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Original Article

High prevalence of prediabetes among the family members of individuals with diabetes. Findings from targeted screening program from south India

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ABSTRACT

Aim: We aimed to screen for prediabetes, diabetes and other cardiovascular risk factors among family members of people with diabetes registered for care in a primary health centre in South India.
Methods: During 2017–2018, we screened eligible family members of individuals with diabetes at their homes. We measured fasting capillary blood glucose (FCBG); for those with FCBG≥126 mg/dl, we confirmed the diagnosis of diabetes with fasting plasma glucose (FPG). We defined prediabetes as FCBG between 100 and 125 mg/dl; diabetes as both FCBG and FPG ≥126 mg/dl. We assessed non-communicable disease risk factors using WHO STEPS questionnaire.
Results: Of total 884 participants, 873 (99%) underwent screening; 280 (32%) had prediabetes, and 19 (2.2%) were confirmed with diabetes. Of newly diagnosed, 17 (90%) were initiated on treatment. Of 873 participants, 180 (20.6%) were newly diagnosed with hypertension. Of the total, 7.3%, 5.2% and 16% reported tobacco use, alcohol use and high salt intake respectively. Nearly half (48%) had overweight.
Conclusion: Though the yield for diabetes is modest (3%), the house to house approach was able to screen 99% of eligible population. High prevalence of prediabetes and undiagnosed hypertension emphasize the need for screening and life style modifications.

1. Background

Diabetes mellitus (DM) is a major health challenge of 21st century and its presence in low and middle income countries (LMIC) poses enormous challenge on their health system. India is home to an estimated 73 million people with diabetes and is next only to China in absolute numbers [1]. Delayed diagnosis predisposes the people with diabetes for acute and chronic complications. World Health Organization (WHO) in its 'Global Action Plan for the Prevention and Control of NCDs 2013–2020' recommends early diagnosis and treatment of diabetes as an effective option to reduce the future risk of cardiovascular disease (CVD) in the community [2]. Also, early diagnosis and linkage with treatment has been recognised as one of the quality indicators in NCD related

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health service delivery. India's 'National Action Plan and Monitoring Framework for Non Communicable Diseases (NCD)'sets a target of halting the raise of prevalence of diabetes by 2025 and also calls for public health campaigns for early detection and treatment of diabetes [3,4]. Hence there is need for developing an effective screening strategy to identify the individuals with diabetes in the community.

The potential options for screening for diabetes includes mass screening, targeted screening and opportunistic screening [5]. Mass screening for diabetes was found to be non-effective in reducing all cause cardio-vascular or diabetes related mortality over ten years and also reported to be less cost-effective by studies from high income countries [6,7]. The National Programme for Prevention and Control of Cancer, Diabetes, Cardio-vascular diseases and Stroke (NPCDCS) in India adopted opportunistic screening of outpatients as a feasible option for screening of diabetes [8]. However, recent studies have shown a huge detection gap in the diagnosis of diabetes in India; more than 50% of estimated cases remain undiagnosed or detected after the end organ damage has occurred [6,9,10].

One of the high risk factor for developing diabetes is the family history of diabetes and also studies suggest that Asian Indians have strong familial aggregation of diabetes compared to the people of other ethnic origin [9,11,12]. The higher risk of diabetes in family members may be due to sharing of genetic and also environmental characteristics like sedentary lifestyle and diet. Compared to other risk groups for diabetes, identifying the family members may require less effort from the health system, as the family is already in contact with the health system for diabetes care. Studies have focused on interventions to educate family members for the care of individuals with diabetes at their home or to educate the family members regarding the risk factors of diabetes. But the screening of family members of individuals with diabetes is less explored [5,13–15]. There is limited literature on yield of targeted screening for diabetes among family members at their home. . One study from Karnataka, India reported poor yield of screening for diabetes among the family members primarily due to difficulties in mobilising them to a health facility for screening [16].Also, studies have reported large drop out between screening test and the subsequent test for confirmation in health facilities [17,18]. Hence screening for diabetes in a high risk group and confirmation at their home itself may increase the proportion of newly diagnosed diabetes. Thus in this study, among adult family members (more than 30 years of age) of individuals with diabetes who are registered in NCD clinics of a selected Primary Health Centre of Puducherry we tried to determine a) the number and proportion eligible and screened for diabetes b) the number and proportion newly diagnosed with diabetes c) the number and proportion newly diagnosed with prediabetes d) the socio demographic, anthropometric and behavioural characteristics associated with prediabetes.

2. Methods

2.1. Study design

This is a cross sectional descriptive study among family members of individuals with diabetes.

2.2. Study setting

The study was carried out in the service areas of a primary health centre (PHC) located at Villianur, Puducherry. Puducherry is a Union Territory located in Southern part of India with literacy rate of 85.4%. Prevalence of type II diabetes ranges from 5.8% to 9.0% in Puducherry [19–21].

The PHC functions round the clock and caters to a population of 77,000. The non-communicable disease (NCD) clinic runs two days in a week and is manned by one medical officer, 3–4 medical interns, a staff nurse, a medical social worker and a pharmacist. Laboratory services for estimating blood glucose (random, fasting and post prandial blood glucose) are available at PHC. All the services including drugs and laboratory tests are provided free of cost. For investigations like lipid profile, renal function tests, ECG and fundus examination, these patients are referred to community health centers and tertiary care centers.

There were few on-going screening activities for DM in the study setting during the time of study. As part of the national program (NPCDCS), opportunistic screening for diabetes was offered for the outpatients of the PHC since 2017. Also, outreach screening was conducted at the level of urban blocks in mobile vans where in screening for diabetes and hypertension was carried out on fixed days by camp approach.

2.3. Study population

All adult (above 30 years of age) family members residing in the same house as that of the individual with diabetes were included. All these individuals with diabetes were registered in PHC for DM care. The family members should have stayed in the selected house for at least last six months and shared a common kitchen with the individual with diabetes. Those family members who were screened for diabetes in the past one year and known case of diabetes and pregnant women were excluded.

2.4. Sample size

We calculated minimum sample size of 811 individuals to be screened, assuming proportion of newly diagnosed diabetes among family members as 5%, relative precision of 30% and 95% confidence level. We included consecutive individuals with diabetes as per their attendance at the clinic and their family members for the study between November 2017 and March 2018.

2.5. Data variables, sources of data and data collection

About 950 individuals with diabetes were registered for care in NCD clinic of the PHC and 100 to 150 individuals visit the NCD clinic per day for diabetes care. We have visited PHC in the first and third week of November 2017 and approached the individuals with diabetes and consent was obtained for screening his/her family members for diabetes. We visited their home and listed all eligible family members. Each family member was interviewed separately. Information on socio-demographic, behavioural characteristics and on co-morbidities was collected using WHO's STEPS questionnaire [22]. Anthropometric measurements like height using wall mounted height measuring tape, weight using bathroom weighing scale (Easycare: EC-3333)and waist and hip circumference using non-stretchable inch tape were measured as per WHO STEPS survey guidelines. Body Mass Index, waist circumference and hip circumference were categorized according to WHO classification for Asian population [23,24]. Blood pressure was measured using digital sphygmomanometer (Omron HEM7121). Two readings were taken 5 min apart and the average value was recorded [22]. Convenient day (within 3 days from the first visit) for estimation of Fasting Capillary Blood Glucose (FCBG) was asked from each of the family member and they were explained about overnight fasting for minimum of 8 h for FCBG estimation.

Fasting Capillary Blood Glucose (FCBG) was estimated using standardized digital glucometer (FreeStyle Optium, Abbott Laboratories, UK) by capillary finger prick method during second visit

[8]. Those individuals with FCBG value 126 mg/dl or above were advised for fasting plasma glucose (FPG) measurement within three days. FPG was measured during third visit and glucose level was estimated using auto analyser using glucose oxidase method in a laboratory situated in the nearby tertiary care institute. FPG value of 126 mg/dl or above in the second test was considered as diagnosis of diabetes and those participants were referred to the PHC for treatment initiation. Status of treatment initiation was ascertained through a phone call to study participants after two weeks. For those who were not started on treatment at two weeks from diagnosis, call was repeated at one month. Also, we confirmed medical records for those who reported treatment initiation. For the purpose of analysis, we considered FCBG between 100 and 125 mg/dl as pre-diabetes and initiation on anti-diabetic medication within a month of diagnosis as 'treatment initiated'.

Family members who were not available during the house visits were visited again for inclusion in the study. Those who were not available even after two house visits were considered as 'non-response'.

2.6. Data entry and statistical analysis

Data was single entered in Epicollect5 software (Imperial college of London) and analysed in Stata 12.0 (StataCorp, College Station, Texas, USA) software. Socio demographic characteristics like age group, gender, education and marital status were expressed as proportion. Number of eligible participants screened, number of prediabetes identified, number newly diagnosed with diabetes and number initiated on diabetes treatment were summarized as proportion with 95% confidence interval. We assessed possible association of prediabetes with socio-demographic characteristics, hypertension and anthropometry using prevalence ratios with 95%

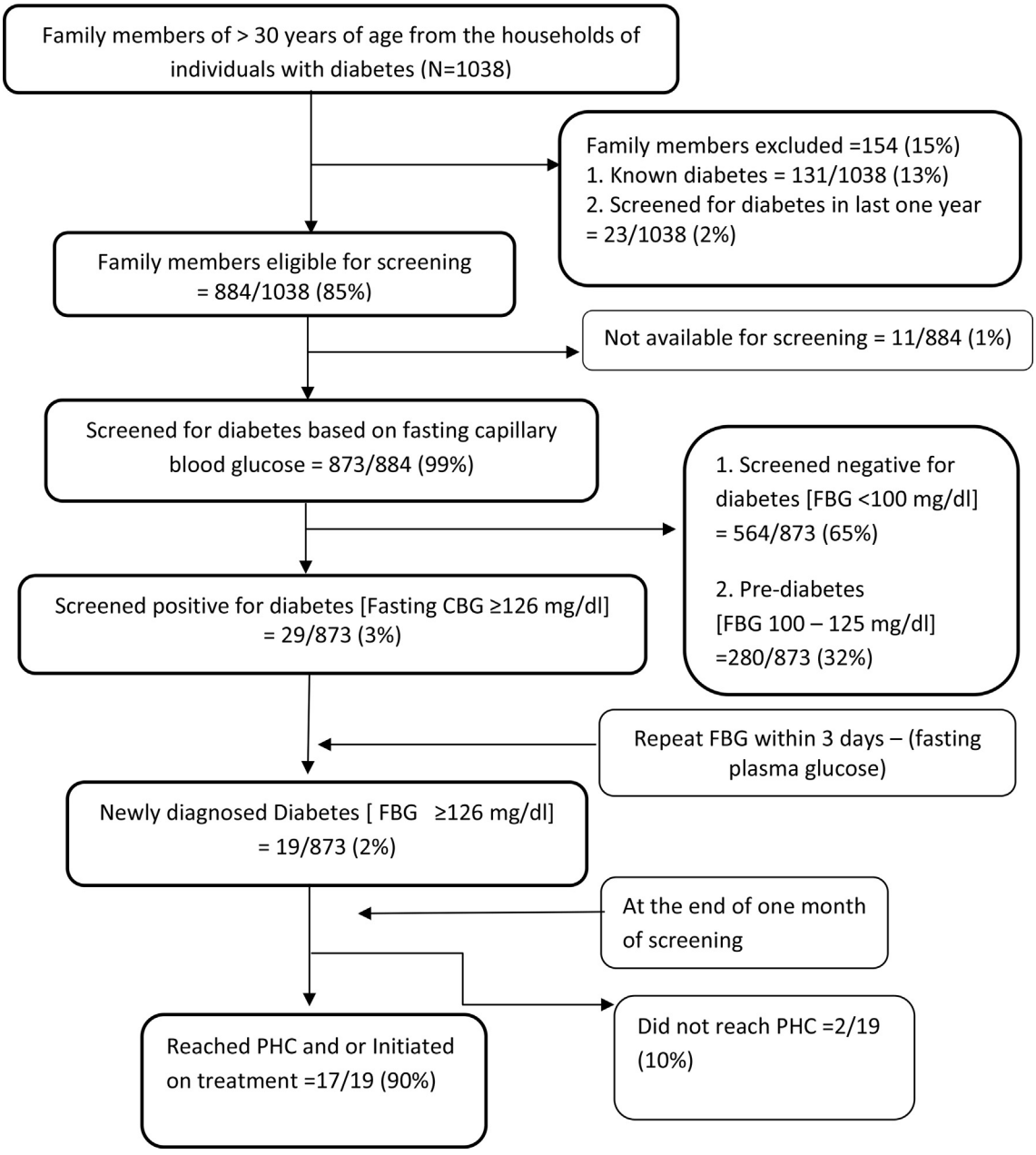

Figure 1. Flow diagram for selection and screening of study participants for diabetes.

CI. Analysis to identify factors associated with presence of diabetes was not done due to small number of newly diagnosed diabetes. Number needed to diagnose one individual with diabetes was calculated by dividing the number of confirmed cases by number of family members eligible for screening.

Ethics approval

The study protocol was approved by Institutional Ethics Committee of the Sri Venkateshwaraa Medical College Hospital and Research Centre, Puducherry, India, and the Ethics Advisory Group of the International Union Against Tuberculosis and Lung Disease, Paris, France. Informed written consent was obtained from the individuals with diabetes and family (>30 years of age) members.

3. Results

A total of 400 individuals with diabetes were approached for the study. Of them 254 (63.5%) individuals with diabetes receiving care at PHC were eligible and gave consent to contact their family members. Of the remaining 146 individuals, 25 (6.2%) were not eligible for the study as they were not living with their family, 85 (21.2%) were not able to trace as we were not able to identify their house and 36 (9%) did not give consent for the study. Of 254 individuals, 143 (56%) were on diabetes treatment for more than five years. We listed 1038 family members aged above 30 years residing with the individuals with diabetes.

Of the 1038 family members, we excluded 154 participants for screening; 131 (12.6%) were already diagnosed with diabetes and 23 (2.5%) were screened in the past one year. Of remaining 884 participants, 873 (99%) underwent screening for DM. Flow of participants is shown in Fig. 1. Mean (SD) age of the those underwent screening was 46 (13) years and 63% were women. Nearly 60% of the participants had received formal education and 71% were living below poverty line. Socio-demographic characteristics of study participants are described in Table-1.

Of the 873 individuals screened with FCBG, 280 (32%; 95%CI: 29.0–35.3) had prediabetes and 29 (3%; 95%CI: 2.2–4.7) were screen positive (≥126 mg/dl). Of the 29 screen positive individuals, 19 (2.2%; 95%CI: 1.3–3.4) were confirmed to have diabetes by FPG and 17 (90%) were initiated on treatment. The NNS to get one screen positive DM was 30 and number needed to diagnose (confirm) one individual with diabetes was 46. Overall prevalence of DM among family members was 14.4% (95% CI: 12.4–16.7).

Prevalence of other cardiovascular risk factors is shown in Table-2. Of total, 7.3% reported tobacco use in last one month; 5.2% were current alcohol users and 16% reported high salt intake. Nearly half of participants (48%) had BMI ≥ 25 kg/m2 (obese) and 97% had high waist circumference. Of 873 participants, 41 (4.7%) were known hypertensives and 180 (20.6%) were newly diagnosed during the survey.

Prevalence of prediabetes in various subgroups is shown in Table-3. Prevalence was significantly higher among individuals reporting alcohol use, high salt intake, adequate intake of fruits and vegetables and among individuals with hypertension and obesity.

4. Discussion

In our study, the coverage of targeted screening among family

Table 1
Socio-demographic characteristics of family members of diabetes subjects from a selected primary health centre, Puducherry, 2017–2018.

Socio demographic characteristics	Number (%)
Total number of participants	873
Age in years Mean (SD)	45.5 (13.1)
31–45 years	514 (58.9)
46–50 years	97 (11.1)
>50 years	262 (30.0)
Gender	
Male	325 (37.2)
Female	548 (62.8)
Education	
No formal education	332 (38.0)
Less than primary or primary completed	94 (10.8)
Secondary completed	268 (30.7)
Higher secondary completed	73 (8.4)
Graduate or post graduate completed	106 (12.1)
Occupation	
Unemployed	124 (14.2)
Employed	366 (41.9)
Home maker	383 (43.9)
Marital status	
Never married	37 (4.3)
Currently married	765 (87.6)
Widowed or divorced	71 (8.1)
Socio economic status *	
Above poverty line	257 (29.4)
Below poverty line	616 (70.6)

*Classified based on the type of ration card available in the family.

Table 2
NCD risk factors of family members of diabetes subjects from a selected primary health centre, Puducherry, 2017–2018.

Selected NCD risk factors	Number of individuals (%)
Total number of participants	873
Tobacco use in last one month	
Yes	64 (7.3)
No	809 (92.7)
Alcohol use in last one year	
Yes	45 (5.2)
No	2828 (94.8)
Physical activity[a]	
Low	400 (45.8)
Moderate	300 (34.4)
High	173 (19.8)
Minutes spent in sitting Median (IQR)	180 (120–300)
High salt intake[b]	
Present	141 (16.2)
Absent	732 (83.8)
Fruits intake[c]	
Adequate (≥5 servings)	338 (38.7)
Inadequate (<5 servings)	535 (61.3)
Vegetables intake[c]	
Adequate (≥5 servings)	508 (58.2)
Inadequate (<5 servings)	365 (41.8)
Hypertension	
Present[d]	221 (25.3)
Absent	652 (74.7)
Body Mass Index (kg/m^2)	
Underweight (<18.0)	14 (1.6)
Normal (18.0–22.99)	339 (38.8)
Pre-obese (23.0–24.99)	99 (11.3)
Obese (≥25.0)	421 (48.2)
Waist Hip Ratio[e]	
Normal	39 (4.5)
High	834 (95.5)
Waist Circumference [f]	
Normal	31 (3.5)
High	842 (96.5)

[a] International Physical Activity Questionnaire scoring.
[b] High salt intake – consumption of high salt containing food like pickle, dried fish and or addition of extra salt during consumption.
[c] One serving is equal to 80 g of fruits or vegetables.
[d] Includes the known hypertensives and those who are newly diagnosed during screening.
[e] Waist–hip ratio cut-off points: 0.90 for men and 0.80 for women.
[f] Waist circumference cut-off points: 85 cm for men and 80 cm for women.

Table 3
Socio-demographic and selected NCD risk factors associated with diagnosis of prediabetes among family members of individuals with diabetes from selected primary health centers of Puducherry, 2017–2018.

Socio demographic characteristics	Total[c]	Diagnosed with prediabetes, n (%)	Unadjusted PR (95% CI)	Adjusted PR (95% CI)
Total number of participants	844	280 (33.2)	–	
Age in years				
Mean (SD)	844	45.5 (13.0)	1.00 (0.99–1.01)	–
Gender				
Male	316	106 (33.5)	1.02 (0.84–1.24)	–
Female	528	174 (32.9)	1	
Education				
Illiterate	321	89 (27.7)	1	
Literate	523	191 (36.5)	1.32 (1.07–1.62)[b]	1.13 (0.92–1.39)
Occupation				
Unemployed	120	45 (37.5)	1	
Employed	355	121 (34.1)	0.91 (0.69–1.19)	–
House wife	369	114 (30.9)	0.82 (0.62–1.09)	
Marital status				
Never married	37	12 (32.4)	1.0 (0.62–1.61)	–
Currently married	742	241 (32.5)	1	
Widowed or Divorced	65	26 (40.0)	1.25 (0.91–1.71)	
Socio economic status [a]				
Above poverty line	241	184 (30.5)	1.30 (1.07–1.59)[b]	1.28 (1.06–1.54)[b]
Below poverty line	603	96 (39.8)	1	
Selected NCD risk factors	Total[e]	Diagnosed with diabetes, n (%)	Unadjusted PR (95% CI)	Adjusted PR (95% CI)
Total number of participants	844	280 (33.2)	–	
Tobacco use in last one month				
Yes	60	50 (83.3)	2.84 (2.42–3.32)[d]	2.54 (2.12–3.05)[d]
No	784	230 (29.2)	1	
Alcohol use in last one year				
Yes	42	20 (47.6)	1.47 (1.05–2.05)[d]	1.06 (0.74–1.53)
No	802	260 (32.4)	1	
Physical activity[f]				
Low	380	132 (34.7)	1.02 (0.79–1.31)	
Moderate	294	90 (30.6)	0.90 (0.68–1.18)	
High	170	58 (34.1)	1	
Minutes spent in sitting Median (IQR)	180 (120–300)	180 (120–300)	1.00 (0.99–1.00)	
High salt intake				
Present	137	70 (51.1)	1.72 (1.41–2.10)[d]	1.32 (1.07–1.65)[d]
Absent	707	210 (29.7)	1	
Fruits intake				
Adequate (≥5 servings)	325	133 (40.9)	1.44 (1.20–1.75)[d]	1.04 (0.83–1.30)
Inadequate (<5 servings)	519	147 (28.3)	1	
Vegetables intake				
Adequate (≥5 servings)	484	198 (40.9)	1.80 (1.44–2.23)[d]	1.51 (1.12–2.03)[d]
Inadequate (<5 servings)	360	82 (22.8)	1	
Hypertension				
Present	207	78 (37.7)	1.19 (0.96–1.46)	1.15 (0.94–1.40)
Absent	637	202 (31.7)	1	
Body Mass Index				
Underweight	14	6 (42.9)	1.49 (0.80–2.80)	1.32 (0.72–2.43)
Normal	331	95 (28.7)	1	
Pre-obese	97	40 (41.2)	1.44 (1.07–1.92)[d]	1.24 (0.93–1.67)
Obese	402	139 (34.6)	1.20 (0.97–1.50)	0.94 (0.75–1.17)
Waist Hip Ratio				
Normal	39	11 (28.1)	1	
High	805	269 (33.4)	1.18 (0.71–1.97)	
Waist Circumference				
Normal	30	8 (26.7)	1	
High	814	272 (33.4)	1.25 (0.69–2.29)	

High salt intake – consumption of high salt containing food like pickle, dried fish and or addition of extra salt during consumption.
† One serving is equal to 80 g of fruits or vegetables.
‡ Includes the known hypertensives and those who are newly diagnosed during screening.
£ Waist–hip ratio cut-off points: 0.90 for men and 0.80 for women.
β Waist circumference cut-off points: 85 cm for men and 80 cm for women.
[a] Ration card.
[b] P value < 0.05.
[c] Number of family members screened.
[d] P value < 0.05.
[e] Number of family members screened.
[f] International Physical Activity Questionnaire scoring.

members was good. Nearly one thirds (32%) were diagnosed with pre-diabetes, one fifths with hypertension and small percentage with DM. About 16% of participants reported high salt intake and nearly half of them were obese.

In the current study, overall prevalence of DM among family members was 14.4%. A study from the same setting in general population aged 20 years and above reported prevalence of about 8.5% clearly indicating the family members have higher risk of having DM [25].

We followed a strategy of home-based screening of family members of individuals with DM who were registered at a primary health centre. This strategy proved to be useful in two ways. First, the coverage of screening among family members was nearly 100%. Second, 90% of newly diagnosed were initiated on treatment as one member of the family was on DM care already. Though the yield was low, considering the advantage of high coverage in this known high-risk group, this strategy can be adopted in the program setting.

In a study in the state of Karnataka, facility based targeted screening among family members was conducted. One family member per registered DM patient was invited to a tertiary care hospital for screening. Though the yield of DM was 9.3%, coverage for even one family member was only 65% [16].

A recent nationally representative study (ICMR-INDIAB study) reported prevalence of prediabetes as high as 14.6% in general population [26]. We detected one third of family members with pre-diabetes which was twice as high as that of general population. Considering the annual progression rate to DM as 5–10%, this group needs to be followed up for screening on a priority basis [27–29]. Successful adoption of life style modifications among prediabetes can lead to 40–70% relative reduction in DM conversion [30–32]. With high levels of obesity and pre-diabetes in the family members with inherent risk of developing diabetes, there is need for empirically recommending all family members of individuals with DM to follow life style modification and this requires training of primary care physicians and frontline workers.

Hypertension in spite of being a common co-morbidity with DM, is often left undiagnosed. In our study, one fifth of family members were newly diagnosed with hypertension. Under the national program (NPCDCS), anti-hypertensive drugs are available at primary health centers and linking these individuals to care will prevent or delay related disease complications.

We faced few challenges in this study. During the data collection period, a rumor was being circulated through social media message in the study area, HIV/AIDS was being spread by unknown people in the pretext of diabetes screening. Though the individuals with diabetes knew and recognised us, other family members were afraid to give blood samples. We overcame this hurdle by involving Auxiliary Nurse Midwifes from the subcenter, providing official identity cards for field research staffs and furnishing permission letter from the local health authority (Director of health and family welfare department) at the time of data collection. Another challenge we faced was transporting blood samples from the field to the laboratory. The blood glucose values drop by 5–7% per each hour after collection. Even addition of anticoagulants cannot prevent glucose loss due to glycolysis during first 2 h [33,34].As the tertiary care centre laboratory was located within 2 h from the study area; and dedicated staff and transport facility were available, this situation was manageable in this study. These challenges have to be considered while implementing or replicating this study in program implementation mode.

The study has the following strengths. First, the response rate for screening for DM was very high (99%). Approaching the study participants through their family member who is already in contact with the health system for care for diabetes under NPCDCS, repeated contacts either in person or through phone, notifying in advance and contacting them on their convenient day and time would have aided in increasing the response rate. Second, we used plasma glucose for confirming the diagnosis of diabetes and we followed internationally accepted definitions for diabetes and pre-diabetes. Third, we followed globally accepted guidelines (STEPS) for assessing the cardio vascular risk factors.

The study has few limitations. The study was carried out in single primary health centre in southern part of India and the results cannot be generalized to other settings. The selected PHC is located in urban area of Puducherry with two tertiary care institutes situated within 10 km. All the wards are well connected with all the health centers through road. These wards also serves as service areas for urban health training centre for both of the teritary care institutes with ongoing routine care. Estimates of yield could higher or lower in other settings based on past screening activities and its coverage. We could not differentiate Type 1 and Type 2 diabetes because of the screening strategy adopted.

This study shows the high response rate and feasibility achieved through home based screening. However, in a high load NCD clinic setting whether this approach is feasible under programmatic settings has to be explored in further. Recently, various states have explored the feasibility of training Community Health Volunteers (CHVs) in screening against NCDs. If this strategy is successful, even under programmatic settings this home based screening might be feasible.

To conclude, one out eight family members had diabetes. Though the yield of home-based screening for DM was low, the screening coverage was high. This screening strategy was beneficial in detecting large numbers of pre-diabetes and hypertensives.

Criteria for inclusion in the authors'/contributors' list

Gomathi Ramaswamy[1*]: Guarantor, involved in designing, literature search, data acquisition, data analysis, statistical analysis and manuscript preparation.

Palanivel Chinnakali[2]: Involved in designing, concept, manuscript preparation and manuscript editing.

Sriram Selvaraju[3]: Involved in designing and manuscript review.

Divya Nair[1]: Involved in literature search and data acquisition.

Pruthu Thekkur[4]: Involved in designing, concept, manuscript preparation and manuscript editing.

Kalaiselvi Selvaraj[5]: Involved in designing, concept, manuscript editing and manuscript review.

Roopa Shivashankar[6]: Involved in manuscript editing and manuscript review.

Akash Ranjan Singh[7]: Involved in designing and manuscript review.

Halevoor Nanjundappa Vrushabendra[1]: Involved in designing, manuscript preparation and manuscript editing.

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