DEVELOPMENT OF AN INTEGRATED RISK ASSESSMENT PLATFORM FOR THE MANAGEMENT OF CARDIOVASCULAR DISEASES, DIABETES AND HYPERTENSION

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Abstract: Health care is an important requirement of life. It is defined as the prevention, treatment or management of health related problems by using diverse strategies and services. Information Technology (IT) has pervaded every sphere of life including health care. It not only includes information systems in hospitals for managing clinical information about patients but also includes telemedicine, computer-assisted instructions to patients as well as doctors, and extends to computer-assisted imaging and surgery. IT has now become a key component in Disease Management Systems used in the assessment and management of chronic diseases such as Diabetes and Coronary artery disease. We have developed an Integrated Risk Assessment and Health Management System [IRAHMS] to assess the risk of developing "life-style" diseases such as Cardio Vascular Disease, Type 2 Diabetes Mellitus and Hypertension. This includes a patient clinical information database; a Framingham data based cardiovascular risk calculator and a module that provides personalized health management advice and healthy life style modifications that help an individual to lead a healthy life. The system also features an interactive risk analysis facility to analyze the contribution of each clinical parameter to the overall risk that can help motivate patients to see the overall benefits of risk factor modification or elimination.

1 INTRODUCTION

Disease risk prediction plays an important role in the primary prevention of cardiovascular disease, hypertension or diabetes. At least 25 % of the coronary patients die suddenly without any prior symptoms. The International Diabetes Federation recently published findings revealing that in 2007, the country with the largest numbers of people with diabetes is India (40.9 million) (Yadav *et al*. 2008). Statistics indicate that there is one person in the world dying of diabetes every ten seconds. Cardiovascular disease (CVD) and Hypertension (HTN) are the leading causes of mortality in persons with type 2 Diabetes Mellitus (DM) (Bhopal *et al*. 2005). Hence risk prediction, primary health care, prevention and management of these inter related diseases is critically important.

In this paper, an integrated risk assessment methodology has been suggested that is primarily based on the Framingham Heart Studies (Black 2002; Wilson *et al*. 1998; Department of Health and Ageing: Australian Government 2008). We have developed an Integrated Risk Assessment System that takes in to account the patients' important clinical data as well as anthropological details and calculates an individual's risk of developing cardiovascular disease, Diabetes and Hypertension. The main contributions of this paper are:

(i) Development of an integrated platform for early prediction of the probability of occurrence of CVD, HTN & DM.

(ii) Provision for "Interactive Risk Analysis (IRA)" where the variation of risk against each of the clinical health parameters is visually depicted in the

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form of a "Slider" for all the three diseases, allowing the user to change the risk factor profile of the patient and to see the consequent benefits/risks to the patient.

(iii) Provision for "Visual Analysis" of risk variance that can be used by medical professionals to educate the patient on his own health progress with subsequent visits.

(iv) Provision of "Healthy Life Style" advice based on the calculated risk that can help a patient adopt "therapeutic" life style changes related to diet, exercise etc, thereby favourably affecting his chance of developing CVD.

(v) Development of a simple "Patient Education Module" that can be effectively used by doctors and non-physician health care providers to educate a patient on his own prevailing medical condition, through pictorial illustrations.

This integrated system developed by the authors can be very effectively used by health care professionals for day-to-day patient diagnosis and advice. The system can play an effective role in a medical school as a "Medico's Educational Kit'. In the current scenario in most developing countries where there is acute shortage of doctors especially in remote rural areas, this system can be used to help non-physician workers in Primary Health Centres to arrive at a few basic diagnostic decisions on patients visiting these centres.

2 RELATED WORK

Research has been carried out on the prediction of CVD in Asians using the FINRISK model (Bhopal *et al.* 2005). The Framingham and FINRISK models have been shown to give similar results in expected patterns. Incidentally, the SCORE model (Paynter *et al*. 2009) shows a variation in predicted risks, reflecting its lack of inclusion of HDL and diabetes as risk factors. National mortality data and modelled predictions agree reasonably well for South Asians combined and Bangladeshi & Pakistani men, but not for Indian men and Pakistani and Bangladeshi women (Bhopal *et al*. 2005). The model used in this paper suggests that potential gains from controlling major established risk factors could be substantial in South Asians and greater than in Europeans.

The authors conclude that the FINRISK (Bhopal *et al*. 2005) and Framingham models predict CVD outcomes with better accuracies in South Asians as a group but inconsistent with some subgroups. The conclusion is compatible with work using the Framingham equation (Quirke et al. 2003), which mainly focuses on adjustment and refinement of Framingham scores to specially suit the Black and Minority Ethnic Groups (BMEG) in the UK.

The Framingham risk prediction tool has been updated recently (D'Agostino *et al*. 2008). As a first step, the authors use the tool to estimate the risk for a general class of population. Later, they modify the tool to address individual risk assessment. A sex-specific multivariable risk factor algorithm has been used by the authors and it has been demonstrated that the scores obtained by this specific categorization yields better accuracies in terms of CVD prediction.

Analysis has been performed on the data pertaining to a section of men and women in the age group of (30–74) years at 5-year age increments, to systematically assess the risk factor combinations that allow risk thresholds to be reached and how different risk burdens translate into vascular age (Mendis *et al*. 2007).

Two non-genetic risk prediction models have been proposed in another research work (Paynter *et al*. 2009). The first model includes the covariates from the Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults' risk score, as well as family history of diabetes (high-risk equivalent) in individuals. The second model uses the covariates from the Reynolds Risk Score, a model that includes additional biomarker information, as well as data on family history.

The other Prediction tools for risk of cardiovascular diseases include the following.

- PROCAM (Prospective Cardiovascular Munster Study) - The scoring system developed to predict acute coronary events (Mendis *et al*. 2007).
- Reynolds risk score developed to predict CVD in women, based on family history of CVD, high-sensitivity C-reactive protein, and hemoglobin A1C (the latter in individuals with diabetes) (Ridker *et al*. 2007).
- SCORE (Systematic Coronary Risk Evaluation) - HEARTSCORE system, developed to predict fatal CVD (Perez-Lopez *et al*. 2010).
- QRISK score, using the QRESEARCH database (Cox *et al*. 2007).
- ASSIGN risk score, based on the Scottish Heart Health Extended cohort (Woodward *et al*. 2007).

Cardiovascular disease (CVD) is the leading cause of the growing global disease burden due to noncommunicable diseases. Risk prediction tools that easily and accurately predict an individual's absolute risk of CVD are a key to targeting limited health care resources at high-risk individuals who are likely to benefit the most. Health systems in low-income countries do not have the basic infrastructure to support resource-intensive risk prediction tools, particularly in a primary healthcare setup (Mendis *et al*. 2007).

The risk prediction strategies as described above are very vital to the management of Cardio Vascular and related diseases. But there is still a wide scope to develop comprehensive prediction systems that consider multiple diseases and help healthcare professionals in predicting the probability of occurrence of these diseases. Risk assessment models that are currently available work as stand-alone models and do not integrate modules on treatment/management of the identified risks. Also, the tables and monograms used in the Framingham risk assessment modules are time consuming and cannot easily be used in day-to-day practice due to time constraints.

The system developed as an outcome of this research aims to simplify the risk assessment process and also integrates the modules for management of the identified risks. In addition, the system provides visual cues to the risks in a simplified manner to patients, helping them understand their risks, thereby increasing patient participation and compliance in the management of chronic life style diseases where patient motivation is the key to success.

These should help doctors to educate patients on the exact causes of these diseases and also illustratively advise patients on the diet plan required and the life style modifications.

3 TECHNIQUES OF RISK PREDICTION

Fig.1 shows the Integrated Risk Assessment and Health Management System (IRAHMS) developed in this research for all the three diseases. The three major risk assessment subsystems are CVD, HTN and Type 2 Diabetes.

The personalized summary report contains the risk probabilities of all three diseases (CVD, DM and HTN) since they are highly inter-related.

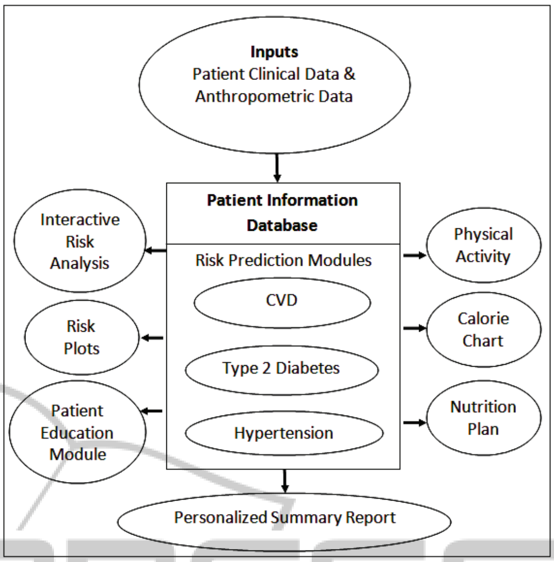

Figure 1: Integrated Risk Assessment and Health Management System [IRAHMS].

3.1 Cardio Vascular Disease (CVD)/ Coronary Heart Disease (CHD)

Framingham Heart Study is used to determine an individual's risk of developing CVD in the subsequent five and ten years (Black 2002). The model has been improved in such a way that a major emphasis is given to the total cholesterol and HDL Cholesterol (HDL-C), thereby giving extra weight to cholesterol as a major risk factor (Wilson *et al.* 1998).

3.1.1 5-Year Risk Prediction

The risk assessment model for 5-year CVD risk prediction (Black 2002) is analyzed based on Framingham Heart Study. The risk factors included in this model are age, smoking and diabetic status, Total Cholesterol (TC), HDL-C and Systolic Blood Pressure (SBP) measurement. Scores corresponding to each of the above clinical parameters are calculated. The cumulative score is used to find the risk probability. Fig. 2 shows the samples of the points used for the risk assessment.

3.1.2 10-Year Risk Prediction

The 10-year CVD risk prediction model for men and women is analyzed with a score sheet using TC or LDL-C categories (Wilson *et al.* 1998) with cholesterol as a major risk factor. It considers age, TC (or LDL-C), HDL-C, Blood Pressure (BP), diabetes and smoking as the major risk factors. It estimates risk for CVD over a period of 10 years based on Framingham experience in men 30 to 74 years old as a baseline. The tables in Fig.3 are used for CVD risk prediction for the subsequent 10-years.

2a. Find Points for Each Risk Factor					
Age (if male)				HDL Cholesterol	
Age	Pts	Age	Pts	HDL C	Pts
30	-2	50-51	10	25-26	7
31	-1	52-54	11	27-29	6
32-33	0	55-56	12	30-32	5
34	1	57-59	13	33-35	4
35-36	2	60-61	14	36-38	3
37-38	3	62-64	15	39-42	2
39	4	65-67	16	43-46	1
40-41	5	68-70	17	47-50	0
42-43	6	71-73	18	51-55	-1
44-45	7	74	19	56-60	-2
46-47	8			61-66	-3
48-49	9			67-73	-4

2b. Points (continued)			
Systolic B.P.			
SBP	Pts	Other Factors	Pts
98-104	-2	Smoking	4
105-112	-1	Diabetic Male	3
113-120	0		
121-129	1	Diabetic Female	6
130-139	2		
140-149	3	ECG LVH	9
150-160	4		
161-172	5	0 points for each NO	
173-185	6		

2c. Add Point For All Risk Factors
Total Points = Sum of Risk Points For (Age, HDL C, Total C, SBP, Smoker, Diabetes, ECG-LVH).

2d. Look Up Risk Corresponding to Point Total							
Probability of CVD							
Pts	5 yr	Pts	5 yr	Pts	5 yr	Pts	5 yr
<1	<1%	10	2%	19	8%	28	19%
2	1%	11	3%	20	8%	29	20%
3	1%	12	3%	21	9%	30	22%
4	1%	13	3%	22	11%	31	24%
5	1%	14	4%	23	12%	32	25%
6	1%	15	5%	24	13%		
7	1%	16	5%	25	14%		
8	2%	17	6%	26	16%		
9	2%	18	7%	27	17%		

Figure 2: Sample of points used for risk assessment (Black 2002).

Blood Pressure					
Systolic (mm Hg)	Diastolic (mm Hg)				
	<80	80-84	85-89	90-99	>=100
<120	0 [0] points				
120-129		0 [0] points			
130-139			1 [1] points		
140-159				2 [2] points	
>=160					3 [3] points

HDL – C			
(mg/dl)	(mmol/L)	LDL Points	Cholesterol Points
<35	<0.90	2	[2]
35-44	0.91-1.16	1	[1]
45-49	1.17-1.29	0	[0]
50-59	1.30-1.55	0	[0]
>=60	>=1.56	-1	[-2]

Diabetes		
	LDL Points	Cholesterol Points
No	0	[0]
Yes	2	[2]

Smoker		
	LDL Points	Cholesterol Points
No	0	[0]
Yes	2	[2]

Key	
Color	Relative Risk
Green	Very low
White	Low
Yellow	Moderate
Rose	High
Red	Very high

Figure 3: Ten-year risk score tables for men and women (Wilson *et al*. 1998).

Fig.4 shows the snapshot of the system for CVD risk prediction in the subsequent 5-years and 10-years. The 10-year risk prediction in the graphic is based on elevated TC.

3.1.3 Design of an Interactive Risk Analysis Mechanism: The SLIDER

Based on domain inputs from the medical experts, a SLIDER facility has been added to the system as shown in Fig.4. The philosophy and usage of the slider is as follows:

All the clinical parameters that are modifiable through medical intervention (soft attributes) are provided with a radio button as shown. Once a particular radio button is selected(corresponding to

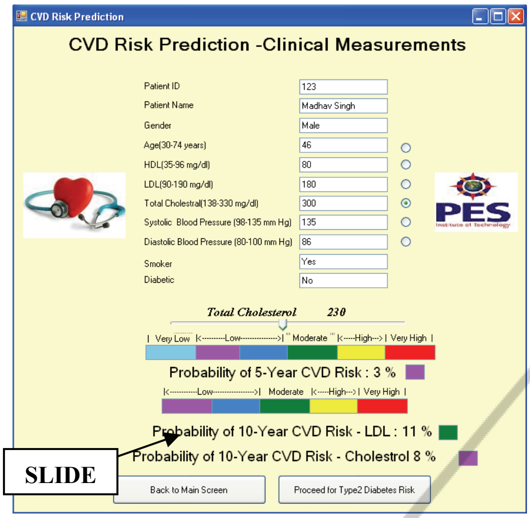

Figure 4: CVD risk assessment subsystem.

the clinical parameter chosen), the slider can be varied over its range (for example, TC over the range 150-330 mg/dl) and the corresponding change in risk percentages are displayed as indicated in Fig.4, keeping all the other attributes unchanged. This feature is very distinct and very useful since the effect of a change in the said parameter is directly translated into the Risk and displayed. Doctors can use this feature to advise and educate the patient on the need to control the health parameter in order to bring the risk down to an acceptable level. The same analogy holds for the other clinical parameters also.

A sample graph of change in 5-year risk percentages as a consequence of Total Cholesterol changes is shown in Fig.5.

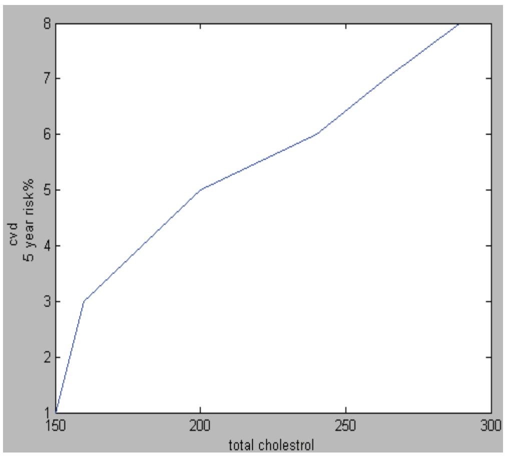

Figure 5: Variation of 5-year risk for changes in total cholesterol.

The doctor uses this analysis to educate the patient on the need to control the cholesterol levels to bring down the risk percentages to an acceptable level.

The color code depicted in Fig.4 is based on Framingham color charts and the color boxes shown next to the predicted risk percentages indicate the severity of risk. This varying slider value of the parameter being changed does not modify the database content for the patient. It only indicates visually to the patient, the effect of changing the clinical parameter on the risk probability.

3.1.4 CVD Risk Plots

One another useful feature that has been implemented in this system is the risk plot. Upon subsequent visits by the patient to the doctor, there is a need to graphically visualize as to how the risks are getting changed between visits. For this purpose, 2-D plots are implemented as shown in Fig. 6.

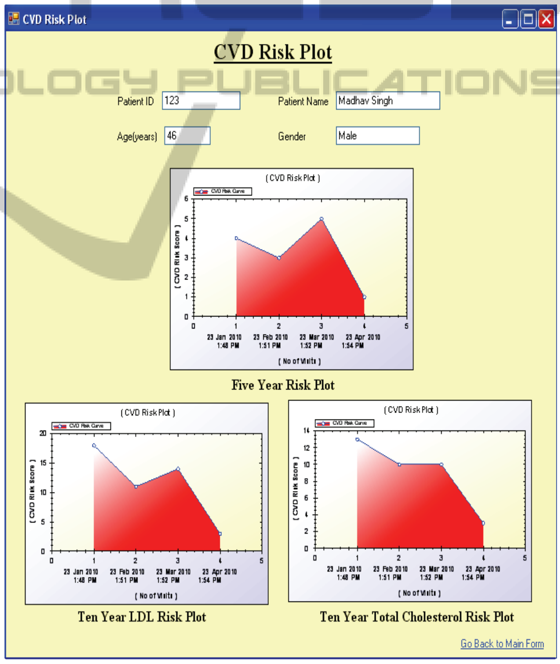

Figure 6: CVD risk plots.

As seen in Fig.6, the plots convey to the doctor as well as the patient, the trends in risks over subsequent visits. These trends can be used by the doctor to advise the patient on the variation in risks over the visits. There are a few ways in which these trends could be effectively utilized for analysis. For example, due to the right usage of medication, diet regulation and physical exercises, the risk has come down in Fig.6 during Visit-2. During the third visit, the patient did not follow doctor's advice completely and suddenly, there is an increasing trend in risk.

This is visually depicted in Fig.6.

Again, these risk plots can be used by the doctors to even assess the effectiveness of a drug for a particular patient condition.

3.2 Hypertension

Risk score for predicting hypertension is based on Framingham Heart Study (Parikh *et al.* 2008). Hypertension is defined as a condition with the Systolic blood pressure of 140 mm Hg or higher or the diastolic blood pressure of 90 mm Hg or higher. The clinical predictors of hypertension considered in this study are gender, age, SBP, Diastolic Blood Pressure (DBP), Body Mass Index (BMI), Parental Hypertension (maternal or paternal hypertension), whether the person is currently a smoker or not, HDL-C, Triglyceride (TGL), TC, Blood Glucose and whether the person is physically active or not, out of which the risk score for first seven attributes are taken from Framingham Heart Study and the risk score for the next five attributes are calculated based on the odds ratio (Wang *et al.* 2006).

The odds ratio is a measure of effective size, describing the strength of association or non-independence between two binary data values. The odds ratio is a way of comparing whether the probability of a certain event is the same for two groups.

3.2.1 Hypertension Risk Assessment

From the Framingham heart study and based on odds ratio, risk scores for different predictors of hypertension are as shown in Fig.7:

Systolic Blood Pressure(mm Hg)	Points
< 110	-4
110-114	0
115-119	2
120-124	4
125-129	6
130-134	8
135-139	10

Blood Glucose	Points
< or =126	0
>126	3

Parental Hypertension	Points
None	0
One	1
Both	2

Figure 7: Hypertension risk score tables (Parikh *et al.* 2008).

The scores assigned based on Odds Ratio for the above attributes are the same as that of Framingham study. The total effective risk score is the cumulative value of the individual scores. Risk percentages for 1-year, 2-years and 4-years given by the Framingham study for different risk scores are considered to fit a curve using MATLAB Curve fitting tool which gives a fifth degree polynomial as shown in Fig.8. The Polynomial corresponding to Fig. 8 is obtained as:

$$f(x) = p1*x^5 + p2*x^4 + p3*x^3 + p4*x^2 + p5*x + p6$$

This curve fitting helps in translating the risk scores to risk percentages. Fig.9 shows a snap shot of the Hypertension Risk Prediction subsystem. In line with the CVD Risk Assessment subsystem, this Hypertension risk assessment subsystem also has a Slider option to study the effect of the clinical parameter variation on the risk percentages (For Ex., Total Cholesterol shown in Fig.9).

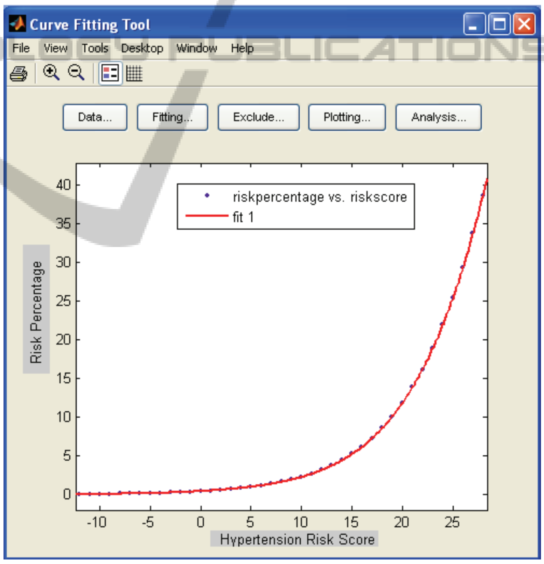

Figure 8: Derivation of hypertension risk probability from risk scores.

3.3 Type 2 Diabetes

Diabetes mellitus is a metabolic disease characterized by hyperglycaemia resulting from defects in insulin secretion, insulin action, or both. Type 2 diabetes is a chronic (long-term) disease marked by high levels of sugar in the blood. The Risk Factors for Diabetes are Age, Family History, Central Obesity, Physical Inactivity and Sedentary Living, Insulin Resistance, Urbanization, Stress etc.

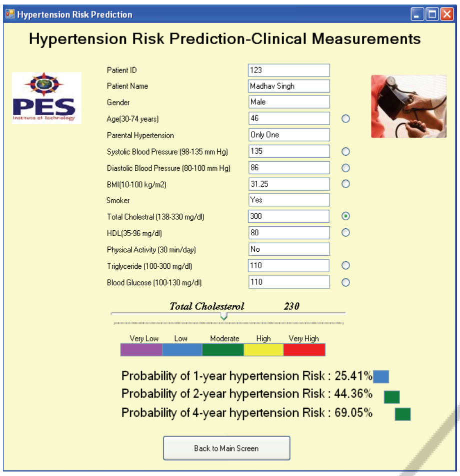

Figure 9: Hypertension risk assessment subsystem.

3.3.1 Type 2 Diabetes Risk Assessment

The type 2 diabetes risk assessment model has been developed to provide a basis for both doctors and healthcare workers to assess the patient's current level of risk of developing Type 2 Diabetes over the subsequent five years. Fig.10 shows the snapshot of the system for diabetes risk assessment.

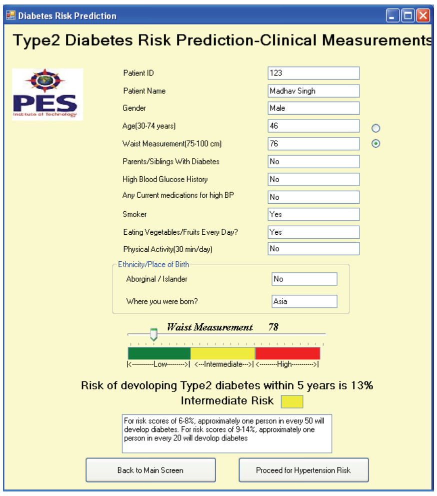

Figure 10: Diabetes risk assessment subsystem.

In the development of diabetes risk assessment model, a range of factors are considered that directly influence the occurrence the disease including alcohol, smoking and obesity.

3.3.2 Analysis of Risk Factors

The risk score (Department of Health and Ageing: Australian Government 2008) is derived for a population with ages 25 years or older, and the score of zero is given for those with an age less than 25 years. Thus the use of this model for a population of age less than 25 years is inaccurate. The score measures physical activity by duration but not by intensity. Thus, a person who walks for two hours in a week scores the same as someone who spends two hours in the gym in that week. Detailed analysis (Yadav *et al*. 2008) shows very little change in the computed score when the intensity of physical activity is considered. The scores in Fig.11 are used to arrive at the 5-year diabetes risk prediction.

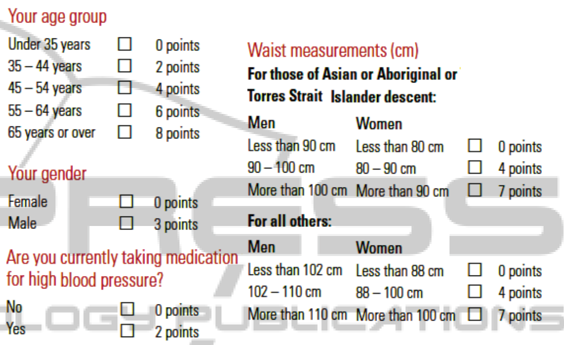

Figure 11: Scores for five-year diabetes risk assessment (Woodward *et al*. 2007).

The waist measurement is part of a risk score along with other factors; Here, three classes namely (<90 cm, 90-100 cm, >100 cm) for men are used. A more granular classification is likely to provide better risk prediction. In the Australian context (Department of Health and Ageing: Australian Government 2008), population of Aboriginal and Torres Strait Islander origin have a much higher mean overall score than does any other ethnic group. Hence users of the risk score can be confident that when used on an Aboriginal and Torres Strait Islander population, the risk score is likely to accurately reflect their overall risk.

The Slider option to assess the risk in relation to the clinical parameter variation is provided in line with the option explained under the CVD subsystem. For example, in the snapshots, the Waist Measurement is varied using the slider to observe the change in risk percentages. The doctor uses this analysis for diagnosis, treatment and to educate the patent on the need to bring down the weight in order to reduce the diabetes risk.

4 HEALTH MANAGEMENT

As brought out in the system model of Fig.1, this Health Management sub system has been developed as an aid to patients to assess the dietary requirements and the physical activity prescription, purely personalized for the patients' health condition. Also, a patient education module has been developed to brief the patient about his precise health condition that warrants a personalized treatment. The following sections deal with the components of this Health Management sub system.

4.1 Nutritious Food, Calorie Charts and Physical Activity

Healthy lifestyle can be achieved by learning some nutritional basics and personalizing them to an individual (Wang et al. 2006). The model provides guidelines and tips for creating and maintaining a satisfying, healthy diet called DASH (Dietary Approaches to Stop Hypertension). DASH is recommended for people with hypertension or pre hypertension. DASH diet eating plan has been proven to lower blood pressure in studies sponsored by the National Institutes of Health. It is based on a Diet plan rich in fruits and vegetables, and low-fat or non-fat dairy products which is a key feature of high-fiber, low caloric-density, balanced meals with appropriate serving sizes.

The system provides simple suggestions that aid in lifestyle modifications. For health benefits, physical activity should be moderate or vigorous and add up to at least 30 minutes a day. The activity pyramid (available with the system) is a guide that can be used to plan for an active lifestyle. The health management part of the model includes general health and hygiene guidelines for patient education purposes.

Health management part of patient education module for a patient pertaining to the three diseases (CVD, Diabetes and HTN) contains the functioning of different body parts like heart, cells etc. It also contains the symptoms of a disease, the disease stages based on parameters like cholesterol and their effect on the patient health condition for the three diseases.

4.2 Personalized Summary Report

A very interesting feature of the Integrated Risk Assessment and Health Management System (IRAHMS) is the generation of a personalized summary report that is to be handed over to the patient along with the doctor's diagnosis and treatment, at the end of a session with the doctor. Fig.12 shows a representative report.

The personalized summary report along with the doctor's comments for a patient during a visit is generated including the risk levels for all three disease conditions. It also includes dietary and physical activity recommendations based on individual patient risk levels with do's and don'ts of physical activity and food habits. This report can be used as a guideline by the patient to keep up with the doctor's advice and also to be vigilant about his personal health.

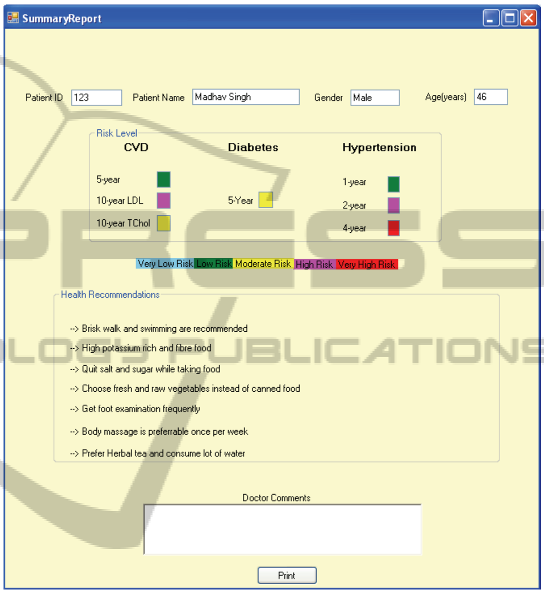

Figure 12: Personalized summary report.

5 CONCLUSIONS AND FUTURE WORK

The integrated risk assessment system developed in this work helps a doctor to assess the individual patient's risk for all the three major diseases. The risk plots also help the doctor to assess the effectiveness of a drug and monitor the trends in the patient's risk percentages over subsequent visits. With the interactive risk analysis (using a slider), the doctor/health worker can advise and educate the patient on the need to control the clinical parameters in order to bring down the risk.

Work is underway to extend this IRAHMS as a web portal where both patients and doctors can log in through proper authentication. Patients will be able to remotely log into the system and update their clinical parameters. Doctors will access this information and update the summary report based on their analysis. This process will extensively help in patient healthcare especially in cases where doctor's personal intervention is not required and the advice to patients can be provided over this portal. This will have a very high impact on the present overall healthcare system where doctors' availability is very scarce in remote rural areas.

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REFERENCES

Black, H. R., 2002, 'Cardio-Vascular Risk Factors', *Yale University of Medicine Heart Book*, Chapter 3, pp. 32-36.

Wilson, P. W. F., D'Agostino, R. B., Levy, D., Belanger, A. M., Silbershatz, H. & Kannel W. B., 1998, 'MD Prediction of Coronary Heart Disease Using Risk Factor Categories', *American Heart Association*.

'Australian Type2 Diabetes Risk Assessment Tool', *Australian Government, Department of Health and Ageing*, July 2008.

Bhopal, R., Fischbacher, C., Vartiainen, E., Unwin, N., White, M & Alberti G, 2005, 'Predicted and observed cardiovascular disease in South Asians: Application of FINRISK, Framingham and SCORE models to Newcastle Heart Project data', *Journal of Public Health*, Vol. 27, No.1, pp. 93-100.

Paynter, N. P., Chasman, D. I., Buring, J. E., Shiffman, D., Cook, N. R. & Ridker, P. M., 2009, 'Cardiovascular Disease Risk Prediction With and Without Knowledge of Genetic Variation at Chromosome' , *Annals of Internal medicine*, Vol. 150, No. 2, pp.65-72.

Quirke, T. P., Gill, P. S., Mant, J. W. & Allan, T. F., 2003, 'The applicability of the Framingham coronary heart disease prediction functions to black and minority ethnic groups in the UK', *Department of Primary Care and General Practice, University of Birmingham,* pp. 785– 786.

D'Agostino, R. B., Vasan, R. S., Pencina, R. J., Wolf, P. A., Cobain, M., Massaro, J. M. & William B. Kannel, 2008, 'General Cardiovascular Risk Profile for Use in Primary Care The Framingham Heart Study', *American Heart Association, Inc*., pp. 743-753.

Mendis, S., Lindholm, L. H., Mancia, G., Whitworth, J., Alderman, M., Lim, S. & Heagerty, T., 2007, 'World Health Organization (WHO) and International Society of Hypertension (ISH) risk prediction charts: assessment of cardiovascular risk for prevention and control of cardiovascular disease in low and middle-income countries', *Cardiovascular Diseases, World Health Organization*, Geneva, Switzerland, pp. 1578-82.

Ridker, P. M., Buring, J. E., Rifai, N & Cook, N. R., 2007, 'Development and validation of improved algorithms for the assessment of global cardiovascular risk in women: the Reynolds Risk Score', *Journal of American Medical Association*, Vol. 297(6).

Pérez-López, F. R., Cuadros-López, J. L., Fernández-Alonso, A. M., Cuadros-Celorrio, A. M., Sabatel-López, R. M. & Chedraui, P., 2010, 'Assessing fatal cardiovascular disease risk with the SCORE (Systematic Coronary Risk Evaluation) scale in post-menopausal women 10 years after different hormone treatment regimens', *Gynecological Endocrinology*, 26(7):533-8.

Cox, J. H., Coupland, C., Vinogradova, Y., Robson, J., May, M. & Brindle, P, 2007, 'Derivation and validation of QRISK, a new cardiovascular disease risk score for the United Kingdom: prospective open cohort study', *British Medical Journal*.

Woodward, M., Brindle, P. & Pedoe, H. T., 2007, 'Adding social deprivation and family history to cardiovascular risk assessment: the ASSIGN score from the Scottish Heart Health Extended Cohort (SHHEC)', *British Medical Journal*, Heart 2007.

Parikh, N. I., Michael, J., Pencina et al, 2008, 'A Risk Score for Predicting Near-Term Incidence of Hypertension: The Framingham Heart Study', *Annals of Internal Medicine*.

Wang, W., Lee, ET; Fabsitz RR et al, 2006, 'A Longitudinal Study of Hypertension Risk Factors and Their Relation to Cardiovascular Disease the Strong Heart Study', *American Heart Association*, *Hypertension*.

Yadav, R., Tiwari, P. & Dhanaraj, E., 2008, 'Risk factors and complications of type 2 diabetes in Asians', *CRIPS* Vol. 9 No. 2.

'Lowering Your Blood Pressure With DASH', *U.S. Department of Health and Human Services*, National Institutes of Health National Heart, Lung, and Blood Institute, No. 06-4082, April 2006.