Relationship between Salivary Cortisol, Salivary Immunoglobulin A, Serum Oxidative Stress Indices, and Job Stress among Healthcare Workers in A Nigerian Tertiary Hospital

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ABSTRACT

Background: Healthcare workers (HCWs) are highly susceptible to job-related and psychological stress. The current study evaluated the physiological reactions to stress and its biochemical correlates which could add objective evidence to a perception of job stress among HCWs.

Methodology: This was a prospectively designed cross-sectional study to compare stress markers amongst 84 healthy male HCW in a tertiary hospital. They were recruited from various hospital units and categorized as rated by survey responses using Karasek's Job Content Questionnaires as follows: (1) based on job demand (JD): high and low JD; (2) based on job control (JC): low and high JC; (3) based on job strain (JS): no and high JS. Stress markers evaluated were salivary cortisol, salivary immunoglobulin A (IgA), and oxidative stress indices (Malondialdehyde [MDA], Ascorbic Acid, and Total Antioxidant Capacity [TAC]). All laboratory analyses including statistical protocols were carried out according to well-established standard guidelines.

Result: Salivary cortisol was higher in low JC than high JC (p=0.003) subgroups while salivary IgA was higher in high JS compared to the no JS (p=0.041) subgroups. Additionally, JC inversely correlated (r= -0.268; p=0.014) with salivary cortisol. However, other biochemical variables did not differ significantly across categorized groups. However, while the medical doctors had higher MDA compared to other HCWs, the radiographers had higher TAC compared to others; this may indicate oxidative stress among these HCWs (p<0.05).

Conclusion: From the foregoing, HCWs with high JS are under higher stress with low JC which stimulates the HPA axis as an adaptive mechanism. Hence, efforts to promote low JS with high JC are highly recommended among HCWs for optimal service delivery.

Keywords: Healthcare worker, job control, job demand, job strain.

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I. INTRODUCTION

Stress is seen as a non-specific response of the body to pressures or demands upon it and is also viewed as the body's physiological and/or psychological reactions to circumstances that require behavioral changes [1], [2]. Job stress is defined as harmful physical and emotional responses that occur when the requirements of work do not match the capabilities, resources, or needs of the worker which can result from the work itself, for example, heavy workload, low input into decision making or from the social and organizational contexts in which the job is performed, for example, poor communication, interpersonal conflict and lack of social support at the workplace [2], [3].

Work stress has become a relevant research topic in contemporary society because of the impact of stress on health, particularly cardiovascular health, reduced immune function, metabolic diseases, oxidative stress, and mental ill-health [4]-[8]. Psychosocial stressor in the workplace is regarded as the most powerful occupational hazard in various countries [9]. Previous studies on the assessment and impact of job stress utilized only questionnaire surveys involving workers' self-reports of psychosocial working conditions to obtain data. However, the assessment of physiological and/or biochemical correlates could add objective evidence to the subjective perception of job stress.

Previous studies identified numerous stressors among healthcare workers (HCWs) including heavy workload and pressure to work overtime, complaints from patients and their relatives, risk of violence, poor management style, inadequate resources, insufficient training, lack of control over work, low involvement in decision making, low job satisfaction and harassment [10]-[12]. A major difficulty in stress research has been the inherent complexity and subjectivity of the concept and the attendant difficulties in the measurement of stress. To avoid this difficulty, it becomes necessary to assess the worker's perception of his/her working conditions rather than the job titles or duties.

One of the most widely accepted tools for assessing of worker's perception of his or her working conditions is the job demand/control model developed by Karasek [13]. Karasek proposed that the resulting health effects of work stress do not come from a single aspect of work environment but the joint effects of the demands of a work situation and the range of decision-making freedom (control) available to the worker facing those demands. In the Karasek model, job strain (JS) occurs when job demands (JD) are high and job control (JC) i.e. decision latitude is low [13]. In this model, psychological job demands refer to a task's mental workload, time pressures, or arousal needed to carry job under the given circumstances while job control or decision latitude is the combination of skill discretion and decision authority of the workers over their job, both of which when low threatens a personnel's sense of mastery over the job [14].

Currently, there are no specific and direct biochemical measures of stress but there are some physiological correlates that have been suggested. Some hormones, immune substances, and proteins in the body have been studied and suggested as possible biomarkers of stress [10]. The principle employed by these authors was based on the biochemical changes in the body upon the activation of two stress reaction physiological pathways namely: (i) hypothalamus-pituitary-adrenocortical (HPA) axis and (ii) sympatho-adrenal-medullary (SAM) systems [15]. By monitoring such stress-related substances following the activation of SAM and/or HPA system, the level of the perceived stressor could be estimated.

Some of the biochemical parameters that have been employed in stress research include immunoglobulin A (IgA), human chromogranin A (CgA), alpha-amylase, cortisol, dehydroepiandrosterone (DHEA), DHEA sulfate (DHEA-S), testosterone, progesterone among others. Besides psycho-neuroendocrine-immunological changes in response to stress, several studies have linked job stress with oxidative stress [7].

A few studies on job stress based on questionnaire assessment are documented in Nigeria and other African countries. Assessment of physiological response to stress and its biochemical correlates could add objective evidence to the subjective perception of job stress.

Therefore, there is the need to assess the possible relationship, if any, between job stress indicators and some selected but relevant biochemical parameters among HCWs.

II. MATERIALS AND METHODS

A. Study Design

A prospective cross-sectional study in which data was generated through biochemical analyses, clinical assessment, anthropometric measurements, and responses from the self-administered JS questionnaire.

B. Study Area

Conducted in Nnamdi Azikiwe University Teaching Hospital (NAUTH), Anambra State, South-eastern Nigeria.

C. Sample Size Calculation

Sample size (n) was calculated using the single proportion formula [16].

$n = z^2 \, pq/d^2$ where:

z= standard normal deviate given as 1.96

p = prevalence (prevalence of job strain among male health workers in Nigeria was 27.3% [17].

d = precision set at 10%.

q = alternative prevalence (1-P)

$n = 1.962 \times (0.273) \times (1\text{-}0.273)/0.12$

$n = 76.2; n \approx 77$

D. Ethical Approval and Informed Consent

Ethical approval was obtained from the Ethics Committee of NAUTH (NAUTH/CS/66/VOL.8/53). The informed and written consent were obtained from the subjects before the commencement of the study.

E. Study Population

The study populations were hospital-based male HCWs. The female HCWs were not included because of possible variation in serum and salivary cortisol concentrations during the phases of the menstrual cycle.

F. Recruitment and Description of the Subjects

Eighty four (84) hospital-based male HCWs consisting doctors (n=15), nurses (n=11), medical laboratory scientists (n=18), radiographers/ (n=16), pharmacists (n=7); and

clerical staff and ward assistants (n=17) were recruited to the study.

The subjects were grouped as:

i.   high job demand (n=34) and low job demand (n=50)
ii.   high job control (n=39) and low job control (n=45)
iii. high job strain (n=22) and no job strain (n=62)

G. Eligibility Criteria

The inclusion criteria were healthy hospital-based male HCWs between the ages of 20-50 years who have normal glycemic/nutrition status (normal plasma glucose/albumin) and have worked in the same job for at least 6 months and were willing to participate in the study.

Exclusion criteria were saliva flow rate of less than 0.1 ml/min which may suggest improper sample collection [18]. Hypertensive workers, those with a current or past (one week) history of acute infectious illness especially upper respiratory tract infection, and those who had been on glucocorticoids, anabolic-androgenic steroids, antidepressants, and lipid regulating drugs which limited confounding effects of ill-health and medications were excluded.

H. Sampling Techniques

The convenience sampling technique was used for recruitment.

I. Job Strain (JS) Questionnaire

A JD/JC questionnaire based on the job strain model proposed by Karasek was used in this study [13]. The self-administered job demand-control questionnaire contained 11 items concerning the psychosocial aspects of work, each graded on a four-point scale.

Psychological JD included questions related to the amount of work done, conflicting demands, and time pressures put on the individual by the work environment. The JD subscale has 5 items with a total score ranging from 5 to 20. The second subscale, known as JC or decision latitude, has six items measuring influence or control over work, task repetition, and the possibilities for learning new skills. The first four items of the JC subscale measure skill discretion while the last two items of the subscale measure decision authority. The JC subscale has a total score ranging from 6 to 24. Workers were asked to indicate how frequently they experienced the psychosocial work conditions on a four-point Likert scale (1=Never or not applicable to me; 2=Occasionally; 3=Sometimes; 4=Always).

It is important to mention that the generalizability of Karasek's JS model makes it possible to make comparisons among different medical and non-medical occupational groups and this was an important factor in selecting the JS model. In addition to questions related to JD and JC, lifestyle and sociodemographic data were also collected. The validity of the questionnaire was pretested before commencing the study.

J. Grouping of Subjects using the JS Questionnaire

For each participant, response scores were calculated for job demands items and job control items. High job demands were defined as a score in this domain that was higher than the study-specific median score which was 13; low job control was defined as a score in this domain that was lower than the study-specific median score which was 16. Therefore subjects belonging to the high JS group were those that scored above 13 in the JD subscale and simultaneously scored below 16 in the JC subscale while other subjects were classified as no JS group as previously recommended [19].

K. Specimen Collection/Storage

1) Saliva

Un-stimulated saliva was collected into two 5ml plain plastic tubes as previously described [20], [21]. Collected was between 9-11 am to maintain a minimal circadian variation [20]. Participants were asked not to eat or drink (except water) before sample collection. The saliva produced in each of the two containers was weighed before they were pooled and stored frozen. The frozen saliva was thawed and centrifuged at 4000 rpm for ten minutes to remove debris and cells after a single freeze-thawing. The clear supernatants were stored frozen until required for the assay.

2) Blood

Seven (7) milliliters (ml) fasting blood sample was also collected from each participant; 5ml and 2ml were dispensed into plain and fluoride oxalate tubes, respectively. The plain tube specimen was allowed to clot and then centrifuged at 4000 rpm for 10 minutes to separate the sera which were also stored frozen until required for the assay. While the fluoride oxalate tube specimen was centrifuged at 4000 rpm for 5 minutes to separate the plasma and the glucose assay was carried out not later than one hour after sample collection.

L. Laboratory Protocols

Saliva volume was measured by the gravimetric method [22]. Salivary IgA was assayed by enzyme immunosorbent assay (ELISA) technique as previously described [23]. Salivary cortisol was measured by the ELISA method as previously described [21]. Oxidative stress markers (malondialdehyde, ascorbic acid, and oxidative concentration) were determined spectrophotometrically by methods described by [24].

M. Statistical Analysis

Statistical Package for Social Sciences version 20.0 was used for statistical analysis. Descriptive statistics such as mean/standard deviation were used in characterizing continuous data while frequencies/percentages were used for categorical data. Inferential statistics like t-test, analysis of variance (ANOVA), Bonferroni post hoc test, Pearson's correlation coefficient, and Chi-square were used in testing hypotheses. The t-test was used in comparing two groups while ANOVA was used to compare more than two groups of continuous data. Bonferroni post hoc test was used to perform pair-wise comparisons after ANOVA. A p-value <0.05 was considered statistically significant.

III. RESULTS

The results of participants (n=84) were categorized into two groups using the following criteria:

(1) JD: low and high JD, (2) JC: low and high JC, and (3) JS: no and high JS.

There were no significant differences in the mean values of serum total antioxidant capacity, vitamin C,

malondialdehyde, salivary cortisol, and IgA between the low JD group (n=50) and high JD group (n=34) as shown in Table I.

There was no significant correlation between job demand and total antioxidant capacity, vitamin C, malondialdehyde, salivary cortisol, and IgA respectively as shown in Table II.

Table III shows that the mean value of salivary cortisol was significantly higher among the low JC group (10.95±4.93 ng/ml, n=45) when compared with the high JC group (7.89±4.20 ng/ml, n=39). There were no significant differences in the mean values of total antioxidant capacity, vitamin C, malondialdehyde, salivary IgA, and secretion rate of IgA between the groups.

JC had significant negative correlation with salivary cortisol (r= -0.268; p=0.014). There were no significant correlations between JC and total antioxidant capacity; vitamin C, malondialdehyde, and IgA respectively as shown in Table IV.

Table V shows that salivary cortisol was significantly higher in the high JS group (11.65±5.76 ng/ml, n=22) than in the no JS group (8.48±4.12 ng/ml, n=62). The salivary IgA was significantly higher in the high JS group (120.6±23.5 μg/ml) than in the no JS group (105.7±30.5 μg/ml). There were no significant differences in the mean values of total antioxidant capacity, vitamin C, malondialdehyde, and secretion rate of IgA between the groups.

Table VI shows that there were significant differences in the mean values of serum total antioxidant capacity and malondialdehyde in healthcare professionals.

Post hoc analyses also showed that total antioxidant capacity was significantly higher among radiographers (1,276.9±147.7 mg/dl) when compared with medical doctors (1,048±168.2 mg/dl), laboratory scientists (1,120.2±146.2 mg/dl), and nurses (1,032.3±116.3 mg/dl). Post hoc analyses also showed that malondialdehyde was significantly higher among doctors (2.68±2.43 nmol/L) when compared with radiographers (1.18±0.55 nmol/L), and pharmacists (0.74±0.18 nmol/L). There were no significant differences in the mean values of serum vitamin C, salivary immunoglobulin A, secretion rate of IgA, and salivary cortisol among healthcare professionals.

TABLE I: COMPARISON OF BIOCHEMICAL VARIABLES BETWEEN LOW JOB DEMAND AND HIGH JOB DEMAND GROUPS

Parameters	Low job demand	High job demand	p-value
n	50	34	-
	Mean±SD	Mean±SD	
Volume of saliva (ml)	172 ± 0.77	172 ± 1.06	0.963
Flow rate of saliva (ml/min)	0.344 ± 0.15	0.34 ± 0.21	0.963
IgA (mg/ml)	108.2 ± 30.38	111.68 ± 28.50	0.600
SrIgA (mg/min)	36.38 ± 18.38	38.47 ± 23.21	0.647
Salivary control (ng/ml)	8.91±4.29	9.9 ±5.43	0.345
Vit C (mg/dl)	0.74 ± 0.21	0.77 ±0.28	0.416
MDA (nmol/ml)	1.50 ± 1.41	1.69 ± 1.39	0.547
TAC (mg/dl)	1144.1 ± 205.2	1102.7± 194.7	0.357

SrIgA= secretion rate of immunoglobulin A, IgA= Immunoglobulin A, Vit C= Vitamin C, MDA= malondialdehyde; TAC= Total Antioxidant Capacity; Mean±SD: Mean plus or minus standard deviation

TABLE II: PEARSON'S CORRELATION STUDIES OF JOB DEMAND AND VARIOUS BIOCHEMICAL PARAMETERS OF THE PARTICIPANTS

Parameter	N	r	p-value
JD vs IgA	84	0.022	0.840
JD vs IgA Secretion rate	84	0.077	0.485
JD vs salivary cortisol	84	0.122	0.311
JD vs Vit C	84	-0.013	0.910
JC vs MDA	84	-0.013	0.910
JD vs TAC	84	-0.063	0.569

JD=Job demand, vs=versus, IgA= Immunoglobulin A, Vit C= Vitamin C, MDA= malondialdehyde; TAC= Total antioxidant capacity, r = Pearson's correlation coefficient

TABLE III: COMPARISON OF BIOCHEMICAL VARIABLES BETWEEN LOW AND HIGH JOB CONTROL GROUPS

Parameter	Low job control	High job control	p-value
N	45	39	-
	Mean±SD	Mean±SD	
Volume of saliva (ml)	1.85 ± 1.05	1.60 ± 0.72	0.209
Flow rate of saliva (ml/min)	0.371 ± 0.21	0.32 ± 0.14	0.209
IgA (μ/ml)	114.93 ± 27.92	105.02 ± 30.92	0.126
SrIgA (μg/min)	40.77 ± 21.75	34.15 ± 18.79	0.138
Salivary cortisol (ng/ml)	10.95 ± 4.93	7.89 ± 4.20	0.003*
Vit C (mg/dl)	0.73 ± 0.27	0.73 ± 0.25	0.884
MDA (nmol/ml)	1.5 ± 1.13	1.62 ± 1.39	0.581
TAC mg/dl	1128.1 ± 202.6	1146.8 ± 176.5	0.546

SrIgA: secretion rate of immunoglobulin A; IgA: Immunoglobulin A; Vit C: Vitamin C; MDA: malondialdehyde; TAC: Total antioxidant capacity; Mean ± SD: Mean plus or minus standard deviation, *Shows statistically significant difference (p<0.05).

TABLE IV: PEARSON CORRELATION STUDIES OF JOB CONTROL AND VARIOUS BIOCHEMICAL PARAMETERS OF PARTICIPANTS

Parameters	n	R	p-value
JC vs IgA	84	-0.130	0.238
JC vs IgA secretion rate	84	-0.046	0.681
JC vs salivary cortisol	84	-0.268	0.014*
JC vs Vit c	84	-0.083	0.454
JC vs MDA	84	0.013	0.904
JC vs TAC	84	0.006	0.958

JC: Job Control; vs: versus; IgA: Immunoglobulin A; Vit C: Vitamin C; MDA: malondialdehyde; TAC: Total antioxidant capacity; r = Pearson's correlation coefficient, *Statistically significant difference (p<0.05).

TABLE V: COMPARISON OF BIOCHEMICAL VARIABLES BETWEEN NO JOB STRAIN AND HIGH JOB STRAIN GROUPS

Parameter	No job strain	High job strain	p-value
N	62	22	-
	Mean±SD	Mean±SD	
Volume of saliva (ml)	1.69 ± 0.79	1.81 ± 1.15	0.587
Flow rate of saliva (ml/min)	0.338 ±0.15	0.36 ± 0.23	0.587
IgA (μ/ml)	105.7 ± 30.5	120.6 ± 23.5	0.041*
SrIgA (μ/ml)	35.5 ± 19.1	42.0 ± 23.2	0.198
Salivary cortisol (ng/ml)	8.48 ± 4.12	11.65 ± 5.76	0.007*
Vit C (mg/dl)	0.74 ± 0.28	0.69 ± 0.20	0.332
MDA (mol/ml)	1.58 ± 1.26	1.50 ±1.30	0.754
TAC mg/dl	11146.9 ± 196.8	1108.7 ±164.2	0.289

SrIgA: secretion rate of immunoglobulin A; IgA: Immunoglobulin A, Vit C: Vitamin C; MDA: malondialdehyde; TAC: Total antioxidant capacity; Mean±SD: Mean plus or minus standard deviation, *Statistically significant difference (p<0.05).

TABLE IV: BIOCHEMICAL CHARACTERISTICS OF STUDY COHORTS

Parameters	Doctors n=16	MLS n=18	Radiographers n=16	Pharm. n=7	Nurses n=12	f-value	p-value
Vit.C(mg/dl)	0.59±0.19	0.81±0.2	0.74±0.24	0.74±0.28	0.65±0.15	2.388	0.060
MDA (nmol/L)	2.68±2.43[a]	1.31±0.76[b]	1.18±0.55[c]	0.74±0.18[d]	2.22 ± 1.48[e]	3.972	0.006*
TAC (mg/dl)	1048.3±168.2[a]	1120.2±146.2[b]	1276.9±147.7[c]	1086.1±147.7[d]	1032.3±116.3[e]	6.445	0.000*
Salivary volume (ml)	1.48±0.76	1.64±0.79	1.72±0.70	1.92±0.78	1.58±.1.58	0.315	0.867
Salivary flow rate (ml/min)	0.29±0.15	0.32±0.15	0.34±0.14	0.38±0.15	0.31±0.31	0.315	0.867
IgA (µg/ml)	119.8±30.0	119.9±24.7	102.6±29.3	111.2±41.7	93.1±21.9	2.179	0.082
sIgA (µg/min)	35.9±22.7	39.6±20.0	35.6±14.7	39.3±19.4	28.7±29.7	0.487	0.745
Sal.Cortisol (ng/ml)	7.10±3.35	7.80±3.59	10.98±6.48	9.15±3.51	10.37±5.15	1.883	0.125
Vit.C(mg/dl)	0.59±0.19	0.81±0.2	0.74±0.24	0.74±0.28	0.65±0.15	2.388	0.060

MLS: Medical Laboratory Scientists; TAC: total antioxidant capacity; Vit. C: Vitamin C; MDA: Malondialdehyde; IgA: Immunoglobulin A; sIgA: secretion rate of IgA; Post hoc analysis of TAC: c vs a (p=.001) ; c vs b (p=.030); c vs d (p= .059); c vs e (p=0.001); Post hoc analysis of MDA: a vs c (p=0.040); a vs d (p=0.034); a vs b or e (p>0.05).

IV. DISCUSSION

The prevalence of high JS among male health workers in this present study was 26.2% which was similar to the 27.3% reported by [17]. Among the studied healthcare professionals, radiographers and technicians had higher JD when compared with others. On the contrary, JC did not vary across the various subgroups.

Salivary cortisol, which reflects the free plasma cortisol, was measured to evaluate the activity of HPA axis - a stress response pathway [25]. The high JS group had significantly higher levels of salivary cortisol when compared with the no JS group.

The mechanism is the stimulation of HPA axis in stress response. Under stress, the hypothalamus produces corticotrophin-releasing hormone which provokes the release of ACTH from the pituitary. ACTH in turn stimulates the secretion of glucocorticoids from the adrenal cortex. The main glucocorticoid in humans is cortisol which can be measured in saliva as free cortisol. Previous studies had also reported elevated levels of cortisol in high JS workers [14], [26]. A recent review of the relationship between psychosocial work environment and cortisol reported that cortisol measured in saliva was positively associated with job stress and general life stress [27].

The significantly high level of salivary cortisol in the low JC group when compared with the high JC group, and the observed inverse relationship between salivary cortisol and JC provide additional physiological and objective evidence for the direct effect model of JC, which postulates that high JC reduces the level of JS or buffers its effects on workers [28]. JC is particularly very important because it determines the extent to which workers can cope with job stressors.

Therefore, low JC could have played a predominant role in the significantly high level of salivary cortisol in the high JS group in this present study because low JC, a characteristic feature of high JS, had consistently been associated with elevated cortisol levels in previous studies with adverse health consequences [29], [30].

In high JS situations, both adrenaline and cortisol are elevated and elevated levels of both the catecholamine and the stress hormone appear to have severe consequences for myocardial pathology [31], [32].

Higher and prolonged levels of cortisol in the bloodstream such as those associated with chronic stress have negative cardiovascular consequences including elevation of blood pressure, truncal obesity, hyperinsulinemia, hyperglycemia, insulin resistance, and dyslipidemia [33]. This may explain in part the connection between high JS and cardiovascular diseases in prolonged exposure to high levels of stress hormones. While cortisol is a vital and helpful part of the body's response to stress, the body should return to normal through relaxation after stressful events. Unfortunately, in the current high-stress culture with little or no time for relaxation, the body's stress response is activated so often that it may not always return to normal which could result in a state of chronic stress.

Salivary secretory IgA, an immunological marker of stress, was measured to evaluate the possible impact of JS on mucosal immunity as numerous studies had reported that stress could have bi-directional effects on immunity; acute stress enhances, whereas chronic stress suppresses the immune function [34], [35]. Salivary IgA is partly determined by saliva flow, it was further reported in secretion rate [36]. The secretion rate of salivary IgA in this study did not differ within different categories. The absolute concentration of salivary IgA did not differ within different categories except within the JS category when compared with the no JS group, suggesting enhanced mucosal immunity in the high JS group. However, the simultaneous significantly higher levels of salivary IgA and cortisol in physiological concentrations in the high JS group may indicate a normal response to acute exposure to job stress.

Acute stressful situations may have a stimulating effect on immunity, associated with the activation of the sympatho-adrenal-medullary system, which promotes the mobilization of immune cells from the blood to other organs. Although the level of salivary cortisol was significantly higher among the high JS group, the mean value (11.65 ng/ml) was within the physiological limit (1.2-14.7 ng/ml) [23]. Previous studies had shown that physiological levels of endogenous glucocorticoids can have important positive effects on the immune response [37]. Although acute job stress may not have an immediate negative effect on immunity as observed in this present study, chronic exposure would lead to down-regulation of beta-adrenergic receptors by cortisol resulting from hyper-stimulation of HPA axis, alters adhesion molecules expression on leukocytes, with a resultant decrease of immune response to acute psychological challenges in chronically stressed persons [38].

To evaluate oxidative stress, malondialdehyde, vitamin C, and total antioxidant capacity were also evaluated among different cadres of the studied HCWs. While no difference was observed in the concentration of vitamin C among the

professional HCWs, the medical doctors had significantly higher MDA compared to other HCWs while the radiographers had higher total antioxidant capacity compared to other HCWs, which may indicate oxidative stress among these HCWs.

The etiology of the observed oxidative stress in doctors could not be determined in this present study and therefore further long-term studies are required to ascertain whether there is an association between oxidative stress and certain professional groups in the health sector. The non-significant differences in the mean values of total antioxidant capacity, vitamin C, and malondialdehyde when compared within the categories of JD, JC, and JS in this present study lack any directly comparable findings in previous studies since there are no other studies that have used these parameters to assess oxidative stress in JS model.

Reference [38] reported that compared to baseline, total antioxidant status levels in nurses were significantly decreased at the end of both night and day shifts, while total oxidant status levels were significantly increased in the two groups.

Other authors had argued that indirect mechanisms, through behavioral risk factors associated with high JS such as smoking and excess alcohol consumption may be important pathways linking JS with certain cardiovascular risk factors [39]. It was based on this knowledge that the smoking and alcohol consumption status of the subjects were examined. Most studied subjects were non-smokers and no heavy alcohol consumer was reported. Alcohol consumption status had no association with JD, JC, and JS in this present study. The distribution of the subjects by alcohol and smoking status may suggest a healthy lifestyle and this may explain the no significant variation in the oxidative stress parameters observed in this study.

V. Limitations of Study

The study also has some limitations. Firstly, the cross-sectional design that does not give any information about the chronology of job strain exposure and outcome makes conclusions about causality difficult. Secondly, the grouping of subjects was based on subjective appraisals using a self-report questionnaire although there is currently no objective approach in this area of research. Self-reports are associated with perceptual biases as perception is affected by moods, attitudes and by cognitive processes, and social desirability. Finally, the stress outside the work environment such as home stress was not taken into account which could worsen workers' coping ability.

VI. Conclusion

The findings from this study suggest that high JS, a job characterized by high JD and low JC, stimulates the HPA axis leading to an increased level of stress hormone- salivary cortisol among the studied HCWs. Furthermore, the high JS group also had higher IgA levels than the no JS group indicating that the former had enhanced mucosal immunity. Salivary cortisol showed an inverse correlation with JC indicating that cortisol levels in saliva may be affected by the

workers' level of JC, with concentrations increasing as JC decreases. There were no significant differences in oxidative stress parameters between JD, JC, and JS sub-categories. Similarly, JD and JC had no significant correlations with oxidative stress parameters studied. However, oxidative stress occurred in doctors when compared with radiographers/technicians.

Abbreviations

JC: Job control, JD: Job demand, JS: Job strain, HCWs: Healthcare workers.

Conflict of Interest

The authors declare that they do not have any conflict of interest.

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