >200 mg/dl was 1.5% and that of pre diabetics with CPG 140 - 199 mg/dl was 4.0%. The risk profiling identified three broad groups based on CPG values and with the addition of BMI each group was further classified making a total of nine categories for the total population.

Conclusion:

Estimating CPG coupled with BMI is a cost effective and convenient method of screening large segments of a population to estimate the burden of diabetes and risk profile the population to promote targeted preventive and follow-up strategies.

Introduction:

Worldwide the number of people with diabetes is increasing due to population growth, ageing, urbanization, and increasing prevalence of obesity and physical inactivity with India being no exception. In 2000 India had an estimated 31.7 million diabetics which is expected to increase to 79.4 million by 2030.[1]

As the burden of the diabetes increases there are two areas of concern. Firstly, both diabetic patients and health professionals do not fully comprehend the need for rigid monitoring of individual cases of diabetes especially tight control of blood sugar levels.[2] Secondly, the health system is neither adequately equipped to handle this increasing burden of diabetes with the existing number of primary health centres nor is there adequate training of staff on task shifting to handle the problem of diabetes.[3]

Diabetes prevalence data is now available from different parts of India. Very specific references include data from rural Vellore at 4.9%,[4] a prevalence of 3.67% from Central India.[5] Sandeep et al. have shown that the prevalence of diabetes is increasing over the years.[6] Not only is diabetes increasing but it is manifesting in individuals of a younger age group.[6, 7]

Diabetes constitutes one of the main risk factors of cardio vascular diseases (CVD) along with hypertension and increased levels of cholesterol. People with diabetes are two to six times more likely to develop cardiovascular disease than those without diabetes, at a younger age and having more severe effects**.** CVD is the major complication and leading cause of death in people with type-2 diabetes. The risk is increased even at earlier stages of glucose intolerance.[8]

Changes in lifestyle can provide the benefit of not only preventing type-2 diabetes but also independently reducing CVD risk.[8] There is cumulative knowledge emerging on methods of diabetes prevention with life style modifications as one of the most effective methods especially when the disease is diagnosed early.[9]

The American Diabetes Association (ADA) has set clear guidelines in classifying diabetes. Three different blood tests - fasting plasma glucose (FPG), two-hour plasma glucose and casual plasma glucose (CPG) are possible.[10]

The causal chain listing the major risk factors for CVD, are diabetes, cholesterol and blood pressure with over-weight reported as the prime risk factor for diabetes.[11] This strengthens the hypothesis linking Casual Plasma Glucose (CPG) and Body Mass Index (BMI) for community based screening for type-2 diabetes.

The Indian Diabetes Risk Score (IDRS) with 60% sensitivity has a limited population based application.[12] Using different risk factors either individually or as risk scores by combining a select number of risk factors, it is possible to identify an important category of individuals at high risk, wherein an early intervention can prevent or delay the onset of diabetes.[9]

IKP Centre for Technologies in Public Health (ICTPH), Chennai, India, a not-for-profit research organisation has established a village based qualified-nurse facilitated primary health care delivery model in close conjunction with hamlet based Community Health Workers (CHW). To implement the above mentioned healthcare delivery model three villages namely Karambayam, Nattuchalai and Allakudy were selected in the Thanjavur district of Tamil Nadu, South India. The village selection was

based on the following criteria: population size, distance of village from the nearest town, income level and health service availability, such as the presence of a Primary health Centre (PHC).

Methodology:

A cross-sectional census socio-economic survey was carried out in three selected villages in Tanjore, Tamil Nadu. The survey was conducted from September 15, 2008 to January 28, 2009. Every family in the three villages had an opportunity to participate in the survey. The survey had two components; non invasive and invasive (non-clinical and clinical). The focus of this paper is on the invasive component.

The invasive component of the survey was conducted by two teams of ICTPH, each consisting of one experienced male field coordinator and two female qualified nurses.

All individuals aged 18 years and above were selected for measuring weight, height and CPG besides other clinical measurements not considered for this paper. Informed consent was obtained in writing from the respective person interviewed before clinical examinations were conducted.

CPG was measured with Roche Accutrend Plus using glucose test strips. This device offered quantitative result for CPG concentration directly from capillary blood. The test principle was based on reflectance photometry. The device had to be reset with a new code for every new batch of strips that were used and the nurses were trained to do this every time they started using a new batch of strips.

Weight was measured using the TANITA Personal Scale (Tanita Corporation, Tokyo, Japan), which was kept on a firm horizontal surface and subjects were instructed to take their shoes off and stand upright on the scale. Height was measured with a tape (Bio Plus Stature Meter, 200 cm, Model no. 26SM/1013522). This device was screwed to a wooden block 200 cm long and subjects were requested to stand upright without shoes with their back against the block, heels together and eyes directed forward.

The entire process was supervised and monitored by a public health physician who also taught the nurses the use of the various measuring devices that were used for the survey and gave them clear instructions on every step involved in the procedure.

Data was collected from the three villages; one at a time starting with Nattuchalai followed by Karambayam and ending in Alakkudy. A total of 2150 households were interviewed with the first part of the interview schedule which gave a response rate (RR) of 97%.

All collected data was entered in excel work sheets and different quality control measures were applied including double data entry along with scrutiny checks, checking extreme values and cross checking with the original interview schedules.

There were 9221 individuals covered under the survey. The total population above 18 years was 6780, 3619 individuals reported for both CPG and BMI. A CPG concentration of $\geq$ 40 mg/dl to $\leq$ 525 mg/dl and BMI of $\geq$ 10 to $\leq$ 42 were included for analysis. There were 5 individuals with CPG and 14 individuals with BMI outside the selected range making a total of 19 individuals excluded from further analysis, resulting in a total of 3600 individuals for final analysis.

Statistical analysis: The results are expressed mainly as percentages using standard cut-offs; for diabetes the cut-off set by the ADA and for BMI using the cut-offs recommended by the WHO, the international classification adopted for Asians.[10, 13] Categorization was employed to evolve population profiling by using a combination of different cut offs between CPG and BMI. A scatter plot between BMI and CPG was used to depict the population risk profile for type-2 diabetes. The prevalence rate of type-2 diabetes was calculated based on the CPG value of > 200 mg/dl and the high risk population with a CPG range of 140-199 mg/dl. The analysis was done using SPSS V16 software.

This research was approved by the Institutional Review Board of ICTPH. Participation in the research was voluntary. Informed consent was explained in Tamil the local language and the respondents signed this consent form prior to the survey.

Results:

In the three villages there was a total population of 9221 with 4607 males and 4614 females. The crude birth rate was 13.5 per thousand and the crude death rate was 8.2 per thousand. There were very few deaths reported among children. Cardio vascular diseases, accidents, old age, diabetes and cancer were the commonly stated causes of death. Age and sex distribution of the population 18 years and above with available CPG and BMI included in the study is listed in Table 1.

Table 1: *Age and sex distribution of 3600 individuals in three villages in Thanjavur, Tamil Nadu of age ≥18 years with CPG and BMI values*

Age Group	Male		Female		Persons	
	No	%	No	%	No	%
18-24 Years	163	12.1	243	10.8	406	11.3
25-34 Years	214	15.9	469	20.8	683	19.0
35-44 Years	264	19.6	598	26.5	862	23.9
45-64 Years	518	38.5	711	31.5	1229	34.1
65-98 Years	186	13.8	234	10.4	420	11.7
Total	1345	100.0	2255	100.0	3600	100.0

There were two cut-offs for CPG and BMI used in analysis. The population with a CPG range of 40 mg/dl – <140 mg/dl were classified as normal/low risk, and a CPG of above 200 mg/dl as diabetic.

Population reporting a CPG of 140 mg/dl – <200 mg/dl were classified with high future risk of diabetes.

A BMI range of 18.5 - 23 for Asian populations was used to define the normal weight profile.[13] A BMI range of 10 – 18.5 was used for the current study to classify underweight populations, and a range of 23 – 42 for over-weight populations. As listed in Table 2 a total of nine profiling categories were derived.

Table 2: *Selected cut off values for CPG (range 40 mg/dl – 140 mg/dl) and BMI (range 10.0 - 23.0) for nine risk-profiling categorization for 3600 individuals*

S.No.	*RBS & BMI Categories*	*Total (No.)*	*Total (%)*	*Male (No.)*	*Male (%)*	*Female (No.)*	*Female (%)*
A1	CPG <140 BMI <18.5	832	23.1	294	21.1	538	23.9
B1	CPG <140 BMI 18.5-23.0	1657	46.0	657	48.8	1000	44.3
C1	CPG <140 BMI 23.0-42.0	916	25.4	307	22.8	609	27.0
A2	CPG 140-199 BMI<18.5	35	1.0	14	1.0	21	0.9
B2	CPG 140-199 BMI 18.5-23.0	56	1.6	26	1.9	30	1.3
C2	CPG 140-199 BMI 23.0-42.0	50	1.4	19	1.4	31	1.4
A3	CPG >=200 BMI <18.5	3	0.1	1	0.1	2	0.1
B3	CPG >=200 BMI 18.5-23.0	21	0.6	13	1.0	8	0.4
C3	CPG >=200 BMI 23.0– 42.0	30	0.8	14	1.0	16	0.7
	Total	3600	100.0	1345	100.0	2255	100.0

Table 2 classifies the population initially into 3 broad categories based on CPG cut offs at 140 mg/dl and 200 mg/dl. Those above 200 mg/dl are cases of type-2 diabetes. Those between 140 mg/dl - <200 mg/dl are considered as the high risk group for developing diabetes.

The risk profiling of the population based on BMI and CPG as risk factors for diabetes is shown in Fig. 1. Using the framework of scatter plots nine profiles are created to classify the population based on the CPG and BMI. A3, B3 and C3 categories are the frank diabetes cases with a prevalence rate of 1.5%. A2, B2, C2 define the high risk populations based on CPG with a cut-off of 140-199 mg/dl with a prevalence of pre diabetics of 4.0%. A1, B1, and C1 classify the normal categories based on CPG. B1 is the ideal category with ideal CPG and BMI range.

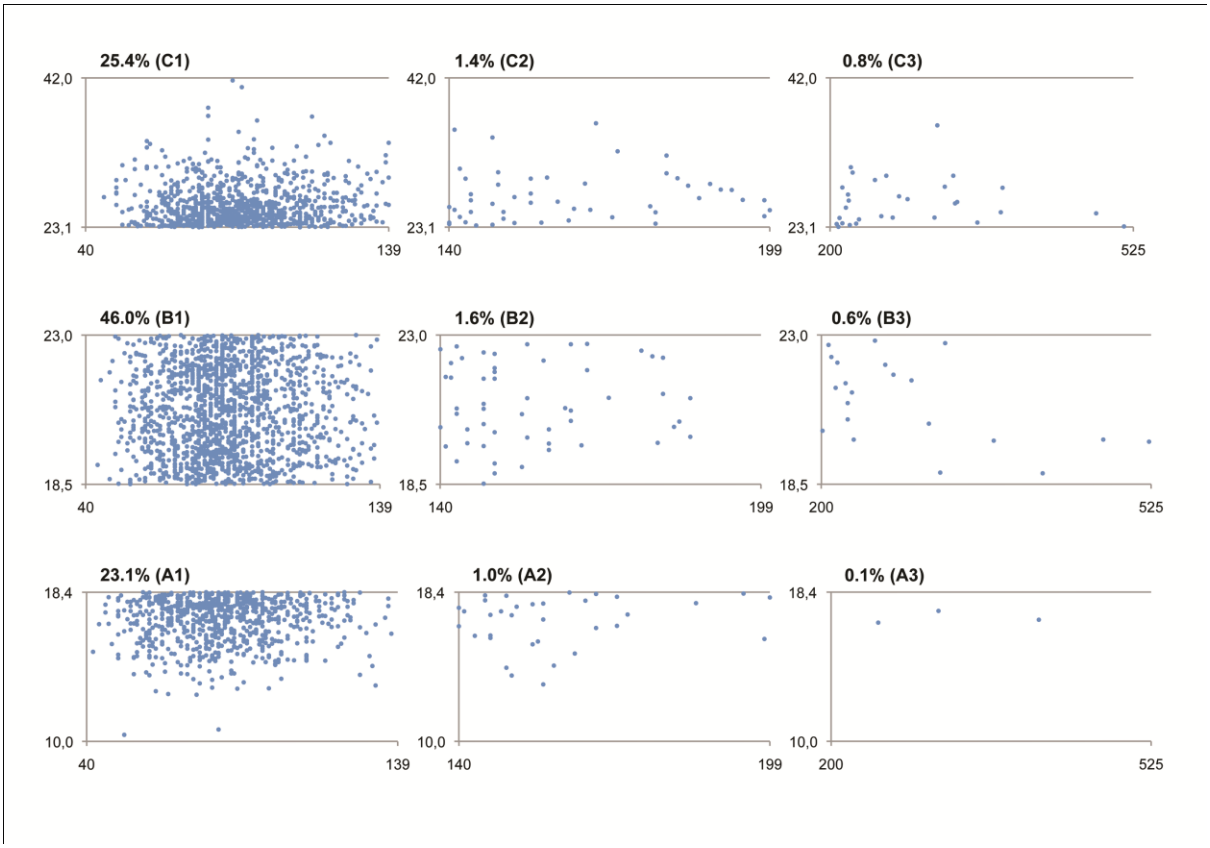

Figure 1*: Scatter plot of 3600 individuals in the three villages in Thanjavur, Tamil Nadu based on BMI and CPG values.* ***X-Axis****: CPG = 40 mg/dl – 525 mg/dl;* ***Y-Axis****: BMI = 10.0 – 42. Nine profiling categories were used.* ***A1:*** *CPG (40 mg/dl – 139 mg/dl) + BMI (10.0 – 18.4);* ***B1:*** *CPG (40 mg/dl – 139 mg/dl) + BMI (18.5 – 23.0);* ***C1:*** *CPG (40 mg/dl – 139 mg/dl) + BMI (23.1 – 42.0);* ***A2:*** *CPG (140 mg/dl – 199 mg/dl) + BMI (10.0 – 18.4);* ***B2:*** *CPG (140 mg/dl – 199 mg/dl) + BMI (18.5 – 23.0);* ***C2:*** *CPG (140 mg/dl – 199 mg/dl) + BMI (23.1 – 42.0);* ***A3:*** *CPG (200 mg/dl – 525 mg/dl) + BMI (10.0 – 18.4);* ***B3:*** *CPG (200 mg/dl – 525 mg/dl) + BMI (18.5 – 23.0);* ***C3:*** *CPG (200 mg/dl – 525 mg/dl) + BMI (23.1 – 42.0)*

Discussion:

This baseline attempted to cover the entire population in measuring the various parameters that contribute to planning an effective health care intervention. Measurements of CPG and BMI were available for 3600 individuals of age 18 years and above constituting 53.7% of the eligible population. This sample was sufficiently large, well spread out between age and sex groups and representative enough to draw valid inferences for further planning.

A number of studies have confirmed comparable sensitivities of CBG and FPG.[14, 15] ADA has accepted CPG along with symptoms of diabetes as an adequate tool to screen a population.[16] The Washington State Department of Health has accepted in their guidelines for general screening for diabetes, symptoms of diabetes plus CPG concentration > 200 mg/dL in addition they have differentiated the use of capillary blood for community level screening and venous blood for individual diagnosis.[17]

This profiling provides an opportunity to stratify the population into different groups requiring targeted interventions. A3, B3 and C3 classify the identified diabetics. A2, B2 and C2 identified as high risk with C2 being at greatest risk of transitioning to the diabetic categories because of the high BMI and CPG. A2 and B2 are also at risk because of elevated sugar levels although without obesity. As per the CPG cut-off population A1, B1, and C1 fall within the acceptable range. B1 is ideal category with both BMI and CPG levels pertaining to the acceptable range. 46% of the population was seen to observe a normal profile.

In the proposed alternate human resource healthcare delivery model group A3, B3 and C3, will ideally receive primary care interventions with the most intensive curative strategies and will require direct nurse management.

With a total prevalence rate of 1.5% for diabetes, A3 population (at a prevalence rate of 0.1%) in particular and additionally B3 population (at a prevalence rate of 0.6%) will require greater follow-up to understand the dynamics of 'lean or normal' type-2 diabetes seen in the Indian populations marked by low BMI.[13]

An effective community based BCC strategy for life style modifications would be promoted striving towards left column transition from A2, B2 and C2 towards B1, with normal CPG and BMI range for Indian populations.[13] A1 and C1 populations require directed BCC strategies towards dietary practices to attain optimal BMI. Though the probability of diseases transition may be relatively lower as compared to the populations in column two wherein outlying BMI values are also coupled with the screened elevated glucose, early targeted life style changes backed by BCC is crucial for minimal long term implication.

In order to derive a community wellness index for type-2 diabetes these nine profiles not only become a tool for categorizing the community for risk profiling leading towards identifying the true disease prevalence which aids appropriate disease management but also become a tool in monitoring the risk profile transition of the population measuring the effectiveness of a given intervention.

In this study information on symptoms and family history of type-2 of diabetes was not obtained. This would have greatly added value in making more definite diagnosis.

This study helps to lay the foundation for obtaining information on incidence of new cases of diabetes as they emerge in a community, specifically as no incidence data on diabetes is available for Asian Indians living in India.[18] The findings also form the basis of introducing effective CVD screening protocols as diabetes is an accepted risk factor involved in CVD.[19, 20]

WHO has predicted that CVD will become the greatest cause of mortality in the world by 2015.[11] Indians would be the most affected among all ethnic populations.[21] Existing Framingham and other similar risk scores have reported to underestimate the risk of CVD morbidity and mortality in Asian Indians. [21, 22, 23]

The framework developed for this project will contribute towards population risk profiling to provide appropriate interventions at the community level. However, additional studies are needed to determine the sensitivity and specificity of this tool before it can be widely applied.

Estimating CPG coupled with BMI is a cost effective and convenient method of screening large segments of a population to estimate the burden of diabetes and risk profile the population to promote targeted preventive and follow-up strategies.

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What is already known?

- Diabetes and over-weight are known risk factors for CVD
- There is no well established diabetes screening/risk profiling tool for Rural Indian populations
- Life style modifications, promoting weight loss, increased physical activity and dietary changes can prevent or delay the onset of diabetes

What this study adds?

- This study establishes CPG coupled with BMI as a cost effective and convenient screening method for diabetic risk of a population
- The presented framework contributes towards population risk profiling for type-2 diabetes leading towards targeted intervention
- This study established the need to further understand the noted dynamics of 'lean or normal' type-2 diabetes for Indian populations

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