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DIRECTIONS FOR THE ENHANCEMENT OF METHODOLOGICAL SUPPORT OF THE PSYCHOSOCIAL RISK MANAGEMENT PROCESS

Purpose. To identify and justify directions for the enhancement of methodological support of the Plan-Do-Check-Act procedures within the Occupational Risk Management Process (ORMP) in order to enhance the effectiveness of forecasting and preventing cases of mental health impairment (MHI) among employees.

Methodology. Analysis of regulatory and legal documents and scientific and technical literature on psychosocial risk management – to define and update the research purpose and tasks; probabilistic-statistical methods and Markov's process theory – to develop directions for enhancement of the methodological support of the Plan and Do procedures of the ORMP, respectively; formalisation method – to improve approaches to implementing the Check–Act procedures of the ORMP.

Findings. It is proposed to apply an optimization model to implement the ORMP's Plan procedure, which will allow finding the minimum required amount of resources for developing safety measures that, with a given probability, will prevent the occurrence of MHI cases in an employee during the planning horizon. And for the Do procedure, a stochastic model is used, which will allow assessing the probability of not exceeding the level of accumulation of negative impact of psychosocial factors (PSFs) in the employee's body at any time during the work shift, taking into account the random characteristics of such impact. For the Check-Act procedures, it is proposed to apply an automated system with functions of constant monitoring of the parameters' values of the cumulative negative impact of psychosocial factors (PSFs) in the employee's body and deducing the consequences of such impact, as well as prompt values correction of such parameters in case they exceed the established standards.

Originality. For the first time, the problems of implementing the Plan procedure of the ORMP have been formulated (in mathematical terms) as the problem of minimising the costs of developing measures to prevent cases of MHI, subject to a given probability of such cases occurring, and the Do procedure – as the problem of finding the marginal distribution of a random Markov process with fading, the parameters of which describe the condition of the employee, as well as the level of accumulation of the negative impact of PF in their body during a work shift. The principles for carrying out continuous monitoring and prompt adjustment of the characteristics of such an impact have been determined.

Practical value. The identified directions form the basis for the development of improved methodological support for Plan-Do-Check-Act (PDCA) procedures within the framework of further research.

Keywords: *occupational safety and health, psychosocial risk, ISO 45003:2021, mental health, psychosocial factors, modelling*

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Introduction. It is the legal and moral duty of any organisation to ensure and support the physical and mental health of every employee whilst they are carrying out their work. To fulfil this duty, the organisation must establish and ensure the operation of an effective occupational health and safety management system (OHSMS) in accordance with the requirements and guidelines of the regulatory documents [1]. One of the key guidelines defining the principles for building and operating modern OHSMS worldwide is the international standard ISO 45001:2018, according to which the approach to occupational health and safety management in organisations must be based on the implementation of the Plan-Do-Check-Act or the PDCA cycle (clause 0.4 of ISO 45001:2018). The essence of this concept lies in creating an effective environment within the organisation for managing occupational health and safety risks (occupational risks) with the aim of preventing incidents, namely cases of harm to the physical and mental health of employees (clause 0.2 of ISO 45001:2018). In this case, the

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effectiveness of the framework for managing occupational risks depends on the presence within the organisation of success factors, which can be broadly divided into methodological (clause 0.3, sub clauses e, g, h) and organisational (ISO 45001:2018 clause 0.3, sub clauses a–d, f, i, j, k). The presence of methodological success factors within an organisation depends on the availability of specialised methodological tools which (in accordance with clause 0.3, sub-clauses e, g and h) must enable:

- the determination of the necessary resources required to achieve the organisation's established objectives for the OHSMS operation (in line with the organisation's financial capabilities);
- carrying out an objective assessment of the risks of incidents occurring (taking into account the safety measures and safeguards that have been developed and implemented, as well as the actual (random and time-varying) negative impact characteristics on employees of hazardous, harmful production and other negative factors (manifestations of 'human' and external factors), which are the main causes of any incidents);
- ensuring continuous monitoring and prompt adjustment of the negative impact on employees of aforementioned negative factors (NF) with the aim of continuously improving occupational health and safety indicators (reducing incidents' amount).

Developing such a toolkit is a complex and non-trivial task that requires the deployment of significant resources, both human (researchers) and financial. Consequently, organisations do not usually develop such a toolkit themselves, but rather adopt it from relevant regulatory and legal documents [2]. Consequently, the effectiveness of methodological success factors depends on the objectivity of the methodological tools used by the organisation.

Organisational success factors are shaped by the organisation itself, and their presence and effectiveness depend on the organisation's own efforts and diligence.

At the same time, despite the fact that the PDCA concept is designed to create an environment for managing any occupational health and safety risks, statistical data on trends in the number of incidents worldwide indicate that modern OHSMSs are not capable of managing occupational risks equally effectively, given the negative impact on employees of various types of hazards. According to the statistical analysis' results, modern OSHMS (which are structured and operate on the basis of the PDCA concept) demonstrate the greatest effectiveness in managing the risks of occupational injuries (caused by the negative impact of certain physical hazards), as well as occupational diseases (caused by the negative impact of physical, chemical and biological hazards) and are least effective in managing psychosocial risks (caused by the negative impact of psychosocial hazards on employees).

Thus, between 2001 (the year the first international ILO-OSH 2001 Guidelines on establishing an OSHMS based on the PDCA cycle were introduced) and 2022 inclusive, the number of occupational injuries in European Union countries (where the PDCA concept was first and most dynamically implemented) fell by almost 60 % (from 1,143 cases to 725 cases per 100,000 population) [3]. At the same time, over the corresponding period from 1981 to 2000 (a period when the PDCA concept had not been implemented in OHSMS), the number of occupational injury cases fell by only 35 % (from 1,601 to 1,183 cases) [3].

Furthermore, according to the data from the European Agency for Safety and Health at Work, the International Labour Organisation (ILO) and the World Health Organisation (WHO), since 2001 there has been a gradual decline (averaging 1.5 % per year) in the number of cases of occupational diseases, caused by physical, chemical and biological factors (vibration, noise, dust, various types of aerosols, viruses (prior to the pandemic) and others) [4].

Instead, the number of incidents caused by the negative impact of psychosocial risk factors (PSFs) on employees has not only failed to decrease since 2001, but has shown a steady upward trend. According to the WHO data, between 2001 and 2016 alone, the number of deaths worldwide from cardiovascular diseases caused by the negative impact on employees of just one type of PSFs – namely, excessive working hours-increased by 29 % [5]. Furthermore, the number of deaths (during the same period) resulting from the negative impact of this single occupational hazard factor alone was almost 1.7 times higher than the combined number of deaths resulting from the negative impact of physical, chemical and biological hazards (750,000 and 450,000 people respectively [5]).

It should be noted, however, that PSFs negative impact on employees are not limited to the incidents mentioned above, but also manifest themselves in the form of disturbances in the functioning of the employee's immune and nervous systems and, above all, in the form of mental health conditions (MHI) of varying severity (depression, schizophrenia, etc.) and associated cases of suicide [6]. Thus, if we compare the overall figures for the number of cases of occupational diseases caused by the negative impact of physical, chemical and biological hazards with the number of cases of mental health impairment (MHI), we can see that as of 2001, the latter were more than twice as high (160 million cases of occupational diseases compared to around 340 million cases of MHI) [6]. Moreover, the trend in these indicators since 2001 is also quite telling. Thus, as of 2019, against the backdrop of a gradual 14 % decrease in the number of occupational diseases caused by the negative impact of physical, chemical and biological hazards, the number of cases of work-related injuries among employees increased by 1.5 times (to 525 million cases) [6].

These negative trends in the rise in MHI cases, which were exacerbated by the effects of the COVID-19 pandemic – during the first year alone, from its onset (2020), the number of cases of psychosocial stress among employees increased (compared to 2019 figures) by almost 25 % (as a result of the implementation of preventive measures related to social isolation, etc.), highlighted the need to develop a separate regulatory document containing guidelines and recommendations for creating an effective psychosocial risk management environment based on the PDCA concept [7]. In 2021, the International Organisation for Standardisation (ISO) developed the world's first international standard containing guidance on implementing an Occupational Risk Management Process (ORMP) within organisations, with the aim of preventing and mitigating mental

health harm, based on the recommendations of ISO 45001:2018 (clause 1 of ISO 45003:2021). The application of the PDCA cycle enabled organisations to implement the psychosocial risk management process within the framework of existing OHSMSs, taking into account the guidance provided in ISO 45003:2021.

However, despite expectations, in practice the positive impact of implementing ISO 45003:2021 within organisations has proved negligible. Indeed, according to WHO estimates, by 2024 (i.e. two years after the introduction of ISO 45003:2021), as a result of ineffective management of psychosocial risks, over 600 million people of working age worldwide were in a state of constant anxiety or depression (14 % more than in 2021), whilst the number of suicides resulting from this condition remained constant (around 700,000 cases per year) [8, 9]. This, in turn, results in the global economy suffering direct financial losses of 1 % annually (US$1 trillion in absolute terms), whilst the decline in labour productivity amounts to 12 billion hours of working time each year [8, 9].

Given that the effectiveness of the OHSMS (within which, in particular, the PRMP takes place) and its ability to achieve the expected results depend on the organisation's possession of the aforementioned success factors (see clause 0.3 of ISO 45001:2018), it is logical to assume that the existing ***problem*** of ORMP low effectiveness and efficiency is linked to the inability of organisations to establish effective success factors. Furthermore, given that the negative trend of increasing cases of mental health issues (MHI) is observed not within individual organisations but on a global scale (World Mental Health Report: Transforming Mental Health for All. Executive Summary), it can be assumed that this cause is systemic [9].

Given that organisational factors for success are shaped by the organisation itself, and their effectiveness also depends on the organisation's diligence and efforts, it would be logical to assume that, if the problem of low effectiveness and efficiency of the ORMP were linked to organisational success factors, the indicators of the number of MHI cases (the effectiveness of ORMP implementation) in different organisations would show contradictory trends. Thus, in certain organisations where there is a more conscientious approach to their development, these indicators would show a positive downward trend, whereas in organisations with a less conscientious approach, the opposite would be true. Furthermore, based on the content of ISO 45003:2021, it can be seen that the sections dedicated to the development of organisational success factors within an organisation are sufficiently clear and detailed (clauses 4, 5, sub-clauses 7.2–7.5, 9.3), in contrast to the sections devoted to the development of methodological success factors (clause 6, subclauses 7.1, 9.1).

The latter would clearly need to include either the relevant methodological tools (for determining resource requirements, risk assessment, monitoring, etc.) or a reference to a supporting standard where the organisation could find such tools. At the same time, it would be logical to assume that such a standard, like ISO 45003:2021 and ISO 45001:2018, should also belong to the ISO series. Furthermore, it would also be logical to assume that, since the guidelines and recommendations set out in ISO 45003:2021 regarding the ORMP implementation are uniform for all organisations worldwide – that is, systematic – all organisations should use the methodological tools contained in the systematic standard of the ISO series to establish methodological success factors. Currently, ISO recommends that organisations use the methodological tools set out in the IEC/ISO 31010:2019 standard, "General risk assessment methods", to support the PDCA cycle (which also underpins the PRMP).

Given that, when establishing methodological success factors, organisations should give priority to the methodological tools set out in IEC/ISO 31010:2019, its potential shortcomings (lack of objectivity) may be a common systemic ***cause of the identified problem*** of ORMP's insufficient effectiveness in organisations.

This conclusion is also confirmed in the section "Gaps in research" of the Guidelines on mental health in the workplace [6]. Thus, the authors note that ORMP's low effectiveness in organisations (the section "Evidence base and rationale") is linked to the inadequacy of the methodological tools used for its implementation, as such tools result in low reliability of the expected outcomes [6]. At the same time, to address the ***issue of low effectiveness*** in implementing ORMP, WHO experts call for (the section "Research gaps") an increase in the number and quality of studies aimed at improving these tools [6].

Literature review. With the aim of updating and identifying approaches to resolving the aforementioned problem, the study analysed: the content and recommendations of the ISO 45001:2018 and ISO 45003:2021 standards – to define the objectives of psychosocial risk management within an organisation and the necessary characteristics of methodological tools that would enable these to be achieved in practice, within the framework of the Plan-Do-Check-Act procedures; the content of the ISO 31010:2019 standard and scientific research dedicated to the issues of developing and enhancing the effectiveness of ORMP methodological support within the framework of the recommendations of ISO 45001:2018 and ISO 45003:2021 – to understand the suitability and objectivity of using the methodologies and approaches set out therein for establishing methodological success factors within the organisation that will ensure the achievement of OHSMS objectives, as well as identifying areas for their improvement. The review of the scientific literature was conducted using bibliographic databases such as ScienceDirect, ResearchGate, PubMed, Wiley Online Library and others, using the following keywords: psychosocial risks at work, psychosocial risk management, psychosocial risk management resources, psychosocial risk assessment, and psychosocial risks monitoring.

The OHSMS, like any other process, must be geared towards achieving the relevant objectives. Section 6 of ISO 45003:2021 stipulates that organisations should, during planning (as part of the Plan procedure, the first procedure in the PDCA cycle), establish a psychosocial risk management (PSRM) objective, as well as the means of achieving it (clauses 6.1.1.2 a, b). Although the text of ISO 45003:2021 does not contain a definition of the PSRM objective (clause 3), based on the definitions in ISO 45001:2018 (which, as noted above, must be used

in conjunction with ISO 45003:2021 for the PSRM implementation), the objective is understood to mean the achievement of a result in accordance with the organisation's occupational health and safety policy (ISO 45001:2018 clauses 3.16, 3.17). In turn, the organisation's occupational health and safety policy (clause 3.15 of ISO 45001:2018) is to prevent the occurrence of any incidents. That is to say, based on this, the PSRM objective is to prevent the occurrence of MHI incidents. Given that a specific hazard source (or several hazard sources) is the cause of a particular hazard, it should be clarified that the PSRM objective is to prevent the occurrence of hazards for each hazard source identified at every workplace. The list of PPFs to be identified at each workplace is given in Tables 1–3 of ISO 45003:2021 (clause 6.1.2.1.2).

At the same time, as noted in clauses 6.1.2.3 and 7.1, in order to achieve the objective, the organisation must determine and ensure the necessary level of resources. In this case, given that the text of ISO 45003:2021 does not specify what volume of resources can be considered "necessary", and based on the PSRM objective, the necessary volume of resources can be considered to be the minimum sufficient volume (based on objective considerations of the actual resource constraints of any organisation), which will enable the PSRM objective to be achieved. Namely, to prevent (clauses 6.2 and 6.1.2.2) the occurrence of any MHI for each identified workplace hazard during a work shift. Given that determining the necessary volume of resources is one of the key steps in achieving the objective, and that the organisation must determine the means of achieving it independently (sub-clause 6.1.1.2 b), the method for determining the volume of resources must also be determined by the organisation independently. At the same time, unlike the identification stage (the first stage of the Plan procedure), which the organisation can implement based on the recommendations of ISO 31010:2019 by selecting one of the five recommended (according to the SA criterion, i.e. the most recommended) methodologies (clause B.1.1, Figure A.1), the methodologies for determining the scope of resources are not provided in Tables A 2 and A 3 (ISO 31010:2019).

As the analysis of scientific research has shown, researchers pay little attention to addressing the issue of developing methodological guidelines for determining the necessary volume of resources for the operation of the ORMP (to achieve the PSRM objectives). Existing studies on this subject are limited to identifying the problem and highlighting its relevance.

Thus, in [10] it is noted that the lack of practical capacity within organisations to determine the necessary level of resources for developing and implementing measures to prevent MHI cases, due to the absence of appropriate methodological support, is one of the main causes of the inefficiency of the occupational health and safety management system in organisations. The authors draw these conclusions from a survey of labour inspectors, but the study does not identify specific ways to resolve the problem in question.

As part of the study [11], which is dedicated to identifying problems in ensuring the effective functioning of PRMP in the workplace, the authors note that in most cases, the development and implementation of measures to prevent occupational injuries among employees is haphazard in nature, which is explained by a lack of understanding on the part of the employer as to what effect the implementation of a particular safety measure will achieve. It is noted that by spending certain amounts of funding on such measures without achieving the expected results, the organisation reduces or even ceases to allocate such funds, which leads to a deterioration in occupational health and safety indicators. While identifying the need to develop a clear methodology for funding such measures, the authors limit themselves to merely recommending that such a methodology be developed.

In the study [12], the authors note that most academic works analysing the practical challenges of ensuring the effectiveness of the ORMP at specific enterprises emphasise that the majority of measures to prevent MHI implemented by enterprises are underfunded, due to the inability of business entities to objectively determine the volume of resources for each identified risk factor. The authors note that the problem of developing an appropriate methodology is relevant, since at present, the level of funding for ORMP in organisations is determined either within the limits of a fixed percentage established by the legislation of a particular country, which is allocated to occupational health and safety measures, or within the limits of actual funding for certain limited measures, the scope of which is determined by the organisation on the basis of subjective considerations.

In [13], the authors note that the issue of funding measures to prevent occupational accidents is particularly relevant for enterprises with small, limited budgets. It is precisely at such enterprises that the numbers of problems arise in ensuring the ORMP effective implementation. The authors propose that, for the rational allocation of resources to safety measures for such enterprises, risk factors should be ranked and funds allocated to measures aimed at minimising the most significant risk factors in the ranking. At the same time, it is unclear from the research findings how organisations should objectively calculate the amount of funds required to minimise the ranked risk factors.

In the study [14], the authors identify, amongst the most pressing issues – in their view – regarding the ORMP effective functioning in Australian organisations, such as improving PSRM measures to ensure a suitable organisational climate and so on, the problem of the impossibility of objectively determining the required level of resources for their funding. Whilst acknowledging the existence of the problem of the impossibility of objectively determining the specified volume of resources, and its significance and relevance for ensuring the PRMP effective implementation, the authors do not, however, propose any ways of resolving it.

Thus, as can be seen from the results of the analysis, the ability within the organisation to objectively determine the necessary volume of resources for achieving the PSRM objectives (to establish ***the relevant effective methodological success factor***, clause 03.e of ISO 45001:2018) ***is absent***, due to the actual lack of the relevant methodological tools.

At the same time, given the organisation's limited resources and the PSRM objectives, this methodological framework should effectively enable the organisation

to address the specific practical task of implementing the Plan phase. Namely, to objectively determine the minimum possible volume of resources required to develop safety measures that will prevent the occurrence of any incidents of occupational harm (for each identified hazard, taking into account the actual, random characteristics of its adverse impact on the employee) during a work shift (ISO 45003:2021).

Furthermore, in accordance with clause 8.1.1.2 of ISO 45003:2021, organisations must assess whether the measures to prevent the occurrence of occupational health hazards, as established following the implementation of the Plan procedure, are effective. In other words, whether they are actually capable of preventing the occurrence of occupational health hazards at every workplace. This verification takes place as part of the next step in the PDCA cycle – the "Do" step – by carrying out an objective assessment of the risk of occupational injuries occurring at each workplace and for each identified hazard, taking into account the safety measures implemented (essentially an assessment of the actual risk of occupational injuries occurring at each workplace) (ISO 45003:2021). In this case, it should be noted that the reliability of the results of the Do procedure, and consequently the actual level of employee safety, depends on the extent to which the methodological tools used by the organisation when assessing the risk of MHI allow for the objective consideration and prediction of the actual characteristics of the adverse effects on employees of the occupational health hazards identified in the workplace. Specifically, the stochastic and dynamic nature of the accumulation of the negative effects of PSFs in an employee's body during a work shift, as well as the elimination of these effects during non-working hours.

Based on the analysis results of the ISO content 31010:2019, which, as noted, should primarily be used by an organisation to assess the risk of critical safety incidents (as part of the "Do" procedure), the only methodology (Annex B) recommended for the objective study and modelling of the stochastic characteristics of dynamic systems is Markov's analysis (ISO 31010:2019, Annex B. 5.9). However, the methodology described in the standard is presented in a simplified form – Markov's diagrams and matrices with a finite set of states and discrete or continuous time – which imposes certain limitations on its scope of application [15]. For example, in the form presented, the methodology allows for solving practical problems concerning the reliability analysis of technical systems where only two discrete states in which the system may reside are considered – operational and non-operational [15]. However, for modelling more complex cases where it is necessary to study stochastic processes with discrete and continuous components, namely processes of stochastic fluctuation (accumulation and elimination) of the negative impact of PSFs in the employee's body, such an approach cannot be applied [15].

It should be emphasised that the existing methods for assessing psychosocial risks, as presented in relevant academic literature, are not geared towards developing approaches that would enable the modelling of the aforementioned real-world dynamic characteristics of the accumulation of the negative effects of PSFs in an employee's body; this is noted, in particular, in works devoted to the systematic analysis of relevant studies [16, 17]. Instead, the vast majority of studies focus on the development and refinement of assessment methods based on conducting employee surveys and their subsequent processing (such as the COPSOQ (Copenhagen Psychosocial Questionnaire), ERI (Effort-Reward Imbalance Questionnaire), JCQ (Job Characteristics Questionnaire), and others [18]. At the same time, although (within the framework of applying such methods) an employee's opinion may formally reflect the actual characteristics of the negative impact of a particular PSF on them (according to the questionnaire's content), it reflects only those characteristics and only at the specific point in time when such an impact was being exerted on the employee.

Despite the widespread popularity of this approach for assessing psychosocial risks, researchers emphasise that, although these methods for assessing the risk of MHIs are marketed as such by their developers, they are in essence merely tools for gathering employees' opinions [19]. Consequently, their results should be used with caution when assessing the risks of MHIs occurring among employees over the planning horizon (for future periods), as the results obtained may indicate (with a certain degree of probability) only the state of safety during the period covered by the survey (i.e. the past period) [19]. Accordingly, such an approach cannot (with a high degree of probability) meet the organisation's expectations regarding the assurance of an adequate level of employee safety in the future, given the random and dynamic changes in the characteristics of the negative impact of the hazard source on the employee over time [19]. In this case, an adequate level of safety is understood to mean the absence (with a probability close to 1) of MHI cases occurring in an employee for each identified PSF within the planning horizon established by the organisation.

This conclusion is also supported by the findings of a study [20], in which the authors assessed the level of psychosocial risks faced by employees at a plywood manufacturing plant using the FPSICO questionnaire (National Institute of Occupational Safety and Health, Spain) and the Psychosocial Risk Assessment Questionnaire (PRAQ) (Ministry of Labour, Ecuador), which are also widely used for risk assessment across the entire region (Ecuador, Amazonia). The results showed that, despite the measures implemented to minimise these risks at the enterprise – which were developed based on the results of a previous survey (using the F-SICO and PRAQ) – the situation regarding cases of mental health impairment among employees remains unsatisfactory across almost all psychosocial factors identified in the questionnaire.

A similar conclusion can be drawn from the findings of a study [18], in which the authors conducted a comparative assessment of psychosocial risks based on survey results using the COPSOQ II, Fine-Kinnick and Analytic Hierarchy Process (AHP) methodologies. Based on the results of the current assessment, the authors found that the safety measures implemented, which had been developed on the basis of a previous assessment of psychosocial risks (in a similar manner), proved to be largely ineffective across almost the entire range of PSFs covered by the survey.

Thus, as can be seen from the results of the analysis, existing approaches to assessing psychosocial risks, which involve surveying employees and processing the data obtained, essentially propose that organisations adopt a so-called "reactive" approach to PSRM. That is, an approach in which the probability and severity of the consequences of psychosocial stress arising in an employee within the planning horizon are assessed on the data analysis basis (regarding the negative impact on the employee of various identified PSFs) obtained in previous time periods (periods covered by the questionnaire).

Formally, strictly speaking, this approach could be considered "proactive", as the data obtained (the risk assessment results) are used to predict the adverse effects' characteristics of PSFs on employees and to develop safety measures for future periods. However, it is evident that in the real-world conditions of "human–machine–environment" systems, where the characteristics of the negative impact of PSFs change constantly and with random intensity, data from the past period should not be used to predict an employee's safety status in future periods. This is because the characteristics of specific PSFs that had a negative impact on the employee during the period (or moment) covered by the survey will not be identical to the characteristics of the negative impact that will be exerted on the employee in future periods (moments). Consequently, a safety architecture within an organisation built on the results of such an assessment is highly likely to be ineffective in future periods (for which it was designed), as confirmed both by the research findings cited above and by the WHO conclusions set out in the section "Evidence base and rationale" of the Guidelines on Mental Health in the Workplace (hereinafter the Guidelines) [6]. According to these, the low effectiveness and reliability of the recommendations set out in the Guidelines is due to the fact that they were developed (as in the studies analysed) on the basis of an analysis of the results of employee surveys [6].

Ensuring an objective assessment of psychosocial risks (establishing ***an appropriate and effective methodological success factor***, clause 03, sub clause g of ISO 45001:2018) as part of a truly "proactive" approach is only possible through the objective forecasting of the actual random and dynamic characteristics of the negative impact of psychosocial factors on the employee over time (taking into account the safety measures implemented following the completion of the Plan procedure), which, in turn, requires the use of specialised methodologies for conducting the psychosocial risk assessment procedure (implementation of the Do procedure). As noted above, in accordance with the content of ISO 31010:2019, organisations are recommended to use Method B.5.9 (Markov's analysis) as such a methodology. However, given that in ISO 31010:2019 it is presented in a rudimentary form, which does not allow it to be applied for the assessment of psychosocial risks (modelling the random and dynamic characteristics of the PSFs negative impact on the employee over time), there is a need to address ***the issue*** of its improvement. Furthermore, given the virtual absence of research aimed at its improvement (based on the conducted analysis' results), this ***issue can be considered pressing one***.

The next steps in the PDCA cycle are the implementation of the monitoring (Check) and corrective action (Act) procedures. In accordance with clause 9.1.1 of ISO 45003:2021, the organisation must develop and implement a systematic approach to monitoring the ORMP effectiveness (clause 9.1.1, clause 9.1.1(f)), and, based on the results of monitoring, take the necessary corrective action if a hazard to an employee's mental health or a risk of such a hazard is identified (clause 9.1.2). However, the text of ISO 45003:2021 does not specify how these procedures should be implemented or at what intervals. The text of ISO 45001:2018 (clauses 9.1.1 and 9.1.2) states that the organisation must determine for itself the methods for monitoring and corrective action, as well as the frequency of such activities.

The analysis of the literature has shown that, in practice, the monitoring procedure is mainly carried out using the following approaches. The first of these involves monitoring an employee's mental health by obtaining and analysing a biological material sample (BMD) from the employee [21]. The advantage of this approach is that the analysis results objectively reflect the employee's psychological and emotional state at the time the sample was taken.

However, a major drawback of this approach is that its implementation will always face potential resistance from employees (given the need for them to provide biological samples for testing), as well as the labour-intensive nature of the process (particularly within large organisations). The existence of these drawbacks imposes significant time constraints on when such monitoring can be carried out (for example, no more frequently than once every six months or once a year), which, given the constant and dynamic nature of the PSF negative impact on employees – leading to the rapid onset of cases of occupational disease – is unacceptable for the organisation. These shortcomings limit the popularity of this approach among organisations [21].

The following approach is currently the most widespread in organisations and involves monitoring through the establishment of "two-way" communication between the employee and the designated person (inspector) responsible for ORMP [22]. Such "feedback" may take the form of discussions (after a shift, or during a shift) between the employee and the responsible person (inspector), or a survey of the employee regarding changes in their psychological and emotional state during the shift and the reasons for such changes. Based on the results of these discussions and surveys, corrective measures are developed where necessary. A positive aspect of this approach is that monitoring of the employee's psycho-emotional state can be carried out regularly within its framework, at least once per shift. However, as noted in the study [23], conducting such conversations or surveys too frequently may also provoke a resistance reaction from the employee. Another drawback of this monitoring approach is that employees may not always be able to speak openly about the specifics of their psychological and emotional state, particularly if the causes relate to certain interpersonal relationships within the workforce or family circumstances. Furthermore, an employee may fail to notice (or overlook) certain (less significant) changes in their psycho-emotional state (caused by the negative impact of certain PSFs of lesser intensity) during a work shift, against the backdrop of more significant psycho-emo-

tional stresses (the negative impact of more intense stress factors) [24].

The findings of the study [25], in which the authors propose monitoring employees' psychological and emotional state on an ongoing basis, can be regarded as a progressive development of this approach. To this end, the authors developed a special programme for interactive devices (tablets), with an interface that invites employees to answer four specific key questions using various types of "emoticons" that characterise the employee's current internal psycho-emotional state. The devices were placed in high-traffic areas where employees could answer the questions continuously and anonymously. A positive aspect of this approach is its anonymity, which allows employees to be candid when answering questions. Furthermore, the proposed response format (emoticons) makes it easier to provide answers, as it offers a convenient and understandable way for employees to describe their psychological and emotional state. Furthermore, unlike the approaches analysed above, this monitoring format and the device's placement allow data on the psychological and emotional state of the group (team) to be collected much more frequently during a work shift than under previous approaches (increasing the frequency of monitoring). The latter is a very important aspect, as it enables a timely response to negative changes in the team's psycho-emotional state and the implementation of corrective measures. However, a serious drawback of this approach is that its application leads to what is known as the "depersonalisation" of monitoring. In other words, the proposed approach may provide the organisation with an understanding of the dynamics of changes in the psychological and emotional state of the team, rather than that of each individual employee, which contradicts the fundamental principles of ORMP.

As can be seen from the results of the analysis, the approaches outlined allow the organisation to carry out monitoring procedures and, consequently, corrective procedures at regular intervals. This, in turn, gives rise to the likelihood that an incident (MHI) may occur involving an employee in the interval between monitoring procedures. This probability is determined by the actual random and dynamic characteristics of PSFs negative impact on the employee during a work shift, when an MHI incident, as a result of such an impact, may suddenly occur precisely in the interval between the completion of the previous monitoring procedure and the start of the next one.

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To minimise this probability, it is evident that monitoring of an employee's psycho-emotional state during a work shift should be conducted continuously over time, which, in turn, will allow for the prompt elimination of identified hazards (or risks of their occurrence) to improve ORMP indicators (prevention of occupational accidents), which is the focus of the study [25]. In turn, resolving ***the issue*** of ensuring the ability to continuously monitor an employee's psycho-emotional state throughout a work shift will enable the organisation to establish ***an effective methodological success factor*** for implementing the Check and Act procedures, namely to continuously monitor OSH performance indicators for their improvement (clause 03, sub clause h of ISO 45001:2018), through the application of corrective actions.

It should be noted, however, that in practice there are known approaches capable of ensuring the continuity of the monitoring procedure throughout a working shift. Thus, to implement a continuous (constant) monitoring procedure, certain monitoring tools are used which can detect external changes in an employee's psycho-emotional state (indicators of pupil reactions, facial expressions, gaze direction, etc.) during working hours. However, a drawback of this approach is that, as noted in the study [26], unlike, for example, indicators of stress hormone levels in the body, such indicators mainly indicate a temporary impairment of the employee's cognitive functions and do not always indicate a risk of or an occurrence of an MHI. Consequently, in practice, this approach is generally applied not for MHI monitoring, but for monitoring an employee's cognitive functions, the impairment of which may lead to accidents, industrial accidents and disasters [27]. Given this shortcoming, ***the issue*** of refining the approach to ensure continuous monitoring and the prompt elimination of hazards to prevent cases of occupational mental disorders ***can be considered a pressing one***.

Based on the results of the analysis, it can be concluded that it is ***currently impossible to establish effective methodological success factors for implementing the Plan-Do-Check-Act procedures within the organisation***, due to the lack of methodological tools for implementing the Plan procedure, the inadequacy of methods for assessing psychosocial risks to enable the objective implementation of the Do procedure, and the inadequacy of approaches to implementing the Check and Act procedures, which, in turn, prevents organisations from effectively implementing the ORMP cycle and preventing the MHI occurrence among employees.

The purpose of this research is therefore to identify and justify areas for improving the methodological framework of the Plan-Do-Check-Act procedures within the process of managing psychosocial risks in an organisation, with a view to enhancing the effectiveness of forecasting and preventing the MHI occurrence among employees.

Methods. Based on the results of research studies dedicated to investigating the mechanisms underlying the MHI occurrence in employees, it is known that such cases result from the accumulation of the PSFs negative impact in the employee's body [28]. Depending on the level of accumulation (which, in turn, depends on the duration and intensity of the PSFs negative impact on the employee during the work shift), psychophysiological changes of varying severity occur in the employee's body, which are conventionally referred to as stress phases [28].

The first phase is characterised solely by the initial signs of physiological changes in the body's functioning (rapid heartbeat, dilated pupils, increased blood pressure, etc.), which do not yet cause the MHI, but manifest themselves only as feelings of anxiety, alertness, heightened attention, etc. [28]. During this phase, the employee's body can recover independently from the PSFs effects (for example, during a rest period involving psychological relaxation techniques, etc.) and maintain homeostasis, unlike in subsequent phases of stress, when dangerous physiological processes begin to occur in the body (disruption of hormonal balance, metabolism, immune system function, etc.), leading to MHI [28].

Therefore, from a practical point of view, ***the primary task of the organisation*** when implementing the ORMP (as part of the PDCA cycle) is to ensure (with a high probability σ, close to 1) that the level of accumulation of negative impact i – that one identified in the workplace as a PSF ($i = 1, 2, 3, ..., n$) – does not exceed certain values (criteria for the risk of developing occupational health problems), which characterise the body's transition from the first to subsequent stress phases. The moment of such a transition is characterised by a change in the physiological indicators of the employee's bodily state, namely, a change in the levels of stress hormones (cortisol, catecholamine) and blood glucose (physiological indicators of stress or PIS), which subsequently leads to the onset of MHI [28] Since the levels of these PISs in the human body are quantifiable (unlike the vast majority of PSFs listed in Tables 1–3 of ISO 45003:2021), their standardised values (ω) can generally be considered criteria for the risk of occupational health problems in an employee [28].

Consequently, as part of the organisation's Plan procedure, it is necessary to determine the amount of resources (U_i) required for the development and implementation of preventive safety measures (points 1–10 of the Guidelines), which, in turn, with a guaranteed high (close to 1) probability σ_a, ensure that the standardised values of the PIS (ω) in the employee's body are not exceeded at any given moment t during the working shift (*time T*) for the i^{th} PSF, taking into account the random and dynamic characteristics of its negative impact [6]. That is, the fulfilment of the condition

$$\lim_{t\to\infty} P\{\psi(t)) \le \omega\} > 1 - r_a, \quad (1)$$

where $\psi(t)$ is the level of negative impact accumulation of PSFs in the employee's body at time t; $r_a = 1 - \sigma_a$ is the risk of a work-related injury occurring in the employee.

It should be noted that, in accordance with clause 3.17 of ISO 45001:2018, the value of r_a must be determined by the organisation itself, based on an understanding of its resource capabilities.

At the same time, given that, in practice, $r_a > 0$, (i.e. there is always a probability that an employee may experience a MHI case during a working shift), the organisation must, in addition to U_i, also budget for screening programmes, i.e. the identification of employees with MHI cases and the development of specific safety measures for them, which cannot be provided for (given their special nature) within the scope of the U_i, resource (paragraph 13 of the Guidelines) [6]. Let us denote the amount of resources required for this as W_i.

Given the practical limitations on resource capacity within any organisation, from a practical standpoint, the desired outcome of implementing the ORMP is to ensure a small (close to 0) value of r_a for each i – i.e. the PSF – within the minimum possible resource volume S ($S = U_i + W_i$). To this end, during the Plan procedure, the organisation must be able to solve the ***corresponding optimisation problem***, namely the problem of minimising the volume of S resources subject to the constraint r_a (whereby the value of r_a may be considered an acceptable level of risk of MHI occurring for the organisation). In practice, this optimisation problem can be solved by constructing appropriate economic-mathematical models. The most convenient method for constructing such models is the convex optimisation method, which, due to the property that every local minimum or maximum of a convex function is global, simplifies the search for the optimal solution (Stephen Boyd, 2009).

Consequently, the ***focus*** of developing the methodological framework to enable the implementation of the Plan procedure and the establishment of the corresponding methodological success factor for the organisation (clause 0.3, sub-clause e., ISO 45001:2018) is the construction of an optimisation model based on the S criterion of minimising subject to the constraint r_a, using the convex optimisation method.

As can be understood (the "Literature Review" section), the execution of the next ORMP procedure – the Do procedure – involves assessing the probability (σ_f) that at a specific (arbitrary) point in time t during a work shift, the accumulation of negative impact i – the PSF of the employee's body – does not exceed the standard FPS (ω) value, taking into account the actual (random and dynamic) characteristics of the impact and the preventive security measures put in place (based on the results of the plan). In other words, in applying the Do procedure, the organisation should verify whether the following condition is actually met in practice

$$r_f \le r_a, \quad (2)$$

where, $r_f = 1 - \sigma_f$ is the estimated (actual) level of MHI risk occurring (taking into account the preventive safety measures in place).

As already noted, the primary objective of the preventive safety measures introduced (as part of the Plan procedure) is to fulfil condition (1). To this end, the organisation implements measures aimed at reducing the intensity of the negative impact on employee i of that PSF and limiting the duration of such effects (during the work period), as well as enabling the employee's body to recover from its effects (during the rest period, during enforced breaks associated, for example, with sudden equipment failures and outside working hours). During a work shift, periods of work and rest constantly alternate, forming so-called alternating processes (processes D_0 and D_1 respectively), during which fluctuations in the values of $\psi(t)$ occur in the employee's body. Therefore, we shall assume that during process D_0, the employee's body accumulates the negative effect i – that PSF with random intensity a_i – and during process D_1, the consequences of this negative effect are eliminated, with random intensity m_i.

To enable the description of the dynamics of fluctuations in the accumulation of the negative impact of PSFs

in an employee's body during the durations of processes D_0 and D_1, we introduce random variables that characterize the employee's state and production conditions at a certain random moment in time t over the course of a work shift:

- $\mu(t)$ is a variable that takes the value 1 if, at time t, the employee is in the working mode (at the workplace), and the value 0 if the employee is in the rest mode. When $\mu(t) = 1$, the negative impact of the i^{th} PSF accumulates in the employee's body with intensity a_i,; when $\mu(t) = 0$, the effects of the negative impact are eliminated from the body with intensity m_i;

- $\beta(t)$ is a variable that takes the value 1 if at time t the production situation (equipment failure, other extraordinary situation) requires the employee to leave the workplace for a certain time (during the work regime) or to remain outside the workplace (to extend the rest regime for the period of equipment restoration or the duration of other extraordinary situation during the rest regime) and the value 0 if such situations did not arise. When $\beta(t) = 1$, the consequences of the negative impact are removed from the body with intensity m_i, when $\beta(t) = 0$, the negative impact from the i^{th} PSF accumulates in the employee's body with intensity a_i.

In the notation adopted above, the process of oscillation of the negative impact of PSF in the employee's body within D_0 and D_1 can be described by the following differential equation (with probability 1)

$$\psi'(t) = aI(\mu(t) = 1; \quad \beta(t) = 0) - mI(\mu(t) = 0; \\ \beta(t) = 0 \vee 1; \quad \psi(t) > 0), \tag{3}$$

where $I(D)$ is D event indicator.

In this form, (3) cannot be solved by applying the mathematical apparatus of the theory of Markov processes, as provided by the recommendations of ISO 31010:2019 (the section "Analysis of literature"), since the presented process is not Markov's one. However, if we introduce into consideration the component ($\varsigma(t)$), which characterizes the time remaining from the moment t to the change of the state of the process D_0 to D_1 and vice versa, then the process (3) becomes Markov's one. Thus, from a mathematical point of view, the task of implementing the Do procedure consists in finding a probability distribution that characterizes the dynamics of the accumulation of the level of the PSFs negative impact in the employee's body, namely

$$\Psi(t) = (\psi(t), \mu(t), \beta(t), \varsigma(t)). \tag{4}$$

Based on the theory of Markov's processes, to describe the random process of oscillations $\psi(t)$ during a work shift (which by its features refers to the so-called "random walks" processes), it is recommended to use a special mathematical apparatus of the theory of Markov's processes with drift (Franciszek Grabski, 2015).

Therefore, the ***direction*** of developing methodological support for the implementation of the Do procedure and the formation of the corresponding methodological success factor of the organisation (clause 0.3, clause g., ISO 45001:2018) is to build a stochastic model to find the probability of not exceeding $\psi(t)$ normalized values ω at an arbitrary time point t (in order to verify condition (2) based on the application of the mathematical apparatus of the theory of Markov's processes with drift.

Considering that the fulfilment of condition (2) also assumes that in real conditions of functioning of the system "man – machine – environment" the $r_f > 0$ value, the main task of implementing the Check procedure is to carry out continuous (the section "Literature analysis") monitoring of $r_f > 0$, $\psi(t)$ indicators of each employee and their comparison, in real time, with normalized values ω.

Obviously, the point at which the indicators exceed the threshold values of accumulation level of PSFs negative impact in the employee's body values ω, requires immediate use of operational measures to reduce them. The latter is the main task of the Act procedure. Since the accumulation level of negative impact i – that PSF in the employee's body fluctuates depending on the characteristics a_i and m_i, the organization's ability to ensure that the ω values are not exceeded (within the framework of the Check – Act procedures) depends on the ability to constantly monitor and promptly adjust the parameters a_i and m_i. This, in turn, can be achieved, taking into account the random nature of the $\psi(t)$ fluctuation process, exclusively within the framework of the appropriate automated system application.

Therefore, the ***direction*** of objective implementation of Check-Act procedures and formation of the corresponding methodological factor of organisation success (clause 0.3, clause h., ISO 45001:2018) is the development of an automated system of constant monitoring and prompt adjustment of parameters a_i and m_i.

Results. From a mathematical point of view, solving the optimization problem defined above (within the framework of the corresponding direction) for the Plan procedure implementation, taking into account the notations adopted above, involves finding the vector $\vec{U} = (U_1,...,U_n)$, which minimizes the function

$$S(\vec{U}) = \sum_{i=1}^{n} [Q_i + d_i c_i (W_i + U_i)^{-h_i}], \tag{5}$$

by restriction

$$1 - \prod_{i=1}^{n} F_i(\omega / T) = r_a, \tag{6}$$

where d_i is the cost of the consequences eliminating of the MHI occurrence in an employee according to the i^{th} PSFs volume; c_i and h_i are the values obtained from the results of processing statistical data (monitoring data) regarding the actual excess of the values ω of the i^{th} PCF, with the volume of U_i and W_i resources corresponding; $F_i(y) = P\{a_i \le y\}$ is a_i distribution function.

In practice, as a rule, the implementation of the Plan procedure involves solving the problem of finding the minimum required amount of resource to ensure and maintain the r_a value set by the organisation for different laws of the random variable $F_i(y)$ distribution function during time T. This is due to the fact that, according to statistical data, in practice, two cases of stress in an employee are most often encountered [29]. In the first case, the stress state in an employee at the time T occurs as a result of the constant gradual accumulation in his body of the negative impact of certain PSFs (constant dissatisfaction with working conditions, for example, due to lack of respect from management, the team, bullying, etc.). And in the second case, the state of stress at this

level arises as a result of the sudden impact of certain PSFs of high intensity (for example, the occurrence of an extreme emergency situation, manifestations of the "human factor" (conflict), etc.) [29, 30]. In scientific works, it is noted that although today there is no unanimous opinion among researchers regarding the laws that describe the relationships between the possible values of the (a_i) random variable and the probability of the occurrence of a stress state, the procedures' results for monitoring the psychophysiological state of the employee during the work shift indicate that in the first case, the specified random variable, in the time interval T, takes values with a constant probability density [29, 31]. And in the second case, it is distributed according to the exponential law [29].

So, for the first case, the distribution function of the random variable will be

$$F_i(y) = \begin{cases} 0, & \text{at } y \le 0 \\ \dfrac{y}{\lambda_i}, & \text{at } 0 < y < \lambda_i, \\ 1, & \text{at } y \ge \lambda_i \end{cases} \qquad (7)$$

where λ_i is the maximum possible intensity of the negative impact of the i^{th} PSF.

And constraint (6) will take the form

$$1 - \prod_{i=1}^{n} \frac{\omega}{\lambda_i T} = r_a. \qquad (8)$$

Therefore, the task of implementing the Plan procedure for case (7) will look like the task of minimizing the function (5) under the constraint (8).

For the second case, the distribution function will take the form

$$F_i(y) = 1 - \exp(-y/\lambda_i), \quad y > 0, \quad \lambda_i = Mai, \qquad (9)$$

where M is a symbol of mathematical expectation.

And expression (6) will take the form

$$\prod_{i=1}^{n} (1 - e^{-\omega/T\lambda_i}) = 1 - r_a. \qquad (10)$$

Thus, the task of implementing the Plan procedure for case (9) will look like the task of minimizing the function (5) under the constraint (10).

As already noted, the solution of the above-defined (within the relevant direction) task for implementing the D_o procedure involves finding the probability distribution (4), which characterizes the dynamics of the accumulation of the level of the PSFs negative impact in the employee's body. Based on the theory of Markov's processes, to find the specified distribution, it is necessary to introduce the corresponding probability densities (Franciszek Grabski, 2015)

$$\begin{aligned} &\mathbf{P}\{\mu(t) = j, \beta(t) = q, \tau < \varsigma(t) < \tau + d\tau, g < \psi(t) < g + dg\} = \\ &= k_{jq}(g, \tau, t)(1 - Dj(\tau))d\tau dg, \; j = 0,1; q = 0,1; g > 0, \tau > 0; \\ &\mathbf{P}\{\mu(t) = 0, \beta(t) = 0, \tau < \varsigma(t) < \tau + d\tau, \psi(t) = 0\} = \\ &= k_{00}^{-}(\tau, t)(1 - D_0(\tau))d\tau, \tau > 0; \\ &\mathbf{P}\{\mu(t) = j, \beta(t) = 1, \tau < \varsigma(t) < \tau + d\tau, \psi(t) = 0\} = \\ &= k_{j1}^{-}(\tau, t)(1 - D_j(\tau))d\tau, \; j = 0,1; \tau > 0, \end{aligned} \qquad (11)$$

where τ is time elapsed from the start of the process D_0 (or D_1 process) to time t; g is PIS quantitative characteristic indicator (the corresponding stress hormone (usually cortisol. catecholamine or other), which is selected by the organisation as an indicator for monitoring) in the employee's body at time t; k is probability density of the joint distribution of the g indicator and the time remaining until the change of the process D_0 to D_1 and vice versa; j and q are discrete variables that describe the values of μ and β at time t.

To find the desired r_f characteristics (within the framework of the implementation of the Do procedure) it is enough to find the limiting distribution of the random Markov's process introduced by us $\Psi(t) = (\psi(t), \mu(t), \beta(t), \varsigma(t))$relative to (11), namely (Franciszek Grabski, 2015)

$$\begin{aligned} k_{jq}(g, \tau) &= \lim_{t \to \infty} k_{jq}(g, \tau, t); \quad j = 0,1; \quad q = 0,1; \\ k_{00}^{-}(\tau) &= \lim_{t \to \infty} k_{00}^{-}(\tau, t); \\ k_{jq}^{-}(\tau) &= \lim_{t \to \infty} k_{jq}^{-}(\tau, t); \quad j = 0,1. \end{aligned} \qquad (12)$$

From a practical point of view, the solution of (12) requires (Franciszek Grabski, 2015) deriving a system of partial differential equations, boundary conditions and normalization conditions to construct a stochastic model for estimating r_f.

However, it should be noted that the construction of the model is a complex mathematical task which is beyond the scope of this study (which is mainly about setting guidelines for improving methodological support to PDCA procedures).

In general, the assessment of r_f values involves establishing (within the specified model) dependencies between r_f values and a_i and m_i (given that the characteristics of g (12) depend on a_i and m_i characteristics). The specified parameters (a_i and m_i) can be considered controllable, since it is precisely at the change in the characteristics of the specified parameters that safety measures are aimed during the duration of the processes D_0 and D_1. It is clear that for each r_f value, which will be determined by solving (12), some values of a_i and m_i parameters will correspond. At the same time, only those values of parameters a_i and m_i that satisfy the fulfilment of condition (2), taking into account (1), will be acceptable for the organization. Let us denote them as a_{ia} and m_{ia}. Therefore, it is the a_{ia} and m_{ia} values that will be the criteria for implementing the following (after D_0) Check and Act procedures (since they ensure that the values of ω are not exceeded).

Based on this, the task solution of implementing the Check procedure involves the need to constantly monitor the actual a_i and m_i values (we will denote them as a_{if} and m_{if}) and compare such values with the a_{ia} and m_{ia}. indicators (obtained from the solving results (12)). In this case, a positive result of monitoring at time t during T will be considered the $a_{if} \le a_{ia}$ and $m_{if} \ge m_{ia}$ result. In the event of failure to meet at least one of the conditions (i.e., when $a_{if} > a_{ia}$ and/or $m_{if} < m_{ia}$), the main task of the Act procedure is to promptly apply appropriate corrective safety measures (intervention measures, see recommendation 8 of the Guidelines) to bring the a_{if} and m_{if} indicators to values that ensure the fulfilment of $a_{if} \le a_{ia}$ and $m_{if} \ge m_{ia}$ conditions [6].

However, it should be noted that there are certain difficulties in the possibility of monitoring and adjusting the values of a_{if} and m_{if} parameters directly in practice.

The fact is that the values of the a_i and m_i parameters for the vast majority of PSFs that are subject to identification in the workplace (Tables 1–3 of ISO 45003:2021) cannot be objectively measured (using instrumental measurement methods) at this stage of development and technology (currently there are no relevant regulatory indicators, technology and devices for such measurement). Indeed, the question arises of how to directly measure the negative impact characteristics on the employee, for example, such PSFs as role uncertainty, bullying, etc. However, given that changes in the characteristics of the parameters a_i and m_i cause corresponding changes in the FPS of the employee's body (the level of stress hormones changes and other objective indicators), it is possible to carry out monitoring and adjustment procedures based on these indicators. The dynamics of changes in the PIS indicators quite correctly reflects the dynamic changes in the characteristics of a_i and m_i parameters, which is, in particular, noted in studies [32, 33].

Objective and continuous monitoring of these indicators can be implemented in practice using existing portable devices (e.g., wearable fluorescent sensors for real-time measurement of cortisol levels). Such devices are designed to be worn continuously throughout the work shift. They are convenient, compatible with wireless data transmission technologies, and do not interfere with the performance of occupational duties. Moreover, the non-invasive nature of continuous monitoring of relevant PIS indicators minimizes employee resistance to their use [32].

The implementation of the Plan and Do procedures can be illustrated by the following example. An organisation has identified the i^{th} number of PSFs (i = 1, 2, ..., n) at the workplace of a certain employee. The organisation has also determined that appropriate safety measures must be implemented to minimize the negative impact of the i^{th} PSF. The task of the Plan procedure is to determine the minimum required amount of resources for the development of such measures (for each i^{th} PSF), which, with the σ_a probability established by the organisation, will prevent the MHI occurrence in an employee. At the same time, according to the recommendations of ISO 45001:2018, the σ_a value is set by the organisation itself. From a practical point of view, solving the problem of finding the required amount of resources at a given σ_a value involves solving problem (5) with constraints (8) or (10), depending on the negative impact nature of a particular identified PSF. Such tasks can be solved using standard Excel software (Stephen Boyd, 2009). In this case, the σ_a value characterizes the level of employee safety that the organisation can ensure within the framework of developed (funded) safety measures.

The effectiveness of such security measures, as mentioned above, is verified based on the Do procedure results, within the framework of a theoretical experiment to simulate real (random and dynamic) characteristics of the negative impact on the i^{th} PSF employee. The specified experiment involves assessing the employee's safety level (determining the σ_f values) taking into account the specified characteristics of the negative impact and the implemented security measures. To find σ_f for the i^{th} PSF, the organisation solves problem (12) using either analytical solution methods or within the MATLAB software (Franciszek Grabski, 2015). In this case, the Do implementation task is considered successful if condition (2) is met.

The implementation of the procedures for continuous monitoring and operational correction (Chek-Act) using the specified portable devices can be illustrated by the following example of the operation of automated psychosocial risk management system (which is planned to be developed to implement the specified procedures in practice). The portable device (PD) of the i^{th} employee, using wireless technology (Bluetooth, Wi-Fi) is connected to the microprocessor control device (PCD) of the main computer. The PCD in real time constantly processes the signal from the i – PD and compares it with the established corresponding maximum permissible ω values of the indicator controlled by the organisation (for example, cortisol level, etc.). In addition, the PCD contains information about the i^{th} employee's stay in the work mode or in the rest mode (in the process D_0 or D_1, respectively) at a certain time t according to the schedule developed by the organisation for each employee. At the same time, the fact that the monitored indicators do not exceed the established ω values (during the work regime), the IMP understands as the fact of compliance with the $a_{if} \le a_{ia}$ condition. In this case, the automated psychosocial risk management system (ASRM) operates exclusively in the standard "continuous monitoring" mode.

If at a certain point in time t (during the work regime) the indicator that is being monitored reaches the value ω (process D_0 is not completed according to the schedule), the PCD sends a signal to the PD of the i^{th} employee (whose PD transmitted the corresponding value to the PCD) with a warning about the need to apply individual intervention measures (self-management stress measures, etc., in accordance with recommendation 8 of the Guidelines). The corresponding message is immediately sent to the PD of the immediate supervisor and/or the person responsible for supporting the mental health of the organization, who provide assistance and psychological support to the employee (in accordance with recommendation 4 of the Guidelines). In this case, the PCD considers that an extraordinary situation has arisen and the employee should go to the rest regime. The ASRM switches to the "continuous monitoring and operational adjustment" mode, while the PCD switches to monitoring the fulfilment of the $m_{if} \ge m_{ia}$ condition.

If, during the duration of the work mode, the PCD recorded the fulfilment of the $a_{if} \le a_{ia}$ requirement (the corresponding PIS did not exceed the value ω), then at the moment of the current work end, the PCD sends a signal to the PD of the i^{th} employee with a message to switch to the rest mode. In this case, the ASRM remains to work in the "continuous monitoring" mode, and the PCD switches to monitoring the fulfilment of the $m_{if} \ge m_{ia}$. If the IMC receives a signal from the PD of the i^{th} employee (who is in the rest mode) about the gradual decrease in the FPS being monitored, relative to the ω values, the IMC considers that the condition $m_{if} \ge m_{ia}$ is met and the PCD continues to work in the standard "continuous monitoring" mode. At the moment of the end of the current

rest mode, the PCD sends a message to the PD of the i^{th} employee about the need to complete the rest mode and switch to the work mode.

In case of non-compliance with the $m_{if} \geq m_{ia}$ (the employee violates the rest regime, or the qualitative characteristics of such rest do not in fact provide a decrease in the PIS relative to ω), the ASRM switches to the "continuous monitoring and operational correction" mode, while the PCD immediately sends a simultaneous signal to the PD of the i^{th} employee (who is in the rest regime) and the PD of the manager and/or responsible person to implement individual intervention measures (in accordance with the recommendations of the 8 Guidelines) in order to intensify the implementation of the $m_{if} \geq m_{ia}$ condition.

As can be seen, the proposed directions for solving the tasks of implementing the Plan-Do-Check-Act procedures assume that the results of solving the previous task are criteria for implementing the next one. Thus, the r_a, value, which is obtained from the solving task results (5) under constraint (6), is a criterion (2) for the successful solution of task (12). In turn, the solution of (12), provides an opportunity to establish criteria (i.e. the a_{ia} and m_{ia} values) for the successful implementation of the following Check-Act procedures (which assume the fulfilment of the $a_{if} \leq a_{ia}$ and $m_{if} \geq m_{ia}$ conditions. Thus, the methodological support of the Plan-Do-Check-Act procedures, which will be developed within the framework of the proposed directions, will not only allow ***solving the identified urgent problem*** of the need to develop methodological success factors, but will also provide a systematic approach to the implementation of the ORMP by organisations, given the existing links between the results of each of the procedures. Developing methodological support (Models) for Plan and Do to solve tasks (5 and 12) on the implementation of Plan and Do procedures, as well as ASRM for the implementation of Chek-Act procedures of the ORMP is a ***promising direction*** of development of this research.

Conclusions. According to the results of the analysis of statistical data, it was established that modern occupational health and safety management systems are not able to equally effectively minimize occupational risks arising from the effect of negative factors of different kinds on the employee. The least effective of these systems relates to the minimisation of psychosocial risks. One of the main reasons for this inefficiency has been demonstrated to be the failure of the organisation to develop the necessary methodological success factors, in line with ISO 45001:2018 and ISO 45003:2021. This is due to the practical lack of methodological support needed to implement the planning process and the imperfection of the existing methodological support of the Do procedure and existing approaches to implementing the Check-Act procedures within the framework of which the process of managing these risks is carried out.

Based on the research results, it has been identified and justified (taking into account the ISO 45001:2018 and ISO 45003:2021 recommendations) that the focus should be on developing an optimization model where the criterion is the cost of the organization costs for developing measures to prevent cases of mental health damage, and the limitation is the (desired) low level of psychosocial risk established by the organization. The direction of improving the methodological support of the Do procedure (taking into account the recommendations of ISO 31010:2019) is the development of a stochastic model for finding the marginal distribution of Markov's process with demolition, which describes the random fluctuation of the level of accumulation of negative impact in the employee's body of psychosocial negative factors during a work shift. The direction of improving approaches to implementing Check-Act procedures is the development of an automated system with functions of constant monitoring of the parameters' values of the accumulation intensity of negative impact of psychosocial factors in the employee's body (during working hours) and the derivation of the consequences of such impact (during non-working hours), as well as prompt correction of the values of such parameters in case they exceed the established standards.

According to the results of the study, it was determined and substantiated (taking into account the recommendations of ISO 45001:2018 and ISO 45003:2021) that the direction of improving the methodological support of the Plan procedure is the development of an optimization model, in which the minimization criterion is the organization's costs for developing measures to prevent cases of mental health damage, and the limitation is the (desired) low level of psychosocial risk established by the organisation. The direction of improving the methodological support of the Do procedure (taking into account the recommendations of ISO 31010:2019) is the development of a stochastic model for finding the marginal distribution of a Markov process with demolition, which describes the random fluctuation of the level of accumulation of negative impact in the employee's body of psychosocial negative factors during a work shift. The direction of improving approaches to implementing Check-Act procedures is the development of an automated system with functions of constant monitoring of the parameters' values of accumulation intensity of the negative impact of psychosocial factors in the employee's body (during working hours) and the derivation of the consequences of such impact (during non-working hours), as well as prompt correction of such parameters' values in case they exceed the established standards.

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Напрями удосконалення методологічного забезпечення процесу управління психосоціальними ризиками

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Мета. Визначити й обґрунтувати напрями удосконалення методологічного забезпечення процедур Plan-Do-Check-Act процесу управління психосоціальними ризиками (ПУПР) для підвищення ефективності прогнозування й попередження виникнення випадків ушкоджень ментального здоров'я (УМЗ) у працівників.

Методика. Аналіз нормативно-правових документів і науково-технічної літератури із проблематики управління психосоціальними ризиками – для визначення й актуалізації мети й завдань дослідження; ймовірнісно-статистичні методи та теорія марківських процесів – для розробки напрямів удосконалення методологічного забезпечення про-

цедур Plan і Do ПУПР відповідно; метод формалізації – для удосконалення підходів реалізації процедур Check-Act ПУПР.

Результати. Запропоновано для реалізації процедури Plan застосувати оптимізаційну модель, що дозволить знайти мінімально необхідний обсяг ресурсів на розробку заходів безпеки, що із заданою ймовірністю унеможливлять виникнення випадків УМЗ у працівника на горизонті планування. А для реалізації процедури Do – стохастичну модель, що дозволить оцінити ймовірність неперевищення рівня накопичення негативного впливу психосоціальних факторів (ПСФ) в організмі працівника в довільний момент часу протягом робочої зміни, з урахуванням випадкових характеристик такого впливу. Для реалізації процедур Check-Act запропоновано застосувати автоматизовану систему із функціями постійного моніторингу значень параметрів накопичення негативного впливу ПСФ в організмі працівника й виведення наслідків такого впливу, а також оперативного корегування значень таких параметрів у разі перевищення ними встановлених нормативів.

Наукова новизна. Уперше сформульовані (у математичних термінах) завдання реалізації процедури Plan ПУПР як завдання мінімізації витрат на розробку заходів із запобігання випадкам УМЗ при обмежені на задану ймовірність настання таких випадків. А також, процедури Do – як завдання знаходження граничного розподілу випадкового марківського процесу зі знесенням, параметри якого описують стан працівника й рівень накопичення в його організмі негативного впливу ПСФ протягом робочої зміни. Визначені принципи здійснення постійного моніторингу та оперативного корегування характеристик такого впливу.

Практична значимість. Визначені напрями є основою для розробки удосконаленого методичного забезпечення процедур Plan-Do-Check-Act ПУПР у рамках подальших досліджень.

Ключові слова: *охорона праці, психосоціальний ризик, ISO 45003:2021, ментальне здоров'я, психосоціальні фактори, моделювання*