

# Work related stress and blood glucose levels

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*Parole chiave:* Stress lavoro correlato, questionario strumento indicatore, stress soggettivo, glicemia, lavoratori

## Abstract

**Aim.** The aim of the study is to evaluate work-related subjective stress in a group of workers on a major Italian company in the field of healthcare through the administration of a valid “questionnaire-tool indicator” (HSE Indicator Tool), and to analyze any correlation between stress levels taken from questionnaire scores and blood glucose values.

**Materials and methods.** We studied a final sample consisting of 241 subjects with different tasks. The HSE questionnaire – made up of 35 items (divided into 7 organizational dimensions) with 5 possible answers - has been distributed to all the subjects in occasion of the health surveillance examinations provided by law. The questionnaire was then analyzed using its specific software to process the results related to the 7 dimensions. These results were compared using the Pearson correlation and multiple linear regression with the blood glucose values obtained from each subject.

**Results.** From the analysis of the data the following areas resulted critical, in other words linked to an intermediate (yellow area) or high (red area) condition of stress: sustain from managers, sustain from colleagues, quality of relationships and professional changes. A significant positive correlation ( $p < 0.05$ ) between the mean values of all critical areas and the concentrations of glucose values have been highlighted with the correlation index of Pearson. Multiple linear regression confirmed these findings, showing that the critical dimensions resulting from the questionnaire were the significant variables that can increase the levels of blood glucose.

**Conclusions.** The preliminary results indicate that perceived work stress can be statistically associated with increased levels of blood glucose.

## Introduction

The work-related stress can be defined as a set of harmful reactions, physical and emotional, that occur when there is no

balance between the requirements of the workplace and the capabilities, resources or needs of the worker.

The European agreement on work-related stress of October 8, 2004 provides some

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principles, endorsed by Italy with the inter-unions agreement of June 9, 2008.

The art. 28 of Legislative Decree 81 of April 9, 2008 on the protection of health and safety at work provides that, in the assessment of occupational risks, “even those risks associated to work-related stress, according to the contents of the European Agreement of 8 October 2004”, must be included.

To evaluate the subjective experience of workers suffering from work-related stress different strategies have been applied.

One of the most important strategies in the assessment of the work-related stress is based on the use of appropriate psychometric questionnaires. Among the various questionnaires available, one of the most used is the Management Standards (1) by Health and Safety Executive (HSE), the British regulation organization responsible for health and safety at work.

From recent studies this last questionnaire seems to be one of the most complete and it has been officially validated in the United Kingdom and in the Republic of Ireland, and adopted also in Italy through a process formerly promoted by the Italian High Institute for Health and Safety at Work (ISPESL) (2), now merged into the National Institute for Insurance of Accidents at Work (INAIL) according to Law 122/2010.

The analysis tool of HSE provides mean scores for each dimension and allows to identify the organizational performance present in each of them, in order to analyze and compare it with the reference data (3-5).

From the results of several studies (6-12), the HSE questionnaire is considered one of the most valid and reliable for the assessment of work-related stress.

As shown by numerous studies in the literature, the stress is cause of adverse effects on human health through direct (eg neuroendocrine) and indirect (eg promotion of healthy behaviours) mechanisms.

The most common diseases associated are: cardiovascular disorders (13-17); neuroendocrine system disorders (18-21); disorders of the psychic sphere (23); disorders of the immune system (24-26); disorders of the gastrointestinal apparatus (17, 26, 27); skin modifications (28); alterations in the skeletal and muscular system (29-31) etc.

The above mentioned effects of stress on neuro endocrine system may also lead to a substantial increase of the levels of blood glucose through a cortisol-mediated mechanism. In support of this theory there are a few studies in the literature that show a significant association between work-related stress and the onset of Type II diabetes (31-34).

#### *Aim of the study*

The aim of the study is to evaluate work-related subjective stress in a group of workers on a major Italian Company in the field of healthcare through the administration of a valid “questionnaire-tool indicator” (HSE Indicator Tool), and to analyze any correlation between stress levels taken from the questionnaire scores, and the blood glucose levels.

## **Materials and methods**

#### *Study population*

The research was conducted between January and December 2014, starting with an initial working population of n. 294 subjects, both male and female, belonging to a large Italian Company working in the field of healthcare and social assistance.

All workers were health professionals and their tasks can be described as follows: doctors, nurses, biologists, technicians and laboratory workers, medical-social workers, ambulance drivers and operators helping disabled peoples.

All workers have been visited during the

medical investigation for the compulsory health surveillance by the occupational health physicians during the morning shift (between 08:00 and 14:00) of any business day between January and December 2014. For every worker, clinical and anamnestic informations were collected, including information about age, occupational history, medical history, physiological anamnesis (including cigarette smoking and consumption of alcoholic drinks) and current and remote medical situation.

Following the recommendations of the World Health Organization (WHO), we classified as smokers all subjects: 1) who declared to have smoked at least 100 cigarettes in their lives and to be currently smoking; 2) had stopped smoking less than six months before the visit (35).

In order to evaluate their use of alcoholic beverages, each worker had to pass the AUDIT test, developed by the WHO as a screening tool.

### *Questionnaire*

To evaluate the work-related stress perception in the working environment, a dimensional assessment of the subjective components of the stress has been conducted through the use of a standardized and validated questionnaire, developed as HSE/INAIL (see Introduction).

To make its use easier, we adopted the Italian version, recently validated and more apt for self-administration (36).

The HSE questionnaire includes 35 questions each of which provides one single response, based on a 5-point Likert scale with 23 items measuring the frequency (answers from *never* to *ever*) and 12 items which measure the degree of agreement (from *strongly agree* to *totally disagree*). The questions identified 7 key organizational dimensions:

1 - working load: including aspects such as workload, work organization and work environment;

2 - control: the autonomy of the workers on how they carry out their professional activity;

3,4 - support: divided into two subscales: “support from managers” and “support among colleagues”: dealing with the encouragement, support and resources provided by the company, by the employer and by colleagues;

5 - relations: promotion of a positive working to avoid conflict and deal with unacceptable behaviors;

6 - role: awareness of the worker relative to the position he covers in the organization and ensures that there is no conflict;

7 - change: evaluates the extent to which the organizational changes, of any size, are managed and communicated within the company.

The questionnaires were examined to verify the correct and full implementation: in particular if there were multiple answers or non-answers. The answers to each questionnaire were then inserted into the analysis software, provided by the HSE. The analysis tool provides HSE average scores for each dimension and allows to identify the organizational performance present in each of them, so that it can be analyzed and compared with the reference data (3-5).

### *Measurement of Blood Glucose*

During the visits, in the same day of the administration of the questionnaire HSE, a venous blood sample of 10 mL was taken from each worker for the analysis of blood glucose. The blood samples were stored at workplace in tubes for blood collection in a refrigerator at 4°, and then transferred (in a special container at the same temperature) to the laboratory, where plasma obtained after centrifugation was stored at -20° until they were analyzed (within 3 days). The laboratory performed the dosage of blood glucose through enzymatic-colorimetric method. Normal levels of the parameters analyzed were those used routinely by

the laboratory for clinical analysis: Blood glucose ranges from 74 to 106 mg/dL.

#### *Factors of exclusion and description of the final sample*

To avoid the influence of the major confounding factors, from the initial working population of 294 we excluded: (a) all workers with a seniority of less than one year (no. 16); (b) those who reported a positive family history of diabetes (diabetes diagnosed at least in one first-degree relative - parents or brothers - or at least 2 second-degree relatives - grandparents or uncles) (no. 14); (c) all workers with positive personal history of diabetes or obesity (no. 9). We also excluded from the study: (d) all employees who had not completed the HSE questionnaire in every part (no. 23). The final sample obtained was made up of 241 employees, 149 males aged between 28 and 67 years (mean: 48.3,

SD:  $\pm 7.55$ ) and 92 females, aged between 27 and 65 years (mean: 48.5, SD:  $\pm 7.60$ ). The characteristics of such a sample are reported in Table 1.

All workers included in the study have decided to make their personal informations available after they were granted that such data would be classified as “sensitive information”. They also agreed that the data would be treated anonymously and collectively, would be examined with scientific methods and analyzed for scientific purposes in accordance with the principles of the Declaration of Helsinki.

### **Statistical analysis**

#### *Analysis of the HSE/INAIL questionnaire*

The data obtained from the questionnaires were processed using a specific software, provided by the HSE, which allows a

Table 1 – Characteristics of the studied population.

Variable	Type	Total Sample
Number of Subjects		n. = 241
Sex	Males no.(%)	149 (61.8)
	Females n.(%)	92 (38.2)
Smoking habit	Yes no (%)	47 (19.5)
	No no. (%)	194 (80.5)
Consumption of alcoholic drinks	Score Test	
	Test AUDIT	
	Score 0 no. (%)	46 (19.08)
	Score 1 no. (%)	41 (17.01)
	Score 2 no. (%)	55 (22.82)
	Score 3 no. (%)	50 (20.74)
	Score 4 no. (%)	49 (20.33)
Age (years)	Mean (SD)	48.73 (7.60)
	Min-Max	27-67
	Median	49
Length of service	Mean (SD)	17.95 (9.46)
(years)	Min-Max	0-42
	Median	15
Blood Glucose	Mean (SD)	98.75 (15.96)
Range: 74-106 mg/dL	Min-Max	70-208
	Median	96

SD = Standard Deviation

comparison with the reference population (37).

This software permits to compare organizational performance in the management of work-related stress with ideal conditions.

In the working population studied we considered together and separately the two sexes, without creating additional subgroups.

On the basis of the results obtained from the use of specific software, we expected to obtain, for each of the seven dimensions of homogeneous groups of workers, different results characterized by a “color code”.

The red color indicates a serious situation that requires immediate corrective action, and includes the results below the 20th percentile (20% of the lower reference values). The yellow color indicates a clear need for corrective action, and includes the results that are below the mean (<50%) but above the 20th percentile. In the case of values that fall in the blue area we are in the presence of a good level of performance which, however, requires some interventions, with values above the mean (>50%) but below the 80th percentile. The green area indicates a good level of performance with fulfillment of Management Standards, the level must be maintained over time, the values are above the 80th percentile (20% of the higher reference values).

The color code is the basis of the interpretation of the results derived from the analysis of the questionnaire through the software HSE (38). The correlation between numerical score and color varies in 7 different dimensional scales and for each question.

The analysis of the data by HSE method ensures that changes in color, in 7 analyzed dimensions, do not take place at random (38).

### *Comparison between the results of the HSE questionnaire and blood glucose.*

The normal distribution of variables was assessed using the Kolmogorov-Smirnov test, which was statistically significant for blood glucose. This parameter was converted into logarithmic form for the analysis of the index of correlation and multiple linear regression.

The results for the values of blood glucose, for the questionnaire score and for all confounding factors was expressed in terms of mean, standard deviation (SD), median and range (min-max).

In order to assess the degree of correlation between the levels of stress (score obtained in the questionnaire HSE) and the levels of blood glucose, the correlation coefficient of Pearson, two-tailed, after log transformation of the data, was used.

To exclude the influence of the major confounding factors we have finally performed multiple linear regression analysis. The latter was carried out after log transformation of the data, considering the blood glucose as the dependent variable and the score of the questionnaire HSE, age, sex, length of service, the habit of consumption of beverages alcohol (AUDIT test results) and the habit of cigarette smoking as independent variables.

The results were considered significant when p values were <0.05.

The statistical analysis described above was carried out using SPSS® Advanced Statistical™ 21.0.

## **Results**

### *Analysis of the questionnaire software through HSE.*

The average results of each of the individual dimensions investigated, for the total sample of workers, are reported in Table 2.

Table 2 – Results of the HSE Questionnaire, divided by the 7 dimensions, for the total sample

Dimensions of HSE	Type of analysis	Total sample (n. = 232)
Working Load	Mean (DS)	3.73* (0.48)
	95% Confidence Interval	3.66-3.79
	Median	3.75
Control (decisional autonomy)	Media (DS)	3.49** (0.87)
	95% Confidence Interval	3.66-3.61
	Median	3.67
Support from the Manager	Media (DS)	3.39*** (0.89)
	95% Confidence Interval	3.26-3.51
	Median	3.40
Support from Colleagues	Media (DS)	3.77*** (0.76)
	95% Confidence Interval	3.67-3.86
	Median	3.75
Quality of relationship	Media (DS)	3.51**** (0.92)
	95% Confidence Interval	3.39-3.62
	Median	3.50
Definition of the role	Media (DS)	4.52* (0.58)
	95% Confidence Interval	4.43-4.60
	Median	4.80
Changes	Media (DS)	2.69**** (1.13)
	95% Confidence Interval	2.52-2.85
	Median	2.67

Note:

\* the results are included in the green area of HSE questionnaire (data set: Organizational Means)

\*\* the results are included in the blue area of HSE questionnaire (data set: Organizational Means)

\*\*\* the results are included in the yellow area of HSE questionnaire (data set: Organizational Means)

\*\*\*\* the result are included in red area of HSE questionnaire (data set: Organizational Means)

From the analysis of the questionnaire by the HSE software we deduced that the dimensions with the lowest average score, to which workers have therefore associated more frequently stressful (code yellow, 50°-20° percentile) or highly stressful (code red, <20th percentile) conditions are “support from the manager”, “support from colleagues”, “quality of relationships” and “changes” (Table 2).

The dimension to which the employees have rather more frequently attributed a low stressful condition (code blue, between the 50th and the 80th percentile) is “control” (decision-making autonomy).

The dimensions in which they reached the required standards or ideal conditions

(no stressful condition, green area, > 80<sup>th</sup> percentile) are “working load”, and “definition of the role.”

The results obtained from the questionnaire through the HSE software did not change after splitting the sample on the basis of sex.

#### *Analyses of Blood Glucose and correlation with the results of the HSE questionnaire*

The values of concentrations of blood glucose in the population were expressed as mean, standard deviation (SD), median and range (min-max) and they are shown in Table 1.

In the Pearson correlation analysis, for the total sample, the mean scores obtained from the HSE questionnaire, in all critical

Table 3 – Analysis of Pearson correlation coefficient (R) 2 tails, between Glycemic values (log) and the results of HSE questionnaire dimensions in the sample studied

	Load	Control	Managers	Colleagues	Relationship	Role	Changes
Glicemia							
R Pearson	- 0.113	-0.120	-0.276	-0.215	-0.190	- 0.135	-0.233
P (two tails)	0.064	0.057	0.000*	0.003*	0.008*	0.061	0.001*

\*  $p < 0.05$

dimensions (yellow or red areas), were negatively correlated, in a statistically significant ( $p$  two-tails) way, with blood glucose values (log) (Table 3).

After the splitting on the basis of sex, the results obtained remained unchanged and statistically significant.

The multiple linear regression analysis confirmed the significance of the negative correlation between the scores of the HSE questionnaire and the values of blood glucose (log), also respect to confounding factors including age, sex, length of employment, cigarette smoking, habit to drink alcohol) (Table 4). The latest results show that confounding factors analyzed in the study, except for stress, did not influence significantly the glycemical values.

## Discussion

The current regulatory framework for the protection of health and safety at work, represented by the Legislative Decree 81/2008, has specifically identified the “work-related stress” as a risk to be evaluated and managed.

The scientific research to achieve rigorous contributions on this specific topic is important for developing reliable and useful tools for the assessment and the management of work-related stress.

The psychometric properties of the HSE questionnaire were analyzed, in literature, by countless studies, which confirmed the factorial structure and showed significant associations with other indicators linked

to work-related stress, such as anxiety, depression, job satisfaction and frequency of sick leave (6, 7).

In particular, it permits to easily obtain an assessment of different dimensions of the organization to identify the way to reduce the risk of work-related stress. The questionnaire is compatible with the guidelines for the evaluation of work-related stress in the European legislation, inasmuch it provides results for groups of workers, not only for individual workers. Furthermore, it appears to be a useful tool because it can be used both in a preliminary stage of analysis, to get directions on some factors of content (eg. Physical environment) and context (eg. Role in the organization, control, etc.), both in a phase of deep evaluation of the subjective perception by the workers of the factors related to stress.

The current study was carried out on a sample of healthcare operators that work in a wide range of types of employments. The administration of the HSE questionnaire has permitted to analyze individual responses to stressful events in a simple and quick way.

The response rate to the questionnaire has also been close to 100%. This factor is well above the average of response in stress related scientific investigations carried out on healthcare operators (39-40) and it provides a confidence in the reliability of the results obtained from the study.

The statistical analysis, performed on the questionnaire data, showed that the dimensions with the highest average score, to which the workers have associated an highly

stressful condition (yellow or red codes), are “Support from the Manager”, “Support from Colleagues”, “Quality of relationship” and “Changes” (Table 3). For all other dimensions the employees of each group attributed a low or none stressful condition (blue or green codes). These results were unchanged also after the division of the sample on the basis of sex.

The results of the HSE questionnaire show that the dimensions about the “Support from the Manager”, “Support from Colleagues” and “Quality of relationship” are in yellow area, so near the critical level.

On the basis of these results, the most common technique of coping with the working activities actually studied is altered. The mechanisms of management and support of the problems present in the wards, regarding relationship with superiors and relationship between colleagues, are experienced and perceived in a negative way and require focused interventions. The causes of the results can be clarified by investigating the dimension of “Changes”. The Company, to which the working population analyzed belongs, is in a delicate moment, because it is in a phase of switching from public to private property with consequent feeling of insecurity and potential economic and social damages by the employees under contract. In addition, due to the changes under way in the economic sector, the workers often changed venue and employment in their work environment. It’s been widely shown in the literature that these organizational changes have always an impact on the psychological well-being of employees (41-44).

The type of reaction to these events, essential for the teamwork, depends on the assessment of the organizational change that is perceived by employees (42). The result of this perception is reflected in the results of the HSE questionnaire. In fact the workers are associated with a high stressful condition about the dimension of “Changes” (red area). For the same reasons and as a consequence

of an organizational transformation of the Company also the questions about the dimensions of “Support from Managers”, “Support from Colleagues” and “Quality of relationship” are associated with a stressful condition (yellow area).

#### *Correlation between levels of work-related stress and blood glucose.*

The results of our study showed a significant correlation between perceived work-related stress, especially in the dimensions described above, and increased levels of circulating glucose in a group of workers employed in the healthcare business.

Our results confirm what has been shown in several other studies. For example, in a cross-sectional study conducted on Mexican workers (45), an association was found between several cardiovascular risk factors and work-related stress evaluated through a specific questionnaire. In particular, there was an increase, not statistically significant, of blood glucose correlated with increased levels of stress in the workplace.

In another study, conducted on nurses working in the ICU of a hospital in Serbia (46), the correlation between perceived stress, through rating scales, and various health parameters was evaluated.

In that study, the scores of perceived stress linked to the dimensions related to contact with the dying patient, conflicts with supervisors and sense of discrimination, was significantly higher in workers with diabetes mellitus type II.

In 2014, Huth et al published a 13-years prospective study of about 5,000 workers on the relationship between work-related stress and cardiovascular risk factors. The workers who reported a continuous and elevated condition of stress had an increased risk of developing diabetes mellitus type II (34).

In 2000 Kavakami et al analyzed the correlation between work-related stress



and glycosylated hemoglobin (HbA1c) in Japanese workers: an increase of work-related stress and of the perception of poor social support were associated with an increase in HbA1c (47).

In the literature we found two meta-analyses of 2013 on the relationship between work-related stress and cardiovascular risk factors. In the first one (48) eight studies were taken into account for a total of 47,000 subjects. In the second one (49) 13 cohort studies were analyzed, for a total of 174,438 participants with a followup of 10 years.

Both meta-analyses showed an association between work-related stress and insecurity at work and the onset of Type II diabetes.

## Conclusions

The preliminary results of our study, together with other evidences in the literature, suggest that psychosocial stress in the workplace can affect the levels of blood glucose (46); this fact needs to be investigated on a larger number of workers, in order to make a greater stratification taking into account an additional number of variables. In the genesis of this mechanism the high cortisol levels, due to psychosocial stress, have probably an important role.

Cortisol induces the release of hepatic glucose and a decrease in pancreatic insulin secretion, thus reducing the cellular uptake of glucose and causing a rise in blood glucose (33).

Preventive strategies to fight the global increase of diabetes type II should take into account the adverse effects of high levels of work-related stress (34).

In this regard the collaboration of physicians specializing in Occupational Health could play a crucial role in assessing the risk of work-related stress and the implementation of organizational measures aimed at preventing the occurrence of such event.

## Riassunto

### *Stress lavoro correlato e livelli di glicemia*

**Scopo.** Il presente studio si propone di valutare lo stress soggettivo lavoro-correlato in un gruppo di lavoratori di una grande azienda italiana nel campo della sanità attraverso la somministrazione di un "questionario-strumento indicatore" validato (HSE Indicator Tool), e di analizzare eventuali correlazioni tra i livelli di stress desunti dai punteggi del questionario e i valori della glicemia.

**Materiali e metodi.** Abbiamo studiato un campione costituito da 232 soggetti con mansioni diverse. Il questionario HSE, costituito da 35 item (suddivisi in 7 dimensioni) con 5 possibilità di risposta è stato somministrato ad ogni soggetto in occasione delle visite di sorveglianza sanitaria previste dalla normativa vigente. Le risposte sono state poi analizzate tramite uno specifico software per elaborare i risultati relativi alle 7 dimensioni. Tali risultati sono stati confrontati tramite la correlazione di Pearson e la regressione lineare multipla con i valori glicemici ottenuti dallo stesso campione.

**Risultati.** Dall'analisi dei dati i seguenti ambiti sono risultati critici, ovvero associati ad una condizione stressogena intermedia (area gialla) o elevata (area rossa): supporto dei manager, supporto dei colleghi, qualità delle relazioni e cambiamenti. Una correlazione positiva significativa ( $p < 0.05$ ) tra i valori medi di tutte le aree critiche e le concentrazioni dei valori di glicemia è stata evidenziata con l'indice di correlazione di Pearson. La regressione lineare multipla ha confermato tali risultati, evidenziando che le dimensioni risultate critiche al questionario sono le variabili significative in grado di contribuire all'aumento dei livelli di glicemia.

**Conclusioni.** I risultati preliminari ottenuti indicano che lo stress lavorativo percepito può essere statisticamente associato ad aumentati livelli di glicemia.

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