

# STRESS AT WORK ON DRILLING RIGS IN POLAND IN A 20-YEAR RESEARCH PERSPECTIVE: TIME AS A DETERMINANT OF THE STRESS-AT-WORK DYNAMICS

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## Abstract

**Objectives:** Adapting to stress over time is a process involving various cognitive and emotional assessments; it also depends on the objective situation related to working conditions, as well as on individual factors. The aim of this paper is to outline the dynamic nature of stress experienced by workers employed on oil rigs over a period of 20 years. The presented research is part of a larger project and concerns subjective stress. **Material and Methods:** Longitudinal studies included the analysis of data regarding the period of 1993–2014. They concerned 167 Polish oil rig workers, all men; the average age at the beginning of the study was 29 years. Each employee was surveyed at least 4 times over a period of 20 years at intervals of 4–6 years in the workplace. The subjective level of stress at work (based on the *Subjective Job Evaluation Questionnaire*) and the level of declared stress (based on the *Stress Survey*) were examined. **Results:** Oil rig workers show different adaptations to stress over a long term, depending on their subjective perception of stress. Baseline stress levels can vary from person to person over the years. The first group was characterized by high initial stress, but the stress decreased systematically over 20 years (“stress resisting”). Employees from the second group were characterized by low initial stress, but declared a systematic increase in stress in the same period (“stress sensitizing”). Finally, employees from the third group adapted to stress in a flexible way, with subjective stress being most strongly associated with objective stress (“flexible group”). **Conclusions:** The presented prospective study showed differences between the subjective levels of stress depending on the distinguished groups over 20 years, i.e., between-group and intra-group variability. The method of prospective research shows that the perception of stress at work is a dynamic process and it changes over time. *Int J Occup Med Environ Health.* 2023;36(4):477–92

## Key words:

prospective study, stress at work, stress dynamics, psychosocial burdens, work on drilling rigs, work in difficult and dangerous conditions

## INTRODUCTION

At present, stress is considered one of the main workplace hazards. According to a report by the European Agency for Safety and Health at Work, 29% of the employees surveyed experience stress related to their workplace [1]. According to the definition presented by the World Health Organization (WHO), occupational stress is understood as the response people may have when presented with work demands and pressures that are not matched to their knowledge and abilities, and which challenge their ability to

cope [2]. The WHO’s definition of occupational stress draws explicitly on Lazarus and Folkman’s transactional theory of stress [3]. Most concepts of occupational stress are based on a relational approach, thus capturing stress as a subjective phenomenon. Other concepts of stress have been criticized for their simplification and imprecision [4–6].

The novelty of the relational approach stems from the fact that it takes into consideration, in the appearance of stress, both personality and situational factors, while emphasizing the role of the person’s cognitive assessment and per-

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ception of a given situation. Defining stress in terms of transactions highlights its dynamics. This is because, in the course of a stressful confrontation, the overall situation – the person  $\times$  the surrounding – changes. The reflection which develops as stress continues, termed by Lazarus and Folkman as re-evaluation, plays an important role here, making it possible to change the quality and intensity of emotions. The person's own activity, the inflow of new information and its processing, the external support provided or a change in external conditions make it necessary to perform further cognitive assessment. Thus, the secondary assessment takes place [3]. It focuses on coping resources, the possibilities to use them and the likelihood that the actions taken will prove effective. Lazarus highlighted the stress transaction dynamic, claiming that the processual nature of stress involves the ongoing exchange between the person and the surrounding, and the variability of this exchange over time.

Among the numerous theories and research approaches that take into consideration the relational nature of stress transactions, the concepts of the transactional model of stress developed by Cox et al. [1], the psychosocial concept of stress presented by Dudek et al. [7], and the demand-control-support theory by Karasek and Theorell [8], and de Jonge et al. [9] merit special attention in the context of the presented research.

Cox transferred the model proposed by Lazarus to work psychology, creating the transactional model of stress. Based on that model, the stress experienced by an individual is the result of a transaction that occurs between an employee and their work environment. Both individual characteristics and features of the situation that triggers stress are important. In this concept, stress arises from a transaction between the environment, the actual needs, demands and constraints, and the individual and their needs, abilities and values that are not satisfied [1]. Stress at work is defined as a mental state that both reflects and is part of a wider process of interactions between individuals

and their work environment. Despite the widespread recognition of Lazarus and Folkman's concept as a key theory in addressing psychological stress, some of its assumptions have involved certain controversy and doubt [10–13].

Criticism has been expressed as regards the role these authors assign to the cognitive assessment in explaining stress. Some researchers have remarked that the subjective character of the cognitive assessment makes it difficult to determine what actually is stress and what is not [14]. Moreover, Hobfoll [5] found that some stressors make it unnecessary to take cognitive processes into consideration, as the cognitive appraisal loses its subjective character.

In the Polish context, the concept of psychosocial stress by Dudek et al. [7] is worth noting. According to these authors, the relationships between the objective work environment and the employee's perception of it, between that perception and the experience of stress, and between the experience of stress and changes in behavior, physiological functions and health, are a sort of variable interactions. They also draw attention to the psychosocial factors that arise in certain social and organizational working conditions (i.e., excessive demands, a lack of control, and the fact that their potentially detrimental impact on health is determined by the psychological perception of a given event) [7]. Assigning a negative meaning to a situation triggers specific emotions that cause subsequent changes in the human body, resulting in short- and long-term health consequences.

In both these concepts, i.e., by Cox et al. [1] and Dudek et al. [7], individual factors, including personality traits, temper and the ways of coping with stress, are important parts of this process.

The model by Karasek and Theorell [8], extended by de Jonge et al.'s concept [9], assumes that the sense of job satisfaction at work is the result of the interaction of 3 basic psychosocial dimensions: demands, the sense of freedom in decision-making – autonomy/control, and social support. These dimensions determine the characteristics of

working conditions which influence, *inter alia*, the level of job satisfaction, the level of motivation, commitment, as well as the level of stress and emotional exhaustion. According to research findings, the lowest probability of stress at work is observed when the employee is confronted with difficult and demanding tasks but, at the same time, can count on autonomy in decision-making, and on both substantive and emotional support [8,9].

### **Coping with occupational stress**

In the modern concepts, the terms “stress” and “coping” are treated as intrinsically-interrelated phenomena, which has led to a well-established assumption that the effects of a stressful confrontation are mainly determined by coping rather than by the objective functioning of the stressor [10]. Basically speaking, it can be said that it is more important how a person copes with stress than what that stress is.

The coping process covers all activities which a person performs in a given stressful situation; the coping strategy concerns the methods of dealing with stress which a person employs in a specific stress context, whereas the coping style is a relatively stable individual tendency determining the course of coping with stress, which has a status of a personality variable [10,11]. The processual view takes into account the dynamic dimension of coping, which is related to the variable methods of coping, employed at different stages of a given stress episode, and the variable situational conditions. Therefore, in addition to the number of strategies and the diversity of coping methods, people also differ in terms of how flexible their coping process is and how easily they can adapt that process to the actual demands of a specific stressful situation [10].

### **Consequences of stress at work**

Performing work in difficult and dangerous conditions is associated with stress, and employees are exposed to both types of stressors at work, i.e., the “countable” ones (physical, biological, chemical) and those that are

“hard to count” (mental) [15–17]. There is a simultaneous exposure to harmful physical and psychosocial factors. In this view, there are at least 2 processes involved: a direct somatic mechanism and a psychological mechanism of stress. These 2 mechanisms are not alternative explanations for the interaction of the health condition with harmful factors, but they constitute a unity, interacting to different extents in different ways.

Prolonged stress affects employees’ personal and social lives. It lowers their self-esteem, may contribute to the occurrence of burnout syndrome, and may compromise workplace safety [18]. Higher levels of stress and fatigue are associated with lower levels of workplace situational awareness, which in turn indicates increased participation in hazardous behavior at work [19]. There is evidence suggesting that shift work, the lack of control at work, difficult physical working conditions, the lack of support, and interpersonal relationships at work can induce stress, on the one hand, and adverse mental and somatic health outcomes in employees, on the other [20]. However, employees can adapt effectively to challenging working conditions: they have a sense of job satisfaction, and do not suffer major health consequences, either at the level of physical health and its assessment, or at the level of mental well-being [14].

### **Methodological problems connected with stress-at-work research**

In the studies of stress at work, the accuracy and reliability of the diagnostic procedures carried out, and the selection of tools to measure psycho-physical performance, are of particular importance. An analysis of the literature on stress at work shows that the research methodology is usually based on a cross-sectional research formula and often takes the form of online surveys. Many studies are mainly based on the subjective data of respondents, collected through self-report questionnaires [2,15]. In the studies of stress at work, it appears necessary to use a triangulation procedure [1]. Triangulation means the collection of evidence of

stress from at least 3 sources. Stress itself, as a complex process, cannot be researched by employing a single measure, but it should take into account the measurement complexity as well as include a greater variety of studies from different sources. Where possible, it should be prospective in nature.

According to Cox et al. [1], triangulation should include data based on the following simplified scheme: work-related hazards – stress – harm. For the sake of certainty, a potential psychosocial or organizational harm should be identified by referring to at least 3 different types of evidence:

- evidence from an audit of the working environment, including the physical and psychosocial aspects (there may be various physical and psychosocial precursors to stress, which can be assessed in the workplace);
- studies of employees' perceptions of and reactions to work;
- measurements of employees' behavior in relation to work, and their physiological and health condition.

In an ideal scenario, the principle of triangulation should be applied within and between these domains [1]. Incorporating the principle of triangulation into the study of stress experienced by people working in difficult and hazardous conditions is essential to present the complexity of this phenomenon.

Segstrom and O'Connor [21] predict that 4 approaches are going to dominate in the future research on stress – first, consideration of what stress is and where it is located; second, what the coping process is and what its determinants are; third, the need to include personality and life-cycle studies; and fourth, taking into account stress dynamics.

Taking the first approach, interactions between 3 ways of understanding stress will be important, i.e., stress understood as a source in the environment (external stimulus), as an assessment (an individual experiencing stressors), and as an individual response – emotional or physiologi-

cal. Role changes are among the most important stressors – with younger people assuming new roles and older people abandoning them. Stress can spread or stretch from more important life events to the less important, but somehow related, ones.

The second approach will focus on the issues of coping. Coping with stress entails the relationship between stress and the person experiencing it. Coping can be focused on the problem or emotions experienced. Those focused on solving the problem or dealing with the emotions it invokes experience a lower mental and physical pressure than those who avoid confronting the problem and emotions. A thorough understanding of how coping may moderate the stress effect is the principal determinant in the studies of coping with stress.

In the third approach, the authors envisage that the studies of stress will develop in a manner recognizing the need to include personality and life-cycle research. It will be explored why some people cope better and others worse in the same situations. The factors that make people differ in terms of perceiving, responding to and coping with stress include individual personality traits, which can buffer the effect a stressor has on the scale of the experienced tension. Stress affects different people with different personality and temperament profiles at different stages of life. Individual differences can influence the perception of various stressors and the ways of coping with them.

The fourth projected approach, which appears the most important in the context of this article, entails the need to take the stress dynamics into consideration. Minor events may come and go while major events induce a cascade of changes in a person's life. This "cascade" is clearly defined by Hobfoll's conservation of resources theory, in which stress is operationalized as a loss of resources [5]. Having a smaller pool of resources is a predictor of further losses. The most recent studies have focused on short periods of time, such as the past few weeks preceding the survey or the past 5 years.

**Table 1.** A summary of age and time of employment in each analyzed cluster in oil rig workers in Poland, surveyed in 1993–2014 on oil rigs

	1. Stress resisting group (N = 49)		2. Stress sensitizing group (N = 66)		3. Flexible group (N = 52)	
	M±SD	min.–max	M±SD	min.–max	M±SD	min.–max
Age [years]						
1993–1998 – start of research	28.3±7.3	27–45	31.2±6.8	26–47	27.6±8.6	24–47
2010–2014 – end of research	42.5±7.3	46–59	49.9±6.8	34–65	44.8±8.6	41–64
Time of employment [years]	14.2±7.3	11–31	18.7±6.8	13–34	17.2±8.6	13–37

Stressors or stressful events should be understood, according to the authors, in the context of an individual's personality and stage of life. Transactions occur between the person and the events, in the context of other aspects of human life (work, marriage, friendships, hobbies). The authors predict that a dynamic image of the individual's stress, coping and health will emerge, rather than a static one. This is also related to other methods of stress research; studies should be multi-level [21].

There is no complementarity of research into potentially dangerous physical, biological and chemical factors, on the one hand, and psychological research, on the other. Physical factors are “measurable” whereas psychological ones have a qualitative character and it is hard to draw comparisons between them.

From a methodological point of view, there are problems in developing standardized procedures for comparing qualitative data with quantitative measurements, as well as between qualitative data sets from different sources.

The use of the triangulation model in the studies of stress in difficult and hazardous conditions is not common. Most studies use subjective methods, concerning both the assessment of “countable” and psychosocial factors. There is also no good exchange of information regarding the audit results. Referring to the principle of triangulation, there is a greater focus on assessing the impact of moderating factors, such as individual differences, in most studies on stress at work.

The research question was as follows: How has the level of perceived subjective stress in the work of oil rig workers changed over a period of 20 years?

Stress at work is a dynamic process which changes over time and takes into account a prospective research procedure and triangulation, i.e., the study of stress from 3 sources: objective, subjective and health indicators. The notion of stress dynamics is understood as the process by which rig workers adapt to stress over 20 years; stress dynamics indicates how rig workers adapt to stressful working conditions.

## MATERIAL AND METHODS

A total of 167 workers were surveyed, representing the entire crew of drilling rigs in Poland over a period of 20 years (1993–2014). The study subjects were all males. In the presented study, 2 age indicators were adopted: the age of employment on the platforms and work experience on the platforms.

The age of starting work on oil rigs was M±SD 29±7.5 years (min.–max: 27.6–31.2); seniority was M±SD 13.69±7.2 years (min.–max: 11.3–16.9). The exact age in particular measures and the length of service are shown in Table 1.

The respondents were employed in various positions representing the following types of services: drilling, operational, mechanical, offshore, hotel services. The study participants worked on drilling rigs in the following alternating work pattern: 2 weeks off and 2 weeks on

(2×2 weeks), and they belonged to a group of offshore workers. In the context of offshore work, the term means working on a drilling rig or aboard a ship operating the drilling rig, or in the fly-in/fly-out (FIFO) mode. Activities on a drilling rig are performed 24/7, in 12-hour shifts. Each worker was surveyed at least 4 times – upon the commencement of work, during employment, and in the final year of the survey. Those with the longest seniority were surveyed 5 or 6 times; on average, surveys took place every 5 or 6 years. Various methods were used in the study to assess individual characteristics, including temper, personality, social relations, coping styles, psychosocial burdens, social relations, etc.

Considering the ethical aspects of the study conducted, it should be pointed out that all subjects consented to participate in the study, and they were informed about the purpose of the study and the possibility of withdrawing from the study at any stage.

The stress dynamics study is part of a larger project involving a comprehensive assessment of the determinants of stress at work: personality, demographic, psychosocial, health and situational factors. It also includes an analysis of data from the self-assessment of health, physical and mental well-being, and opinions on the impact of stress on various aspects of life.

To assess stress at work in accordance with the principles of triangulation, the following methods were used to examine the objective and subjective levels of stress.

To assess the objective job characteristics, the *Questionnaire for the Assessment of Job Characteristics* (QAJC) was used to measure the overall burden of psychosocial factors, but it also makes it possible to identify the group of factors (formed by individual job characteristics) that constitute the greatest source of occupational stress. The overall assessment is a composite of assessments carried out independently by 2–3 experts (e.g., an occupational health and safety inspector or a manager), so it is not dependent on the stress experienced by employ-

ees in the position under assessment. The tool consists of 34 items describing various job characteristics. Each of these features is assessed on a scale of 1–5, where 1 means that a given feature does not occur at all, and 5 means that it is the greatest nuisance at a given workplace. In addition to the general indicator of stress at work, you can create a profile for the position, reflecting individual groups of threats (factors):

- unpleasant working conditions (e.g., dirt, moisture, poor lighting);
- job complexity (e.g., switching from one activity to another, helping others, complex mental tasks);
- threats (e.g., errors threatening health and life, work system);
- conflicts (e.g., conflicts with people outside the company, taking work home, business trips);
- uncertainty resulting from the organization of work (e.g., constant changes at the workplace, time pressure);
- nuisances (e.g., noise, cramped conditions);
- haste (e.g., work done in a hurry);
- liability (e.g., material);
- work-related physical effort;
- competition (e.g., tasks requiring competition).

The internal agreement for the entire questionnaire is 0.64 (Cronbach's  $\alpha$ ) [22].

To assess perceived stress at work, the *Questionnaire for the Subjective Job Assessment* (QSJA) and the *Survey on Perceived Stress* were used. The QSJA is a method that can be used to assess the subjective perception of work and to measure the individual sense of exposure to psychosocial occupational hazards. The questionnaire consists of 50 items describing various job characteristics, which are grouped into the following factors:

- the sense of mental burden related to the complexity of work – it consists of 9 items, e.g., “It happens that, after returning home, I can't stop thinking about matters related to work”;

- no rewards at work – it consists of 8 items, e.g., “I feel that I am underestimated at work”;
- the feeling of uncertainty caused by the organization of work – it consists of 7 items, e.g., “In my job, I have to switch from one activity to another, and each of them requires a certain concentration of attention”;
- social contacts – it consists of 5 items, e.g., “Helping other people is my primary duty and I devote a lot of time to it”;
- sense of threat – it consists of 5 items, e.g., “Mistakes or omissions made in the work in my position may cause damage to the health of other people, and even threaten their lives”;
- physical nuisance – it consists of 4 items, e.g., too much noise, inappropriate temperature;
- unpleasant working conditions – it consists of 3 items, e.g., dirt, moisture;
- lack of control – it consists of 4 items, e.g., “My work requires vigilance”;
- lack of support – it consists of 3 items, e.g., “If there are any difficulties or troubles in my work, I cannot count on the effective help of my colleagues”;
- sense of responsibility – it consists of 4 items, e.g., “Working in this position, I have no information about whether what I do is good or bad.”

As in the case of the QAJC, there are numbers 1–5 next to each statement, which indicate the degree to which a given feature is burdensome for the evaluator. The indicator of the level of perceived stress is the sum of the points marked by the tested person. The level of the coefficient  $\alpha$  reliability was 0.49–0.93 [22].

Two measures were used for the subjective assessment of stress: the average values from the QSJA and the level of declared stress from the *Stress Survey*. The survey asked the respondents to state their opinions on the burden of physical and mental factors at work, the impact of work on stress at home, beliefs about the effectiveness of coping with difficult situations and others. In the pre-

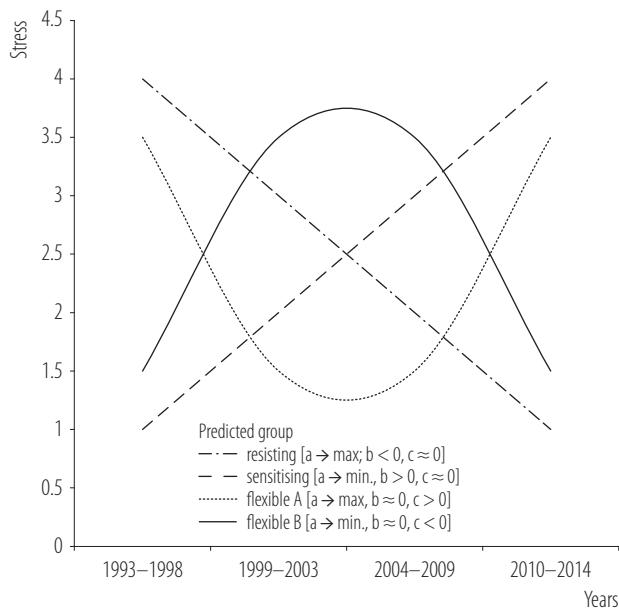
sented research, only the opinion on stress at work was taken into account. Items were evaluated using a 10-point Likert scale, with 10 pts – the highest rating (very high impact), 1 pt – the lowest rating (low, no impact).

## RESULTS

Following the principle of triangulation, objective stress levels were analyzed separately (based on an assessment of 36 jobs by 3 competent judges) in terms of objective stress levels and declared stress on the basis of self-report questionnaires and survey responses. Then, an analysis of changes in stress levels over the 20-year study period was carried out. The principle was as follows: for each subject, changes in the assessment of stress at work were tracked on the basis of test results from at least 4 measurements performed in 1993–2014. Based on each worker’s estimates of subjective stress at  $\geq 4$  pts in the study period (at least 4 years apart), the parameters of the quadratic function, most accurately describing changes in that employee’s stress intensity as a function of time, were estimated for each employee. Parameters “a”, “b” and “c” were estimated to describe:

- a) the baseline level of stress perceived by the employee,
- b) the general (linear) tendency for increasing or decreasing the perceived level of stress,
- c) the lability (fluctuation) of the level of stress perceived by the employee.

The indicators thus obtained made it possible to describe the individual character of the dynamics of the process of adapting to stress while performing work on a drilling rig. With a view to determining the types of stress dynamics, a cluster analysis was conducted using Ward’s method based on a matrix of Euclidean distances between the subjects calculated for their mutual similarity on the dimensions defined by the parameters of the quadratic function, i.e., “a”, “b” and “c”. Changes in stress, if tested in at least 3 stages, can be described using 2 types of lines – a straight line or a parabola, which may look more or less like in Figure 1.



a – intercept; b – slope; c – fluctuation a; d – fluctuation b.  
Stress – level of subjective stress.

**Figure 1.** Predicted trends of changes in stress dynamics among oil rig workers in Poland, surveyed in 1993–2014 on oil rigs

The dendrogram drawn up on this basis makes it possible to indicate that the population studied features probably 3 groups of rig workers with different stress dynamics. Distinguishing these 3 groups allows explaining 51% of the variation (variance) in the obtained results between individuals.

Table 1 presents the exact characteristics of the parameters for 3 separate cluster groups according to the parameters described above: “a”, “b” and “c.”

The relationship between the model parameters and the type of dynamics is very strong for all the parameters of the quadratic function. Additional *post hoc* comparisons indicate that each group differed significantly from every other group ( $p < 0.05$ ).

The first cluster group is characterized by a fairly high level of stress at baseline compared to the other groups ( $M \pm SD$  6.28 $\pm$ 0.55); these individuals tend to exhibit decreased levels of stress over time ( $M \pm SD$  -0.51 $\pm$ 0.12);

at the same time, this decrease is almost constant and systematic ( $M \pm SD$  0.06 $\pm$ 0.11). This group has been named stress resisting (SR).

The second cluster group includes men whose levels of stress were very low at baseline ( $M \pm SD$  1.03 $\pm$ 0.58); then, they increased ( $M \pm SD$  0.89 $\pm$ 0.09), but these changes were rather linear, i.e., systematic ( $M \pm SD$  -0.03 $\pm$ 0.17). This group has been named stress sensitizing (SS).

Men belonging to the third cluster group were characterized by a relatively high (as compared to the overall population in question) level of stress at baseline ( $M \pm SD$  5.69 $\pm$ 0.62), with an unknown upward tendency – this level remained virtually unchanged ( $M \pm SD$  0.09 $\pm$ 0.14), but it is in this group that the strongest fluctuations in the levels of stress were observed ( $M \pm SD$  1.07 $\pm$ 0.12). This implies that these people are characterized by the U-shaped stress dynamics, with the level of stress being quite high at baseline, then decreasing, and then increasing again. This group has been named the flexible group (FG).

### Classification of subjective stress among oil rig workers

Individual clusters were distinguished in terms of age and seniority, as presented in Table 2.

Then, the subjective levels of stress in each cluster group were tracked separately, taking into account 4 measurements: I (1993–1998), II (1999–2003), III (2004–2009), and IV (2010–2014).

Tables 3 and 4 show the different levels of stress in the 4 measurements for each of the cluster groups and the statistical analysis.

Differences in the stress levels between different types occurred in the first and last measurements. In the first measurement, the type of stress dynamics explains about 13% of the variation in stress, while in the last measurement, the type of dynamics explains about 8% in the last measurement. Looking in detail at the *post hoc*



**Table 2.** Results of ANOVA: distinguishing 3 groups of oil rig workers in Poland, displaying different stress dynamics surveyed in 1993–2014 on oil rigs

Parameter	Stress in cluster groups (M±SD)			Significance of differences test		Post hoc Tukey's test		
	1. stress resisting (N = 49)	2. stress sensitising (N = 66)	3. flexible (N = 52)	F(2, 164)	$\eta$	1 vs. 2	1 vs. 3	2 vs. 3
Intercept	6.28±0.55	1.03±0.58	5.69±0.62	360.293	0.829	<0.01	<0.05	<0.01
Slope	-0.51±0.12	0.89±0.09	0.09±0.14	293.221	0.963	<0.01	<0.01	<0.01
Fluctuation a	0.06±0.11	-0.03±0.17	1.07±0.12	295.876	0.802	<0.05	<0.01	<0.05

**Table 3.** Summary statistics of stress taken in 4 measures in each analyzed cluster of oil rig workers in Poland, surveyed in 1993–2014 on oil rigs

Measure time	Stress in cluster groups (M±SD)		
	1. stress resisting (N = 49)	2. stress sensitising (N = 66)	3. flexible (N = 52)
1993–1998	4.48±1.35	3.37±1.47	4.42±1.33
1999–2003	4.01±1.46	3.62±1.43	4.01±1.48
2004–2009	3.72±1.39	4.10±1.50	3.85±1.39
2010–2014	3.51±1.03	4.37±1.47	4.42±1.54

**Table 4.** A summary of ANOVA and Tukey's honest significant difference for comparing clusters of oil rig workers in terms of intensity of subjective stress in each measurement, surveyed in 1993–2014 on oil rigs, Poland

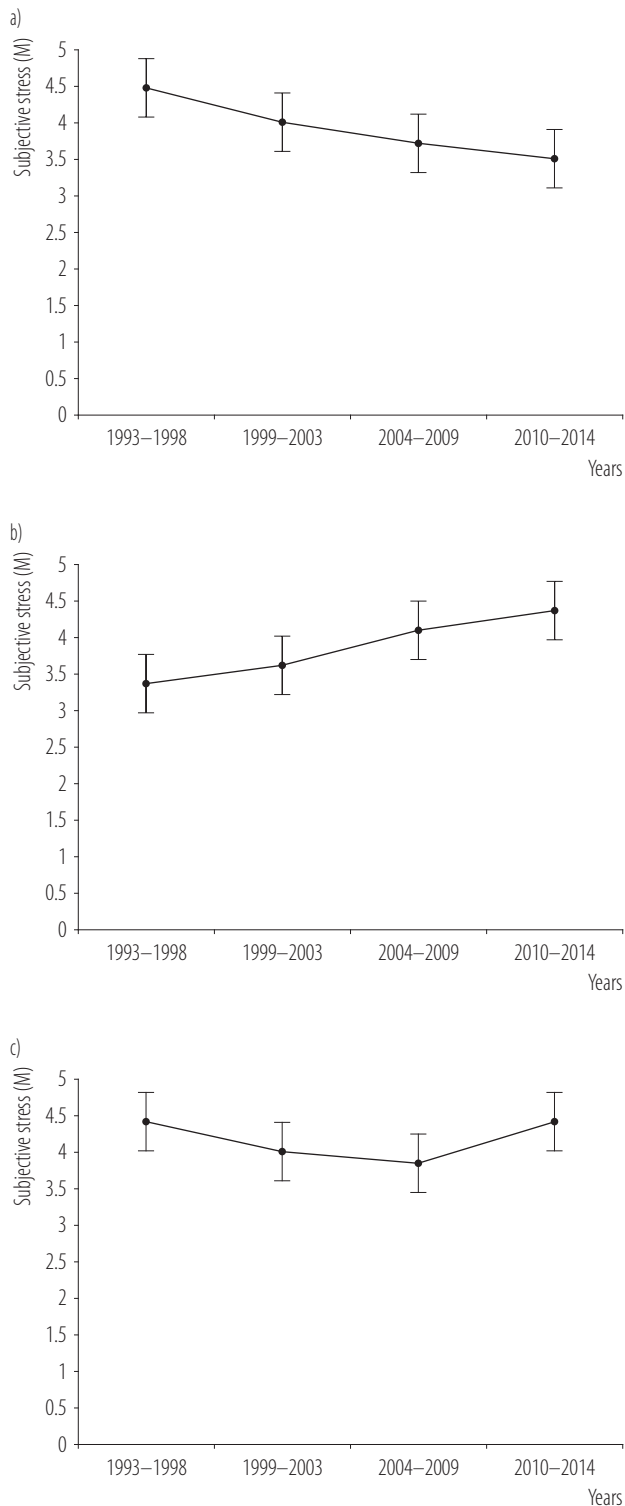
Measure time	F(2, 164)	p	$\eta^2$	p		
				SR–SS	SR–FG	SS–FG
1993–1998	12.003	0.000	0.128	<0.001	0.411	<0.001
1999–2003	1.435	0.241	0.017	0.078	0.500	0.076
2004–2009	1.054	0.351	0.013	0.082	0.320	0.175
2010–2014	7.091	0.001	0.080	<0.001	<0.001	0.429

FG – flexible group; SR – stress resisting; SS – stress sensitizing.

comparisons using Tukey's honest significant difference method, it can be observed that, in the first measurement, the SS group was significantly different from the other 2 groups in terms of stress levels, with the stress level being significantly lower in the SS group than in the SR and FG groups, and the latter 2 groups did not differ in terms of stress levels. In the last measurement, the SR group was significantly different from

the SS and FG groups, but the latter 2 groups also did not differ from each other.

In the second and third measurements, the differences were statistically insignificant. The SS group significantly differed from the SR group in terms of the level of subjective stress. The results emphasize that in the SS and SR groups the changes were gradual, continuous and linear, in the SS group initially low stress increased, and in the SR group



**Figure 2.** Average subjective stress in each analyzed cluster taken in 4 measures in 3 groups: a) stress resisting, b) stress sensitizing, c) flexible, among oil rig workers in Poland, surveyed in 1993–2014 on oil rigs

**Table 5.** Results of the ANOVA  $3 \times 2$  test for estimating the impacts of time on the level of subjective stress in oil rig workers in Poland, surveyed in 1993–2014 on oil rigs

Source of variability	F	df	p	$\eta^2$
Type of stress dynamics	3.655	2;164	0.028	0.15
Measurement (time)	0.301	1;164	0.584	0.04
Interaction time $\times$ type	4.401	2;328	0.013	0.12

initially higher stress gradually decreased. In the FG group, the changes were not systematic, but they were variable. Figure 2 shows stress fluctuations in the 3 groups (SR, SS, FG) under consideration in 4 measurement periods.

The subsequent stage of the analysis was to examine whether the subjective stress changed over time, i.e., whether it changed at the end of the study compared to the baseline. In addition, an attempt was made to answer the following question: can stress dynamics modify (moderate) this change?

In order to answer that question, an ANOVA test was performed in a  $3 \times (2)$  mixed model, whereby stress dynamics acted as the inter-group factor and time (the start of the study vs. the end of the study) as the intra-group factor (the so-called repeated measures factor). As part of the analysis, F-values and p-values were estimated for the following 3 effects:

- type of stress dynamics, i.e., for differences between the focus groups,
- time, i.e., for differences between the first and last measurement of the level of stress, and
- their interaction, i.e., for differences between the first and last measurement of the level of stress in each focus group separately.

The results of the analysis point to a statistically significant difference in the average level of stress depending on the type of stress dynamics ( $F(2, 164) = 3.655$ ,  $p = 0.028$ ,  $\eta^2 = 0.15$ ), while the average change in the level of subjective stress is not significant ( $F(1, 164) < 1$ ,  $p = 0.584$ ,  $\eta^2 = 0.04$ ). However, it can be noted that there is a sta-

tistically significant interaction between the 2 factors ( $F(2, 328) = 4.401, p = 0.013, \eta^2 = 0.12$ ). This means that changes in the level of subjective stress depend on the dynamics (more specifically, on its type), which explains 12% of variance in the differences between subjective stress at baseline vs. at the end of the study. Time contributes to the type of dynamics of perceived (declared) subjective stress at work. In cluster group 1 (SR) stress was found to decrease; in cluster group 2 (SS), stress was found to increase; and in cluster group 3 (FG), the levels of stress did not change in general (but certain decreases and increases were observed in the levels of stress in the observation period).

The following conclusions can be drawn from the above analysis: objective stress on drilling rigs is constant. The level of perceived subjective stress among employees of drilling rigs tends to differ over a period of 20 years. Based on the focus analysis, 3 groups were distinguished differing in terms of stress dynamics: cluster group 1 (SR); cluster group 2 (SS), and cluster group 3 (FG).

The level of perceived subjective stress at work was found to change over time within the distinguished groups. Cluster group 1 (SR) was characterized by quite a high level of stress at baseline; compared to the remaining groups, these subjects exhibited a tendency towards a systematic decrease in the level of stress over time (Figure 2a). Cluster group 2 (SS) was composed of men starting from a very low level of stress which was then growing systematically over time (Figure 2b); cluster group 3 (FG) included men characterized by a relatively high (compared to the overall population in question) level of stress at baseline, which then exhibited a slight upward tendency – this level remained virtually unchanged, but it is in this group that the strongest fluctuations in the levels of stress could be seen, which implies that these people are characterized by the U-shaped stress dynamics (flexible A in Figure 2c), with the level of stress being quite high at baseline, then decreasing, and then increasing again.

It is, therefore, possible that oil rig workers learn to adapt to stress (stress dynamics) and develop ways of adapting to difficult working conditions over many years of work. How they do it is important, but it is also significant that it can change over time. What determines belonging to a particular cluster group is the subject of successive studies presented in fragmentary research.

## DISCUSSION

The principle of triangulation applied in the presented study and the prospective nature of the study certainly meet the suggestion made by Segestrom and O'Connor [21] that studies of stress should be multi-level, as many studies dealing with stress at work are criticized for their static interpretation of the process, poorly selected research procedures, and single-level research [21]. The part of the study presented in this article showed a dynamic image of stress, rather than a static one. This was only possible because a longitudinal (20-year) perspective was used, during which the same employees working mostly in the same jobs and under relatively similar conditions, related to the functioning of an enterprise, were studied.

The fact that the time perspective is important in coping with stress was recognized by Schwarzer and Taubert [23]. They claimed that it is not only past or present stress that poses a challenge to people, but also future (anticipated) threats which can either disrupt one's current functioning or give time to prepare accordingly.

Stress dynamics, a topic that is not common in literature, was addressed by Plopa and Makarowski [24] in their study. During a 6-month fishing expedition to the South Atlantic, the levels of stress were measured 4 times and different stress response profiles were obtained. Under the conditions of prolonged isolation, the impact of life experience, including the experience of stress, was found to change over time. A fundamental shortcoming of the study, unfortunately, is that stress is understood

by the authors as the level of anxiety as a condition and characteristic feature, which is connected with individual characteristics and not with an assessment of the subjective occupational stress burden.

The flexibility in coping with stress at work, as demonstrated in the study, allows for a better understanding of the individual mechanisms of adaptation to work conditions in a longer time perspective. It is a process of constantly searching for new and more effective solutions. Flexibly coping individuals, who are capable of recognizing that some of their actions are ineffective, have a wide repertoire of coping strategies, seek new solutions and demonstrate reflectiveness in recognizing ineffective actions [25].

Declared subjective stress among drilling rig workers is much lower than actually determined objective stress. The differences between objective and subjective stress are statistically significant, but this may be due to the fact that these workers are more likely to find working conditions stressful than to admit that they themselves are exposed to such stress. This conclusion, unfortunately, is only a hypothesis, and in order to verify it, it would probably be necessary to ask the same men to estimate the stress they themselves experience and the stress experienced by their colleagues in the same position, using exactly the same scale and the same tool. A declaration of experiencing stress at work may only imply an apparent immunization. It would thus prove necessary to take into consideration the likelihood of falsified declarations regarding the levels of stress. Such an attitude may result from an inclination towards fulfilling the culturally prescribed role of the strong and tough male who is not “allowed” to even admit to feeling stressed [26].

Work on offshore drilling rigs is entirely dominated by men, as are other high-risk occupations such as miners or emergency service workers. This working environment imposes certain behavior patterns linked to a stereotypical approach to masculinist values. Typically “masculine”

behaviors such as proving one’s strength, not making mistakes, manifesting calmness, and not showing one’s feelings are promoted. A study by Ely and Meyerson [26] conducted on 2 drilling rigs situated in the Gulf of Mexico, launched for the purposes of the Rex and Comus study, revealed that changes in employee behavior could be achieved through changes in the organizational culture, the former entailing the diminishing or discontinuation of the promotion of typically “masculine” behaviors. As a result of these changes, employees began to share their insights, problems and concerns, to help each other with purely physical tasks without feeling ashamed or fearful of being ridiculed, and to admit to making mistakes at every level without the risk of being stigmatized. Recent research on this subject matter suggests that, for contemporary oil industry workers, the features of a “macho” or a “tiger”, associated with the risks they face, are slowly becoming obsolete. Contrary to the idea that the oilfield contains a homogeneous and clear-cut identity of oil industry workers, linked to hazard- and risk-oriented attitudes and a hyper-masculinity of their values and priorities, the contemporary oilfield allows men to define their roles, both professional and associated with their gender, in different ways, as remote “providers.” Such historical stereotypes may be propagated by outdated theoretical paradigms [27].

Perhaps the attitude of the still common stereotype of a strong man on Polish drilling rigs makes workers reluctant to admit to experiencing higher levels of subjective stress.

The results of the study also show that the levels of mental stress are lower among offshore employees than in the general population. Although offshore employees work under difficult physical conditions, their mental health is mainly influenced by stressors occurring in the psychosocial working environment [28]. Therefore, the positive impact of stress on the health and well-being of employees should also be taken into consideration; there is per-

haps a good match between the individual features of workers and their job demands, and over time such ways of coping with stress are activated that indicate a positive adaptation to stress [13]. It may also be the case that these employees have the most adaptive individual features which allow them to effectively adapt to stress.

Some researchers also draw attention to the beneficial environmental factors of working on offshore drilling rigs. Employees spend a lot of time with one another, so there is a potential to build social relationships; there are long periods off work, and for many of them the pace of work is moderate. In addition, their work can be perceived as meaningful, as they can observe a direct link between their effort and the outcome – the oil and gas obtained from the deposits. All these aspects can have a positive impact on employees' well-being, involvement and health [29]. In the studies of stress at work, the so-called "healthy worker effect" is often observed, which – in the case of drilling rig workers – may result from high physical job demands. People with serious health problems may leave the job or stop working, thus leaving only the healthier and better-adapted subjects in the population surveyed [29]. However, this effect was not present in this study because the entire population of drilling rig workers employed in 1993–2014 was surveyed.

#### **Limitations and further research directions**

As drilling rig workers form a specific occupational group, it is not known whether the obtained results can be generalized to other occupational groups representing difficult and dangerous occupations. However, it seems that the results indicating temporal variability in the assessment of subjective stress can be viewed as a certain universal mechanism of adapting to occupational stress in the long-term perspective. A more important problem is probably whether this involves an adaptive approach in short-term situations, even during intense stress (e.g., when making decisions) or during long-term stress

exposure. Drilling rig employees work under permanent potential stress (potential explosions of oil and gas, collapse of the rig, being exposed to news about disasters on drilling rigs around the world, etc.), which means that the processes of adapting to difficult and dangerous conditions are likely based on other psychological resources, where factors related to personality and support networks acquire a greater significance.

Another factor adversely affecting the reliability of obtained results is collecting data using subjective questionnaires, which might introduce misrepresentations, as indicated by most researchers focusing on the offshore mining industry. Respondents might conceal or understate their health problems for fear of losing their jobs or being redeployed to a position on land, which might result in lower wages [17,20].

Due to this method of collecting information, the data is subjective and its accuracy when obtained from the description provided by the studied individual could be put into question, particularly in connection with the problem of negative affectivity, which might influence not only the employees' perception of their work environment, but also their self-assessment of mental health or well-being. In addition, it is highly probable that the subjectively existing stress is understated due to an attitude of dissimulation that is characteristic of employees who work in difficult occupations. The limitations presented above might interfere with the actual relationships between mental health and stress at work, as well as coping styles.

There is emerging research aimed at increasing the objectivity of studies on stress at work, focused on monitoring physiological factors and attempting to use electronic devices which detect stress intensity. One attempt to solve this problem is, e.g., the construction of the Empatica E4 device (Empatica Inc., Cambridge, USA) – an armband which collects data on electrodermal activity, skin temperature and blood volume pulse. In this scenario, an instance of

physiological stress classified as a moment of acute stress is recorded as an actual stressful event only after the event is verified by the client using a web-based platform. Supplying additional, contextual information to this data allows the client and health professional to discover the patterns and to adjust their interventions to actual needs. It is likely that the combination of this contemporary trend with studies of subjective stress will help to determine the actual nature and intensity of stress at work [30].

Another technique that is being introduced is the daily recording of changes and stress coping methods using the diary method. This allows the identification of the daily stressors and events which cause frustration, irritation or anxiety, and which intensify the sense of difficulty and impossibility of achieving the assumed objectives and plans [21].

The objective and subjective stress levels were assessed using the tests which are applied only on the domestic market, prepared by the Institute of Occupational Medicine [7]. In the context of contemporary research, it would be more advantageous to use an internationally-recognized test, such as the *Copenhagen Psychosocial Questionnaire* (COPSOQ II). However, at the time of starting this study, no Polish version of the COPSOQ II was available. Further results of complex research will focus on the issue of determining which factors influence effective coping with stress at work and which determine the health consequences of stress at work – whether demographic, individual, or related to psychosocial work conditions or social support.

### **Applicative value**

Despite the limitations regarding its application in studies, the principle of triangulation and the prospective nature of the research, as well as the fact of studying the whole personnel of an enterprise in the workplace, and in real time, certainly fulfill the requests voiced by researchers for studies on stress to be multi-level, involving a dynam-

ic, not static, understanding of this process, and employing a careful selection of research procedures. Only longitudinal studies using a variety of research methods can reveal the mechanisms involved in stress-related processes in terms of the cause-and-effect categories.

### **CONCLUSIONS**

The presented part of the research demonstrates the complexity of perceiving the subjective stress related to work. It is a complex process which changes over time.

The data dynamics reveals that the declared subjective stress allows to divide workers into 3 vastly different groups in terms of the perceived (declared) stress at work.

The baseline levels of stress may change over the years among various individuals. The first group includes those employees who were characterized by high stress at baseline, but declared a systematic decrease in stress over a period of 20 years, while those in the second group were characterized by low stress at baseline but declared an increase in stress which was systematic rather than involving sharp leaps. Only employees in the third group adapted to stress in a flexible way, their stress levels periodically decreasing and increasing. Perhaps such fluctuating stress levels (as in the FG group) are more adaptive in the sense that it is the most aligned with reality (i.e., with objective stress both at work and at home). A tendency to constantly decreasing subjective stress levels (as in the group in which stress levels are systematically decreasing) is connected with the lowest level of adaptation to objective stress – this group involves the weakest relationship between both types of stress, which might be indicative of a tendency towards denial or the association of such an attitude with other demographic and individual circumstances (personality traits and psychosocial loads).

One of the important conclusions stemming from the analysis is the fact that subjective stress is significantly lower than objective stress, which might indicate a well-selected professional group in terms of stress manage-

ment and a positive impact of work-related stress on its subjective perception, or a peculiar defensive attitude, characteristic of this professional group.

Stress dynamics, i.e., the way in which employees of drilling rigs adapt to stressful working conditions over a period of 20 years is a moderator of the change in subjective stress levels.

The presented prospective study indicates that the differences between subjective stress levels depending on the differentiated groups over a period of 20 years, i.e., inter-group variability (between the SR, SS and FG) and intra-group variability.

The method of prospective research shows that the perception of stress is dynamic rather than static, revealing the way in which the perception of subjective stress changes in groups and individuals over time.

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