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STRESS LEVELS AND ASSOCIATED DISEASES IN

BANGALORE CITY POLICE PERSONNEL

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The research project on 'stress levels and associated diseases in Bangalore City Police Personnel' provided an opportunity to gain an insight into the stress levels of the police personnel, their life style modifying diseases arising out of work style and impact of stress in early on-set of metabolic syndrome. The research involved extensive field work, clinical evaluation and data analysis. Working with police personnel was a challenge as they are always engaged in official work and on their toes for the security of the public.

At the outset, I express my sincere thanks to BPR&D for sponsoring the project and facilitating data collection through official channel.

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Dr. B G Sudarshan

EXECUTIVE SUMMARY

Modern life style induces stress. It is more prominent in Police due to the nature of work. They are prone to physical and psychological problems which can affect their professional and personal life. Exposure to chronic stress leads to early on-set of metabolic diseases and hence early mortality and morbidity. The objective of the present research was to identify the operational and organisational stressors in Bangalore City police, investigate effect of stress on physiological parameters and correlate the changes to the stress induced diseases in them.

Operational and organisational stressors in Civil, Traffic and Armed police were estimated using Questionnaire. Based on the severity of stress, police personnel belonging to Armed and Unarmed were selected for clinical, biochemistry, Heart Rate Variability and hormonal analysis. In the first phase 950 respondents aged 25 to 55 years were administered the questionnaire. Further, 605 respondents of age 30 to 45 years were studied for the stressors.

Operational stresses were of high incidence in Bangalore East Division of civil police followed by North East Division and incidences of these stresses were high in both Traffic and Civil police. Causative factors were overtime demands and irregular food habits. Organisational stresses were of high incidence in Bangalore East Division followed by Bangalore South. The causative factors were prolonged working hours, inadequate pay scales and promotional policies.

Mean operational and organisational stresses were greater in 30 to 34 years and lower in 45 to 50 years of age. Organisational stresses were lower in 45 to 50 years than that in 30 to 35 years. No significant difference was found in operational stresses between the two age groups. Operational stresses were lower in women police than that in the male, because of less overtime demands in women police. While promotional policies equally caused stresses in both male and female police, inadequate pay scales, problems related to coping with superiors and prolonged working hours were of greater concern in men police.

Police of 30 to 45 years of age (with high stress) who form the major working force were focused for further investigation by clinical, biochemistry and hormonal studies. Stresses were correlated with physiological parameters as indicators of health with its associated diseases. Body Mass Index, three months average blood sugar levels, FBS, Total Cholesterol

and Low Density Lipoproteins were higher in Unarmed Police, suggesting Metabolic Syndrome and associated complications. ECG for HRV were lower in unarmed, suggesting changes in Autonomic Nervous System. The results were analysed for both Traffic and Civil police. Biochemistry parameters were suggestive of Traffic police at higher risk levels than the Civil police for metabolic syndrome.

Results were analysed for men and women in Civil Police, as the number of women police respondents were less in Traffic. Number of women respondents provided by Bangalore City Police were limited due to administrative issues. Men police were at higher risk for increase in cholesterol, obesity, gastritis, heart diseases based on biochemistry investigation.

Women respondents are more prone to CVD when HRV is considered as an independent risk factor for CVD. Around 57 % of unarmed police were found to be at high risk for CVD as compared to 6.8 % in armed police. The study indicated that BMI is statistically significant for HRV parameters and is a major risk factor for CVD.

Causative factors for operational stresses are found to be overtime demands and irregular food habits. It is recommended to evaluate the adequacy of police staff. Causative factors for organisational stresses were prolonged working hours, inadequate pay scales and promotional policies. It is recommended to regularise working hours, revise pay scales and promotional policies commensurate to the nature of police job. The police in the age group 30 to 35 years are subjected to prolonged working hours due to inadequate staff. It is recommended to investigate the entry level staffing and pay scales. Inadequate pay scales, problems related to coping with superiors and prolonged working hours are of greater concern in Men police than that in the Women. As these are the stressors for Organisational stresses, it calls for behavioural corrections. As most of the biochemistry and clinical evaluations indicated predominance towards the onset of metabolic syndrome due to the stressors identified, it is recommended to institute regular health check-up including the health parameters studied in the present research.

It is recommended to include additional parameters as part of regular health check up, such as diurnal variations of salivary cortisol levels, interleukins and study of HRV by long term recording using Holters, for determining physiological variations due to stresses. Periodic psychological evaluation is recommended to assess stresses. The effect of stresses on the performance of the police has to be further investigated.

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GLOSSARIES

ACTH	Adrenocorticotrophic hormone
ODIN	Occupational Disease Intelligence Network
SOSMI	Surveillance of Occupational Stress and Mental Illness
CISF	Central Industrial Security Force
SNS	Sympathetic Nervous System
PNS	Parasympathetic Nervous System
ANS	Autonomous Nervous System
SPR	Sympathetic-to-Parasympathetic Ratio
HRV	Heart Rate variability
CVD	Cardiovascular disease
BMI	Body Mass Index
CHD	Coronary Heart Disease
HDL	High-Density Lipoprotein
WHO	World Health Organization
IFG	Impaired fasting glucose
HRV	Heart rate variability
MI	Myocardial infarction
SDNN	Standard deviation of RR intervals
RMS	root mean square
RMSSD	Differences between consecutive RR intervals
FFT	fast Fourier transform
AR	autoregressive
VLF	very low frequency
RSA	Respiratory Sinus Arrhythmia

1. Research Objectives

- ❖ Studying of the extent of health status abnormalities among Bangalore City Police Personnel and its distribution between armed and unarmed police personnel.
- ❖ Studying the correlation of stresses with different physiological parameters as indicators of health with its associated diseases among Bangalore City Police Personnel.

1.1 Research Plan for first phase (20 June 2013 to 19 June 2014)

- ❖ Design of Questionnaire for studying stresses in English and in local language (Kannada).
- ❖ Selection of respondents on the basis of stratification and age group.
- ❖ Administration of the questionnaires to different divisions of Bangalore city police namely civil, traffic and city armed reserve police.
- ❖ Evaluation of the responses in the completed questionnaires adopting Fontana Stress Scale Scoring Pattern.
- ❖ Statistical analysis of the data to identify relatively 200 highly stressed (stress level $\geq$ 50 %) police personnel for further clinical and biochemical investigations.

1.2 Research plan for second phase (20 June 2014 to 19 June 2016)

- ❖ Clinical and biochemical investigations for 75 to 100 police personnel identified with stress levels $\geq$ 50 %.
- ❖ Statistical Analysis of the clinical investigation and biochemical estimation reports using SPSS (V 20.0.0).
- ❖ ANN modelling and interpretation of clinical investigation and biochemistry investigation reports.
- ❖ Correlation of the diseases with stress levels.

1.3 Time phasing of Research Tasks

Task	Duration in months					
	0 to 3	4 to 6	7 to 9	10 to 12	13 to 21	22 to 24
Design of Questionnaire						
Selection of respondents						
Administration of questionnaires						
Evaluation of the responses						
Statistical analysis of responses & identification of respondents for further study						
Clinical and biochemical investigations						
Statistical Analysis of the clinical and biochemistry investigations						
ANN modelling for predictions						
Correlation of diseases with stressors						
Final Technical Report						

2.0 National and International Scenario on the Study of Stress (Review of Literature)

The modern day life style has created severe stress which is increasing every day even among common man and more so among Police personnel due to multiple factors. The increase in population, the police personnel coming from diverse sections of the society and with insufficient exposure to the societal realities and the ever increasing work load in the job, lead to enhanced stress in police personnel. Added to the above is the nature of work, strict internal hierarchies, exposure to critical incidents, prolonged working hours, gender discrimination, negative public opinion, political pressure and strict organizational policies also enhance the stress levels in the police personnel to a greater extent. The increased stress levels lead to various physical as well as psychological health problems which has a negative effect on their professional and personal life. The present study is an attempt to assess the stress levels and its associated diseases among Bangalore City Police Personnel.

The increasing population, the increasing disparity between the have and have-not, and the rising aspirations among people on account of exposure from the media have all added up to greater stress experienced by the police personnel. Internationally there have been innumerable studies on the influence of stress among police personnel. Wide range of advanced training, and stress mitigation process have been introduced to cope the stress among Police personnel. However more research needs to be carried out in India. Even though the state and national governments have carried-out reviews and have suggested improved working conditions for police personnel, better training and even increase in numbers of police personnel, to keep up with the ever increasing population density. Due to ever increasing work load not all reforms have been implemented. Hence, there is a need to relook at national and international status of work done and also analyse the current status among the police personnel. The present work is a step in that direction.

2.1 Mental Stress

The term stress has a precise physiological definition. It is a state of physiological or psychological strain caused by an adverse stimulus, physical, mental or emotional, internal or external that tends to disturb the functioning of an organism and which an organism naturally

desires to avoid. Thus “stress” can be viewed as, that which could be caused due to both psychological and physiological components [1].

The phenomenon of stress has been examined in several disciplines, including psychology, anthropology, physiology, medicine and management [2]. However, the concept of stress was first proposed by Hans Selye (1936). Selye’s well-known definition of stress, based on his research, is that stress is “the nonspecific response of the body to any demand made upon it” [3].

Zeidner and Endler [4] defined the term stress as a condition that arises when an individual experiences a demand that exceeds his or her real or perceived abilities to successfully cope with it, resulting in disturbance to his or her physiological and psychological equilibrium.

Taber’s Cyclopedic Medical Dictionary defines stress as "the result produced when a structure, system or organism is acted upon by forces that disrupt equilibrium or produce strain". "Workplace stress" has harmful physical and emotional response that can happen when there is a combination of high demands in a job and a low amount of control over the situation [5].

2.2 Stressors

People can experience either external or internal stressors. External stressors include adverse physical conditions such as pain, hot or cold temperatures or stressful psychological environments such as poor working conditions or abusive relationships. Internal stressors can also be physical like infections, inflammations or psychological and detail effect on individual organs. An example of an internal psychological stress is intense worry about the harmful event that may or may not occur [6].

Some of the intense stressors at work place include:

- ❖ Under participation in decisions that affect the work responsibilities.
- ❖ Unrelenting and unreasonable demands for performance.
- ❖ Lack of effective communication and conflict- resolution methods among workers and employers.
- ❖ Lack of job security.

- ❖ Long working hours.
- ❖ Excessive time spent away from home and family.
- ❖ Office politics and conflicts between workers.
- ❖ Non-commensurate wages with levels of responsibility.
- ❖ Political interference.
- ❖ Inadequate equipment and lack of training on equipment.
- ❖ Harassment at work place and so on.

As stated by the Canadian Mental Health Association: Fear of job redundancy, layoffs due to an uncertain economy, increased demands for overtime due to staff cutbacks act as negative stressors at work place. Some of the most visible causes of workplace stress include Job insecurity, high demand for performance, technology, and workplace culture, personal or family problems. Job related stress is likely to become chronic because it is such a large part of daily life and stress in turn reduces a worker's effectiveness by impairing concentration, causing sleeplessness and increasing the risk for illness, back problems, accidents and loss. Work stress can lead to harassment or even violence while on the job. At its most extreme, stress that places such a burden on the heart and circulation can be fatal.

2.3 Women police Personnel Stress

A UN Women report of 2011 estimates that, globally, women average just 9 % of the police, with rates falling as low as 2 % in some parts of the world. On average, women do not make up more than 13 % of the police force in any region. In most developed countries, women make up to 25% of the total force, with Scandinavian countries having around 30%. In view of low women police personnel stress is evident to build.

On other hand women may suffer from mental and physical harassment at workplaces, apart from the common job stress. Sexual harassment in workplace has been a major source of worry for women, since long. Further women may also suffer from tremendous stress such as hostile work environment harassment, which is defined in legal terms as offensive or intimidating behaviour in the workplace can consist of unwelcome verbal or physical conduct. Subtle discriminations at workplaces, family pressure and societal demands add to these stress factors [6].

Stress thus has a profound impact on the emotional, cognitive and physical well-being and the quality of life of individuals. It has been strongly linked to numerous chronic health risks, such as cardiovascular disease [7], diabetes, obesity [8], hypertension, and coronary artery disease [9]. Physiological reactions induced by stress are symptomatic of mental illnesses, such as anxiety disorder and depression which is a leading cause of suicides [10]. Chronic stress can induce mood swings, social isolation, and aggression which negatively affect interactions with peers, friends, and families, leading to a broader array of social issues.

2.4 Stresses among Police Personnel

Police personnel's work is a difficult, dangerous, and often thankless job. The police personnel are one of the most stressed groups of people in the society. In fact, stress has led to many problems in both personal and professional life. Many factors are affecting on police personnel. Invariably, all the cadres do face many problems such as personal, familial and professional and other social problems, which put great pressure on their commitments. The work status, multiple roles in the family, their psychological and demographic makeup, etc., may drag them to be stress prone. However, the extent to which the independent and combined effects of these variables influence the stress levels makes an interesting scientific problem. Psychological and sociological factors influence health and physical problems in two distinct ways. Firstly, they can affect the basic biological processes that lead to illness and disease. Almost any type of stress causes an immediate and marked increase in adrenocorticotrophic hormone (ACTH) secretion from the anterior pituitary gland followed by an increased secretion of Cortisol from the adrenal cortex. Cortisol is a stress hormone which decreases the permeability of the capillaries, migration of the white blood cells into the inflamed areas as well as suppresses the immune system, thereby causing decrease in the lymphocyte production [11-13] and phagocytosis of the damaged cells. Secondly, longstanding behavior patterns may put people at risk to develop certain physical disorders. Sometimes, both these avenues contribute to the etiology or maintenance of disease.

It has been estimated that between 25% and 30% of police officers have stress-based physical health problems, most notably high blood pressure, coronary heart disease, and gastrointestinal disorders [14-16]. Law enforcement tends to impose a higher degree of stress and a multiplicity of stress situation on the police personnel than other professions [14,17 – 24].

In the Occupational Disease Intelligence Network (ODIN) system for Surveillance of Occupational Stress and Mental Illness (SOSMI) in Manchester, policing features among the top three occupations most commonly associated with workplace stress by both occupational physicians and psychiatrists [25].

There is a lot of research material on external and occupational sources of stress in police work, emphasizing on the organizational and operational problems. A majority of Indian [26,27] and international [28,29] studies have found high stress levels in police, which is disturbing as psychiatric morbidity in police can have many direct and indirect negative consequences for society. Therefore, apart from physical fitness, they have to be mentally fit to do full justice to their duties. Previous studies have commented on the high stress levels in police and its association with physical and mental ill-effects. High psychological stress is seen to have a negative impact not only on their work ability but also in the personal and interpersonal spheres of their lives.

In our complex modern society, there has been an increased level of stress, especially for police personnel. This has triggered many problems, in both personal and professional life.

Deb *et al.*, in a study on traffic constables under Kolkata Police, disclosed that 79.4% of them were moderately or highly stressed [26].

A study by Rao *et al.* on Central Industrial Security Force (CISF) personnel found 28.8% of them scoring positive for high stress on GHQ-30. The study also found higher psychiatric morbidity in the high-stress group [27].

Collins *et al.* in a cross-sectional study on county police constables and sergeants in the United Kingdom found that the high-stress group constituted 41% of the population and showed significant association with having negative job perception [28]. Lipp [29] found 43% of senior Brazilian police officers under significant stress.

Zukauskas *et al.* identified in their study on police officers that consequences of stress included depression, alcoholism, physical illness, and suicide [30] Kohan *et al.* correlated job stress with high substance use among police [31].

Mathur et al [32] identified parameters which induce high stress in police personnel, such as work conditions, work overload, lack of recognition, fear of severe injury/killed on duty, inadequate equipment, shooting someone in line of duty, anti terrorist operations, confrontation with public, lack of job satisfaction and Police hierarchy.

Bhaskar et al [33] reported that intrinsic factors to the job and closely related to the work as major contributors to stress related problems among police personnel. Bureau of Police Research and Development [34] identified various stressful aspects at work, home and community environment to understand their impact on health. Spragg [35] suggested that post traumatic stress disorder is a major problem among police personnel. Saathoff and Buckman [36] reported adjustment disorders followed by substance abuse and personality disorders. Vena et al [37] reported that Ischemic heart diseases and Acute Myocardial infarction are very high among police officers subjected to higher degrees of stress.

Channa Basavanna et al [38] prescribed general health questionnaire and six indices semi structured questionnaire for measuring the factors responsible for work related stress in police personnel. Chakraborty [39] observed that higher incidence of disciplinary problems, poor peer relations and poor authority relations, conflict between patients and their fathers are related more to psychiatric problems in general and attempted suicides in specific.

Violanti et al [40] reported that atypical working hours and stress induced by it are responsible for metabolic syndrome. Violanti et al [41] conducted research on association of post traumatic stress disorder with metabolic syndrome. The authors observed that officers with severe PTSD symptoms are approximately three times more likely to have the metabolic syndrome. Shabana Tharkar [42] et al conducted a study on Indian police on their exposure to stress and the related complications of health. The authors observed that police personnel are more prone to stress induced diseases rather than general population. Tharkar et al [42] studied the prevalence of cardiomyopathy in police personnel with general population where in there was a high prevalence among police personnel compared to the general public. Atanu Saha [43] evaluated cardiovascular risk factors among police and found them to be on high proportion. Hartley [44] studied the association of depressive

disorders with metabolic syndrome and observed increasing trend between stress and associated diseases.

Chronic stress, as experienced in working situations, can lead to a chronic activation, overload and eventually exhaustion of the hormonal, cardiovascular, neural and muscular systems due to insufficient recovery and repair. Long term consequences include, for example, an impairment of immune systems, delay of healing processes and musculoskeletal overload [45].

Exposure to chronic stress is a good predictor of cardiovascular disease. Ongoing troubles and the failure to resolve negative emotional states such as anger and anxiety generate imbalance between the Sympathetic (SNS) and Parasympathetic Nervous System (PNS), the two branches of Autonomous Nervous System (ANS). An increase in the Sympathetic-to-Parasympathetic Ratio (SPR) is now being linked to increased cardiovascular morbidity and mortality [46-48]. Chronically stressed individuals show decreased Heart Rate variability (HRV) [49,50].

2.5 Various parameters as indicators of stress induced diseases

Cardiovascular disease (CVD) is the single largest cause of death in the developed countries and is among the leading causes of death and disability in the developing nations as well. There are an estimated 31.8 million people living with coronary artery disease (CAD) in India alone [51]. Furthermore, in contrast to developed countries, CVD tends to occur at a younger age in Indians with 52 % of CVD deaths occurring under 70 years and 10 % of heart attacks occurring in subjects <40 years [52].

Major risk factors for ischemic vascular disease include increased age, male sex, raised LDL cholesterol, reduced HDL cholesterol, and increased blood pressure, smoking, diabetes mellitus, family history of CVD, obesity, and sedentary lifestyle. For many of these risk factors, including elevated LDL cholesterol, observational studies show a continuous gradient of increasing risk of CVD with increasing levels of the risk factor, with no obvious threshold level.

The various indicators are:

- **Body Mass Index (BMI):** The price we are paying for an affluent and developed society is a sedentary life style and faulty dietary habits which result in an imbalance between energy intake and energy expenditure, which, in turn leads to obesity. Over weight and obesity represent a rapidly growing threat to the healthy populations in an increasing number of countries [53]. Obesity is becoming a global epidemic [54] and in the past 10 years in Europe and the United States, dramatic increase in obesity has occurred in both children and adults [55].

Obesity is associated with an increased risk of morbidity and mortality as well as reduced life expectancy. Complications are either directly caused by obesity or indirectly related through mechanisms sharing a common cause such as a poor diet or a sedentary lifestyle. Overweight and obesity may account for as many as 15-30% of deaths from Coronary Heart Disease (CHD) and 65-75% of new cases of type 2 Diabetes Mellitus [56]. The strength of the link between obesity and specific conditions varies. One of the strongest is the link with type 2 diabetes. Excess body fat underlies 64% of cases of diabetes in men and 77% of cases in women [57].

Over weight and obesity are associated with an increased risk of disabling conditions such as arthritis and impaired quality of life in general. A variety of adaptations in cardio respiratory structure and function occur in the individual as adipose tissue accumulates in excess amounts, even in the absence of co-morbidities [58]. Hence, obesity may affect the heart and lungs through its influence on known risk factors such as dyslipidemia, hypertension, glucose intolerance, inflammatory markers, obstructive sleep apnoea, hypoventilation, and the prothrombotic state, in addition to as yet unrecognized mechanisms. The cardiovascular disorders due to obesity result in increased mortality from complications such as coronary artery disease, heart failure, arrhythmias and sudden death [59].

Obesity is often defined simply as a condition of abnormal or excessive fat accumulation in adipose tissue, to the extent that health may be impaired. Body Mass Index provides the most useful, albeit crude, population-level measure of obesity. It can be used to

estimate the prevalence of obesity within a population and the risks associated with it. Obesity produces an increment in total blood volume and cardiac output that is caused in part by the increased metabolic demand induced by excess body weight [60]. The increase in blood volume in turn increases venous return to the heart, increasing filling pressures in the ventricles and increasing wall tension. This leads to left ventricular hypertrophy and this can decrease the diastolic compliance of the ventricle which can further progress to diastolic dysfunction and as wall tension increases further, can lead to systolic dysfunction. Thus through different mechanisms like increased total blood volume, increased cardiac output, left ventricular hypertrophy and further diastolic dysfunction, obesity may predispose to heart failure [60].

- **Dyslipidemia:** Dyslipidemia, defined as elevated total or Low-Density Lipoprotein (LDL) cholesterol levels, or low levels of High-Density Lipoprotein (HDL) cholesterol, is an important risk factor for CHD and stroke [61]. The term dyslipidemia is used to denote the presence of any of the following abnormalities, occurring alone or in combination - increased concentration of TC or LDL-C or serum TG or a decreased concentration of HDL-C [52].

Dyslipidemia is a widely recognized risk factor for cardiovascular diseases, a leading cause of death in both developed and developing countries [62,63]. The World Health Organization (WHO) estimates that dyslipidemia is associated with more than half of the global cases of ischemic heart disease and more than four million deaths per year [64]. Evidence demonstrates that dyslipidemia can be prevented and controlled, which is cost-beneficial and with effective prevention programs can decrease the incidence and mortality of cardiovascular diseases [65,66].

The prevalence of hypercholesterolemia ($TC \geq 200$ mg/dl) alone, as reported in numerous studies across India, has varied from about 20 % to 35 % [52]. However, what is more important is the pattern of dyslipidemia. When compared with the western populations, Indians and migrant Asian Indians tend to have higher triglyceride levels and lower HDL-C levels [67-75]. In contrast, mean serum cholesterol levels among Asian Indians have been shown to be similar to that of the general population in the US and lower than the levels in the UK [76]. The low HDL-C levels and hypertriglyceridemia are metabolically interlinked and their combination has been termed as “atherogenic dyslipidemia”, which

is also characterized by increased levels of small-dense LDL particles with relatively normal total LDL-C, and insulin resistance [77,78]. Atherogenic dyslipidemia is particularly common in South Asians and has been shown to have a strong association with type 2 diabetes mellitus, metabolic syndrome and CVD [79,80].

In fact, as shown in the INTERHEART study, dyslipidemia appears to be the strongest contributor of acute myocardial infarction (MI) in South-Asians [81].

- **Diabetes :** CVD is a major complication of diabetes and the leading cause of early death among people with diabetes—about 65 percent of people with diabetes die from heart disease and stroke. Adults with diabetes are two to four times more likely to have heart disease or suffer a stroke than people without diabetes. High blood glucose in adults with diabetes increases the risk for heart attack, stroke, angina, and coronary artery disease [82]. People with type 2 diabetes also have high rates of high blood pressure, lipid problems, and obesity, which contribute to their high rates of CVD [83]. Smoking doubles the risk of CVD in people with diabetes.

The complications due to diabetes include CHD, stroke, peripheral arterial disease, nephropathy, retinopathy, and possibly neuropathy and cardiomyopathy. Because of the aging of the population and an increasing prevalence of obesity and sedentary life habits in the United States as well as in other countries, the prevalence of diabetes is increasing. Thus, diabetes must take its place alongside the other major risk factors as important causes of CVD.

The most prevalent form of diabetes mellitus is type 2 diabetes. This disorder typically makes its appearance later in life. The underlying metabolic causes of type 2 diabetes are the combination of impairment in insulin-mediated glucose disposal (insulin resistance) and defective secretion of insulin by pancreatic β -cells. Insulin resistance develops from obesity and physical inactivity, acting on a substrate of genetic susceptibility [84,85]. Insulin secretion declines with advancing age [86,87], and this decline may be accelerated by genetic factors [88,89]. Insulin resistance typically precedes the onset of type 2 diabetes and is commonly accompanied by other cardiovascular risk factors: dyslipidemia, hypertension, and prothrombotic factors [90,91]. The common clustering of these risk factors in a single individual has been called the metabolic syndrome. Many

patients with the metabolic syndrome manifest impaired fasting glucose (IFG) [92] even when they do not have overt diabetes mellitus [93]. The metabolic syndrome commonly precedes the development of type 2 diabetes by many years [94]; of great importance, the risk factors that constitute this syndrome contribute independently to CVD risk.

- **Salivary Cortisol:** The hormone cortisol has been considered to be a physiological response to stress that leads to a psychological influence on physical activity of the body [95]. It is the key regulator of the physiological stress response in humans [96]. Cortisol is the major glucocorticoid produced in the adrenal cortex. Cortisol is actively involved in the regulation of blood sugar, blood pressure maintenance, anti-inflammatory function, regeneration of cells in the body and immune function [95]. Cortisol production has a circadian rhythm. The cortisol levels rise in the early morning and drop to the lowest concentration at night. Levels rise independently of circadian rhythm in response to prolonged stress [95]. While a certain amount of this hormone is essential, and many situations such as physical activity can normally increase cortisol levels, abnormal elevation or prolonged cortisol secretion may be harmful to one's health. Studies have shown that prolonged secretion of cortisol is associated with increase in stress and depression leading to an increase in sympathetic cardiac control and a decrease in parasympathetic cardiac control [97]. Also, high cortisol reactivity to stress plays a role in promoting food intake and if maintained overtime may cause a risk of developing metabolic syndrome [98].

Cortisol, the end product of the HPA axis, has been used as a stress biomarker [99,100]. Serum cortisol level is fluctuated by circadian rhythm, and is elevated by activation of the HPA axis caused by stress regardless of circadian rhythm [101, 102]. It is the reason behind utilizing cortisol as a stress biomarker.

- **Heart Rate Variability:** Heart rate variability (HRV) describes the variations between consecutive heartbeats. The regulation mechanisms of HRV originate from sympathetic and parasympathetic nervous systems and thus HRV can be used as a quantitative marker of autonomic nervous system. Stress, certain cardiac diseases, and other pathological states affect on HRV.

The interactions between autonomic neural activity, BP, and respiratory control systems produce short-term rhythms in HRV measurements [103-105]. HRV is thus considered a measure of neurocardiac function that reflects heart–brain interactions and ANS dynamics.

The clinical importance of HRV was noted as far back as 1965 when it was found that fetal distress is preceded by alterations in HRV before any changes occur in the heart rate itself [106]. In the 1970s, HRV analysis was shown to predict autonomic neuropathy in diabetic patients before the onset of symptoms [107]. Low HRV has since been confirmed as a strong, independent predictor of future health problems and as a correlate of all-cause mortality [108,109]. Reduced HRV is also observed in patients with autonomic dysfunction, including anxiety, depression, asthma, and sudden infant death [110-115].

Based on indirect evidence, reduced HRV may correlate with disease and mortality because it reflects reduced regulatory capacity, which is the ability to adaptively respond to challenges like exercise or stressors. For example, patients with low overall HRV demonstrated reduced cardiac regulatory capacity and an increased likelihood of prior myocardial infarction (MI) [116]. Chronic stress is associated with lower HRV [117].

Generally the HRV means the total power (TP, 0.003–0.4 Hz) of frequency domain. HRV analysis methods can be divided into time-domain, frequency-domain, and nonlinear methods.

- **Time-domain methods:** The time-domain parameters are the simplest ones calculated directly from the raw RR interval time series. The simplest time domain measures are the mean and standard deviation of the RR intervals. The standard deviation of RR intervals (SDNN) describes the overall variation in the RR interval signal whilst the standard deviation of the differences between consecutive RR intervals (SDSD) describes short-term variation. For a stationary time series SDSD equals to the root mean square (RMS) of the differences between consecutive RR intervals (RMSSD).

There are also other commonly used parameters like NN50 which is the number of consecutive RR intervals differing more than 50 ms. The pNN50 is the percentage value of NN50 intervals. The prefix NN stands for normal-to-normal intervals (i.e. intervals between consecutive QRS complexes resulting from sinus node depolarizations). In practice, RR and NN intervals usually appear to be same. Furthermore, there are some geometric measures like the HRV triangular index and TINN that are determined from the histogram of RR intervals [118].

- **Frequency domain methods:** The RR interval time series is an irregularly time-sampled signal. This is not an issue in time domain, but in the frequency-domain it has to be taken into account. If the spectrum estimate is calculated from this irregularly time-sampled signal, implicitly assuming it to be evenly sampled, additional harmonic components are generated in the spectrum. Therefore, the RR interval signal is usually interpolated before the spectral analysis to recover an evenly sampled signal from the irregularly sampled event series [119].

In the frequency-domain analysis power spectral density (PSD) of the RR series is calculated. Methods for calculating the PSD estimate may be divided into nonparametric [e.g. fast Fourier transform (FFT) based] and parametric (e.g. based on autoregressive (AR) models) methods [120].

The PSD is analyzed by calculating powers and peak frequencies for different frequency bands. The commonly used frequency bands are very low frequency (VLF, 0-0.04 Hz), low frequency (LF, 0.04- 0.15 Hz), and high frequency (HF, 0.15-0.4 Hz). The most common frequency-domain parameters include the powers of VLF, LF, and HF bands in absolute and relative values, the normalized power of LF and HF bands, and the LF to HF ratio. Also the peak frequencies are determined for each frequency band. For the FFT based spectrum powers are calculated by integrating the spectrum over the frequency bands. The parametric spectrum, on the other hand, can be divided into components and the band powers are obtained as powers of these components. A detailed description of this can be found in [121]. This property of parametric spectrum estimation has made it popular in HRV analysis.

- **Nonlinear methods:** It is realistic to presume that HRV also contains nonlinear properties because of the complex regulation mechanisms controlling it. The interpretation and understanding of many nonlinear methods is however, still insufficient.

One simple and easy way to comprehend nonlinear method is the so called Poincare plot. It is a graphical presentation of the correlation between consecutive RR intervals. The geometry of the Poincare plot is essential. A common way to describe the geometry is to fit an ellipse to the graph [122]. The ellipse is fitted onto the so called line-of-identity at 45° to the normal axis. The standard deviation of the points perpendicular to the line-of-identity denoted by SD1 describes short-term variability which is mainly caused by Respiratory Sinus Arrhythmia (RSA). The standard deviation along the line-of-identity denoted by SD2 describes long-term variability.

3. Methodology

3.1 First Phase of the Project

The questionnaire included Socio demographic profile, organisational and operational stress related questions. Administration of the Questionnaire: Permission was accorded to meet 12 DCPs by the Joint Commissioner of Police (Crime). Bangalore City Police has been divided as Armed and Unarmed Police Personnel. Armed Police Personnel - three divisions and Unarmed Police Personnel - nine divisions which included two Traffic Police divisions were permitted for the research project.

The Questionnaire was prepared in English and then translated into the local language i.e. Kannada. Kannada questionnaire was retranslated to English to check whether the questions conveyed the same meaning in both the languages. The police personnel with minimum ten years of service were considered for the study. The Stress Questionnaire consisting of Operational and Organizational Stress Questionnaires was administered to 950 Bangalore City police personnel (Armed - 245 and Unarmed - 705) from all the 12 divisions separately. Out of 950 completed and evaluated questionnaires, 605 (Armed – 169; Unarmed – 436 which includes 157 Traffic Police) completed Questionnaires were selected for further study on the basis of the age group. Police personnel in the age group of 30 – 50 years were considered for the study with the main focus on the age group 35 – 45 years. This was a self administered questionnaire which was designed based on “The Operational and Organizational Questionnaires” – Two valid measures of stressors in Policing developed by Don R McCreary and M M Thompson [123] and also on the inputs obtained from different cadres of the Bangalore City Police Personnel. The Questionnaire comprised of 26 questions - 12 questions related to Operational Stress and 13 questions related to Organizational Stress. 26th question was framed in particular for women police personnel with regard to gender discrimination in the Police Department. Questionnaire is provided in Appendix – A.

Evaluation of the Stress Questionnaire: Evaluation of the completed Stress Questionnaire was done based on the responses given by the Police Personnel. The scoring was done by adapting the Professional Stress Scale / Fontana Stress Scale [124] developed by David Fontana so as to identify the presence of sources of stress in a police personnel. Scoring pattern for each question is provided in Appendix – B.

3.2 Second Phase of the Project

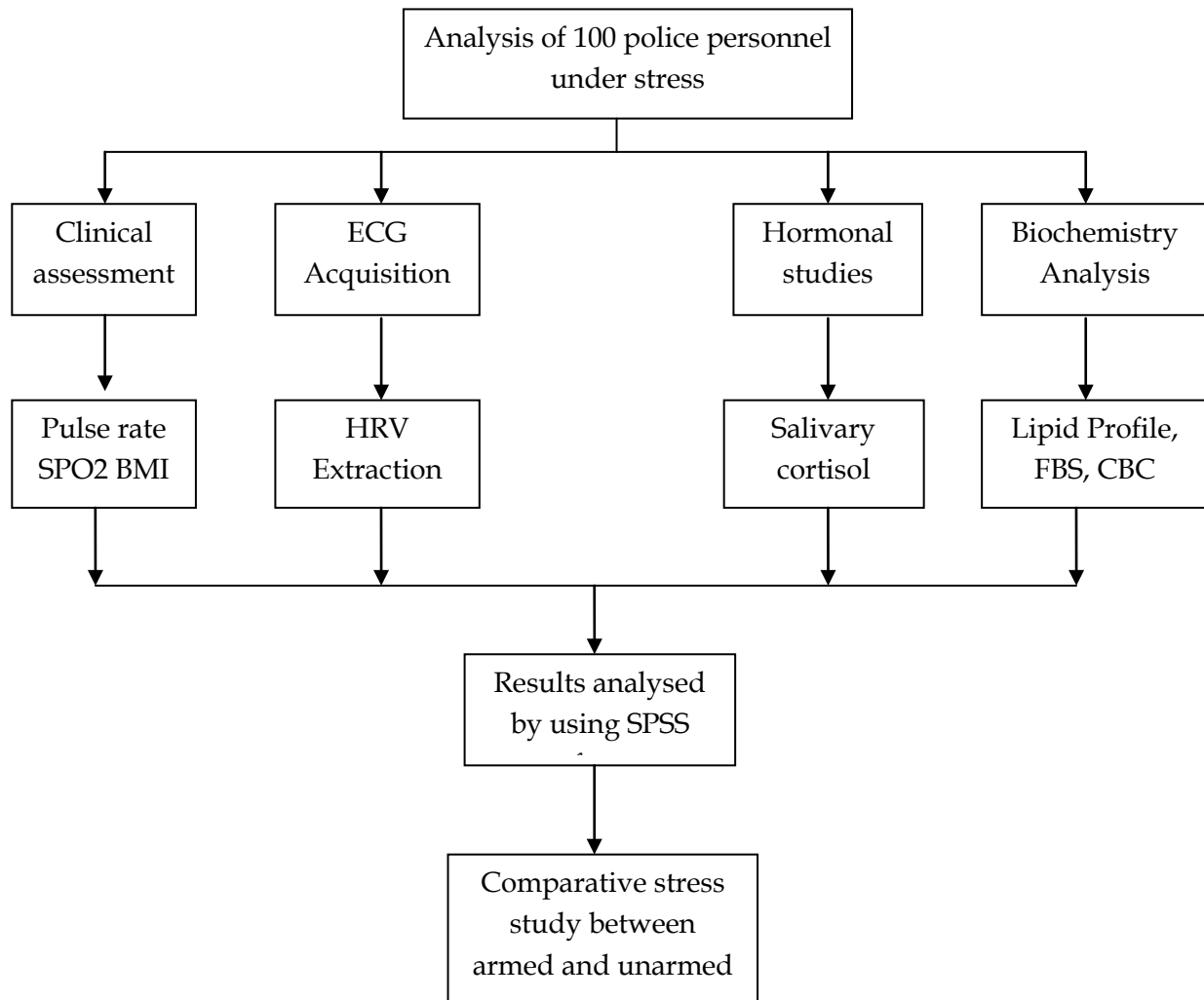


Fig. 3.1 Flow chart for Methodology of Research Work

A. Clinical Assessment: Clinical assessment of the 100 police personnel was done and entered in the case sheet. (Appendix-C) The important physiological parameters recorded were:

1. Pulse rate
2. Oxygen saturation,
3. Height
4. Weight and BMI (based on height and weight)
5. Blood pressure (recorded using Sphygmomanometer)

6. Habits such as smoking and alcohol were noted as they were major factors which can cause diseases along with stress.
7. General physical examination and systemic examination was conducted for various systems such as cardiovascular system, Respiratory system, Per-abdomen, and findings were entered in the case sheet.

B. Diagnostic assessment: Blood samples were collected from the selected police personnel having stress levels $\geq 50\%$ in coordination with diagnostic centres in compliance with the requirements of the haematological investigation. The blood tests done are:

- A. Fasting Lipid Profile: Lipid profile is a group of parameters which gives an estimation of Cardio-vascular diseases. A typical lipid profile consists of TG, TC, HDL-C and LDL-C. Fasting is absolutely essential for the test as 9-12 hrs of fasting is necessary for accuracy of the results that too LDL.
- B. HbA1C and Fasting Blood Sugars: This test gives an average of three months blood sugar levels and FBS was also ordered for knowing the recent blood sugars.
- C. Complete Blood Count: This test gives us an indication of general condition of the patient.
- D. Electro cardio Gram (ECG): Twelve lead ECG was recorded for extraction of HRV data which provides valuable information about the Autonomic Nervous system and to study modulation between Sympathetic and Para sympathetic nervous system. It also provides the preliminary information on the functioning of cardiovascular system. The instrument used was Aspen-3S and was kept in manual mode so that reading of minimal 2minutes duration was achieved
- E. Hormonal study: Salivary cortisol levels were estimated by collecting the samples in the morning using the saliva of the respondents. Since it is a non invasive test it is most preferred. Specific instructions for collection of saliva were also given to avoid sputum.

All the biochemical / hormonal investigations were conducted by reputed NABL accredited laboratory in Bangalore so as to ensure authenticity / accuracy in the results obtained. Standard / Normal values for the parameters assessed are presented in Table 3.1.

Table 3.1 Various Parameters and their normal range/ levels

Parameters	Normal level / Range	Risk	High Risk
BMI	Normal ≤ 24.99	Overweight 25 – 29.9	Obese ≥ 30
Dyslipidemia			
1 Total Cholesterol	≤ 200	$\geq 200 - 249$	≥ 250
2 Triglycerides	≤ 150	$< 60 > 40$	< 40
3 LDL	< 130	151-200	> 200
4 HDL	> 60	$< 130 - 150$	> 150
Diabetes			
Hb1Ac	4 – 5.6	5.6-8	≥ 8
FBS	≤ 100	110-139	> 140
Salivary cortisol			
Men : 21 – 30 years	0.112 – 0.743		Men : 21 – 30 yrs ≤ 0.36
Women : 21 – 30 years	0.272 – 1.348		Women : 21 – 30 yrs ≤ 0.65
Men : 31 – 50 years	0.122 -1.551		Men : 31 – 50 yrs ≤ 0.67
Women : 31 – 50 years	0.094 – 1.515		Women : 31 – 50 yrs ≤ 0.65
RMSSD	> 25		< 25
LF/HF ratio	> 1		< 1

3.2.1 Statistical Analysis of the data

Statistical calculations were done using SPSS software (V20.0.0). Descriptive data are presented as Mean Standard Deviation and Range. Pearson's correlation coefficient was used to measure the relationship between the measurements. A p-value of 0.05 or less was considered as significant and a p-value between 0.05 and 0.1 as indicative and a p-value beyond 0.1 as insignificant for statistical significance.

3.2.2 HRV Analysis

HRV analysis was performed using Kubios Software HRV 2.2. Frequency domain methods are to be preferred to time domain methods for short term recordings. The recording should be at least 10 times the lower frequency bound of the investigated component, but no longer (to ensure stability of the signal) with a minimum of one minute to assess the HF component and two minutes for the LF component. Hence, frequency domain parameters LF, HF and LF/HF ratio were calculated. However, RMSSD value in the Time Domain Measure is the only statistical parameter which can be considered for short term recordings (Appendix-D).

3.2.3 Artificial neural network

Artificial neural network (ANN) is a computer modelling technique based on the observed behaviour of biological neurons [125] patterns between independent and dependent variables. This is a non-parametric pattern recognition method that can recognize hidden [126] patterns. ANN has been used in oncology, diabetes, hypertension, and other diseases [127-134], a few researchers developed and evaluated feasibility of ANN model for predicting risk of CVD [135,136].

ANN is a nonlinear statistical data modelling tool that can be used to model complex relationships between inputs and outputs or to find patterns in data. The processing elements or nodes are arranged in 'input' hidden and 'output' layers, each layer containing one or more nodes [137]. The input layer consists of the data thought to be of value in predicting the outputs of the model [138,139]. Each data point is represented by a node in the input layer. The output layer estimates the probability of the outcome as determined by the model. Each layer comprises one or more processing elements all interconnected in a way that each node in the hidden layer is connected to each node in the input and output layers [138,139]. Each connection carries a “weight” or value that determines the relevance of a particular input for

the resulting output [138,139]. ANN makes predictions based on the strength of connections between the neurons in the input, hidden, and output layers [138,139]. The results of the output layer in ANN model represent the probability of a characteristic of interest (CVD). The ANN model was performed with WEKA 3.8 tool.

Fig. 3.2 presents the frame work describing the basic ANN design. Parameters are BMI, FBS, Hb, Hb1Ac, TC, TG, HDL, LDL, RMSSD, LF, HF and LF/HF.

Of the 100 participants in the second phase, 75 % of the subjects were randomly selected to provide the training group for constructing Artificial Neural Network (ANN) model. The remaining 25 % of the participants were assigned to the validation group.

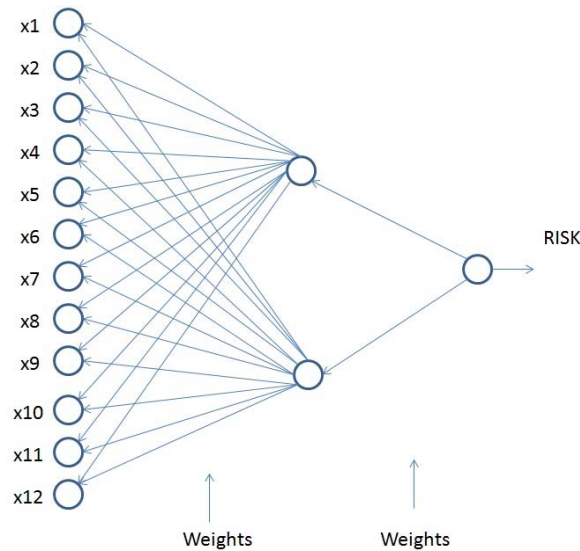


Fig. 3.2 Framework of artificial neural network model for predicting an individual's risk of CVD

The input layer contained 12 neurons. In the hidden layers, the number of neurons was 2. The output layer had only one neuron representing the probability of CVD.

Abbreviations:

X₁, BMI; X₂, Hb; X₃, Hb1Ac; X₄, FBS; X₅, TC; X₆, TG; X₇, HDL; X₈, LDL; X₉, RMSSD; X₁₀, LF; X₁₁, HF; X₁₂ and LF/HF

4. Results and Discussion

4.1 First Phase of the Project

Data analysis and Key Observations from the Initial study of completed Questionnaires:

The obtained data was analysed for Bangalore City Police Personnel including various parameters such as age group, sex distribution, marital status, years in service, educational qualification and stress levels. Initially the data was analysed in general and subsequently with reference to the age group of 35 to 45 years. 57.5 % of the respondents were found to be in the age group of 35 to 45 years, while 12.2 % in the age group of 30 to 34 years, and 30.2 % in the age group of 46 to 50 years (Fig. 4.1).

With respect to gender, 94 % were males and 6 % were females (Fig. 4.2). Around 50% of the respondents were undergraduates or graduates. Only 19 % were matriculates and around 32 % possessed PUC or its equivalent (Fig. 4.3). Around 95% were married (Fig. 4.4). Around 75 % of the respondents possessed over 10 years of service (Fig. 4.5). The scores varied from 0 to 81 for men, and 0 to 84 for women. Typically, respondents

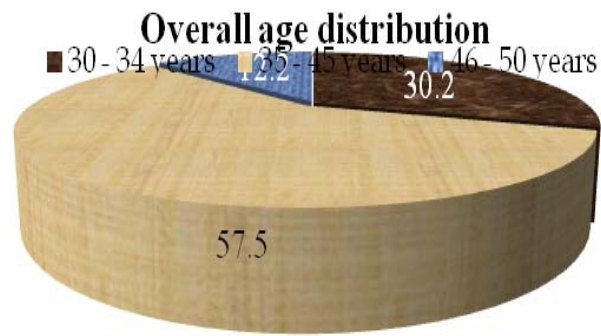


Fig. 4.1: Overall Age Distribution among Police Personnel



Fig. 4.2: Overall Sex Distribution among Police Personnel

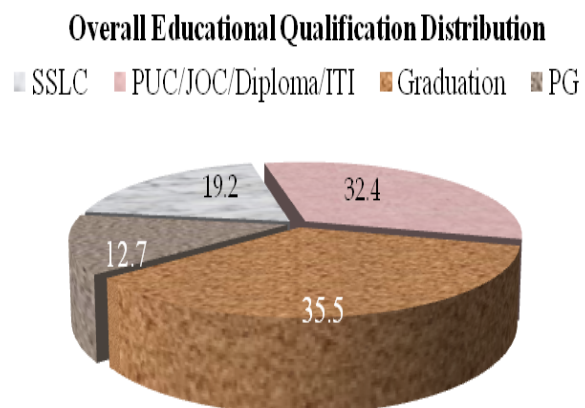


Fig 4.3: Overall Educational Qualification Distribution among Police Personnel

with score of above 50 % are considered to be under severe stress. The data is expressed in terms of percentage level of stress, as the scales are different for men and women, where as the stress level in percentage is similar.

More than 47 % of the respondents suffered from stress levels of more than 44%, suggesting that close to 50% of the personnel are under the influence of moderate to severe stress. This calls for a serious mitigation process to overcome the same (Fig. 4.6).

Around 58 % of the people studied were in the age group of 35 to 45. The age group of 35 to 45 is also the age of onset of metabolic syndrome. Hence, the target group was 30 to 45 years of age. Educational background of the police personnel in the age group of 30 to 45 years is presented in Fig. 4.6.

Amongst the respondents in the age group of 35 to 45 years, around 51 % were found to under moderate to severe stress levels (≥ 44 %).

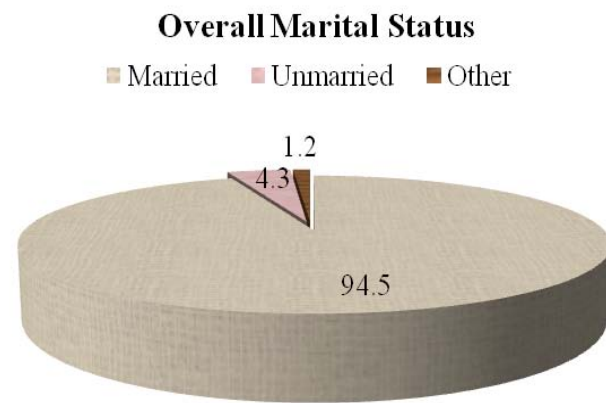


Fig. 4.4: Overall Marital Status among Police Personnel



Fig. 4.5: Service completed (in years) among Police Personnel (Overall)

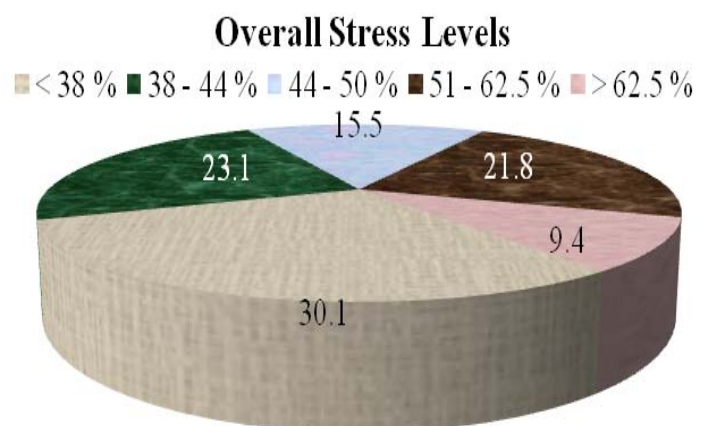


Fig 4. 6: Overall stress Levels

Table 4.1 Statistical Data of Various Parameters

Parameters	Percentage (%)	35 to 45 years
Age Distribution		
30 – 34 years	30.2	
35 – 45 years	57.5	
46 – 50 years	12.2	
Sex Distribution		
Male	94.4	95.22
Female	5.6	4.78
Educational Qualification		
SSLC	19.2	18.06
PUC/Diploma/JOC/ITI	32.4	39.16
Graduation	35.5	31.65
Post Graduation	12.7	11.13
Marital Status		
Married	94.5	97.05
Unmarried/Other	5.5	2.95
Service (in years)		
0 – 5 years	5.8	1.53
6 – 9 years	20.3	7.57
≥ 10 years	73.9	90.90
Stress Levels (in %)		
< 38 %	30.1	30.89
38 – 44 %	23.1	18.17
44.1 – 50 %	15.5	15.80
50.1 – 62.5 %	21.8	22.91
> 62.5 %	9.4	12.84

Police personnel in the age group 35 to 45 years form the backbone of the police force because of their experience, the age to work and drive to grow up in the career. Due to work pressure and family responsibilities they are more prone to stress. The same is reflected in the data, with over 51% of them with moderate to severe stress levels. The complete data is presented in Table 4. 1. The age group of 35 to 45 years need more attention as compared to others, as they form the bulk of the working force with major responsibilities.

4.1.1 Operational Stress and Organizational Stress:

Shown in Fig. 4.7 is the overall operational stress among various divisions among different age groups based on the responses.

It was observed that the Overall Operational Stress was found to be maximum for Civil Police, next in the case of City Armed

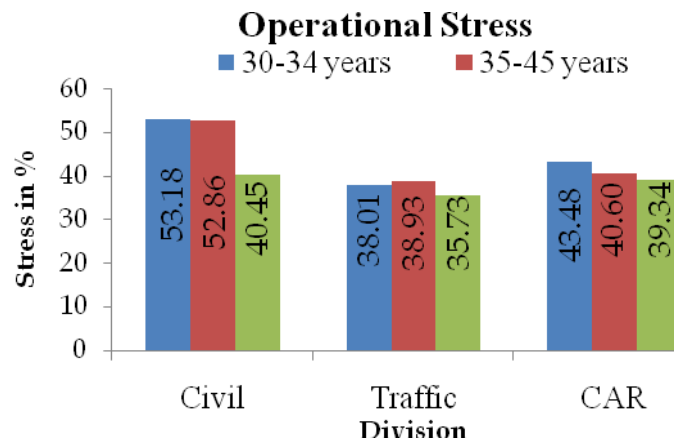


Fig. 4.7 Overall Operational Stress among Police Personnel

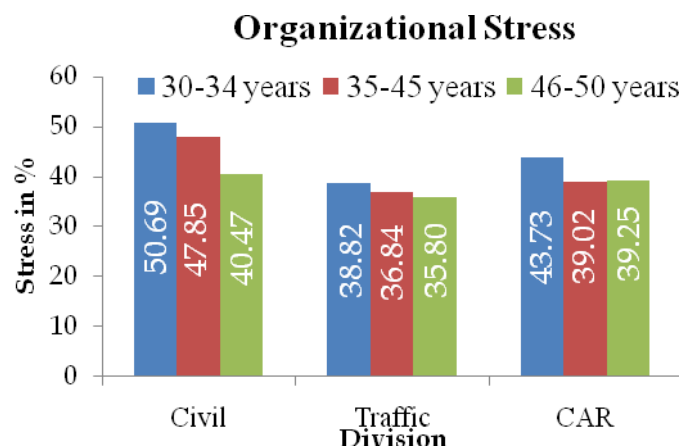


Fig. 4.8: Overall Organizational Stress among Police Personnel

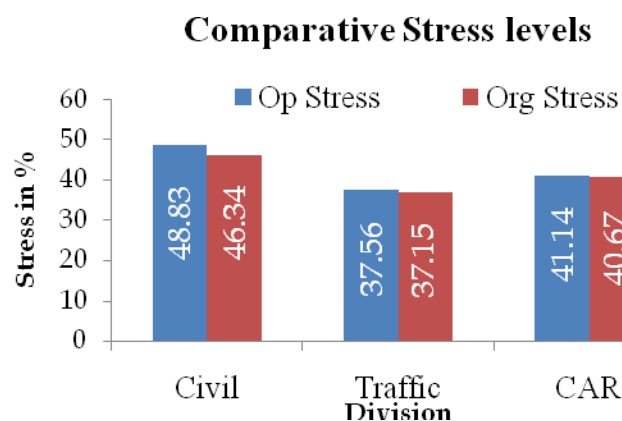


Fig. 4.9: Comparison between Operational Stress and Organizational Stress levels among various divisions of Police Personnel of various divisions

Reserve Police and relatively the lowest in Traffic Police. Further, maximum operational stress was found to be 53.18 % in case of civil police in the age group 30 to 34 years.

Presented in Fig. 4.8 is the overall organizational stress among Police Personnel under various age groups. It is seen from Fig. 13 that overall organizational stress considering 'age group' as a parameter was found to be maximum in the age group of 30 to 34 years, lesser for 35 to 45 years and least for 46 to 50 years. Also, maximum organizational stress was 50.69 % for civil police in the age group 30 to 34 years.

Comparative stress levels (operational stress and organizational stress) among Bangalore City Police Personnel of various divisions and different age groups are given in Fig. 4.9 and Fig. 4.10 respectively.

Between Overall Operational Stress and Overall Organizational Stress, the former was found to be more than the latter, for all age groups, except in the age group 46 to 50 years in which case both the former and the latter were found to be the at the same levels.

Overall operational stress (48.83 %) and organizational stress (46.34 %) were maximum for civil police, when individual DCP ranges are considered. When age group was considered as a parameter, overall operational and organizational stress was maximum in the age group 30 to 34 years and were 48.23 % and 46.97 % respectively.

On the basis of initial analysis of the completed questionnaires, 200 police personnel whose stress levels are $\geq 50\%$ have been identified for further diagnostic/ clinical assessment in the age group 30 to 45 years. Diagnostic assessment will be carried out for 100 police personnel (Armed and Unarmed). As armed police showed lesser stresses, they are considered as control group.

Operational Stress: The stress induced by work related stressors is termed as Operational Stress. These stressors (which cause stresses) which are found to be of high incidence include:

- i. Irregular shifts
- ii. Overtime demands
- iii. Irregular food habits

Organisational Stress: The stress induced by organisation related stressors is termed as Organisational Stress. These stressors which are found to be of high incidence include:

- i. Promotional policies
- ii. Inadequate pay scales
- iii. Coping with superiors
- iv. Prolonged working hours

Table 4.2 Distribution of operational stress in the respondents division-wise

No	Division	Incidence of Operational stresses based on the stressors (%)			
		Irregular shifts	Overtime demands	Irregular food habits	Mean
1	Bangalore South	40.0	75	82.5	65.83
2	Bangalore North	60.65	73.7	78.7	71.01
3	Bangalore East	57.14	85	100	81.3
4	Bangalore west	42	81	91.3	71
5	North east	70	79	97	80
6	South East	40	70	95	68
7	Central	65	83	87	78
8	Traffic East	25	48	76	50
9	Traffic West	52	60	83	65
10	CAR (HQ)	44	53	73	57
11	CAR (South)	57	77	77	70
12	CAR(North)	31	52	64	49

Operational stresses were found to be in high incidence in Bangalore East Division of civil police followed by North East Division. The incidence of these stresses are found to be high in Traffic and Civil police. Overtime demands and irregular food habits were the main stressors. These results are evidenced by biochemistry and clinical investigations presented in Table 4.7.

Table 4.3 Distribution of organisational stress in the respondents division-wise

No	Division	Incidence of Organisational stresses based on the stressors (%)				
		Promotional policies	Inadequate pay scales	Coping with superiors	Prolonged working Hours	Mean
1	Bangalore South	78	63	55	90	72
2	Bangalore North	64	57	43	90	64
3	Bangalore East	86	93	64	93	84
4	Bangalore west	57	39	48	88	58
5	North East	65	53	65	85	67
6	South East	73	49	51	92	66
7	Central	74	57	65	91	72
8	Traffic east	55	38	42	63	50
9	Traffic West	42	42	33	65	46
10	CAR(HQ)	51	45	32	64	48
11	CAR(South)	44	45	31	53	43
12	CAR(North)	57	38	36	77	52

Organisational stresses were found to be of high incidence in Bangalore East Division followed by Bangalore South. Prolonged working hours, followed by inadequate pay scales and promotional policies are the major stressors. Organisational stresses were greater in civil police than those in Traffic and Armed police, which are also evidenced by Bio-chemistry and clinical investigations (Table 4.7).

The distribution of overall stresses (organisational and operational) in the respondents division-wise is presented in Table 4.4.

Table 4.4 Distribution of overall stress Division wise

No	Division	Operational Stress	Organisational stress	Overall stress
1	Bangalore south	65.83	63	64
2	Bangalore North	71	57	64
3	Bangalore East	81	93	87
4	Bangalore west	71	39	55
5	North-East	80	53	63
6	South East	68	49	59
7	Central	78	57	68
8	Traffic East	50	38	44
9	Traffic west	65	42	54
10	CAR(Hq)	57	45	51
11	CAR(South)	70	45	57
12	CAR(North)	49	38	44

Operational stresses are of greater incidence than the organisational stresses. Civil police of Bangalore East Division showed highest incidence of both operational and organisational stresses.

Table 4.5 Distribution of stresses (Both operational and organisational) Age Group-wise

Division	Age Group in years (OPRL - Operational & ORGL - Organisational)					
	30-34		35-45		46-50	
	OPRL	ORGL	OPRL	ORGL	OPRL	ORGL
Bangalore South	73	94	71	75	No Respondents	No Respondents
Bangalore North	73	70	67	78	71	71
Bangalore East	83	96	76	91	67	83
Bangalore West	100	100	73	78	72	67
North-East	73	73	92	90	50	50
South-East	78	69	69	83	60	87
Central	57	83	78	87	80	87
Traffic East	53	74	63	70	59	63
Traffic West	67	71	66	70	58	69
CAR(Hq)	65	75	51	62	51	48
CAR(North)	42	79	50	78	54	62
CAR(South)	75	78	60	73	63	59
Mean	70.27	87.45	74.18	85.0	68.5	74.6

The overall mean operational stress and organisational stress distribution presented in Table 4.5 indicates that these stresses were greater in the age group 30-34 years and were lower in the age group 45- 50 years. Organisational stresses are lower in the age group 45-50 years than that in 30- 35 years. No significant difference is found in operational stresses between the two age groups. The police in the age group 30 -35 years were found to be more sensitive to inadequate pay scales as they are in the lower rung of the cadre. They are also subjected to prolonged working hours due to inadequate staff.

Distribution of gender based stresses is presented in Figure 4.10 and Figure 4.11. Operational stresses were lower in female police than that in male police, which is because of less overtime demands.

	1	2	3
Male	43	66	82
Female	44	55	79



Fig. 4.10 Incidences of operational stressors in male and female police

	1	2	3	4
Female	41	62	88	71
male	44	77	95	76

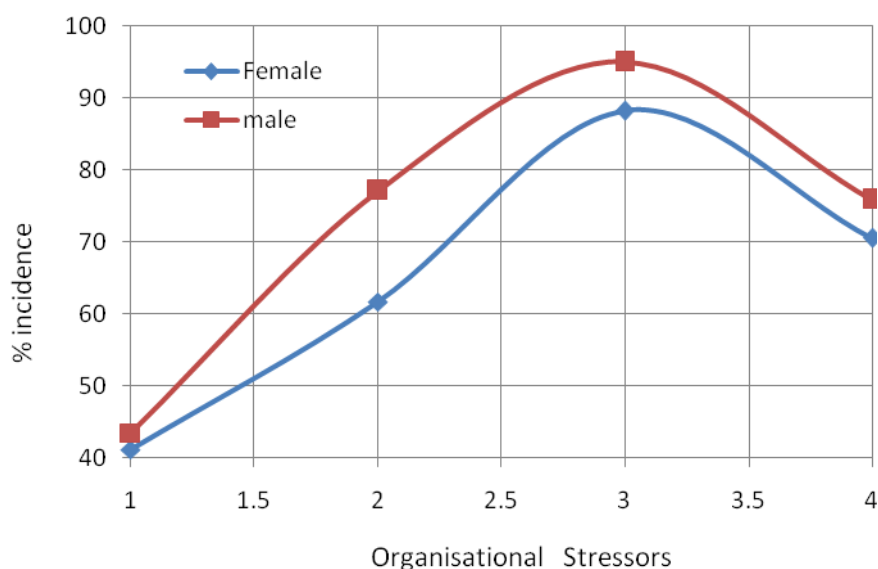


Fig. 4.11 Incidences of Organisational stressors in male and female police

Comparative picture of organisation stresses between Male and Female police suggest that while promotional policies equally caused stresses in both, inadequate pay scales, problems related to coping with superiors and prolonged working hours are of greater concern in Men police than that in Women police. The trend is common in both civil and traffic police.

Table 4.6 The distribution of men and women police respondents.

Classification	Men	Women	Total
Civil police	248	30	278
Traffic police	154	4	158
Armed police	169	-	169
Total	571	34	605

The distribution of men and women police respondents selected for the study after initial screening is presented in Table 4.6. Number of women respondents provided by Bangalore City Police was limited due to administrative issues. Majority of the women police respondents belonged to Civil police. Thus, the distribution of operational and organisational stresses as presented in 4.10 and 4.11 is applicable to civil police.

4.2 Second phase

The data was analysed by comparison between Armed and Unarmed, Men and Women, and amongst the unarmed traffic and civil police personnel. Descriptive data are presented as Mean Standard Deviation values in Table 4.7 for armed and the unarmed. As per the results obtained from the first phase the unarmed were under greater stress than that of the armed and hence the armed personnel is considered as control group.

Table 4.7 Mean Standard Deviation values for Armed and Unarmed Police Personnel

Risk Factors for CVD	Armed (Mean $\pm$ SD)	Unarmed (Mean $\pm$ SD)
BMI	24.35 $\pm$ 2.72	26.51 $\pm$ 3.19
Hb1Ac	5.35 $\pm$ 1.31	6.21 $\pm$ 1.51
FBS	97.9 $\pm$ 25.3	115.05 $\pm$ 51.4
TC	146.66 $\pm$ 26.71	177.5 $\pm$ 37.98
TG	133.39 $\pm$ 73.04	187.05 $\pm$ 125.15
HDL	37.88 $\pm$ 6.52	40.21 $\pm$ 7.24
LDL	84 $\pm$ 24.39	103.93 $\pm$ 33.23
RMSSD	21.24 $\pm$ 19.34	22.24 $\pm$ 19.49
LF	34.7 $\pm$ 27.89	29.79 $\pm$ 25.26
HF	65.02 $\pm$ 27.77	69.74 $\pm$ 25.38
LF/HF	2.11 $\pm$ 7.28	1.46 $\pm$ 4.33

Except the HDL, all the other parameters in Table 4.7 show that unarmed (both civil and traffic) are at a higher risk for the early onset of CVD than the armed. High cholesterol levels tend to be associated with lower HRV [140] which is found to be true in the present research also.

HRV is an indicator of ANS functioning and with stress the HRV value is reduced in the unarmed in comparison with the control group i.e. the armed. In this study only RMSSD values and LF/HF ratio were considered as the ECG recordings are shorter in duration.

The data is presented as Mean Standard Deviation in Table 4.8 for men and women police personnel.

Table 4.8 Mean Standard Deviation values for Men and Women Police Personnel

Risk Factor Levels	Men (Mean $\pm$ SD)	Women (Mean $\pm$ SD)
BMI	25.76 $\pm$ 3.09	24.95 $\pm$ 3.49
Hb1Ac	5.94 $\pm$ 1.62	5.44 $\pm$ 0.58
FBS	109.97 $\pm$ 47.52	98.89 $\pm$ 10.86
TC	167.21 $\pm$ 37.98	153.21 $\pm$ 30.11
TG	177.14 $\pm$ 116.84	111.95 $\pm$ 38.59
HDL	38.31 $\pm$ 6.45	43 $\pm$ 8.08
LDL	97.46 $\pm$ 32.14	87.58 $\pm$ 26.81
Salivary Cortisol	0.38 $\pm$ 0.22	0.48 $\pm$ 0.35
RMSSD	25.38 $\pm$ 34	40.43 $\pm$ 95.74
LF	34.62 $\pm$ 27.63	20.55 $\pm$ 16.61
HF	65.10 $\pm$ 27.73	78.58 $\pm$ 16.4
LF/HF	2.07 $\pm$ 6.36	0.35 $\pm$ 0.45

The data in Table 4.8 indicates that men are at a higher risk for the early onset of CVD in comparison to the women based on the analysis of biochemical investigations. Higher BMI, HbA1C and total cholesterol and lower HDL increase the risk of CVD as per biochemistry investigations.

However, women appear to be more prone to CVD when HRV is considered as an independent risk factor.

Table 4.9 Mean Standard Deviation values for Traffic and Civil Police Personnel

Risk Factor Levels	Traffic (Mean $\pm$ SD)	Civil (Mean $\pm$ SD)
BMI	27.05 $\pm$ 1.33	26.25 $\pm$ 3.76
Hb1Ac	6.35 $\pm$ 1.4	6.14 $\pm$ 1.57
FBS	117.72 $\pm$ 25.13	113.79 $\pm$ 60.27
TC	192.17 $\pm$ 32.47	170.55 $\pm$ 38.8
TG	202.22 $\pm$ 124.17	179.87 $\pm$ 126.63
HDL	41.11 $\pm$ 6.71	39.79 $\pm$ 7.53
LDL	114.94 $\pm$ 24.53	98.76 $\pm$ 35.76
Salivary Cortisol	0.34 $\pm$ 0.19	0.47 $\pm$ 0.32
RMSSD	44.43 $\pm$ 60.93	28.34 $\pm$ 68.31
LF	27.02 $\pm$ 26.18	31.1 $\pm$ 25.07
HF	72.84 $\pm$ 26.97	68.26 $\pm$ 24.83
LF/HF	2.09 $\pm$ 6.95	1.16 $\pm$ 2.33

Comparison of various risk factors for CVD among the traffic and the civil police suggests that with respect to biochemical investigations, traffic police are more stressed and hence prone to early onset of CVD whereas civil police are prone to stress associated diseases when HRV parameters are considered.

Table 4.10 Police personnel and their overall risk for CVD

Category	Normal	Mild Risk	Moderate Risk	High Risk
Armed	6 (13.6%)	21 (47.7%)	14 (31.8%)	3 ((6.8)
Unarmed	-	9 (16.1%)	15 (26.8%)	32 (57.1%)

It is clear from Table 4.10 that 57 % of Unarmed police personnel are at high risk for CVD as compared to 6.8 % in Armed police personnel. Most of the armed police personnel (47.7%) were found to be at mild risk for CVD.

p-values corresponding to correlation tests between BMI and other CVD risk factors for Armed and Unarmed police personnel are presented in Table 4.11 and Table 4.12 respectively.

Table 4.11 p-values between BMI and other CVD risk factors for correlation study - Armed

	BMI	Hb1aC	TC	TG	HDL	LDL	SC	LF/HF	FBS	RMSSD
BMI	-									
Hb1Ac	0.07	-								
TC	0.15	0.30	-							
TG	0.20	-0.07	0.37	-						
HDL	-0.33	0.53	0.32	-0.13	-					
LDL	0.11	0.59	0.84	0.23	0.09	-				
SC	0.01	-0.15	-0.03	0.01	0.29	-0.21	-			
LF/HF	0.18	-0.02	-0.08	0.07	-0.04	-0.05	-0.11	-		
FBS	0.11	0.88	0.24	0.65	-0.19	0.42	-0.17	-0.04	-	
RMSSD	-0.25	0.01	-0.02	-0.05	0.20	-0.07	0.10	0.06	-0.02	-

Table 4.12 p-values between BMI and other CVD risk factors for the correlation study- Unarmed

	BMI	Hb1aC	TC	TG	HDL	LDL	SC	LF/HF	FBS	RMSSD
BMI	-									
Hb1Ac	0.09	-								
TC	0.09	0.21	-							
TG	0.08	-0.15	0.29	-						
HDL	-0.21	0.15	0.07	-0.45	-					
LDL	0.14	0.13	0.91	0.21	0.05	-				
SC	-0.22	-0.13	0.00	-0.18	0.21	-0.02	-			
LF/HF	-0.17	0.17	-0.09	0.07	-0.16	0.00	-0.03	-		
FBS	-0.11	0.85	0.18	0.10	-0.04	0.12	-0.28	0.10	-	
RMSSD	-0.02	-0.03	0.07	0.03	0.08	0.02	-0.08	0.04	-0.02	-

The association of BMI was found to be highly significant with respect to salivary cortisol, HDL and RMSSD parameters in Armed Police personnel and with HDL, salivary cortisol, LF/HF ratio, FBS and RMSSD parameters in Unarmed Police personnel respectively. This

indicates that BMI is statistically significant for HRV parameters thereby is a major risk factor for CVD.

Also the correlations between the stress parameters, namely, salivary cortisol, RMSSD and LF/HF ratio with most of the other parameters were found to be statistically significant. Among the nine parameters; in armed personnel, each HRV parameter associated strongly with six other parameters and with seven parameters in unarmed police personnel respectively. This implies that the unarmed are under greater stress than that of the armed.

4.2.1 Artificial Neural Network (ANN) for predicting stress induced diseases

ANN was used to predict CVD based on the parameters such as BMI, FBS, Hb, Hb1Ac, TC, TG, HDL, LDL, RMSSD, LF, HF and LF/HF of the respondents. The model was trained using 75 % of the data collected in the second phase and validated using the remaining 25 % of the responses. The probability of CVD in the respondents was predicted using the model. The model was found to exhibit high sensitivity and specificity [145].

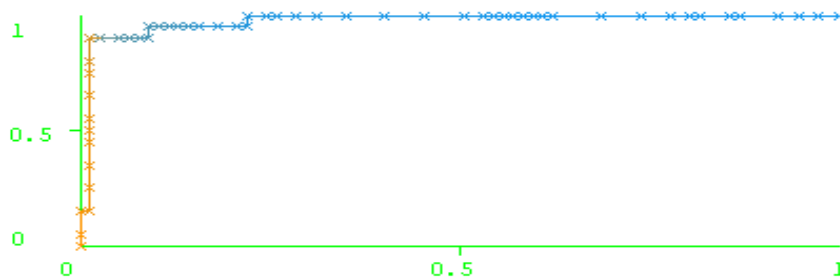


Figure 4.12 ROC Curve

In the present research, the results of the predictive performance showed that the ANN model can accurately predict the CVD risk with sufficient sensitivity (82.5 %) and specificity (65 %). The ROC curve for the ANN model is shown in Figure 4.12 and ROC (0.80 ± 0.01) indicated predictive accuracy.

4.3. Scope of the present research

1. Out of the 100 respondents identified in the first phase only 70 % were traced for biochemistry and clinical investigations of the second phase of research. This is because of transfers, promotions and postings of a few people outside Bengaluru. A fresh survey as per the first phase was conducted to identify 30 % new respondents under severe stress, leading to slight deviations in the stratification of the respondents. Thus, length of service as a stressor was partially fulfilled.
2. HRV was initially planned based on Holters. Owing to the cost of the Holter and the requirement of 48 hours monitoring, HRV analysis was carried out using the acquired ECG and Kubios Software. As it is a short duration recording (around two minutes), the study was limited to frequency domain parameters only. This has resulted in loss of accuracy compared with that of time domain analysis.
3. As the respondents were engaged in their official work, only one sample was taken in the morning. The salivary cortisol tests would have yielded better results if diurnal variations of cortisol were studied.

5. Conclusion

Operational stresses were found to be of high incidence in Bangalore East Division of civil police followed by North East Division and the incidence of these stresses are found to be high in both Traffic and Civil police. The causative factors for these stresses are found to be overtime demands and irregular food habits.

Organisational stresses were found to be of high incidence in Bangalore East Division followed by Bangalore South. The causative factors for these stresses were found to be prolonged working hours, inadequate pay scales and promotional policies.

The stress levels between the armed and unarmed police suggested that unarmed police showed significantly greater incidence of both operational and organisational stresses. This is evidenced by biochemistry, clinical and HRV analyses. The results do not suggest evolving exclusive causative factors for stresses in the Armed police.

The overall mean operational stress and organisational stress distribution indicates that these stresses were greater in the age group 30 to 34 years and were lower in the age group 45 to 50 years. Organisational stresses are lower in the age group 45 to 50 years than that in 30 to 35 years. No significant difference is found in operational stresses between the two age groups. The police in the age group 30 to 35 years were found to be more sensitive to inadequate pay scales as they are in the lower rung of the cadre. They are also subjected to prolonged working hours due to inadequate staff. Entry level staffing and pay scales need further investigation.

Operational stresses were lower in female police than that in male police, which is because of less overtime demands in female police. Comparative picture of organisation stresses between Male and Female police suggest that while promotional policies equally caused stresses in both, inadequate pay scales, problems related to coping with superiors and prolonged working hours are of greater concern in Men police than that in Women police. The trend is common in both civil and traffic police. Majority of the women police respondents belonged to Civil police. Thus, the distribution of operational and organisational stresses identified in the study is applicable to civil police.

Extent of health abnormalities due to the stresses was investigated in police in the age group of 30 to 45 years (which forms the major working force and has significant years of service) as this age group showed greater operational and organizational stresses by clinical (pulse rate, BP, BMI), biochemistry (FBS, HbA1C, Fasting Lipid Profile, ECG, HRV Analysis) and hormonal studies (salivary cortisol levels). The stresses were correlated with physiological parameters as indicators of health with its associated diseases.

Body Mass Index (BMI), three months average blood sugar levels (Hb1Ac), Fasting Blood Sugar (FBS), Total Cholesterol and Low Density Lipoproteins (LDL) were higher for the Unarmed Police (Both Civil and Traffic). These values were suggestive of Metabolic Syndrome which is a group of biochemical and physiological abnormalities associated with the development of cardiovascular disease and type 2 diabetes and associated complications. Also, ECG for Heart Rate Variability (HRV) were lesser in the unarmed, which is suggestive of changes in Autonomic Nervous System (ANS). It is an indicator of Cardiovascular functioning.

The results of these investigations were analysed for both Traffic and Civil police. The biochemistry parameters were suggestive of Traffic police at higher risk levels than the Civil police for metabolic syndrome. The only contrasting observation was the lower levels of HRV values in Civil police than that of the traffic police. This shows the changes in ANS amongst Civil police to be predominant.

The results of the investigations were analysed for Men and Women in Civil Police, as the number of women police respondents were insignificant in Traffic Police. The number of women police respondents provided by Bangalore City Police were limited due to administrative issues. Men police were at a higher risk for increase in cholesterol levels, obesity, gastritis, heart diseases as such as the early onset of CVD in comparison to the women respondents based on biochemistry investigations.

Women respondents seemed more prone to CVD when HRV is considered as an independent risk factor for CVD. Around 57 % of unarmed police were found to be at high risk for CVD as compared to 6.8 % in armed police personnel. The study indicated that BMI is statistically significant for HRV parameters thereby is a major risk factor for CVD. The correlations amongst the stress parameters namely salivary cortisol, RMSSD, LF/HF ratio with other parameters were found to be good.

6. Recommendations for combating stresses in Bangalore City Police

The causative factors for operational stresses are found to be overtime demands and irregular food habits. It is strongly recommended to scientifically evaluate the adequacy of the police staff and initiate action to maintain the required police staff. This would eliminate both overtime demands and irregular food habits.

The causative factors for organisational stresses were found to be prolonged working hours, inadequate pay scales and promotional policies. It is recommended to regularise working hours, revise pay scales and promotional policies commensurate to the nature of police job.

The police in the age group 30-35 years are subjected to prolonged working hours due to inadequate staff. It is recommended to investigate the entry level staffing and pay scales.

Inadequate pay scales, problems related to coping with superiors and prolonged working hours are of greater concern in Men police than that in the Women. As these are the stressors for Organisational stresses, it calls for behavioural corrections.

As most of the biochemistry and clinical evaluations indicated predominance towards the onset of metabolic syndrome due to the stressors identified, it is recommended to institute regular health check-up including the health parameters studied in the present research.

It is recommended to include additional parameters as part of regular health check up, such as diurnal variations of salivary cortisol levels, interleukins and study of HRV analysis by long term recording using Holters, for determining physiological variations due to stresses. Periodic Psychological evaluation is recommended to assess stress.

The effect of stresses on the performance of the police has to be further investigated.

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APPENDIX - A
POLICE STRESS QUESTIONNAIRE

Code _____ Enrolment Number _____

- Which of the following best describes your usual work schedule?

- 1 day / afternoon / night shift 2 split shift
3 irregular shift/on-call 4 rotating shifts

- Does your work include / involve over-time demands?

1. Never 2. Sometimes 3. Often 4. Always

3. Are you given sufficient time to complete the job assigned to you?

1. Always 2. Often 3. Sometimes 4. Never

4. Have any of the following become common features of your life in the past 12 months?

- Insomnia (sleeplessness) Yes / No
- Myalgia (body ache) Yes / No
- Indigestion / poor appetite Yes / No
- Dizzy spells or palpitations Yes / No
- Sweating without exertion or high air temperature Yes / No
- Faintness or nausea sensations without any physical cause Yes / No
- Extreme irritation over small things Yes / No
- Difficulty in making decisions Yes / No
- Inability to stop thinking about problems or the day's events Yes / No
- Lack of enthusiasm even for cherished interests Yes / No
- Having more responsibility than you can handle Yes / No
- Feeling self confidence / self esteem lower than earlier Yes / No

5. What is the risk of you being injured when on the job?
1. No Risk 2. Low Risk 3. Moderate Risk 4. Very High Risk
6. Are you able to follow regular and healthy food habits during your routine work schedule?
1. Always 2. Often 3. Sometimes 4. Never
7. Do your family members and friends understand about your work?
1. Always 2. Often 3. Sometimes 4. Never
8. Have you received / heard negative comments from the public about your department?
1. Never 2. Sometimes 3. Often 4. Always
9. Has your family felt / experienced the effects of the stigma associated with your job?
1. Never 2. Sometimes 3. Often 4. Always
10. Are you satisfied with the promotional policies?
1. Often 2. Sometimes 3. Rarely 4. Never
11. What is the frequency of transfers in last five years?
1. As per the Rulebook 2. Once in 2 years 3. Yearly 4. Once in 6 months
12. All in all, how satisfied would you say you are with your job?
1. Very Satisfied 2. Somewhat satisfied 3. Not too satisfied 4. Not at all satisfied
13. I am clear as to what my duties and responsibilities are ;
1. Always 2. Often 3. Sometimes 4. Never

14. I am subject to personal harassment in the form of unkind words or behavior;

1. Never 2. Sometimes 3. Often 4. Always

15. I have unachievable deadlines ;

1. Never 2. Sometimes 3. Often 4. Always

16. Do you

- a. get help and support you need from colleagues; ☐ Yes ☐ No
- b. receive the respect at work you deserve from my colleagues; ☐ Yes ☐ No
- c. feel the relationships at work are strained? ☐ Yes ☐ No

17. Is work culture supportive in your organization?

1. Always 2. Often 3. Sometimes 4. Never

18. Is most of your stress related to

- a. Work environment ☐ Yes ☐ No
- b. dealing with superiors in the organization? ☐ Yes ☐ No

19. Are there enough people/staff to get all the work done?

1. Always 2. Often 3. Sometimes 4. Never

20. Do you receive the required help and equipment from the department to get the job done?

1. Always 2. Often 3. Sometimes 4. Never

21. For a well done job, are you likely to be appreciated by your superior / higher officers?

1. Always 2. Often 3. Sometimes 4. Never

22. In the last 12 months, were you threatened / harassed in any way by public while you were on job?

1. Never 2. Sometimes 3. Often 4. Always

23. How do you feel working for the police department?

1. Great 2. Satisfied 3. Frustrated 4. Depressed

24. Please estimate the average number of hours per week that you work (both on and off site).

1. 30-40 2. 40-50 3. 50-60 4. 60-Above

25. How fair is what you earn in your job?

1. somewhat more than you deserve 2. about as much as you deserve
3. somewhat less than you deserve 4. much less than you deserve

26. (For Women Police only) Is there gender discrimination in your department?

1. Never 2. Sometimes 3. Often 4. Always

SOCIODEMOGRAPHIC QUESTIONNAIRE

Code _____ Enrolment Number _____

1. Gender Male / Female Age _____
2. Mother Tongue : _____ Religion : _____
3. Highest educational qualification _____
4. Current Marital Status: Married / Unmarried / Divorced / Separated / Widowed
5. How many members are there in your family including yourself? _____
6. Please give details about the educational status of your child / children, if any.

Gender	Name of the institution	Class in which the child is studying

7. Where do you reside? Police Quarters / Private residence
8. Date of joining the Police Department : _____
9. No. of years in service : _____
10. Designation at the time of joining the organization : _____
11. Present Designation : _____
12. Current annual income : _____
13. Are you computer literate? 1 Yes 2 No
14. Do you agree for your medical examination (blood test, ECG) to be done by us? Yes / No

APPENDIX - B

Scoring Pattern of Questionnaire and Interpretation of Scores for Stress levels

Question #	A	B	C	D	Max marks
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1	0	0	1	0	1
2	0	1	2	3	3
3	0	1	2	3	3
4	Yes – 1; No - 0				12
Total Sub Questions : 12					
5	0	1	2	3	3
6	0	1	2	3	3
7	0	1	2	3	3
8	0	1	2	3	3
9	0	1	2	3	3
10	0	1	2	3	3
11	0	1	2	3	3
12	0	1	2	3	3
13	0	1	2	3	3
14	0	1	2	3	3
15	0	1	2	3	3
16 For a) and b) Yes – 0; No – 1 For c) Yes – 1; No – 0					3
17	0	1	2	3	3
18	Yes – 1; No - 0				2
19	0	1	2	3	3
20	0	1	2	3	3
21	0	1	2	3	3
22	0	1	2	3	3
23	0	1	2	3	3
24	0	1	2	3	3
25	0	1	2	3	3
26	0	1	2	3	3
Total :	For Men : 81; For Women : 84				

Interpretation of the Score:

The scale is designed to assess undesirable responses to stress.

Score : For Men: 0 – 20 & for Women 0 – 21 : Stress is not a major problem in life.

For Men: 21 – 40 & for Women 22 – 42 : This is a moderate range of stress for any busy professional person. It's nevertheless well worth looking at how it can be reasonably reduced.

For Men: 41 – 60 & for Women 43 – 63 : Stress is clearly a problem and the need for remedial action is apparent. The longer one works under this level of stress, the harder it often is to do something about it. It becomes a strong case for looking carefully at one's professional life.

For Men: 61 – 81 & for Women 64 – 84 : At these levels, stress is a major problem and immediate remedial action is necessary. One may be nearing the stage of exhaustion in the general adaptability syndrome. The pressure must be eased without any delay.

APPENDIX - C

CASE SHEET

A. Socio-demographic Data

1. Name with code:

2. Age: YEARS

3. Sex:

4. DCP Range:

5. Present Posting:

6. Police ID Number:

7. Present post held:

1. Chief Complaints:

2. History of Present Illness:

3. Past History:

K/C/O Asthma / TB / DM / HTN / Previous surgeries / Medications / Depression /
Epilepsy

4. Family History:

5. Personal History:

a) Smoking:

b) Alcohol:

c) Drug Abuse:

6. General Physical Examination:

- a) Well / moderate / Poorly built
- b) Pallor / Icterus / Cyanosis / Clubbing / Lymphadenopathy / Oedema
- c) Height:
- d) Weight:
- e) BMI:

7 Vitals:

- a) BP:
- b) Pulse rate:
- c) Oxygen saturation:

8 Systemic examination:

- a) CVS:

b) RS:

c) P/A:

d) CNS:

Investigations:

- 1 CBC
- 2 LIPID PROFILE
- 3 FBS
- 4 HbA1c
- 5 ECG
- 6 SALIVARY CORTISOL

Final Remarks:

APPENDIX – D

A Typical Snap shot HRV results

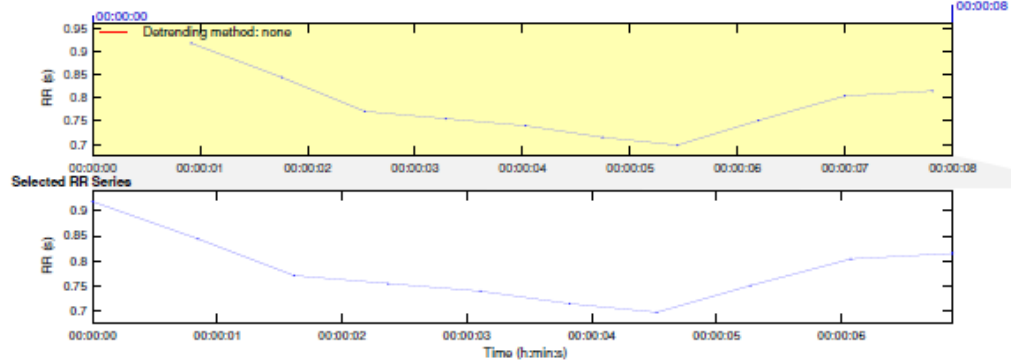
HRV Analysis Results

RRIntervals.txt - xx/xx/xx - xx:xx:xx

Page 1/1

RR Interval Time Series

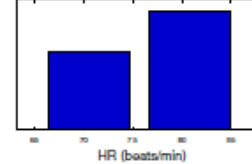
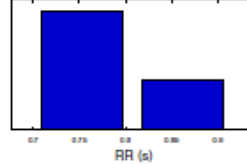
Results for a single sample



Time-Domain Results

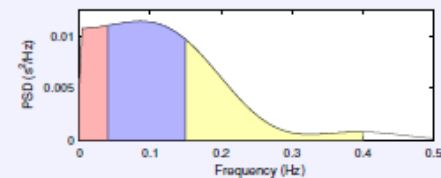
Variable	Units	Value
Mean RR*	(ms)	781.1
STD RR (SDNN)	(ms)	85.8
Mean HR*	(1/min)	77.28
STD HR	(1/min)	6.21
RMSSD	(ms)	43.2
NN50	(count)	4
pNN50	(%)	44.4
RR triangular index		10.000
TINN	(ms)	240.0

Distributions*



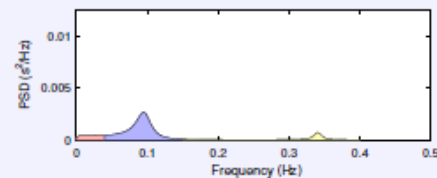
Frequency-Domain Results

FFT spectrum (Welch's periodogram: 256 s window with 50% overlap)



Frequency Band	Peak (Hz)	Power (ms ²)	Power (%)	Power (n.u.)
VLF (0-0.04 Hz)	0.0391	423	17.8	
LF (0.04-0.15 Hz)	0.0859	1214	51.2	62.3
HF (0.15-0.4 Hz)	0.1523	733	30.9	37.6
Total		2372		
LF/HF		1.656		

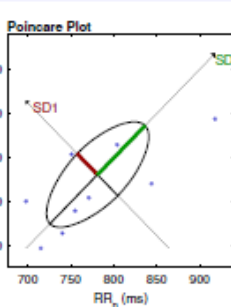
AR Spectrum (AR model order = 16, not factorized)



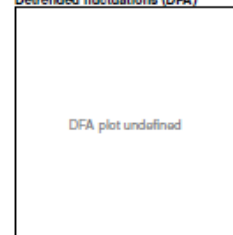
Frequency Band	Peak (Hz)	Power (ms ²)	Power (%)	Power (n.u.)
VLF (0-0.04 Hz)	0.0391	17	12.8	
LF (0.04-0.15 Hz)	0.0938	100	75.0	86.0
HF (0.15-0.4 Hz)	0.3398	16	12.2	14.0
Total		133		
LF/HF		6.164		

Nonlinear Results

Variable	Units	Value
Poincare plot		
SD1	(ms)	33.5
SD2	(ms)	78.4
Recurrence plot		
Mean line length (Lmean)	(beats)	-
Max line length (Lmax)	(beats)	-
Recurrence rate (REC)	(%)	-
Determinism (DET)	(%)	-
Shannon Entropy (ShanEn)		-
Other		
Approximate entropy (ApEn)		-
Sample entropy (SampEn)		-
Detrended fluctuations (DFA): α_1		-
Detrended fluctuations (DFA): α_2		-
Correlation dimension (D2)		-
Multiscale entropy (MSE)		-



Detrended fluctuations (DFA)



*Results are calculated from the non-detrended selected RR series.

Research Progress Key Snap Shots



Administering Questionnaire during parade at Thanisandra Parade Ground



Answering Questionnaire during parade at Mysore Road Ground



A typical photograph of a) Blood sample collection and b) ECG recording of police man