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Utilizing statistical methods to assess the association between demographic variables and angiographycally confirmed CVD

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Abstract

Background: Reasons for the high propensity to develop CVD, the high case fatality and the high premature mortality include biological mechanisms, Social determinants and their interactions. Hence understanding the influence of demographic variables such as Gender, Age, Education, Marital Status, Work Type on the prevalence and severity of CVD was crucial for developing targeted prevention strategies. This will guide individuals in modifying their lifestyle for CVD free life. This investigation is important due to the prevalence of CVD and the need to address gaps in understanding; we can gain insights into the distribution and impact of CVD within populations.

Objective: Utilizing statistical techniques to analyze and quantify the relationships between demographic variable statuses correlated with the presence of angiographically confirmed CVD.

Materials Methods: The data of 274 study participants visiting Cardiology Department from Krishna Hospital, Karad, Maharashtra with complaints of CVD was used. Chi-Square test was applied to study association of demographic study parameters with CVD. Logistic regression was carried out to develop the regression model.

Results: Age, Edu, Marital Status were significantly associated with CVD. Logistic regression analysis also detected same variables for best identification of CVD.

Conclusion: As age advances the risk of CVD increases. This notices that one should be health conscious as age increases and underscores the importance of maintaining good health awareness with advancing age.

Subject Classification: *62Fxx, 62J07, 62P10.*

Keywords: *Chi-square test, Logistic regression, ROC.*

1. Introduction

Demographic factors are significant contributors to CVD risk. These encompass aspects like sedentary lifestyle, age, and family medical history. [1] The risk of developing CAD tends to increase with advancing age, along with other factors such as education and occupation. Employing logistic regression and ROC curve analysis can enhance the accuracy of result prediction and optimize performance.[2] Predicting CVD risk emerges as a vital strategy for effective disease management.[3] A study examining the impact of demographic variables on angiography confirmed their association with CVD. Study Participants were classified based on angiography findings into three groups: those without any disease (normal), those with luminal irregularities < 50% categorized as no significant cases, and those with luminal irregularities ≥ 50% classified as significant cases.

2. Methods and Materials:

2.1 *Study Participants:*

In this study the Demographical status (Age, Gender, Place, Education, Marital Status, Work Type, and Family Type) with Angiography Report were investigated. Patient visiting with complaints like Hyper-Tension, Diabetic, Chest-Pains, Cold sweat [fear, anxiety, illness] of cardiovascular disease (CVD) was enrolled in the study. On the basis of Angiography report, individuals were categorised as Cases (>50 % stenosis = significant) and non-Cases (normal or <50 % stenosis = non- significant). Total 411 individuals visiting Cardiology Department with complaints of CVD were enrolled. Split validation method was used and 2/3rd of these samples (274) were randomly selected as the training set and the remaining 1/3rd (137) as the test set. The trial data set 2/3$^{rd.}$ of 411 subjects was selected in same proportion i.e.2/3$^{rd.}$for each of the gender and its respective angiography report (Normal / Not Significant / Significant) as shown in table 1.

Table 1

Distribution of whole sample into Trial and Test data with reference to angiography report.

		Male(n)	Female(n)	Total(n)
Whole Data	Normal	67	48	115
	Not-Significant	23	09	32
	Significant	182	82	264
Total		272	139	411
Trial Data Set	Normal	45	32	77
	Not-Significant	15	06	21
	Significant	121	55	176
Total		181	93	274
Test Data Set	Normal	22	16	38
	Not-Significant	8	03	11
	Significant	61	27	88
Total		91	46	137
By using Statistical way –Proportion, data split up.				

Association between CVD and study variables was performed for deep understanding of CVD by applying appropriate tests like Chi-square test and Logistic regression. We used backward logistic regression method to find reduced model that best explains the outcome. Statistical Analysis done with the help of SPSS-28 version. Further ROC curve analysis performed to identify cut off probabilities for high and equalized Sensitivity, the ability to identify correctly patients with disease, as well as Specificity that the ability of identifying correctly individuals without disease.

2.2 *Data Collection*

This is cross-sectional (Observational Analytical) study design. We interviewed all eligible participants' having symptoms of CVD based on a questionnaire, designed specifically to fulfil the required data of the study. The study related data (Appendix I) regarding Cases and non-Cases were collected from patients visiting the Department of Cardiology, KVV - Krishna Hospital and medical research centre, Karad, Maharashtra.

2.3 *Statistical Analysis*

To study association of various study parameters with CVD, Chi-Square test was applied. On basis of significant study parameters Logistic regression analysis was performed to develop the statistical model for predicating cardio-vascular disease. Receiver Operating Characteristics (ROC) analysis was carried out to detect the cut-off probability value for accurate prediction of CVD.

3. Results

Amongst these 274 subjects, 98 (35.8%) were angiographycally normal or not significant while 176 (64.2%) were angiographically significant. There was not a single subject with Angiographycally significant report at younger age group (20-29). Age of Angiographycally normal or not significant subjects ranged between 21 to 84 years with mean age 54.3 years and SD 12.7 years. While age of angiographycally significant subjects ranged between 36 to 84 years with mean age 60.5 years and SD 9.5years.

As compare to younger people with age 50 and above are much more likely to suffer from developing coronary heart disease. It means that, as age advances proportion of participants with angiographycally significant report increased significantly (χ^2 linear by linear trend =18.108, $p<0.001$).

Table 2

Distribution of Angiography report in relation to Demographic characteristics.

Demographic Variables Normal /Not Significant n (%)		Angiography Report		Total n (%)	χ^2 value, P value
		Significant n (%)			
Age (in Years)	20-29	03 (100)	00 (00)	3(1.09)	25.810 <0.001*
	30-39	9 (75)	3 (25.0)	12(4.37)	
	40-49	21(55.3)	17 (44.7)	38(13.86)	
	50-59	30(34.9)	56 (65.1)	86(31.38)	
	60-69	22(24.2)	69 (75.8)	91(33.21)	
	70-79	11 (29.7)	26 (70.3)	37(13.05)	
	80-89	2 (28.6)	5 (71.4)	7(2.55)	
Gender	Male	60(33.1)	121(66.9)	181(66.05)	1.590 0.207
	Female	38(40.9)	55(59.1)	93(33.94)	
Place	Rural	75(33.9)	146(66.1)	221(80.65)	1.665 0.197
	Urban	23(43.4)	30(56.6)	53(19.34)	
Education Level	Illiterate	11(22.9)	37(77.1)	48(17.51)	7.650 0.054*
	<10th std.	21(30.4)	48(69.6)	69(25.18)	
	10 – 12 std.	35(39.3)	54(60.7)	89(32.48)	
	Diploma, Deg.	31(45.6)	37(54.4)	68(24.81)	
Marital Status	Married	87(33.9)	170(66.1)	257((93.79)	5.332 0.021*
	Unmarried, Divorced	11(64.7)	6(35.3)	17(6.20)	
Family Type	Jiont, Three Generation	35(41.7)	49(58.3)	84(30.65)	1.836 0.175
	Nuclear	63(33.2)	127(66.8)	190(69.34)	
Work Type	Sedentary	12(44.4)	15(55.6)	27(9.85)	4.470 0.107
	Moderate	46(41.1)	66(58.9)	112(40.75)	
	Heavy.	40(40.8)	95(54.0)	135(49.3)	
Total		98(35.8)	176(64.2)	274(100)	
Used software: SPSS Version-28,instat.					

The number of male cases and female cases were 181(66.1%) and 93(33.9%) respectively. Male and female cases with angiographycally significant report were 121(66.9%) vs 55 (59.1%); revealed men have a higher propensity of developing coronary heart disease than women.

Majority of participants 221(80.65%) were from rural areas while very small number of participants, 53(19.34%) were from urban areas. Out of which angiographycally significant were 146(66.1%) in rural while 30(56.6%) in urban areas. Place of residence did not showed significant association with angiography report.

Evidence of a relationship between education and angiography report showed (Table 2), as education level increased, proportion of participants with angiographycally significant report decreased significantly (χ^2 linear by linear trend = 7.580, p=0.006).

Data showed that majority of the Participants were married 257(93.7%), while very few 17(6.20%) were single as unmarried or divorcee. Comparing association of angiography report with marital status about 2/3 $^{rd.}$ amongst married while 1/3 $^{rd.}$ amongst single angiographycally significant (χ^2= 6.607, $p < 0.010$).

The distribution of study population based on type of family revealed that majority of the study participants, 190(69.34%) belonged to nuclear family while 84(30.65%) participants belonged to joint or three generation type family. High proportion (66.8%) of participants from nuclear type families were angiographycally significant report. There was no statistically significant association between family type and angiography report.

The study sample composed 135(49.3%) i.e. half of the participants engaged in heavy work while 112 (40.75%) were doing moderate type

Table 3

Distribution of risk of developing CVD at above age of 60 years and 60 - 69 years age with respect to Demographic Parameters:

Participants Characteristics	Age-Group ≥ 60 =135	Significant =100	Age Group 60-69	Significant n (%)
Education: Illiterate	60	47(78.33 %)	18	16(88.88)
Marital status: Married	132	97(73.48 %)	17	15(88.23)
Work Type: Heavy	62	47 (75.80 %)	4	4(100)
Family Type: Nuclear	97	75(77.31%)	3	3(100)
Place: Rural	109	78(71.55%)	3	3(100)
Gender: Male	86	66(76.74)	2	2(100)
Used software: MS Excel.				

work and 27 (9.85%) were doing sedentary type work. As severity of work type according to physical participation increases i.e. sedentary type work to heavy work, proportion of participants with significant angiography report increases (χ^2 Linear-by-linear trend = 4.101, p= 0.043).

Participants having maximum percentage of angiographycally significant reportwere with age of 60 years and above. Hence we studied these cases according to demographic parameters. Mostly significance is greater with respect toilliteratracy, married peoples doing heavy work in nuclear familiars as residence in ruralmale.

Specifically participants aged 60-69 years showed high risk of developing CVD with respect to above characteristics. I.e. it was seen that, illiterate, nuclear families males having aged 60-69 years who were residing in rural areas found to have high chance of developing CVD.

Backward Logistic Regression was carried out with all explanatory variables for detecting variables those notably contribute in predicting angiography report. This analysis revealed (Education, Age, and Gender) in table 4 as contributing considerably in identification of angiography report.

Table 4

Distribution of risk factors of CVD

		B	**S.E.**	**Wald**	**d.f.**	**Sig.**	**Exp(B) 95 % C.I.**
Gender	Male	.785	.307	6.547	1	.011	2.193 (1.202-4.002)
	Female	Reference					
Education	Illiterate	1.236	.471	6.875	1	.009	3.442 (1.366-8.672)
	Below 10^{th} Std.	.708	.385	3.384	1	.066	2.029 (.955-4.314)
	10^{th}-12^{th} Std.	.304	.352	.746	1	.388	1.355 (.680-2.703)
	Diploma, Degree	Reference					
Age	20 - 29	Reference					
	30 - 39	1.159	.738	2.467	1	.116	3.188 (0.750-13.545)
	40 - 49	1.923	.698	7.592	1	.006	6.838 (1.742-26.847)
	50 - 59	2.518	.702	12.851	1	.000	12.405 (3.131-49.151)
	60 - 69	2.153	.759	8.052	1	.005	8.613 (1.946-38.113)
	70 - 79	2.141	1.078	3.946	1	.047	8.510 (1.029-70.387)
Constant		-2.319	.750	9.556	1	.002	.098
Used Logistic Regression through SPSS-28 software.							

Table 5

Model Prediction for Angiography Report with cut off probability 0.5

Observed	**Predicted**		**Percentage Correct (n)**
	Angiography Report		
Angiography Report	**Normal / Not Significant (n)**	**Significant (n)**	
Normal / Not Significant	37	61	37.8
Significant	19	157	89.2
Overall Percentage			70.8

Since, model Prediction for normal / not significant and significant angiography report was not equal as per cut off probability 0.5, ROC curve analysis was carried out to detect balanced and as high as possible Sensitivity and Specificity. The area under the ROC curve was 0.706. Sensitivity, Coordinates of the curve showed approximately balanced sensitivity (71 %), the ability of a test to correctly identify with a disease and Sepcificity (63.3%) a test to currectly identify people without disease at cut off probability 0.658.

ROC Curve:

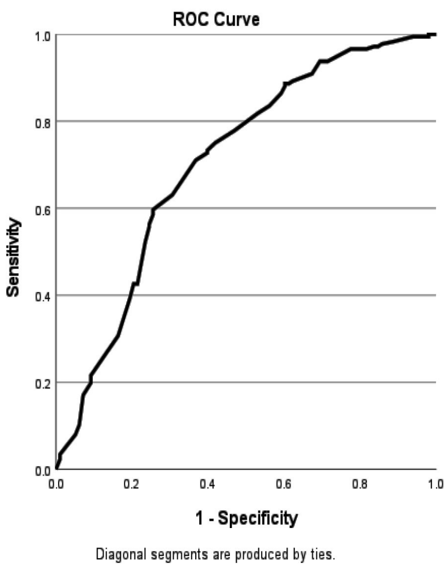

Table 6

Model Prediction for Angiography Report with cut off probability 0.658:

Observed	Predicted		Percentage Correct (n)
	Angiography Report		
Angiography Report	Normal / Not Significant (n)	Significant (n)	
Normal / Not Significant	62	36	63.3
Significant	51	125	71.0
Overall Percentage			68.2

The following table 5 debites classification of normal / not significant and significant angiography report as per model with cut probability 0.658.

Above table 6 revealed that 63.3% of normal / not significant participants were correctly predicted by the model while 71.0 % participants with significant angiography report were correctly predicted by prediction model. Over all correct prediction percentage of model for angiography report was 68.2 %.

By using Table 3(Backward Logistic Regression Model) target variable "Y" was computed in numerical expression given as:

Y = 0.786*(Male= 1) + 1.236 * (Illiterate = 1) + 0.708 * (Below 10 thStd. = 2) + 0.304 * (10 – 12 thStd. = 3) + 1.159 * (Age 30-39 = 1) + 1.923 * (Age 40-49 = 2) + 2.518 * (Age 50-59 = 3) + 2.153 * (Age 60-69 = 4) + 2.141 * (Age 70-79 = 5) -2.319.

Table 7

Test processing summary for observed Angiography Report with predicted Angiography Report cut off probability 0.658

Observed Angiography Report	Predicted Angiography Report		Percentage Correct (n)
	Normal / Not Significant (n)	Significant (n)	
Normal / Not Significant	36	13	73.46
Significant	48	40	54.54
Overall Percentage			64.00

These commands, the coefficients are applied to compute the predicted log odds. Which are store in the new variable "Y". The value of Y is then used to compute the predicted probability by [1/ 1+Exp (-Y)] of the target event and store that probabilities in the new variable by choosing cut off value < 0.657 as 1 (1 = normal behavior / not significant) and else (2 = significant).

The performance of a logistic regression model including accuracy was 64.00 %. (Table 7) i.e correctly predicted observations out of all observations.

4. Discussion

Gender wise distribution of Angiography Report:

Similar to Kambara H et. al [4], Kohro T et. al [5] and DeoraS et. al [6] among 274 study participants, majority were males [181(66.05%) vs females 93(33.94%)]. However, Male and female cases with angiographycally significant report revealed quite high proportion of males compared to females [121(66.9%) vs 55 (59.1%)](χ^2 =1.590, p = 0.207).

Age wise Angiographic Report:

Participants with complaints of CVD symptoms found in the age range of 20-80 years. Similar to the findings of a study carried out by the American Heart Association (AHA)[7], maximum participant's belonged to 60-69 years age group, 91(33.21%), while 44(15.6%) belonged to ≥70 years age. There was not a single subject with angiographycally significant report at younger age group (20-29). Age of angiographycally normal or not significant subjects ranged between 21 to 84 years with mean age 54.3 years and SD 12.7 years. Similarly age of angiographycally significant subjects ranged between 36 to 84 years with mean age 60.5 years and SD 9.5years. The comparison of mean age of angiographycally normal or not significant and angiographycally significant revealed significantly longer period taken (6.2 years (t = 4.603, p<0.001)) for existence of CVD. However 69.7% participants with angiographycally significant report were below 50 years age. This indicates that Indians are at an increased risk of angiography at a younger age.[8,9] The prevalence of CVD has also been shown to increase with age, in both men and women.[10,11]

Place wise distribution of Angiography Report:

Coronary heart disease prevalence rates in India have been estimated over the past several decades and have ranged from 1.6% to 7.4% in rural populations and from 1% to 13.2% in urban populations. [12] However, in present study majority of participants, 221(80.65%), were from rural areas while very small number of participants, 53(19.34%) were from urban area. Of these 146 (66.1%) participants from rural area and 30(56.6%) participants from urban area resulted into angiographycally significant report. It means Residential area wise proportion of angiographycally significant report was differing slightly (χ^2 =0.1665, p=0.197).

Education wise Distribution of Study Subjects:

Most of illiterate people, 37(77.1%), resulted angiographycally significant report. As education level increased, proportion of participants with angiographycally significant report decreased significantly (χ^2 linear-by-linear trend = 7.580, p=0.006). The status variable 'education level' was significant among factor with angiography report.

Similar to present study Degano I R et al revealed that education and cardiovascular disease (CVD) are inversely associated but in this study researchers have not elucidated the role of mediating factors. This study shows an inverse association between education and CVD incidence in general population from North-Eastern Spain, when compared participants with university education to participants with primary or lower education. [13]

Distribution of Angiography Report with Marital Status:

When considered marital status, there were about 2/3rd (66.1%) amongst married while about 1/3rd (35.3%) amongst single with angiographycally significant report (χ^2 =5.332, p=0.021). The odds ratio, when compared angiographycally significant report amongst married in relation to single was 3.582 with 95% CI 1.28 to 10.01. It was comparatively small with narrow range of CI in study of Wong C W et al. [14] (OR 1.42; 95% CI 1.00 to 2.01).

Distribution of Angiography Report with Family Type:

The proportion of angiographycally significant reports in participants from nuclear type families (66.8%) was similar to proportion of angiographycally significant reports observed in participants from joint or three generation type family (58.3%). However, majority of the study participants admitted with complaints of CVD, 190(69.34%), belonged to nuclear family while 84(30.65%) participants belonged to joint or three generation type family. This indicates unsafe or fear in individuals residing in nuclear type families.

Distribution of Angiography Report according to Work Type:

Half of the participants engaged in heavy work 135(49.27%) while 112 (40.87%) were doing moderate type work and 27 (9.85%) were doing sedentary type work. The trend analysis revealed that as severity of work type increases (from sedentary to heavy), proportion of participants with significant angiography report increases (χ^2 Linear-by-linear trend = 4.101, p= 0.043).

Though unemployed people are facing cardiac disease more than employed people [14], there is no study showing occupational heavy lifting as an independent risk factor for cardiovascular disease.[15]

R^2, which tells how much of the variation in the outcome variable is explained by the model, of 0.170 is small. However, small R- squared values are not necessarily problematic while higher values are not necessarily good [16]. An R-square ranging between 0.10 & 0.18 is perfectly fine. [17]

Area under the ROC curve is 0.706. As per standard guidelines, discrimination is said to be fairly accurate if 0.7≤ Area under ROC ≤ 0.8, the cutoff detected in present study is fairly accurate

Hence, the model seems to provide a moderate fit to the data, explaining around 12.4% (Cox and Snell R^2=0.124) to 17.0% (NagelkerkeR^2=0.170) of the variability in the dependent variable.

4.1. *Conclusion*

Our investigation highlights a higher frequency of CVD among individuals with lower levels of education. Men tend to develop CVD at a younger age and are more susceptible to coronary heart diseases. There is substantial evidence linking age, marital status, and occupation. Among participants aged 60 and above, three-quarters were diagnosed with CVD based on angiography results, whereas among those aged 60 to 69 years, 96% were diagnosed with CVD.

In short, Angiographic investigation is the invasive and costly issue. To know the necessity of Angiography one should undergo this painless statistical investigation; i.e. exposure to the regression model; prior to the gold standard; Angiography. This model prediction will help clinician as well as patient and relatives mentally preparing for confirmation of the presence or absence of the disease.

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