ORIGINAL RESEARCH ARTICLE

Cardiovascular Risk Screening in A Rural Area in India and Markov Modelling for Cost Effectiveness

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ABSTRACT

Introduction: Cardiovascular diseases (CVDs) are the major cause of death in India. This study aimed to assess the CVDs risk factors in a remote rural area and its cost effectiveness Markov Model.

Methods: Community based screening for known Hypertension, Diabetes and both were done. Basic Demography, health status assessment, Basic health related serum and blood analysis were done. Markov Modelling was done to assess the Cost effectiveness of the screening programme.

Results: There were 7% of the participants having CVD risk of more than 40%, 3% with 30 to 40% risk, 11% were with 20-30% risk, 22% were with 10-20% risk and 57% were with less than 10% risk. In the higher risk group (>40% risk) participants with both 'HTN and DM' were having higher risk (11%). Participants with higher age, Female, Illiterate, Anaemia, lower per-capita income, both HTN and DM, smokers, Hypercholesterolemia, Hypothyroidism, and CKD were having higher CVDs risk of >40%. Markov analysis for active screening was shown to be highly cost-effective with the ICER value of INR 78730 per one unit of Quality Adjusted Life Year (QUALY) gained.

Conclusion: Cardiovascular Diseases risk is higher among HTN and DM patients in the rural community in India. The screening and management at the community level are highly cost effective.

Key-words: Diabetes, Hypertension, Rural, Community, Screening, Markov

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INTRODUCTION

Cardiovascular Diseases (CVDs) are the top most health problem globally.[1] In India 63% of the mortality is associated with CVDs.[2] CVDs have higher prevalence in rural are due to poor access to health care. More than two third of the population in India is in rural area.[3] Studies have shown rural community has higher health disparity.[4,5] CVDs and its risk factors are gaining public health importance in the recent days. As per National Health Policy of 2017, India has committed to reverse the growing Non Communicable Diseases (NCDs) incidence.[6] In response to the 'Sustainable Development Goal', India aimed to reduce the premature mortality to one third, by 2030.[7,8] To achieve this, India has come up with a National Strategic plan to strengthen the primary care to reach 75 million (7.5 crores) of people with Hypertension (HTN), Diabetes (DM) or Both with a comprehensive management plan.[2] This will be the world largest programme to cover the NCD through Primary Care level.[2] WHO/ISH CVDs risk prediction Chart especially with cholesterol predicts the risk better and is the widely used worldwide.[5,9–11] Limited community based studies are available from remote rural area on the wider application of comprehensive screening in HTN and DM patients and our study is bridging this gap. Even though research studies address efficacy and effectiveness, there is a huge gap in understanding the cost-effectiveness of the medical interventions. World Health Organization prioritizes the studies which has cost-effectiveness analysis as it has huge programme implications.[12] This study will comprehensively discuss the CVDs Risk score among the HTN and DM patients and the cost effectiveness of such a screening programme in the rural community.

METHODOLOGY

Setting: This study was conducted in a Rural Health Training Centre under Department of Community Medicine of a Medical College in Puducherry. Site was located in a remote rural area of Chengulpet District of Tamil Nadu. This centre caters around 10 adjoining villages. This centre also maintains the electronic record of the demographic and health details of the participants which includes the details of diabetes, HTN, Asthma etc.[13] In this study we had line listed the hypertension and diabetes patients from the existing electronic record and included in the study after getting the consent. Demographic and health details were collected from the participants. Fasting serum Cholesterol profile, Kidney Function Test, Thyroid Stimulating Hormone (TSH), fasting blood sugar (FBS) and hemoglobin were performed in the NABL accredited medical college lab. Participants from nearby three villages were asked to come to the facility, participants from the rest of the seven villages were approached by the outreach camps in their villages. All the participant were offered appropriate care and follow-up through the Rural Health Training Centre (RHTC). This study was conducted in August-September 2017.

Operational Definitions: Definitions used to analyse the data are, The ten years CVD risk was calculated using WHO ISH Chart.[14] BMI of 18.5-22.9 was taken as normal, 23-24.9 as overweight and 25-29.9 as obese class one and more than or equal to 30 as obese class two. Current smoker was defined as person used any form of smoke such as cigarette, cigar, beedi etc. at least once in and a person consumed alcohol at least once in the last one year was taken as current alcoholic.[15] Serum cholesterol level of ≥200 mg/dl (≥5.2 mmol/l) was considered as hypercholesterolemia.[16] Metabolic syndrome was classified with standard definition using central obesity, Triglycerides, HDL cholesterol, blood pressure and FBS.[17,18] The participants having eGFR≤60 ml/min/1.73m2 were classified as CKD.[19] The TSH>=10 was classified as Overt hypothyroidism, the TSH between 4.5 to 9.0 was considered as highly abnormal, TSH of 2.5-4.4 was considered as intermediate abnormal and the TSH of <2.5 was considered as normal.[20] This study was done by the Medical Trainees posted in the RHTC and was supervised by the Assistant Professors of Community Medicine Department. Institute Ethical Committee approval was obtained (Ref No - RC-18/55) and the ethical principles are followed as per ICMR ethical guideline.[21] Data management was carried out using Epidata Software and the appropriate analysis were done with Stata Version 14.0, adjusted prevalence ratio was calculated in Stata using 'poisson' command.[22]

Markov modelling for cost-effectiveness: Markov-deterministic modelling with societal perspective was done to assess the cost effectiveness of this community-based screening intervention programmed. Markov model is considered suitable for chronic diseases. Markov chain engine designed in the Microsoft Excel used to find out the Incremental cost effectiveness ratio (ICER) and cost effectiveness acceptability curve (CEAC) analysis which is available in 'KIBOHUT webpage' was used for analysis.[23] Probability Sensitivity Analysis, ICER plot and CEAC were performed using Monte Carlo simulation. Various input parameters were used in the model setting which is given in Table 2. Cost of the current survey was calculated using the human resource, consumables, non-recurring, travel and overhead. The annual cost per year per unit was calculated per person screening for CVD risk assessment and management at the community level. The cost of standards of care, which is a passive management of HTN and DM at the community level was calculated based on our experience for a year per unit.

Hazard ratio was calculated from the current study prediction (Table 1) using WHO ISH Chart which predicts the CVDs risk for next 10 years.[14] The adjusted risk calculated for 10 year was 20% and 2% per year. Hence the hazard ratio of 0.98 per year for used in our analysis. Utility of DM, HTN, 'both DM and HTN' and Myocardial Infarction (MI) were re-

trieved from review of literature.[24] Only MI was considered among the CVDs due to its high prevalence. Per-capita Gross Domestic Product (GDP) and mean daily wages were taken from recent reports.[25,26] Discounted rate of 3% were considered for analysis.[27] All the costs were adjusted for current year (2024) and converted in USD (1USD=83.47INR).

RESULTS

There were 7% of the participants having CVD risk of more than 40%, 3% with 30 to 40% risk, 11% were with 20-30% risk, 22% were with 10-20% risk and 57% were with less than 10% risk. In the higher risk group (>40% risk) participants with both 'HTN and DM' were having higher risk (11%). Participants with higher age, Female, Illiterate, Anaemia, lower per-capita income, both HTN and DM, smokers, Hypercholesterolemia, Hypothyroidism, and CKD were having higher CVDs risk of >40%. Markov analysis for active screening was shown to be highly cost-effective with the ICER value of INR 78730 (USD 943) per one unit of Quality Adjusted Life Year (QUALY) gained (Figure 1). Lifetime cost of intervention was INR 6,71,272 (USD 8042) and the QUALY saved was 12.1 per unit. Lifetime cost of standard of care was INR 5,65,609 (USD 6776) and the QUALY saved was 10.8, per unit.

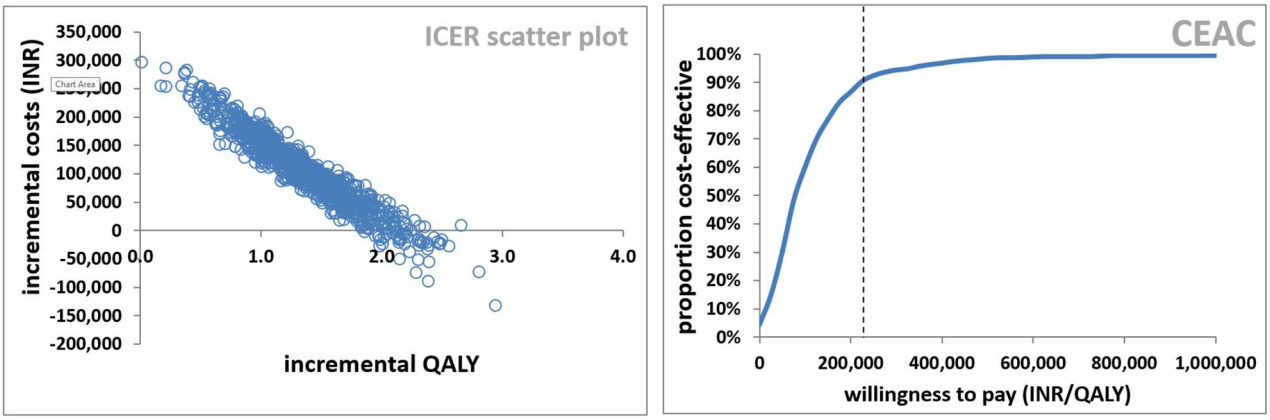
Table 1: Cardiovascular risk among Hypertension and Diabetes participants in study area

Variables	WHO cardiovascular diseases risk score					Total	p-value
	<10%	10-<20%	20-<30%	30-<40%	>=40%		
Cases (%)	**172 (57%)**	**67 (22%)**	**33 (11%)**	**10 (3%)**	**21 (7%)**	**303**	
Age							<0.01
Low to 49	79(90)	5(5.7)	2(2.3)	1(1.1)	1(1.1)	88	
50-59	64(75)	12(14)	4(4.7)	2(2.4)	3(3.5)	85	
60-69	21(26)	29(36)	16(20)	4(05)	10(13)	80	
70-high	8(18)	21(42)	11(22)	3(6)	7(14)	50	
Gender							0.08
Male	57 55)	31 (30)	8 (08)	3 (03)	4 (04)	103	
Female	115 (57)	36 (18)	25 (13)	7 (03)	17 (09)	200	
Education							<0.01
Illiterate	80 (50)	35 (22)	25 (16)	3 (02)	16 (10)	159	
Literate	92 (64)	32 (22)	8 (06)	7 (05)	5 (03)	144	
Anaemia							0.06
Yes	110 (53)	44 (21)	27 (13)	7 (04)	19 (09)	207	
No	62 (65)	23 (24)	6 (06)	3 (03)	2 (02)	96	
HTN and DM							<0.01
HTN only	60 (59)	29 (28)	5 (5)	2 (02)	6 (06)	102	
DM only	60 (79)	11 (14)	4 (05)	0 (0)	1(01)	76	
Both HTN and DM	52 (42)	27 (22)	24 (19)	8 (06)	14 (11)	125	
Per-capita income							0.6
<=2000	112 (55)	45 (22)	22 (11)	7 (03)	17 (08)	203	
2001-4000	52 (61)	17 (20)	11 (13)	2 (02)	3 (04)	85	
>4000	8 (53)	5 (33)	0	1 (07)	1 (07)	15	
Smoker							<0.01
Yes	18 (26)	18 (26)	16 (23)	6 (09)	11 (16)	69	
No	154 (66)	49 (21)	17 (07)	4 (02)	10 (04)	234	
BMI							0.06
Underweight	15 (41)	12 (32)	5 (14)	2 (05)	3 (08)	37	
Normal	38 (44)	27 (31)	10 (12)	3 (03)	9 (10)	87	
Overweight	36 (69)	7 (13)	4 (08)	2 (04)	3 (06)	52	
Obese	83 (65)	21 (17)	14 (11)	3 (02)	6 (05)	127	
Hyper-Cholestrolemia							0.06
Yes	69 (49)	33 (23)	20 (14)	5 (04)	14 (10)	141	
No	103 (64)	34 (21)	13 (08)	5 (03)	7 (04)	162	
Current alcoholic							0.06
Yes	19 (59)	10 (31)	0 (0)	1 (3)	2 (06)	32	
No	153 (57)	57 (21)	33 (12)	9 (3)	19 (07)	271	
TSH levels							0.8
>=10	5 (56)	1 (11)	2 (22)	0 (0)	1 (11)	9	
4.5-9.9	16 (55)	6 (21)	4 (14)	0 (0)	1 (10)	9	
2.5-4.4	57 (65)	14 (16)	8 (9)	4 (5)	5 (5)	88	
<2.5	68 (53)	35 (27)	14 (11)	4 (3)	7 (5)	128	
Not Tested	26 (53)	11 (23)	5 (10)	2 (4)	5 (10)	49	
Chronic Kidney Disease							<0.01
Yes	13 (32)	13 (32)	9 (22)	2 (5)	4 (9)	41	
No	159 (61)	54 (21)	24 (9)	8 (3)	17 (6)	262	
Metabolic Syndrome							<0.01
Yes	94 (64)	21 (14)	15 (10)	7 (5)	10 (7)	147	
No	78 (50)	46 (29)	18 (12)	3 (2)	11 (7)	156	

Table 2: Markov Model Input parameters

Input Parameters	Model Value	Standard Error	Distribution	Reference
Cost of the CVD risk screening - intervention	INR 7880	800	Gamma	Current study
Cost of the standard of care	INR 1000	100	Gamma	Assumption
HZR of death of intervention	0.98	0.1	Normal	Current study
HZR of disease of intervention	0.98	0.1	Normal	Current study
Utility of DM patients	0.76	0.01		Ref No. [24]
Utility of HTN patients	0.89	0.01		Ref No. [24]
Utility of HTN and DM patients	0.68	0.01	Beta	Ref No. [24]
Utility of MI patients	0.67	0.01	Beta	Ref No. [24]
Per capita GDP	2,14,000	21400	Gamma	Ref No. [26]
Mean Daily Wages	635	63	Gamma	Ref No. [25]
Discount Rate	3%	-	-	Ref No. [27]

HZR – Hazard ratio, GDP – Gross Domestic Product



The dotted black line in cost effective acceptability curve indicates the one GDG for 2023-2024, India.

Figure 1: Incremental cost-effectiveness ratio and Cost-effective acceptability curve of screening programme

DISCUSSION

Important findings in our study were that first, the moderate to high risk (>=10% risk) for CVDs was found to be 2.7 times higher than the general population. In our study >=10% risk was 43% however in the general population this was only 17% .[5]

Association of risk with Age, Sex, HTN and DM, Smoker, Hypercholestrolemia and metabolic syndrome are the part of risk prediction chart. These variables are highly significant as it is a dependent factor for risk score. Hence these variables were not included in the advanced analysis. In addition to this data is showing that the CVD risk among lower illiteracy, per-capita income, hypothyroidism, Anaemia and CKD were found to be showing higher proportions with doubtful significant. In the advanced analysis (adjusted prevalence ratio) none of these variables were found to be significant. Significance of association was difficult to establish, may be due to the low sample size. Association of CVDs with Anaemia and CKDs are well documented in the previous literatures.[28] CKD patients are also invariably suffering from anaemia due to erythropoietin deficiency.[29] In addition to this participants with lower literacy rate are associated with CVDs which are demonstrated in other studies also.[30,31] This again reiterates the importance of CVD risk assessment in the rural level to ensure the care to the needy people.

Understanding the importance of burden of NCDs, Government of India has introduced National Programmed for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS) in 2010 in 100 districts across 21 states.[32] In a phased manner this programmed has been implemented all over the country after the initial success. In 2016 population-based screening of NCDs was introduced in the programme. Following this NCD management at primary level was introduced through Ayushman Bharat-Health and Wellness Centre. Secondary and Tertiary care for NCDs were taken care by Ayushman Bharat – Pradhan Mantri Jan Aarogya Yojana (PM-JAY).[2] In 2023 the coverage has been widened and the NPCDCS programme was renamed as NP-NCD. This programme mainly identifies the people with NCDs at population-based screening and aimed to provide appropriate care through primary and secondary health care systems. Our study finding further strengthens the initiative of Government of India.

Whenever the Incremental (ICER) cost effectiveness ratio is below the countries per-capita income or willingness to pay, the intervention will be considered as cost effective. ICER is a value which gives the

cost required to save one QUALY with a specific intervention. Probabilistic Sensitivity Analysis(PSA) used to ascertain the ICER and the CEAC is plotted against multiple values obtained from multiple monte-carlo simulation.[33,34] In our intervention Cost effectiveness acceptability curve is shown in the figure 1, which has reached 90% of acceptability at INR 1,25,000 (USD1,498) which is far below the per capita income of Indians or willingness to pay threshold (INR 2,14,000 - USD 2564), which is shown as a dotted line in figure 1. Thus, our brief analysis of cost effectiveness is supporting the population-based screening for NCDs especially in the remote rural area. Model parameters were kept simple to increase the robustness of the data. Our finding is also supported by the recent cost effectiveness studies from India.[35]

Major strength in this study was, this screening is done in a remote rural area. This screening included investigations in a comprehensive manner. This is one of few studies done in remote area. This Study was a part of service to the needy people in the rural area. However, this study was done among only previously diagnosed HTN and DM participants in a single site. The cost of investigations is high and could not be replicable.

Conclusion

Cardiovascular Diseases risk is higher among HTN and DM patients in the rural community in India. The screening and management at the community level are highly cost effective.

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