AMJ Australasian Medical Journal [AMJ 2019;12(7):189-199]

Epidemiology of frequent admitters of cardiovascular diseases in urbanizing Pune population

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RESEARCH

Please cite this paper as: Syed Abrar A, Chavan Chandrakant, Badani Rajesh, Diwan Arundhati, Periasamy Muthu, Wankhade Varsha. Epidemiology of frequent admitters of cardiovascular diseases in urbanized Pune population. AMJ 2019;12(7):189–199.
https://doi.org/10.35841/1836-1935.12.7.189-199

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ABSTRACT

Background
Ischemic heart disease is known to be prevalent in Indian population

Aims
To study the prevalence of cardiovascular diseases in Pune population and to elucidate comorbidities and the risk factors associated with frequently admitted CVD patients.

Methods
A descriptive cross-sectional study was carried out for a period of five years (2011–2015) in Pune India. Data was retrieved from Life Line software at Bharti Hospital. ICD-10 was followed throughout the study. Comorbidities and risk factors were estimated in frequent CVD admitters. For estimation of oxidative stress, antioxidant marker enzymes were estimated from plasma samples of CVD patients. Chi-square test was employed for the study of association in proportions. Kruskal-Wallis test was performed to test significance of difference.

Results
Among 939 cardiac patients, MI represented as the most common CVD especially in men (38.79 per cent). Higher level of Lipid peroxidation was reported in MI (14.43±1.82) than IHD (13.06±2.23), HCM (7±1.47) and control (2.44±0.74) (p<0.001). MI patients show higher comorbidities and increased risk of developing complications. Glutathione reductase (U/mg) was decreased in MI (1.76±0.2) and HCM (1.8±0.3) patients than IHD (2.14±0.4) and Control samples (2.17±0.3) (p<0.05).

Conclusion
MI is more often observed in frequent admitters of CVDs. IHD patients show higher comorbidities than other CVDs in this population. Oxidative stress was found to be more in MI than other cardiac disorders.

Key Words
Cardiac diseases, oxidative stress, rheumatic heart disease, distribution

What this study adds:

1. What is known about this subject?
Coronary heart diseases in urban Indian population has risen from 4 per cent to 11 per cent in five decades.

2. What new information is offered in this study?
Myocardial infarction is the most prevalent type of CVD in this population from last five years (2011–2015). Comorbidities were higher in ischemic heart diseases.

3. What are the implications for research, policy, or practice?

With increasing cardiac disorders in Indian population, routine screenings is needed and follow up check-ups.

Background

Cardiovascular diseases (CVDs) are the leading cause of mortality worldwide. More than 3 million deaths occurred due to CVDs below the age of 60 years and 17 million deaths occurred in year 2008 alone,[1] however there has been a continuous decline in deaths due to CVDs both in men (11 per cent) and in women (14 per cent) from 1991 to 2013.[2] CVDs affect India a decade earlier than their European counterparts.[3,4] In Indians 52 per cent deaths occur due to CVDs before the age of 70 years, whereas it is 23 per cent in western population.[5] Various studies have shown that Indians are at high risk of myocardial infarction at a younger age (<40 years) irrespective of migrant or resident status.[6] South Asian population shows higher levels of ApoB/ApoA-1 ratio than western population.[7] Conventional risk factors like systolic blood pressure, plasma cholesterol, and overweight are elevated in urban areas or migrant Indian population.[8] As per the Jaipur Heart Watch-2 study, high prevalence of risk factors such as smoking, low physical activity, hypertension, hypercholesterolemia, diabetes, and obesity were observed in men and women in coronary artery disease.[9] High prevalence of diabetes, a history of hypertension, tobacco smoking, increased fasting glucose, and increased ratio of visceral to total body fat are risk factors for acute MI.[10] Reactive oxygen species (ROS) play a key role in initiation, clinical consequences and progression of CVDs[11] by acting as a signalling molecule and affect wide range of process in CVDs and maintain homeostasis.[12] The aim of the study is to unravel the distribution of cardiac diseases in frequent admitters of CVD across different age groups in urban Indian population, and to show the status of risk factors and oxidative stress in different sub-groups of CVDs.

Method

Sample Size

Sample size calculation was estimated by Raosoft sample size calculator with 90 per cent confidence level.

Disease identification criteria:

Aortic regurgitation (Trivial -severe) based on following criteria:

Vena contracta width (cm) - Mild (<0.3), Severe (>0.6)

Jet width/LVOT diam. (per cent)-Mild (<25), Severe (>65)

Regurgitation volume (ml) - Mild (<30), Moderate (31-59), Severe (>60)

Pressure Half time (ms) - Mild (>500), Severe (<200)

Mitral Regurgitation (Trivial-severe)

Vena contracta (cm) - Mild (<0.3), Severe (>0.7)

PISA radius (Nyquist 40cm/s) - Mild (<0.4), Severe (>1.0)

Regurgitation orifice area (cm^2) - Mild (<0.20), Moderate (0.21-0.39), Severe (>0.40)

Diastolic dysfunction- (I)-E/A<1, DT>230, s/d>1, LA increased

(ii)- E/A, A1-2, DT-130-230, LA↑, s/d<1

(iii)- E/A>2, DT<130, e-reduced, LA↑, s/d<1**,** E/e>13

Diabetes Mellitus- Mild (100-125mg/dl), severe (>126mg/dl)

Hypertension- ≥ 140/90 mm HG

Fatty liver- based on USG technique, stiffness of liver and echogenicity between spleen and liver

Rheumatic Arthritis- Pain and swelling in multiple joints

Megaloblastic Anaemia- Anaemia, Complete blood count (CBC), RBC's appearance

Type of study and patient selection

A descriptive cross-sectional study was carried out for a period of five years (2011–2015) at Bharti Hospital, Pune. The patient population is diverse and hospital admits patients from the state of Maharashtra, and also from other states of India due to the fast urbanization process. The patients also represent a heterogeneous population with diverse ethnic and economic status.

Data collection

Clinical history of CVD patients was obtained from the Medical Record Department (MRD) by selecting appropriate International classification of diseases (ICD) codes. Patient records were retrieved from Life Line software by applying one ICD code at a time and patient details of particular ICD code were selected from first day –last day of that particular year. The medical records were carefully traced employing the IPD no.'s of the patients by a trained staff. Data sheets were formatted in standard data collection forms. Primary symptoms were selected in registry file entry regardless of other comorbidities. ICD-10 was followed throughout the study (Table 1).

Exclusion criteria for antioxidant enzyme estimations

CVDs patients either on antioxidant drugs or having cancer were excluded from the current study. HCM patients

showing hypertension (140/90mmHg), aortic stenosis, cancer, cardiac arrhythmias, were excluded from this study.

Estimation of antioxidant enzymes in Plasma samples

Written informed consent was taken from all the participants. For biochemical assays, plasma was isolated from 5ml fresh blood and immediately stored at -80^{o} C. Catalase enzyme activity was estimated by the method of Aebi[13] and Glutathione peroxidase assay was performed by the method of Richard.[14] Glutathione S- transferase activity was estimated according to Habig's method.[15] Glutathione reductase and Superoxide dismutase enzyme assays were performed as per the method of Goldberg.[16] Malondialdehyde was estimated by the method of Ohkawa.[17] Normal range values of all biochemical estimation were extracted from hospital records.

Statistical analysis

Data were stratified into five different age groups as <20 years, 21–40 years, 41–60 years, 61–80 years and >80 years and all parameters were represented as mean±SEM. Normality were estimated by Shapiro-Wilk test. Proportions were compared by χ^2 test. One-way ANOVA was used for statistical significance and comparisons by Tukey's post hoc test. Pearson's correlation was used for strength of association between heart physiology and various other marker enzymes. Past 3 software was used for statistical calculations. Graphical representation was performed in Graph Pad Prism 7 software. p<0.05 were considered as significant for the current study.

Results

Distribution and prevalence percent of CVD

A total of 939 patients (549 males and 390 females) diagnosed with different cardiac disorders were investigated for the current study. We observed an age associated increase in the prevalence of various cardiac disorders as higher per cent were present in age group of 61–80 years (42.5 per cent) (Table 2).

MI was most prevalent type of CVD especially in males (38.79 per cent) as compared to females (20.51 per cent) followed by IHD in males (9.65 per cent) and females (10 per cent). Cardiomyopathy is less prevalent in males (4.55 per cent) than females (5.38 per cent) **(**Table 3). RVHD was more prevalent in the age group of <40 years. In the age group of 21–40 years, total prevalence of RVHD was 56.60 per cent (52.38 per cent in males and 57.64 per cent in females). The distribution of RVHD in the age group of <20 years was 14.15 per cent (9.52 per cent males and 15.29 per cent females).

Acute coronary syndrome was less prevalent in <20 years of age groups than RVHD and cardiomyopathy. In the age group of 21–40 years, distribution of MI was 12.74 per cent (Males 15.68 per cent and females 6.12 per cent) while IHD was 1.07 per cent (males 1.88 per cent, females 0 per cent) and cardiomyopathy 4.76 per cent (males 8 per cent, females 0 per cent). Maximum distribution of MI was in age group of 41–60 years, of total 40.84 per cent (males 47.59 per cent, females 26.53 per cent) while IHD was 34.4 per cent (males 35.84 per cent, females 32.5 per cent) RVHD 21.69 per cent (males 28.57 per cent, females 20 per cent) and cardiomyopathy was 26.1 per cent (males 36 per cent, females 29.41 per cent) **(**Table 4).

Comorbidities associated with different frequent admitters

IHD patients show higher comordities (164.47 per cent) than MI (153.22 per cent), cardiomyopathy (126.15 per cent) and RVHD (74.5 per cent). RVHD patients show significantly higher episodes of mitral regurgitation (39.62 per cent) as compared to MI (19.28 per cent), IHD (18.27 per cent), and Cardiomyopathy (33.33 per cent) (p<0.01). Significantly higher ST changes were present in MI patients (38.23 per cent), RVHD (3.77 per cent), IHD (17.20 per cent) and Cardiomyopathy (9.5 per cent) (p<0.001). IHD patients show significantly higher scores of diastolic dysfunction and hypertension (27.95 per cent, 58.06 per cent), MI (20.58 per cent, 33.33 per cent), RVHD (2.83 per cent, 9.43 per cent) and Cardiomyopathy (7.14 per cent, 28.57 per cent) respectively (p<0.001). Cardiomyopathy patients observed significantly higher per cent of diabetes mellitus (28.57 per cent) than MI (26.14 per cent), IHD (21.5 per cent) and RVHD (0.94 per cent) (p<0.001) **(**Table 5).

Risk factors were comparatively higher in MI patients as compared to other frequent admitted CVD patients. Cholesterol ratio (Cholesterol/ HDL) was significantly higher in IHD patients 4.10±0.14 mg/dl than MI (3.93±0.07mg/dl), RVHD (3.77±0.2mg/dl) and Cardiomyopathy (3.18±0.15 mg/dl) indicating higher risk of heart disease (p<0.01). CPK and CPK-MB, markers of heart attack were significantly higher in MI (282.1±17.22IU/L, 64.7±3.63IU/L) than RVHD (227.3±59.41IU/L, 38.3±7.3IU/L), IHD (189.2±19.63IU/L, 29.3±2.23IU/L) and Cardiomyopathy (197.5±38.90IU/L, 34.8±5.27IU/L) (p<0.01) respectively. Cardiomyopathic patients show significantly lower blood outflow (32.9±2.6 per cent) than MI (41.6±0.6 per cent), IHD (49.4±1.4 per cent) and RVHD (53.1±2.2 per cent) (p<0.001). IVS diameter was significantly altered in IHD (11.8±0.62mm), MI (11.1±0.5mm), RVHD (10.2±0.2mm) and Cardiomyopathy (10.9±0.5mm) (p<0.01) (Table 6).

A positive Pearson's correlation was analysed between various marker enzymes and heart physiology in different CVDs. In IHD a negative correlation was observed between CPK and LVEF (R=-0.54, *P*<0.01) and between CPK and IVS (R=0.44, *p*<0.01). In RVHD patients negative correlation was observed between IVS and ALT (R=-0.56, *p*<0.01). In MI patients negative correlation was found between AST and LVEF (R=-0.40, *p*<0.01), in cardiomyopathy patients a positive correlation was observed between CPK-MB and IVS (R=0.47, p=0.05) and positive correlation was observed between LA and alkaline phosphate (R=0.52, *p*<0.01) **(**Figure 2).

Oxidative stress in CVD patients

Oxidative stress in various CVD types were estimated in plasma samples to check the severity of cardiac pathophysiology. MI patients show lower levels of glutathione reductase U/mg (1.76±0.2) as compared to control (2.17±0.3), HCM (1.8±0.3) and IHD patients (2.14±0.4) (*p*<0.05). Significantly higher level of malondialdehyde (MDA) was observed in MI patients (14.43±1.82) as compared to control samples (2.44±0.74), HCM (7±1.47) and IHD samples (13.06±2.23) (*p*<0.001). Significant higher level of glutathione S-transferase was observed in HCM samples (0.06±0.02), IHD (0.12±0.08) and MI (0.05±0.01) as compared to control samples (0.008±0.003) (*p*<0.05) (Figure 3).

Discussion

This is the first study to the best of our knowledge showing distribution of cardiac disorders in the most frequent admitters from last five years (2011–2015) in the population of Indian origin. This study elucidates that both males and females in the fast urbanizing Indian population are equally at risk of various cardiac disorders except in myocardial infarction where prevalence in male is more than females. Population-attributable risk for men ≤55 years was 93.1 per cent and for women ≤65 year was 96.5 per cent. Women have first MI 9–10 years later than men. This study gives a detailed insight of various CVDs in more comparative way as per the age, sex and type of CVDs. IHD and stroke have maximum share of mortality in Indian population (83 per cent) with IHD as a predominant one. Mortality due to IHD and stroke is higher in Indian population as compared to global average value.[19] Prevalence per cent of IHD in our study was in according to other studies[20-22] but prevalence is more in females also. In urban population of Chandigarh RHD was 1.23/1000 males and females 2.07/1000 in all the age groups.[23] RVHD is the main cause of atrial fibrillation in Indian population as the mean age of onset is 38 years as per CRAFFT study. In the present study mitral regurgitation is more common in RVHD than aortic regurgitation. MR constitutes higher per cent of isolated lesions in 25.6 per cent of all the cases as compared to 5.8 per cent aortic regurgitation.[24] MI patients show higher risk factors, increased oxidative stress as compared to other CVDs. According to Singapore myocardial infarction registry, consisting MI cases in the age group of 20–64, reveals that men are at four times higher risk than females.[25] Significantly, higher ST changes were present in MI patients indicating complications in the electrical conductivity due to damaged tissue. In India 25 per cent of acute MI occurs below 40 years of age and 50 per cent under 50 years of age.[26,27] Among the North East Indian population, Acute MI (AMI) is more prevalent at a younger age group of 40–45 years.[28]

IHD patients have higher comorbidities in this population as compared to frequent admitters of CVD **(**Table 5). Higher levels of cardiovascular comorbidities were recorded such as atrial fibrillation, heart failure, prior MI, diabetes mellitus, hypertension, and stroke in MI patients.[29] CPK and CPK-MB markers of heart attack were significantly higher in MI. Mean serum CPK value were significantly higher in acute MI patients, than patients with CAD without MI and control group.[30] CPK and CPK-MB markers of heart attack were significantly higher in MI. Mean serum CPK value were significantly higher in acute MI patients, than patients with CAD without MI and control group.[30] Serum alkaline phosphatase is associated with increased risk in CHD and overall CVD events which is to a large extent associated with CVDs risk factors and inflammation.[31] Higher levels of alkaline phosphatase in MI patients lead to coronary calcification in dose dependent manner thus increasing the risk in MI patients.[32]

Higher level of oxidative stress could contribute or exaggerate heart disease abnormalities by affecting mitochondrial energy production. Significant higher levels of MDA were estimated in MI patients as compared to IHD, HCM and control groups as also reported in.[33] Glutathione reductase is lower in MI patients as compared to control samples, IHD, and HCM samples. GR, GPX are significantly lower in AMI implying that glutathione system is damaged in AMI.[34] Lower levels of SOD attributed due to ischemia and reperfusion as higher level of superoxide anions are released by ischemic cells.[35]

Conclusion

An important finding of this study is that Myocardial infarction is the most prevalent type of CVD in the fast urbanizing population especially in the age group of 40–60

years. Ischemic heart disease and Cardiomyopathy are almost equally distributed among males and females may be due to fast urbanization and westernization. IHD patients exhibit higher comorbidities than other frequent admitters. Further, CVD patients in general show higher oxidative stress level than control group in this population and in particular oxidative stress were more in MI patients.

Limitations

This study focuses only on one study centre. A detailed comparative cross-sectional study of CHD should be conducted in other tertiary centres. This study gives a detailed comparative analysis of most common antioxidants levels in CHD as compared to healthy individuals. Pro-oxidants which includes a number of chemicals including pharmaceutical drugs which may be involved in production of ROS or inhibition of antioxidant pathway needs to be addressed. Data sheets should be formatted as per usage of drugs by cardiac heart disease patients which may help in unravelling the role of pro-oxidant in different CHD groups.

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PEER REVIEW

Not commissioned. Externally peer reviewed.

CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

FUNDING

Board of College and University Development (BCUD) Savitribai Phule Pune University, DRDP, UGC-CAS and DST-PURSE.

ETHICS COMMITTEE APPROVAL

Permission from Institutional Human Ethics Committee at Savitribai Phule Pune University and Bharti Hospital, Pune was received.

Table 1: Inclusion of ICD codes in current study

Diagnosis	ICD code
Hypertensive heart disease	11
Angina pectoris	20-20.0
Acute Myocardial Infarction	21-21.1
Acute Ischemic Heart disease	24
Cardiomyopathy	42-42.0
Atrial fibrillation	48
Heart failure	50-50.1
Rheumatic Heart Disease	9.9

ICD = International classification of diseases

Table 2: Distribution of CVDs as per age groups in 20 year of strata

Age group (Years)	Men n=549 n (%)	Women n=390 n (%)	Total n=939 n (%)
<20	7(1.27)	11(2.82)	18 (1.92)
21–40	82(14.93)	72(18.46)	154 (16.4)
41–60	208 (37.88)	120(30.76)	328 (34.94)
61–80	225(40.98)	174 (44.61)	399 (42.5)
>80	28 (5.10)	16 (4.10)	44 (4.7)

CVDs = Cardiovascular diseases

Table 3: Prevalence of various highly distributed CVDs in fast urbanizing population during five years

Type of CVDs	Year (I) n (%)	Year (II) n (%)	Year (III) n (%)	Year (IV) n (%)	Year (V) n (%)	Total n (%)
RVHD						
(Men)	4 (4)	4 (4.65)	7 (6.14)	1 (0.8)	3 (2.41)	19 (3.46)
(Women)	57 (46.34)	14 (26.41)	8 (8.88)	2 (2.89)	5 (9.09)	86 (22.05)
IHD						
(Men)	22 (22)	15 (17.44)	6 (5.26)	7 (5.64)	3 (2.4)	53 (9.65)
(Women)	21 (11.7)	8 (15.09)	3 (3.33)	5 (69)	2 (2.5)	39 (10)
MI						
(Men)	33 (33)	22 (25.58)	45 (39.47)	62 (50)	51 (40.8)	213 (38.79)
(Women)	16 (13)	7 (13.20)	25 (27.77)	25 (36.23)	7 (12.72)	80 (20.51)
Cardiomyopathy						
(Men)	4 (4)	7 (8.13)	2 (1.75)	8 (6.45)	4 (3.2)	25 (4.55)
(Women)	4 (3.25)	4 (7.54)	7 (7.77)	6 (8.69)	0 (0)	21 (5.38)

IHD= Ischemic heart disease, MI= Myocardial infarction, RVHD = Rheumatic valve heart disease. MI was frequently reported in men as compared to women, RVHD was higher per cent in women.

Table 4: Distribution of CVDs according to sex and age groups

Age group (yrs.)	Total n (%)	Men n (%)	Women n (%)
RVHD			
< 20	15 (14.15)	2 (9.52)	13 (15.29)
21-40	60 (56.60)	11 (52.38)	49 (57.64)
41-60	23 (21.69)	6 (28.57)	17 (20)
61-80	4 (3.7)	0 (0)	4 (4.7)
>80	1 (0.94)	0 (0)	1 (1.17)
IHD			
< 20	0 (0)	0 (0)	0 (0)
21-40	1 (1.07)	1 (1.88)	0 (0)
41-60	32 (34.4)	19 (35.84)	13 (32.5)
61-80	44 (47.31)	26 (49.05)	18 (45)
>80	11 (11.82)	8 (15.09)	3 (7.5)
MI			
< 20	0 (0)	0 (0)	0 (0)
21-40	39 (12.74)	33 (15.86)	6 (6.12)
41-60	125 (40.84)	99 (47.59)	26 (26.53)
61-80	112 (36.6)	64 (30.76)	48 (48.97)
> 80	13 (4.24)	7 (3.36)	6 (6.12)
Cardiomyopathy			
< 20	4 (9.52)	2 (8)	2 (11.76)
21-40	2 (4.76)	2 (8)	0 (0)
41-60	14 (26.19)	9 (36)	5 (29.41)
61-80	21 (50)	11 (44)	10 (58.82)
> 80	0 (0)	0 (0)	0 (0)

Table 5: Prevalence of secondary complications (comorbidities) associated with CVDs in urbanizing population

Complications	RVHD n (%)	IHD n (%)	MI n (%)	Cardiomyopathy n (%)	p value
Mitral regurgitation (MR) (Trivial-Severe)	42(39.62)	17 (18.27)	59 (19.28)	14 (33.33)	<0.01
Aortic regurgitation (AR) (Trivial-Severe)	16(15.09)	12 (12.90)	23 (7.51)	7 (16.66)	0.11
ST changes	4 (3.77)	16 (17.20)	117 (38.23)	4 (9.5)	<0.001
Diastolic dysfunction (grade I-grade IV)	3 (2.83)	26 (27.95)	63 (20.58)	3 (7.14)	<0.001
Diabetes Mellitus (Type I- Type II)	1(0.94)	20 (21.50)	80 (26.14)	12 (28.57)	<0.001
Hypertension	10 (9.43)	54 (58.06)	102 (33.33)	12 (28.57)	<0.001
Fatty liver (grade I- grade II)	1(0.94)	6 (6.45)	19 (6.20)	1(2.38)	0.15
Rheumatic arthritis	2 (1.88)	1(1.07)	4(1.30)	0 (0)	0.83
Megaloblastic anaemia	0 (0)	1(1.07)	2 (0.65)	0 (0)	0.71

Table 6: Estimation of risk factor markers among CVD patients during five year period

Risk factors	RVHD	IHD	MI	Cardiomyopathy	p value
Total Cholesterol/HDL (mg/dl)	3.77±0.2	4.10±0.14	3.93±0.07	3.18±0.15	<0.01
Serum CPK (IU/L)	227.3±59.41	189.2±19.63	282.1±17.22	197.5±38.90	<0.05
Serum CPK-MB (IU/L)	38.3±7.3	29.3±2.23	64.7±3.63	34.8±5.27	<0.0001
Serum AST (IU/L)	32.7±4.1	28.8±1.6	46.1±4.26	31.9±2.99	<0.001
Serum ALT (IU/L)	41.1±5.9	30±1.9	38.5±2.5	40.7±3.3	<0.05
IVS (mm)	10.2±0.2	11.8±0.62	11.1±0.5	10.9±0.5	<0.01
LVEF (%)	53.1±2.2	49.4±1.4	41.6±0.6	32.9±2.6	<0.001
Serum Alkaline Phosphatase (IU/L)	80±5.3	78.1±3.5	86.9±3.1	77.4±5.4	0.34
Sugar Fasting (mg/%)	116.6±11.3	124±7.2	138.1±6.1	150.2±16.8	0.22

ALT = Alanine aminotransferase, AST = Aspartate aminotransferase, CPK = Creatinine phosphokinase, CPK-MB = Creatinine phosphokinase-MB, IVS = Interventricular septum, LVEF = Left ventricular ejection fraction.

Figure 1: Flow chart diagram of research design of current study

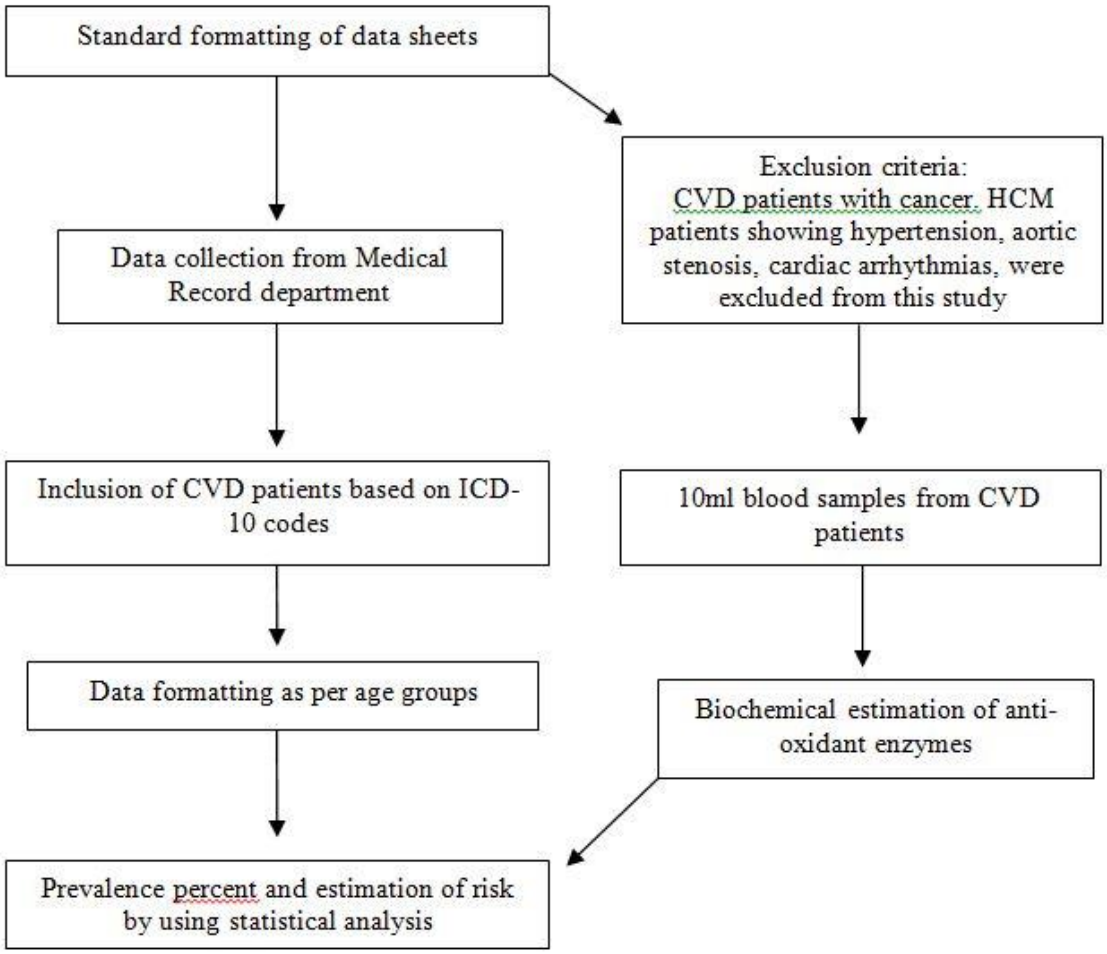

Figure 2: Association of various marker enzymes with heart physiology in different CVDs

(a) Correlation of LVEF (%) and CPK (IU/L) in IHD patients; (b) Correlation of IVS (mm) and CP-MB (IU/L) in IHD patients; (C) Correlation of IVS (mm) and ALT (IU/L) in RVHD patients; (d) Correlation of LVEF (%) and AST (IU/L) in MI patients; (e) Correlation of IVS (mm) and CPK-MB (IU/L) in Cardiomyopathic patients; (f) Correlation of Left auricle diameter (mm) and alkaline phosphate (IU/L) in Cardiomyopathic patients.

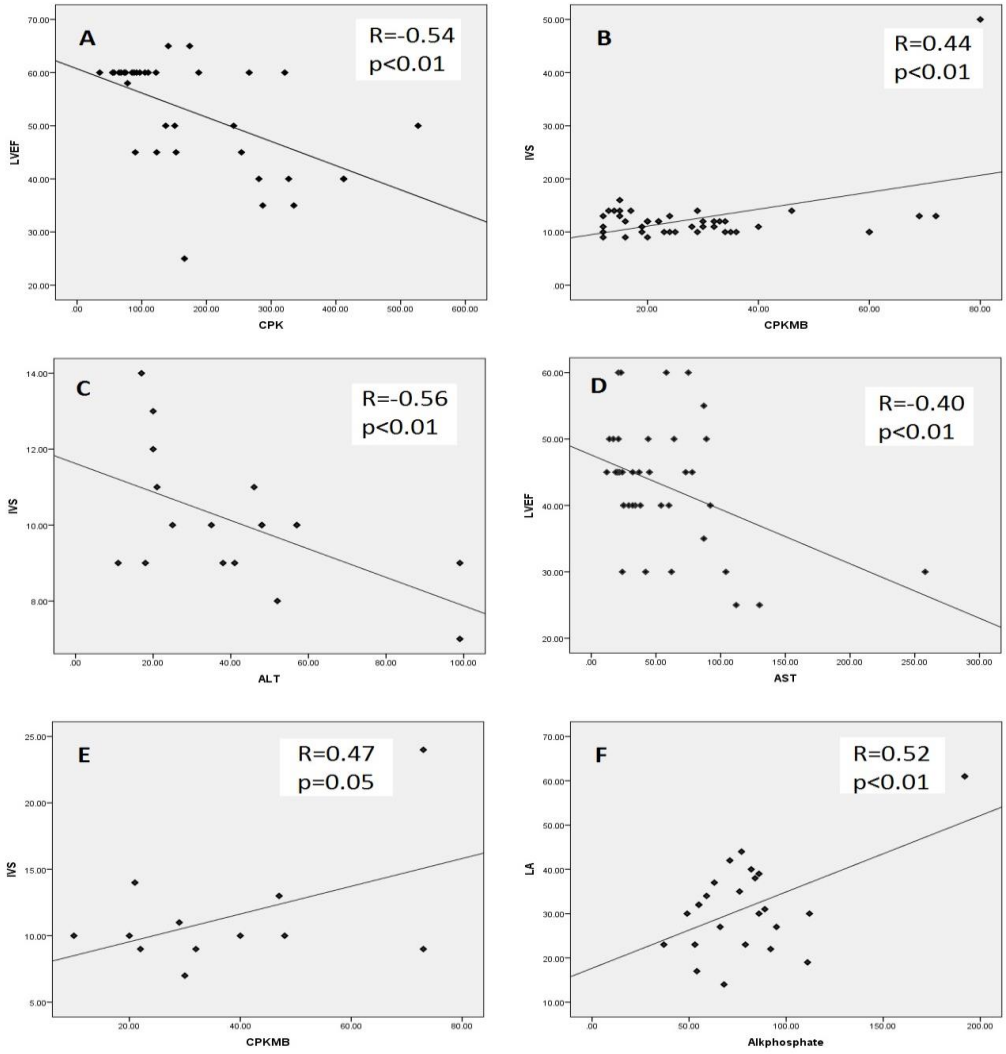

Figure 3: Biochemical estimation of antioxidant enzymes in various CVDs in urbanized population