Psychosocial Work Environment and Oxidative Stress among Nurses

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Abstract:
Background
Work stress among nurses has increased in recent years due to the demands of clinical nursing

Objectives:
To investigate psychosocial work stress among nurses using the effort–reward imbalance (ERI) model with assessment malondialdehyde (MDA) as an oxidative stress marker and total antioxidants.

Methods
The present study was conducted on 204 registered nurses worked at two tertiary hospitals in Menoufia governorate, Egypt through the period from the 1st of February to the end of July 2016. Two questionnaires were applied including general demographic and occupational histories as well as effort–reward questionnaire. Blood analysis was performed to assess MDA and total antioxidant levels.

Results
ERI was prevalent among the study participants (72.5%). ERI was more prevalent among young married nurses who worked more than 10 years. Nurses that worked at ICUs complained more of ERI (43.2%) while nurses that worked at operation rooms complained more of overcommitment (62.5%). MDA levels were significantly positively correlated with E/R ratios (rho = 0.350, P ≤ 0.001)

Conclusions
Work stress was prevalent among the studied nurses as revealed by the high ERI and MDA levels. Young married female nurses complained more of work stress. ICUs and operating rooms were the most stressful departments at the studied hospitals. Hence, implementing programs and strategies that eliminate stressful working conditions at hospitals is critical to the reduction and prevention of work stress among nurses.

Keywords:
Work Stress; Nurses; ERI; MDA; Antioxidants

1. Introduction:

Nursing staff is exposed to high physical and psychosocial work load. Patients' needs and safety, long shifts, work overload, work-related conflicts, shortage of staff, conflicts with supervisors, bias, and lack of organizational support are stressful factors in nursing jobs\(^1,2\) that might be associated with increased levels of sickness, absence, high rate of staff turnover, burnout, and poorer physical and psychological health \(^3\). Moreover, stressful nursing is likely to affect the provision of care and treatment outcomes \(^4\).

The effort–reward imbalance (ERI) model is a theoretical concept proposed by Siegrist \(^5\) validated approach to measure chronic psychosocial work stress by identifying non-reciprocity between the occupational efforts and rewards that has been found to predict poor health \(^6\). Moreover, the ERI model includes an overcommitment scale that depends on personality characteristics, including attitudes, behaviors Moreover, and emotions that reflect excessive work effort combined with a strong desire for approval \(^7\). Overcommitment has been found to be associated with insomnia \(^8\), poor self-rated health \(^9\), and emotional exhaustion at work \(^10\). The ERI model is popular in stress-related research because it consists of both situational and personal stressors’ characteristics \(^11\).

Stressful conditions, including occupational stress, lead to the excessive formation of free radicals or reactive oxygen species and cause oxidative stress \(^12\). Free radicals are formed in the human body in the cytosol, mitochondria, lysosomes, peroxisomes, and plasma membranes under both physiological and pathological conditions. They initiate a cascade, causing lipid peroxidation that directly damages biological membranes and generates a number of secondary products, including aldehydes such as malondialdehyde (MDA), which is the most abundant aldehyde resulting from lipid peroxidation \(^13\).

The human body have an integrated antioxidant system that includes enzymatic and nonenzymatic antioxidants that are usually effective in blocking the harmful effects of free
radicals. Once the balance between free radicals production and the antioxidative defense activity is disrupted, oxidative stress can occur, which may result in cell injury or death, and subsequent damage and, finally, chronic disease \(^{14}\).

Many biomarkers of oxidative damage are labor- and time-intensive and may not be appropriate for use in epidemiologic studies or clinical trials involving hundreds or thousands of subjects. On the other hand, MDA is a widely used, sensitive, and appropriate oxidative biomarker \(^{15}\).

Previous studies found an association between elevated MDA levels and occupational stress, such as the study carried out by Casado et al., \(^{12}\) who reported a positive correlation between MDA and occupational stress in workers of a prehospital emergency service. Tsuboi et al. \(^{16}\) also found a correlation between elevated MDA levels and depressive symptoms in nurses who complained of low job stress.

There are few studies on the psychosocial factors at work places in Egypt. The present study aimed to investigate the psychosocial work stress among nurses defined by the ERI model with assessment of MDA as an oxidative stress marker and total antioxidants.

2. Participants and Methods:

2.1 Design and sample:

This was a cross sectional study conducted at two tertiary hospitals, the Menoufia University Hospital and the Psychiatric and Addiction Treatment Hospital at the Menoufia governorate, Egypt. Data collection was conducted from February 1 to the end of July 2016.

All the nursing staff that worked in the two studied hospitals (257 nurses) were targeted to the study. Twenty four nurses were excluded firstly as they had one or more items of the exclusion criteria of the study that included recent acute infectious illness, chronic diseases (of
liver, kidney, diabetes mellitus), malignancy, smoking, pregnancy and psychiatric disorders. The remaining 233 nurses were invited to participate in this study but 29 disagreed to participate. The final sample size of this study was 204 participants, with a response rate of approximately 87.6% (204/233). The participants were distributed over all hospitals' departments including operating rooms (at General and Special Surgeries), Intensive Care Units (medical and surgical), and other departments (Internal Medicine, Psychiatric and Pediatric departments).

2.2: Measures:

All the participants were interviewed by the authors after the work shift at the administration departments of the studied hospitals and subjected to the following:

2.2.1 Structured interview questionnaire:

This tool was developed and used by the researchers based on the review of the relevant literature. It included socio-demographic data (age, gender, education levels, marital status) and occupational history (jobs titles, hospital unit, duration of work, and shift work system).

A pilot study was carried out in 10 subjects that were excluded from the study sample to test feasibility and applicability of the questionnaire, and modifications were done accordingly.

2.2.2 Effort–Reward Imbalance (ERI) model to assess work stress:

ERI is one of the worldwide models to assess work stress. It was originally developed by Siegrist et al.\(^\text{17}\). The model reflects the non-reciprocity of social exchange (i.e., high effort/low reward at work) which leads to a state of emotional distress. In addition, the model includes a pattern of coping with job demands, which is known as overcommitment. The ERI model consisted of 23 items divided into three components: effort (6 items), reward (11 items), and overcommitment (6 items). The effort component included physical load, time pressure,
interruptions, responsibilities, working overtime, and increasing demands at work. The reward component consisted of financial, esteem, promotion and job security factors.\(^{18}\)

The Arabic-translated version of the ERI questionnaire was applied in this study.\(^{19}\) Items on the effort scale were answered using a 5-point rating scale (1: disagree; 2: I am not at all distressed; 3: I am somewhat distressed; 4: I am distressed; and 5: I am very distressed), with higher scores indicating higher effort at work. The 11 items measuring reward were framed similarly, but the coding was reversed so that a lower summary score for reward indicates a higher subjective rate of distress due to low reward.\(^{19}\) The overall ERI score was calculated as effort divided by reward with a correction factor for the different number of items in each scale:

\[
E/R \text{ ratio} = \frac{\text{effort score}}{\text{reward score \times 1.834}}; \text{a score of one or less represents a balance between effort and reward, whereas scores above one reflect a perceived disproportionate effort and stress}.\(^{17}\)
\]

In addition, the overcommitment scale included esteem, promotion, and security subscales that were measured by six questions scored using a 4-point scale (1: strongly disagree; 2: disagree; 3: agree; 4: strongly agree) with a total score ranging from 0–24. A high overcommitment score was indicated by a total score in the upper tertile of the total score.\(^{20}\)

In this study, Cronbach’s alpha values of the ERI model were 0.83 for effort, 0.87 for reward, and 0.75 for overcommitment.

2.2.3 Biochemical analysis:

About 10 mL of blood was drawn from each participant using a 19-gauge butterfly needle connected to a plastic syringe. Then the content of the syringe was transferred immediately to polypropylene tubes, which were then centrifuged at 3,000 rpm for 10 minutes at 10–18 °C. The
serum supernatant samples were stored in plastic tubes at −80 °C until assayed. The following serum markers were assessed:

**Total antioxidant capacity** was measured by colorimetry, Biodiagnostic Kit. Egypt. The principle depends on Cu²⁺ ion is converted to Cu⁺ by both small molecule and protein. The Protein Mask prevents Cu²⁺ reduction by protein, enabling the analysis of only the small molecule antioxidants. The reduced Cu⁺ ion is chelated with a colorimetric probe, giving a broad absorbance peak around 570 nm, which is proportional to the total antioxidant capacity 21).

**MDA levels** were determined through a spectrophotometrical method. The principle depends on the reaction of thiobarbituric acid with MDA in acidic medium at a temperature of 95 °C for 30 minutes to form thiobarbituric acid reactive product; the absorbance of the resultant pink product can be measured at 534 nm 22).

The biochemical analysis was performed at the central laboratory of the Menoufia University Hospital.

### 2.3: Ethical considerations:

The Menoufia Faculty of Medicine Committee for Medical Research Ethics reviewed and formally approved the study before its beginning. Informed formal consent was obtained from each participant prior to the beginning of the study. All subjects involved in the study received detailed information concerning the aims of the research study. Also, an official approval was obtained by the researchers from the administrators of the studied hospitals.

### 2.4: Statistical analysis:

Results were collected, tabulated, statistically analyzed by IBM personal computer and statistical package SPSS version 20. Two types of statistic analyses were performed. Descriptive statistics: e.g., percentage (%), mean, and standard deviation (SD); and Analytic statistics:
Mann–Whitney U test, which is a non-parametric test of significance used for comparison between two groups having quantitative variables not normally distributed, Kruskall–Wallis test, which is a non-parametric test of significance used for comparison between more than two groups having quantitative variables not normally distributed, and the Chi-squared ($\chi^2$) test was used to study the association between two or more qualitative variables. Binary logistic regression analysis was performed to examine the independent effects of the marital status and the unit types on ERI. We adjusted for age, gender, education level, job titles, years of experience, and shift work. The results are shown as odds ratio (OR) and 95% confidence interval (CI). Spearman's rank correlation coefficient (rho) was used to study the association between E/R ratios, MDA, and total antioxidant levels in the ERI group. A P-value of <0.05 was considered statistically significant.

3. Results:

Table 1 shows ERI and overcommitment in relation to characteristics of the studied participants. More than half (54.9%) of the studied group was 20–30 years old. The majority of the participants were females (94.1%) and married (92.2%). Secondary-educated nurses prevailed and were followed by those with university education (37.3% and 35.3%; respectively). Two thirds (66.7%) of the participants worked rotating shifts, including night shifts. About 47.1% of the participants worked for more than 10 years. The prevalence of work stress among the studied nurses (as revealed by ERI score of >1) was high (72.5%) while overcommitment was prevalent in about one third of them (31.4%). ERI was significantly predominant among lower aged (from 20–40 years), married, female nurses. In addition, nurses that worked in ICUs followed by nurses that worked in the operation rooms had significantly more ERI (43.2% and 32.4%; respectively). Moreover, ERI was significantly prevalent among
those who worked for more than 10 years (51.4%), followed by those who worked less than 5 years (35.1%). Total antioxidant levels were significantly higher in the ERI group, but there was no significant correlation between these levels and the E/R ratios (rho = 0.01; P = 0.866, Fig 1).

High overcommitment scores were significantly predominant in nurses that worked in operating rooms (62.5%). Moreover, the MDA levels were significantly higher in the high overcommitment group than in the lower one.

Married nurses and working at operation rooms and ICUs were still significantly associated with ERI (OR = 8.09, 95% CI: 1.645–39.782; OR = 37.27, 95% CI: 8.172–169.967; and OR = 13.34, 95% CI: 3.821–46.589, respectively), as shown in Table 2.

The MDA levels were significantly elevated with age (>30 years). Also, there were significant differences in the MDA levels in the studied participants regarding the working departments; the highest levels were observed in nurses that worked in operation rooms (4.23 ± 3.18), followed by those that worked in ICUs (3.03 ± 1.47) than in other departments as shown in Table 3.

Although there was no significant increase in the levels of MDA in the ERI group (Table 2), these levels were significantly positively correlated with E/R ratios (rho = 0.350; P ≤ 0.001), as shown in Fig 2.

4. Discussion:

The aim of this study was to determine the psychosocial work stress assessed by ERI mode and its association with oxidative stress parameters (MDA and antioxidants) in a sample of nurses. MDA levels were significantly positively correlated with E/R ratios. Moreover, MDA levels were significantly higher in nurses with high overcommitment, which is a coping mechanism to excessive work-related commitment. These findings suggested that nurses
working in a desynchronized environment might be less able to cope with the negative effects of the ERI model and might be under stress. This is consistent with the research by Tsuboi et al. who reported a positive correlation between elevated MDA levels and depressive symptoms in nurses that complained of job stress. Also, the association between psychiatric disorders and increased MDA levels was found by Khanzode et al. in patients with major depression.

Moreover, MDA levels in all the studied participants (3.20 ± 2.21 µmol/L) might be more than four times higher than the normal value for MDA, which is less than 0.7 µmol/L. These finding show that the oxidative stress among nurses may be much higher than that of general population.

Three hypothesis related to the ERI model were postulated: the extrinsic hypothesis suggested that high effort and low reward lead to strain and health effects; the intrinsic hypothesis stated that overcommitment was responsible for the development of strain and the negative health effects; and the intrinsic interaction hypothesis, which stated that the negative effect of ERI was exaggerated by overcommitment. Our findings might support the intrinsic hypothesis as revealed by the significant higher MDA levels in nurses with high

Research evidence for the role played by overcommitment in predicting strain is, however, mixed and inconclusive. Several studies provided evidence for the intrinsic overcommitment hypothesis, whereby employees who are more overcommitted tend to report poorer physical and psychological health, but other studies fail to find support this prediction.

Overcommitment was considered as a predictor of ERI by some researchers as highly overcommitted employees tend to invest much effort in their work over the appropriate levels
and judge their extrinsic rewards to be low as a result, they perceive ERI\(^{31}\). Accordingly, the MDA might reach significant levels in the ERI group with prolonged overcommitment, especially as MDA levels were positively correlated with E/R ratios.

Overall, 72.5% and 31.4% of the nurses reported having experienced ERI and overcommitment, respectively. This high prevalence of ERI and overcommitment may be the result of the overburdened health care system in Egypt, understaffing among the nursing staff, lack of resources, inadequate salaries, difficult work schedules, inadequate security, and poor career advancement\(^{32}\). Moreover, Chandola et al.\(^{33}\) reported that the imbalance between the efforts spent and the rewards received is likely to be experienced by employees who have little choice of alternative workplaces or who accept this imbalance for improvement of their future chances in addition to, if employees exhibit overcommitment. Therefore, this stressful working environment needs improvement and promotion.

The prevalence of ERI and overcommitment experienced by nurses in the current study were different from those of studies performed in other countries. For example, Sakata et al.\(^{34}\) reported that 12.2% and 44.4% of the medical residents in Japan experienced ERI and overcommitment, whereas Conway et al.\(^{35}\) reported that 16.1% and 26.3% of the health care workers in Italy experienced ERI and overcommitment. A survey on a group of nurses in the ORSOSA study in France identified ERI in 10.7% of the nurses and overcommitment in 40.8% of the nurses\(^{36}\). In the current study, nurses had a higher prevalence of ERI. This difference might be explained by the variations in culture and nature of the health system, including structural and service delivery problems in different countries\(^{37}\).

High ERI in the present study was predominant among nurses aged 20–30 years. Younger nurses were more engaged in work duties and this might expose them to more work stress. This
result was coincided with that of a previous Egyptian study conducted by Arafa et al.\textsuperscript{38}. Also, Wisetborisut et al.\textsuperscript{39} found that older workers reported less burnout than younger ones and that this may result from a longitudinal developmental process that helps over time to protect them from psychological distress and burnout.

About half of the nurses who experienced ERI in this study were employed for more than ten years. As nurses with more years of experience have more responsibility and expect more reward at work place. This result coincided with that of Lee et al.\textsuperscript{40}, who revealed that public health nurses of younger age and longer past clinical experience perceived more occupational stress. On the contrary, Dagget et al.\textsuperscript{41} found no variation in job-related stress and length of service in Ethiopian nurses, but they applied different tools in the assessment of job stress.

Of the covariates analyzed in this study, ERI in nurses was significantly different among nurses who worked in different hospital units. ERI was more common in nurses who worked in operating rooms than in those who worked in other departments. The operating room is a complex, stressful, and potentially hazardous environment. Moreover, nurses in the operating room have to care for the patients’ conditions, cooperate with the surgeon to perform difficult procedures, and share with the team dynamics and environmental conditions\textsuperscript{42}. Kawano\textsuperscript{43} reported that the operating room nurses developed fatigue independently of demographic or job-related stress factors.

Overcommitment was significantly experienced by nurses who worked in ICUs than by those who worked in other departments. Nurses who worked in ICUs mainly care for critical cases and patients at high risk of death; therefore, they were exposed to higher work load and work stress. In contrast, Lin et al.\textsuperscript{23} found that overcommitment was more common in nurses who worked in acute wards than in those who worked in ICUs or emergency rooms, while Sakata et al.\textsuperscript{34} found
no significant differences in effort, reward, and overcommitment between specialties of Japanese medical residence.

In addition, MDA levels were significantly higher in participants aged 30–40 years and that worked in operation rooms and ICUs, which is in accordance with the results for overcommitment and ERI in the current study, reflecting the stressful environment of these units. This result coincided with that of Casado et al. 44) who observed significant higher levels of MDA in nurses aged 30–39 years and that worked in ICUs than in those of the control group.

Previous studies as that carried out by Block et al. 45) found a strong association between smoking and MDA levels. On the other hand, Ayaori et al. 46) did not find elevated MDA levels in smokers. We did not investigate the effect of smoking in this study as it was put in the exclusion criteria of the studied participants. Also, the levels of serum MDA showed a statistically significant increase after Intense Exercise 47).

The levels of total antioxidants in this study were significantly higher among nurses with ERI. This might be a protective body response against work stress as the oxidative stress can be effectively neutralized by enhancing cellular defenses in the form of antioxidants 48). Moreover, more than half of the participants with ERI were of younger age (20–30 years) and had a better antioxidants defense response. In addition, the antioxidant levels in the present study were not significantly correlated with E/R ratio, suggesting that these higher levels were not associated with ERI in the studied participants.

Also, the antioxidant enzymes, especially the inducible superoxide dismutase enzyme, have been shown to be elevated at risk of exposure to low doses of various stressors as found in cigarette smokers 49), asbestos-exposed workers 50), ionizing radiation-exposed workers 51) and in athletes 52) who have higher antioxidants levels than controls.
This study had several limitations. First, it had a cross sectional study design, so we were unable to prove any chronobiological effects of work stressors and we can't derive any conclusions on the causality of ERI and oxidative stress in nurses. Second, the small sample size might limit the generalizability of this study. Despite these limitations, this study reflects the association between psychosocial work environment and oxidative stress in the nursing job. Therefore, these results should be verified with large-scale and multicenter studies.

**Conclusion and recommendations:** In our study, we found that the psychosocial work environment may be associated with occupational stress among nurses, as revealed by ERI, overcommitment, and elevated MDA levels. However, this association may be improved through implementation of appropriate stress reduction interventions including education and practice changes at hospitals to help the nurses to cope with their job stressors.

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**Conflicts of interest**

The authors declare that there are no conflicts of interest associated with this manuscript.

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Tables:

Table 1. ERI and overcommitment in relation to characteristics of the studied participants

| Characteristics                      | Total (n=204) | ERI ≤ 1 (n=56) | ERI >1 (n=148) | *P value | Overcommitment Low (n=140) | Overcommitment High (n=64) | *P value |
|--------------------------------------|--------------|----------------|----------------|----------|---------------------------|---------------------------|----------|
| **Age (years):**                     |              |                |                |          |                           |                           |          |
| 20-30                                | 112 (54.9)   | 24 (42.9)      | 88 (59.5)      | <0.001   | 76 (54.3)                 | 36 (56.2)                 | 0.846    |
| >30-40                               | 76 (37.3)    | 32 (57.1)      | 44 (29.7)      |          | 52 (37.1)                 | 24 (37.5)                 |          |
| >40                                  | 16 (7.8)     | 0              | 16 (10.8)      |          | 12 (8.6)                  | 4 (6.2)                   |          |
| **Gender:**                          |              |                |                |          |                           |                           |          |
| Females                             | 192 (94.1)   | 56 (100.0)     | 136 (94.1)     | 0.028    | 132 (94.3)                | 60 (93.8)                 | 0.880    |
| Males                               | 12 (5.9)     | 0              | 12 (8.1)       |          | 8 (5.7)                   | 4 (6.2)                   |          |
| **Education levels:**                |              |                |                |          |                           |                           |          |
| Secondary school                    | 76 (37.3)    | 20 (35.7)      | 56 (37.8)      | 0.313    | 52 (37.1)                 | 24 (37.5)                 | 0.630    |
| University                          | 72 (35.3)    | 24 (42.9)      | 48 (32.4)      |          | 52 (37.1)                 | 20 (31.2)                 |          |
| Technical Institute of nursing      | 56 (27.5)    | 12 (21.4)      | 44 (29.7)      |          | 36 (25.7)                 | 20 (31.2)                 |          |
| **Marital status:**                 |              |                |                |          |                           |                           |          |
| Single                               | 188 (92.2)   | 8 (14.3)       | 8 (5.4)        | 0.035    | 12 (8.6)                  | 4 (6.2)                   | 0.567    |
| Married                              | 16 (7.8)     | 48 (85.7)      | 140 (94.6)     |          | 128 (91.4)                | 60 (93.8)                 |          |
| **Job title:**                      |              |                |                |          |                           |                           |          |
| Nurse                                | 136 (66.7)   | 32 (57.1)      | 104 (70.3)     | 0.076    | 88 (66.7)                 | 48 (75.0)                 | 0.088    |
| Supervisor                           | 68 (33.3)    | 24 (42.9)      | 44 (29.7)      |          | 68 (33.3)                 | 16 (25.0)                 |          |
| **Unit type:**                      |              |                |                |          |                           |                           |          |
| ICUs                                 | 76 (37.3)    | 12 (21.4)      | 64 (43.2)      | <0.001   | 56 (40.0)                 | 20 (31.2)                 | <0.001   |
| Operating rooms                     | 60 (29.4)    | 12 (21.4)      | 48 (32.4)      |          | 20 (14.3)                 | 40 (62.5)                 |          |
| Other departments                    | 68 (33.4)    | 32 (57.2)      | 36 (24.4)      |          | 60 (42.9)                 | 4 (6.2)                   |          |
| **Years of experience:**            |              |                |                |          |                           |                           |          |
| < 5                                  | 72 (35.3)    | 20 (35.7)      | 52 (35.1)      | 0.026    | 48 (34.3)                 | 24 (37.5)                 | 0.427    |
| 5-10                                 | 36 (17.6)    | 16 (28.6)      | 20 (13.5)      |          | 28 (20.0)                 | 8 (12.5)                  |          |
| >10                                  | 96 (47.1)    | 20 (35.7)      | 76 (51.4)      |          | 64 (45.7)                 | 32 (50.0)                 |          |
| **Shift work:**                     |              |                |                |          |                           |                           |          |
| Day shift                            | 68 (33.3)    | 20 (35.7)      | 48 (32.4)      | 0.657    | 48 (34.3)                 | 20 (31.2)                 | 0.670    |
| Rotating shift                       | 136 (66.7)   | 36 (64.3)      | 100 (67.6)     |          | 92 (65.7)                 | 44 (68.8)                 |          |
| **Total antioxidant levels** (nmol/l)| 0.59±0.33    | 0.52±0.21      | 0.62±0.36      | 0.014**  | 0.57±0.34                 | 0.64±0.30                 | 0.440**  |
| Mean ± SD                           | 3.20±2.21    | 3.10±1.75      | 3.23±2.36      | 0.691**  | 2.12±1.41                 | 3.60±2.32                 | <0.001** |

*p value for χ² test
**: Mann-Whitney test was used
Table 2. Binary logistic regression analysis for covariates of ERI in the studied participants

|                                | OR (95% CI)       | P value |
|--------------------------------|-------------------|---------|
| **Age (years):**               |                   |         |
| 20-30                          | 1.34 (0.84–2.14)  | 0.607   |
| >30-40                         | 0.91 (0.53–1.67)  | 0.998   |
| >40                            | 1.00 (reference)  |         |
| **Gender:**                    |                   |         |
| Females                        | 0.88 (0.55–1.42)  | 0.995   |
| Males                          | 1.00 (reference)  |         |
| **Education levels:**          |                   |         |
| Secondary school               | 0.31 (0.070–1.370)| 0.123   |
| University                     | 0.94 (0.097–3.036)| 0.956   |
| Technical Institute of nursing | 1.00 (reference)  |         |
| **Marital status:**            |                   |         |
| Single                         | 1.00 (reference)  |         |
| Married                        | 8.09 (1.645–39.782)| 0.031   |
| **Job title:**                 |                   |         |
| Nurse                          | 1.84 (0.195–2.357)| 0.595   |
| Supervisor                     | 1.00 (reference)  |         |
| **Unit type:**                 |                   |         |
| Other departments              | 1.00 (reference)  |         |
| ICUs                           | 13.34 (3.821–46.589)| <0.001  |
| Operating rooms                | 37.27 (8.172–169.967)| <0.001  |
| **Years of experience:**       |                   |         |
| < 5                            | 1.00 (reference)  |         |
| 5-10                           | 1.29 (0.244–6.790) | 0.767   |
| >10                            | 1.17 (0.638–2.115) | 0.997   |
| **Shift work:**                |                   |         |
| Day shift                      | 1.00 (reference)  |         |
| Rotating shift                 | 0.82 (0.274–2.440) | 0.718   |

Adjusted for age, gender, education levels, job titles, years of experience and shift work OR, Odds ratio; CI, confidence interval.
Table 3. MDA levels in relation to characteristics of the studied participants

| Characteristics          | MDA levels (umol/l) Mean ± SD | Test of significance | P value |
|--------------------------|-------------------------------|----------------------|---------|
| **Age (years):**         |                               |                      |         |
| 20-30                    | 2.76 ±1.87                    | Kruskall-Wallis test= | 0.009   |
| >30-40                   | 3.88 ±2.64                    | 9.36                 |         |
| >40                      | 3.06 ±0.92                    |                      |         |
| **Gender:**              |                               |                      |         |
| Females                  | 3.09 ±2.13                    | Mann-Whitney test=   | 0.133   |
| Males                    | 7.78 ±2.90                    | 1.50                 |         |
| **Education levels:**    |                               |                      |         |
| Secondary school         | 3.47±2.71                     | Kruskall-Wallis test= | 0.941   |
| University               | 3.01±1.96                     | 0.121                |         |
| Technical Institute of nursing | 3.10±1.79                  |                      |         |
| **Marital status:**      |                               |                      |         |
| Single                   | 3.47 ±1.44                    | Mann-Whitney test=   | 0.153   |
| Married                  | 3.18 ±2.27                    | 1.43                 |         |
| **Job title:**           |                               |                      |         |
| Nurse                    | 3.26 ±2.36                    | Mann-Whitney test=   | 0.912   |
| Supervisor               | 3.07 ±1.88                    | 0.11                 |         |
| **Unit type:**           |                               |                      |         |
| ICUs                     | 3.03 ±1.47                    | Kruskall-Wallis test= | 0.006   |
| Operating rooms          | 4.23 ±3.18                    | 10.24                |         |
| Other departments        | 2.59 ±1.64                    |                      |         |
| **Years of experience:** |                               |                      |         |
| < 5                      | 2.98 ±1.99                    | Kruskall-Wallis test= | 0.570   |
| 5-10                     | 2.97 ±1.94                    | 1.12                 |         |
| >10                      | 3.47 ±2.46                    |                      |         |
| **Shift work:**          |                               |                      |         |
| Day shift                | 3.30 ±2.45                    | Mann-Whitney test=   | 0.843   |
| Rotating shift           | 3.15 ±2.09                    | 0.20                 |         |
rho = 0.01  P=0.866
Fig (1): Correlation between E/R ratio with total antioxidant levels in the studied participants
rho= 0.350      P=< 0.001

Fig (2): Correlation between MDA levels and E/R ratios in the studied participants with ERI.