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ORIGINAL ARTICLE

Screening for coronary heart disease and diabetes risk in a dental setting

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Abstract
Objectives Diabetes mellitus (DM) and heart disease, among the most prevalent chronic conditions worldwide, are increasing among younger adults who are unaware of their risk status. Previous studies in the United States have shown the efficacy of screening for risk of heart disease and diabetes in a dental setting. A screening strategy was applied to facilitate early identification of individuals at increased disease risk in a single Indian dental institute.
Methods 158 patients >30 years old, with no reported heart disease or diabetes, and unaware of any increased disease risk were enrolled. Blood pressure, total cholesterol, high-density lipoprotein levels and body mass index were collected. The Framingham Risk Score (FRS) was calculated as an indication of global risk of developing a coronary heart disease (CHD) event within 10 years; hemoglobin A1c level was used to determine DM risk.
Results Eleven percent had increased risk of heart disease (FRS >10 %) and 32 % had abnormal A1c levels (>5.7 %). At least one risk factor was present in 61 and 39 % presented with two or more risk factors. Hypertension and obesity were the most common risk factors.
Conclusions The use of a dental setting in a developing country could serve as a resource for early identification of patients at increased risk of developing CHD and DM, yet unaware of their increased risk. The dental setting can also serve as an entry point into the medical care system by identifying asymptomatic patients at increased risk of disease and referring these individuals to a primary care provider.

Keywords Risk assessment · Screening · Diabetes mellitus · Coronary heart disease · Dental setting · Framingham risk score · Hemoglobin A1c

Introduction

Diabetes mellitus (DM) and cardiovascular disease (CVD) are among the leading causes of death and disability worldwide. A large proportion of both these diseases are preventable, yet they continue to rise primarily because preventive measures to control risk factors are inadequate. Mortality data from the World Health Organization (WHO)

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for 2008 show an estimated total of 17 million deaths from CVD with an estimated increase to 23 million by 2030 (World Health Organization). Among deaths due to cardiovascular disease, coronary heart disease (CHD) is responsible for 53 % of the associated mortality (American Heart Association Writing Group. Heart disease and stroke statistics 2009). Currently, 80 % of the cardiovascular disease burden is occurring in developing countries (Gaziano et al. 2006a). In developing countries about half the deaths due to CHD occur in patients younger than 70 years compared to 22 % in developed countries, (Gaziano et al. 2006b; Shah and Mathur 2010) making death due to heart disease a significant public health concern for the adult population.

In India, cardiovascular disease is among the largest contributors of mortality with 30–40 % of the deaths attributed to cardiovascular disease (Gupta 2008a). The prevalence and mortality rates of CHD vary among different studies and geographic locations in India and are reported to be between 7–13 per cent in urban areas and 2–7 percent in rural areas (Gupta 2008a). The actual burden may be higher as there are multiple factors which hamper the estimation of the actual burden of CHD in India such as absence of a surveillance program to track the incidence, lack of cause specific mortality data, lack of a large epidemiologic studies, absence of a centralized death registry and irregularities in completion of death certificates (Sharma and Ganguly 2005; Xavier et al. 2008).

The worldwide prevalence of DM among all ages was estimated to be 2.8 % for 2000 and is expected to increase to 4.4 % by 2030 based on data from WHO's global burden of disease study and predicted demographic changes (Wild et al. 2004); 366 million people are estimated to have DM as of 2011 and this is expected to rise to 552 million by 2103 (International Diabetes Federation). The greatest increase in DM prevalence is expected in low-income countries with an estimated increase of 92 % followed by middle-income countries with an estimated 52 % (Wild et al. 2004). Eighty percent of people with DM live in low- and middle-income countries and the greatest number of people with diabetes is between 40 and 59 years of age (International Diabetes Federation). New figures for diabetes prevalence in India suggest a rapidly growing epidemic with an increase from 31.7 million people in 2000 to 62.4 million people in 2011. Estimates for 2030 also suggest an additional 77.2 million people will be prediabetic (Anjana et al. 2011).

The underlying disease risk factors are similar for cardiovascular disease and diabetes, with diabetes itself being a significant risk factor for cardiovascular disease. The well-recognized modifiable risk factors including abnormal lipid levels, smoking, presence of hypertension, diabetes, and abdominal obesity, low fruit and vegetable consumption, low alcohol consumption, and lack of physical activity have been identified in countries of all income levels (Yusuf et al. 2004; Mora et al. 2007; Panwar et al. 2011).

Furthermore, a substantial proportion of individuals with identified risk factors for heart disease and diabetes are undiagnosed or inadequately treated because of factors such as economic status, insurance. In the United States, data suggest that depending on the specific risk factor of interest, the undiagnosed prevalence of disease ranges from 20 to 80 %. Approximately, 50 % of people worldwide with DM are undiagnosed (International Diabetes Federation) and a significant percentage of the population are pre diabetics. The undiagnosed prevalence is likely to be similar or even greater in India and other low- to middle-income countries.

Primary and secondary prevention activities aimed at modifying well-recognized risk factors associated with these diseases (e.g., high blood pressure, high cholesterol, and overweight/obesity) have resulted in substantial reductions in disease-specific incidence, morbidity and mortality (Balducci et al. 2010; Mensah et al. 2005). Effective disease screening requires the existence of well-validated, simple, safe and effective screening techniques. For CHD, the Framingham Risk Score (FRS) is among the most widely recognized and well-validated heart disease risk screening tools (D'Agostino et al. 2001; Versteylen et al. 2011). For DM, the hemoglobin A1c has been endorsed as a well-validated tool for use in a routine health care setting for screening and diagnosis of DM (Saudek et al. 2008).

Using these well-validated screening tools, previous studies by our co-authors in the United States have shown that dentists could play a significant role in identifying patients at increased risk of developing disease, yet unaware of their increased risk (Glick and Greenberg 2005; Greenberg et al. 2007). Among male patients older than 40 years of age with no history or medication use for heart disease and who had not seen physician in the previous year, 17 % of those screened had an increased global CHD disease risk based on the FRS (Greenberg et al. 2007); 21 % had an abnormal hemoglobin A1c level (personal communication, B. Greenberg). The current trends suggest a rise in these conditions in young adults. However, there is a lack of consensus and guidelines on the general age to begin screening. Using the dental setting as a resource for early identification of asymptomatic patients at increased risk of developing CHD and DM who could benefit from medical interventions could be an added component of public health strategies to combat these growing epidemics in low- and middle-income countries where professional and financial health care resources are constrained.

The objective of the current demonstration project was to show the efficacy of applying a modification of the chair side screening strategy previously used to a dental clinic setting in India to determine the utility of using the dental setting in a low- to middle-income country as a means of identifying CHD and DM disease risk in an asymptomatic adult population using existing tools that are easily accessed.

Methods

All procedures were in accordance with ethical standards of Vydehi Institute of Dental Sciences and Research Center, Bangalore, India and the University of Medicine and Dentistry of New Jersey (UMDNJ), Newark, NJ, USA.

Vydehi Institute of Health Sciences is a premier network of academic medical, dental, nursing, physiotherapy, biotechnology and oncology centers. It is a resource for a full range of highest quality healthcare from primary care to the most advanced specialty treatment. Vydehi Institute of Dental Sciences and Research Center caters to the needs of patients from urban and rural areas of south and north India. The dental college and hospital is located in close proximity to International Technology Park Limited (ITPL/ITPB) and caters to needs of urban population. Bangalore is also known as the Silicon Valley of India and has a lot of immigrants from different parts of India who have relocated because of work. The institute also caters to dental needs of approximately 20–25 surrounding villages. The hospital has a satellite center which runs in a rural area. In the satellite center, they perform emergency dental procedures and refer the patients to the hospital for further treatment. The university also conducts dental camps with a well-equipped mobile dental unit in surrounding rural areas. Adjacent to the university, there is a highly reputed Satya Sai Super speciality Cardiac, Neurology and Neurosurgery hospital which provides free treatment to patients from across the country. Hence, a lot of north Indian patients along with their relatives come to the hospital for treatment. These patients and their relatives come to the dental clinic for routine checkups. Approximately 30–40 % of our patients are from north India.

The study population comprised adult patients seen in the Oral Medicine Clinic at the Vydehi Institute of Dental Sciences. Screening began in June 2008 and took place twice a week during a 7-month period. The screening of patients took place during routine dental examination. The regular dental examination took approximately 15 min. The patients were then recalled for the consent, screening, questionnaire, blood pressure recording, and blood tests which were conducted twice a week. This visit lasted approximately 45 min. A total of 562 patients were screened for eligibility and a total of 158 eligible patients were enrolled for screening; written consent was obtained for all study participants. Inclusionary criteria included 30 years or older; no reported history of heart disease, hypertension or medication use for hypertension; no reported history of heart attack, stroke, diabetes, high blood pressure or high cholesterol levels.

Data collection included blood pressure measurements, laboratory measurement of total cholesterol levels, and high-density lipoprotein levels, and participants' completion of a cardiovascular disease risk screening questionnaire that has been previously validated and used (Greenberg et al. 2007). A single investigator recorded the blood pressure at the same time in the morning and in accordance with JNC VII guidelines (Chobanian et al. 2003). All patients were asked to come on fasting, for the blood samples. All the blood samples were collected by two lab technicians and tested immediately at the Vydehi Institute Central Diagnostic Lab at the same time in the morning for total cholesterol levels and high-density lipoprotein levels. The FRS was calculated for each participant using a computer-based program. It was a proprietary excel program based on FRS scoring logarithm (Sullivan et al. 2004) that was validated against the freely available link from the National Heart, Lung and Blood Institute to calculate the FRS.

The prevalence of risk factors (hypertension, hypercholesterolemia, low levels of high-density lipoprotein, obesity, and smoking history) was determined for each person. For each participant, the risk factor burden was categorized into zero, one, two, or three or more risk factors present. A FRS of >10 % is considered a moderate, above-average risk and ≥ 20 % is considered a high risk for developing a CHD disease event within the next 10 years. Clinically abnormal risk factor levels were as follows: elevated systolic blood pressure (≥ 140 mm of mercury), elevated total cholesterol level (≥ 240 mg/dL), below normal high-density lipoprotein level (HDL) (≤ 40 mg/dL) and obesity as body mass index (BMI) >30 (Chobanian et al. 2003; Vasan et al. 2005; Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults 2001). Hemoglobin A1c levels of >5.7 % were considered abnormal per published criteria by the American Diabetes Association. The lab results were available in 1–2 days. The cost of the tests was approximately Rs 375 ($8). The patients are usually recalled for further dental treatment in the dental institute. The patients were asked to visit the investigators in 1–2 days to collect their reports. The patients could visit the investigators during dental institute working hours 6 days a week. A copy of the clinical results was provided to the dentists for calculation of the FRS.

Patients were called back to the clinic for the dentist to review the results with the patient. If clinically abnormal levels were detected for any of the risk factors measured or if the patient's FRS was greater than 10 %, or hemoglobin

A1c > 5.7 % patients were referred to the Vydehi Hospital for further evaluation and treatment as necessary.

90 % of the patients returned to collect their reports. The results were sent by mail to the remaining 10 % of patients who were unable to return as they had already arranged their return travel. A summary of the results together with advice to seek medical referral, as well as communication by phone where possible was done to advise them to seek medical referral. The decision to follow up these patients with a medical opinion was left to the patient.

Statistical analysis

The proportion of subjects who screened positive for increased risk of heart disease and increased risk of individual risk factors is presented. The distribution of the number of abnormal risk factors is also presented. Bonferroni correction factor was not applied when assessing distribution of risk factor prevalence by gender as each risk factor was considered a new test. This set of comparisons by gender was done for the purposes of describing our study population and was not hypothesis driven. Chi-square and Fisher's exact test, as appropriate, were used to test for statistical differences in the distribution of risk factors of interest by gender. We analyzed all data using statistical software (SAS statistical software for Windows, version 9.1, SAS Institute, Cary, NC, USA). Alpha was set at 0.05.

Results

A total of 562 patients were screened. Of them 214 (38 %) were found to be eligible and 158 (74 %) subjects consented to take part in the study. Of the remaining 348 subjects who were ineligible, 252 were outside the age range, 89 had preexisting conditions and 7 others were excluded because of inability to give consent due to psychiatric problems or medical conditions. 90 % of the patients returned to collect their reports and those who did not had already booked their return transport and were sent their results.

Table 1 shows the demographic characteristics of the study population in India during the period of June 2008–January 2009. Among the subjects, 31 % were female and 69 % were male. The majority of the participants 94 % were in the age group of 30–59 years; 30 % were 30–39 years, 40 % were 40–49 years, 25 % in 50–59 years. The geographic distribution of study population included 48 % from rural and 52 % from urban areas; 34 % were from north India as compared to 66 % from south India. Among the study participants, 75.9 % reported that they do not have a primary care physician. Among participants with a primary care physician 80 % reported they do not regularly see their primary care physician (at least once a year).

Table 1 Distribution of demographic characteristics for study population ($N = 158$) in India during period of June 2008–January 2009

Characteristic	*N*	%
Sex		
Male	109	69.0
Female	49	31.0
Age group		
30–39	47	29.7
40–49	63	39.9
50–59	39	24.7
≥60	9	5.7
Geographic area		
Rural	76	48.1
Urban	82	51.9
North India	54	34.2
South India	104	65.8
Have a primary care physician		
Yes	120	75.9
No	38	25.1

Table 2 shows the distribution of risk factors, the FRS and the hemoglobin A1c levels for the total sample by gender in India during the period of June 2008–January 2009. A 10-year FRS of >10 % was seen in 11 % ($n = 18$) of 158 participants. The subjects considered at increased global risk can be divided into two risk classes. 8 % ($n = 13$) were at moderate, above-average risk (>10 % but <20 %) and 3 % ($n = 5$) were at high risk (≥20 %). A significantly greater proportion of men had a FRS >10 % (17 % for men vs. 0 % for women, $p = 0.005$). The gender comparison is meant to further describe this sample and not meant for extrapolation to the general population. Given the small sample size, the 95 % CIs are fairly wide. Abnormal HbA1C values (>5.7 %) were present in 31.6 % of participants. Hypertension and obesity were the most common risk factor among the study participants.

Table 3 shows the distribution of the number of risk factors by gender in India during the period of June 2008–January 2009. At least one of the risk factors was present in 61 % of the participants and 39 % had two or more risk factors present.

Discussion

The results of our study support previous work showing that a dental setting can be a resource to facilitate early identification of people at an increased disease risk for heart disease and diabetes, yet unaware of their increased

Table 2 Risk factor prevalence by gender in India during the period June 2008–January 2009

Risk factor	*N* (%) total	*N* (%) (95 % CI) men	*N* (%) (95 % CI) women	*P* value*
Systolic BP (mm/hg)				
<139	151 (95.6)	106 (97.2) (93–1)	45 (91.8) (84–99)	0.20
≥140	7 (4.4)	3 (2.8) (0–6)	4 (8.2) (0.5–15)	
Cholesterol (mg/dL)				
<160	39 (24.7)	26 (23.9) (16–32)	13 (26.5) (15–39)	0.89
160–239	111 (70.2)	77 (70.6) (62–79)	34 (69.4) (57–83)	
≥240	8 (5.1)	6 (5.5) (2–10)	2 (4.1) (0–10)	
HDL (mg/dL)				
<40	63 (39.9)	50 (45.9) (37–55)	13 (26.5) (15–39)	0.11
40–49	65 (41.1)	40 (36.7) (28–46)	25 (51.0) (37–65)	
50–59	23 (14.6)	14 (12.8) (7–19)	9 (18.4) (1–30)	
≥60	7 (4.4)	5 (4.6) (0.9–10)	2 (4.1 (0–10))	
BMI				
≤30	140 (88.6)	101 (92.7) (88–98)	39 (79.6) (69–91)	0.02
>30	18 (11.4)	8 (7.3) (3–13)	10 (20.4) (9–31)	
Smoking				
Yes	45 (28.5)	45 (41.3) (32–50)	0 (0)	<0.001
No	113 (71.5)	64 (58.7) (50–68)	49 (100.0)	
FRS risk score				
Normal (≤10 %)	140 (88.6)	91 (83.5) (77–91)	49 (100.0)	0.01
Moderate (11–19 %)	13 (8.2)	13 (11.9) (6–18)	0 (0.0)	
Severe (≥20 %)	5 (3.2)	5 (4.6) (1–9)	0 (0.0)	
HbA1c				
Normal (≤5.7 %)	108 (68.4)	76 (69.7) (61–79)	32 (65.3) (52–78)	0.52
Abnormal (>5.7 %)	50 (31.6)	33 (30.3) (22–39)	17 (34.7) (22–48)	

CI confidence interval, *BP* blood pressure, *HDL* high-density lipoprotein, *BMI* body mass index, *FRS* framingham risk score

* Chi-square or Fisher's Exact Test to compare distribution by gender

Table 3 Total number of risk factors by age group and gender for the study sample in India for the period June 2008–January 2009

No. of risk factors	Age	Male* ($N = 109$)	Female* ($N = 49$)
0	30–39	5	9
	40–49	16	6
	50–59	10	5
	≥60	2	2
	Total	33 (30.3 %)	22 (44.9 %)
1	30–39	11	11
	40–49	20	5
	50–59	9	4
	≥60	1	1
	Total	41 (37.6 %)	21 (42.9 %)
≥2	30–39	9	2
	40–49	14	2
	50–59	9	2
	≥60	3	0
	Total	35 (32.1 %)	6 (12.25)

* Chi-square test conducted for overall distribution by gender, $p = 0.024$

risk. This study also extends that work to show that this can be an effective strategy in developing countries to engage individuals with primary care.

A previous retrospective study has shown that cardiovascular diseases and endocrine disorders are the most prevalent conditions that present to the dentist (Bhateja 2012). Our data suggest that the actual rates may be even higher since many of the individuals who present may also be unaware of their risk status. Identification of medical co-morbidities and associated risk factors could play a role in delivery of optimal oral health care. These strategies can facilitate early identification, prompt referral, early initiation of risk reduction measures and also enable the dentist to provide comprehensive dental care by incorporating a detailed assessment of patient's medical history. In a recent article, Ahuja and Parmar (2011) assessed the current demographics in India and the implications for the dental workforce and dental educators and suggested that the rising socioeconomic status and the expanding private sector, including health and dental insurance have led to increased health awareness and demand for quality care. At the same time, the authors note that there remains a large underserved population who still do not have access to oral health care. The authors suggest that scenario coupled with increasing health awareness will warrant solutions that integrate oral health and public health and call for an increasing role for dental educators and dental schools. The results of the present study suggest a role for dental settings in public health efforts to combat these conditions.

Review of research in cardiovascular and diabetes disease epidemiology in India shows that the disease burden estimated by disease prevalence studies is increasing in both urban and rural populations (International Diabetes Federation; Enas et al. 2008; Anjana et al. 2011). The results of our study indicate a high risk factor burden consistent with results from the US. The slight variation in our results could be attributed to the fact that the US-based study included subjects above 40 years, whereas in our study we included subjects above 30 years. Data from that US-based study showed that 21 % of individuals were at risk for diabetes based on abnormal A1c levels applying the current guidelines for an abnormal A1c (>5.7 %) (Personal communication, B, Greenberg). The higher rates of abnormal A1c levels in the current study are not unexpected given the rapidly expanding rates of diabetes in India (International Diabetes Federation). This suggests a need for immediate institution of primary measures to curb the escalating rates of diabetes. Given that these patients were unaware of their risk status, early identification is critical as these people may benefit from entry into the medical system with behavioral or therapeutic intervention.

Socioeconomic factors are major drivers of population-wide escalation of multiple risk factors (Saudek et al. 2008, International Diabetes Federation; Patel et al. 2011; Gaziano et al. 2006a). The changes include increase in per capita income causing lifestyle changes with a shift in eating habits, and adoption of a sedentary lifestyle, resulting in a drastic rise of chronic conditions. The rapid urbanization and westernization in India and many of the middle-income developing countries are increasing mechanization leading to increased sedentary behavior and dietary changes that increase disease risk.

There is ample support in the literature of the benefits of early intervention to impact disease morbidity and mortality associated with heart disease and diabetes. Implementation of primary prevention activities through dietary modifications and increased physical activity are associated with a 35–77 % reduction in the incidence of hypertension (He et al. 2000, 2005; Whelton et al. 2005), a 4–10 % reduction in high cholesterol, (Puglisi et al. 2008) a 17 % reduction in incidence of coronary heart disease mortality, (He et al. 2005) and a sustained decrease of 41 % in diabetes incidence over a 20-year follow-up period (Li et al. 2008). The results of our data suggest that screening with prompt medical referral and measures such as counseling for lifestyle modification may be useful starting points for initiating primary prevention.

Studies have shown that use of FRS in populations other than US produces only a fair estimation of heart disease risk (Guha et al. 2008). Recalibration of Framingham Risk equation may help in these instances (Chow et al. 2009). However, accurate, well-conducted epidemiologic studies providing local data separately for rural and urban areas of Bangalore or the state of Karnataka are lacking and recalibration to national summary data may not be relevant across all areas of India (Chow et al. 2009). Future studies gathering accurate local data and assessing the use of other heart disease risk algorithms are needed.

The study was limited by a small convenience sample which could result in a skewed distribution. This, along with the fact that it was conducted in one setting in India limits generalizability. However, the current study was a demonstration project in which we were trying to show the efficacy of this strategy as a potential strategy to use the dental setting to identify these at risk patients who are not aware of their risk and not actively engaged with medical care using existing tools that are easily accessed in middle and low-income countries. Moreover, national data suggest that this study population does not represent a select group of people with high diabetes or heart disease risk factor prevalence since the study population came from different areas of the country as elaborated in the methods section. The disease prevalence data are similar to other parts of the world as well and results concur with previous findings. The dental college had a combination from people in rural and urban areas. It located in close proximity to International Tech Park (ITPL/ITPB). The urban population in Bangalore has a lot of immigrants from other parts of the country for work. The college also caters to the needs of 20–25 surrounding villages with the help of satellite center and well-equipped mobile dental unit.

In addition, this setting allowed for easy referral of patients to a laboratory to obtain laboratory measurements of interest, which may represent a less common setup in private dental clinics. In the recent years, however, there has been a rapid increase in number of private dental clinics and private labs in close proximity to the clinics which may enable this method to be applied in private setup as well.

Effective prevention needs a global strategy based on knowledge of the importance of disease risk factors for heart disease and diabetes in different geographic regions and among various ethnic groups. Recruitment of additional resources such as dental settings may serve an important role in public health efforts throughout developed and developing nations to control these epidemics and enable early identification of individuals at increased risk of disease who could benefit from early medical intervention. In some areas, depending on the age-specific incidence and prevalence and emerging trends, consideration should be given to including young adults to maximize the benefits of screening. The screening strategy used in this study could be extended to the approximately 150 such institutes in India, thousands of private clinics and several university based hospitals worldwide, once consideration is given to the feasibility and logistical issues, including potential costs and availability of clinical laboratory testing facilities. In addition, dental public health camps conducted by universities as a part of undergraduate and postgraduate curriculum could utilize this screening technique to extend its benefit to rural areas. In our study, we have presented the distribution of risk factors merely for the purposes of describing this study sample and to present preliminary data for future hypothesis-driven studies. It is impossible to know from this study whether screening in this setting will actually reduce adverse outcomes. Our study was not designed to address this. Future studies designed to address this important question should be conducted along with studies to assess the use of finger stick blood to obtain clinic measurements at chair side.

Conclusion

The results of our study show that a dental setting can be a resource to facilitate early identification of people at an increased disease risk for heart disease and diabetes, yet unaware of their increased risk. These results support previous work done in the United States and extends that work to show that this can be an effective strategy in low- and middle-income developing countries to engage individuals with primary care. This study also supports the concept that the dental setting can be a entry point into the medical care setting for inidividuals not previously engaged with a primary care provider.

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