High risk, no fun.

Improving Psychosocial Risk Management in Theory and Practice

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Table of Contents

One in a hundred.

For more educational equality.

Danksagung

Viele Menschen haben mich in den letzten Jahren auf diesem Weg begleitet. Mein größter Dank gilt zuallererst meiner Familie, meiner Partnerin und all meinen Freunden. Danke dafür, dass ihr an meiner Seite seid. Ohne viele Worte zu verlieren, möchte ich Euch allen für die langjährige Unterstützung danken. Ohne Euch wäre ich heute nicht da, wo ich bin.

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In Gedenken an René Reynartz.

List of Tables

List of Figures

List of publications as part of the thesis

Taibi, Y., Metzler, Y. A., Bellingrath, S., & Müller, A. (2021). A systematic overview on the risk effects of psychosocial work characteristics on musculoskeletal disorders, absenteeism, and workplace accidents. *Applied Ergonomics, 95*(22), 103434. https://doi.org/10.1016/j.apergo.2021.103434

Taibi, Y., Metzler, Y. A., Bellingrath, S., Neuhaus, C. A., & Müller, A. (2022). Applying risk matrices for assessing the risk of psychosocial hazards at work. *Frontiers in Public Health, 10,* 310. https://doi.org/10.3389/fpubh.2022.965262

Taibi, Y., Müller, A., Bellingrath, S., Neuhaus, C. A., & Metzler, Y. A. (2023). Managing psychosocial hazards in the workplace: How to link Frequency and Severity using Risk Matrices. *Safety Science*. Manuscript submitted for publication.

Abstract in German

Die Gefährdungsbeurteilung arbeitsbedingter psychosozialer Risiken ist seit der Einführung durch den Europäischen Rat ein verpflichtender Bestandteil im Arbeitsschutz. Die Umsetzung auf nationaler und internationaler Ebene ist nach wie vor unzureichend, trotz eindeutiger Belege, dass psychosoziale Gefährdungen Risikofaktoren für ein breites Spektrum somatischer und psychischer Gesundheitsfolgen darstellen. Organisatorische Akteure sind mit komplexen Bewertungsproblemen konfrontiert, die ohne fundierte Forschung, insbesondere im Bereich der Risikoevaluation, nicht gelöst werden können. Die vorliegende Dissertation bietet daher einen Leitfaden zur Verbesserung des psychosozialen Risikomanagements in Theorie und Praxis. Der Schwerpunkt liegt auf der Überprüfung und Bewertung etablierter Ansätze und der Entwicklung weiterer Möglichkeiten für eine valide Risikoevaluation.

Die erste Studie untersucht in einem Meta-Review den Zusammenhang zwischen psychosozialen Gefährdungen und Muskel-Skelett-Erkrankungen, Fehlzeiten und Arbeitsunfällen. Auf diese Weise können möglicherweise unberücksichtigte Gefährdungen identifiziert werden, die einen Zusammenhang zu bisher wenig untersuchten gesundheitlichen Auswirkungen darstellen. Hohe Arbeitsanforderungen, die Kombination aus geringem Handlungsspielraum und hoher Arbeitsanforderung, eine hohe Gratifikationskrise und eine geringe soziale Unterstützung erhöhen nachweislich das Risiko für Muskel-Skelett-Erkrankungen. Zusätzlich erwies sich auch eine geringe wahrgenommene Fairness als Risikofaktor für Fehlzeiten. Für ein erhöhtes Unfallrisiko hat die Studie aufgrund der geringen Anzahl verfügbarer Studien keine ausreichende Evidenz ermittelt.

In der zweiten Studie wird untersucht, inwieweit sich der Risikomatrixansatz zur Beurteilung psychosozialer Gefährdungen adaptieren lässt. Bei diesem Ansatz wird das Risiko als Kombination der Eintrittswahrscheinlichkeit einer Gefährdung und der möglichen Schadensschwere berechnet. Für die Adaption wird die Schadensschwere auf Grundlage gängiger psychologischer Theorien in verschiedene Kategorien eingeteilt. Die Klassifizierung der Eintrittswahrscheinlichkeit von Gefährdungen erfolgt durch statistische Verfahren. Die Risikomatrix ermöglicht die Berücksichtigung potenziell unterschiedlicher Risikowirkungen von Gefährdungen, unterschiedlicher Schweregrade und eines empirischen Zusammenhangs zwischen Gefährdungen und gesundheitlichen Auswirkungen. Dadurch kann die Risikomatrix dabei unterstützen, bestehende Defizite etablierter Ansätze der Risikoevaluation zu überwinden.

In der dritten Studie wird eine empirische Untersuchung des vorgeschlagenen Risikomatrixansatzes anhand einer Stichprobe von Beschäftigten eines großen deutschen Stahlunternehmens (N=7.242) durchgeführt. Die Ergebnisse werden in eine 4 x 3-Risikomatrix

übertragen, die verschiedene Stufen der Eintrittswahrscheinlichkeit mit unterschiedlichen Graden der Schadensschwere in Kombination setzt. Die Analyse der Studie zeigt, dass für die meisten Gefährdungen das Risiko für negative gesundheitliche Folgen mit zunehmender Eintrittswahrscheinlichkeit ansteigt. Starke Effekte werden für Arbeits- und Umgebungsbedingungen, konkurrierende Anforderungen in Arbeits- und Privatleben und emotionalen Anforderungen in Bezug zu Burnout Symptomen festgestellt. Aufgrund der Übereinstimmung mit bestehenden Forschungsergebnissen, liefert die Studie einen ersten Hinweis auf eine zufriedenstellende Validität des Ansatzes. Die Studie zeigt außerdem, dass sich die Risikowirkung der untersuchten Gefährdungen unterscheidet und eine Priorisierung bei der Risikobewertung erforderlich ist.

Die Dissertation untermauert empirische Erkenntnisse bestehender Zusammenhänge zwischen psychosozialen Gefährdungen und Muskel-Skelett-Erkrankungen, sowie krankheitsbedingten Fehlzeiten. Durch die Darstellung der theoretischen und methodischen Schritte, die zur Umsetzung des Risikomatrixansatzes notwendig sind, zeigt die Dissertation, dass der Ansatz grundsätzlich zur Beurteilung psychosozialer Gefährdungen geeignet ist. Zudem liefert die Dissertation erste Belege für die Validität der Risikomatrix. Darüber hinaus zeigt die Arbeit, dass sich vor allem direkte oder indirekte nicht-klinische Gesundheitsindikatoren für die Risikoevaluation eignen. Um zu prüfen, welche weiteren gesundheitsbezogenen Outcomes geeignet sein können, sollte zukünftige Forschung zu weiteren Outcomes intensiviert werden. Darüber hinaus sollten weitere Studien zur Bewertung der methodischen Qualität und Anwendbarkeit des Risikomatrixansatzes in Betracht gezogen werden. Um die psychosoziale Gefährdungsbeurteilung weiterzuentwickeln, sind außerdem Forschungsarbeiten zu nichtlinearen und Dosis-Wirkungs-Beziehungen erforderlich.

Abstract in English

Risk assessment of work-related psychosocial hazards has been a mandatory part of supervisory duties since the introduction of the European Council. Implementation at national and international level remains insufficient despite the strong evidence that psychosocial hazards are risk factors for a wide range of somatic and mental health outcomes. Organisational stakeholders encounter complex assessment problems that cannot be solved without well-founded research, especially in relation to risk evaluation. The present thesis provides a guidance for improving psychosocial risk management in theory and practice. The focus is on reviewing and evaluating established approaches to risk evaluation and exploring further possibilities for valid risk evaluation of psychosocial hazards.

The first study provides a meta-review on the relationship between psychosocial hazards and musculoskeletal disorders, absenteeism, and workplace accidents. In this way, additional hazards can be identified that may not have been considered in the risk assessment so far, because there is a risk to previously less researched health-related outcomes. High job demands, high job strain, high effort-reward-imbalance and low social support showed strong evidence to increase the risk for musculoskeletal disorders. In addition, low perceived fairness proved to be a risk factor of absenteeism. The study identified insufficient evidence of an increased risk of accidents due to the small number of available studies.

The second study adapts the risk matrix approach from physical onto psychosocial hazards. The approach calculated risk as a combination of the frequency of a hazard and the severity of harm. The adaption is conducted by developing different categories of severity based on psychological theories of healthy work design and classifying the frequency of hazards through statistical procedures. The risk matrix allows the consideration of potential differential risk effects of hazards, different levels of severity of harm, and an empirical relationship between psychosocial hazards and health-related effects within the risk assessment. With that, the risk matrix approach is geared towards overcoming serious shortcomings of established frameworks for psychosocial risk evaluation.

The third study conducts an empirical investigation of the proposed risk matrix approach using a sample of employees of a large German steel company (N=7,242). Results are transferred to a 4 x 3 risk matrix that gradually associates levels of frequency with levels of harm. The analysis of the study shows that most hazards cause their level of risk to increase considerably with an increase in frequency. Strong effects are found for environmental conditions, work privacy conflict and emotional demands in relation to burnout symptoms. The results provide a first indication of the satisfactory validity of the approach due to the concordance with previous research findings.

The study further indicates that the risk impact of the hazards differs, and therefore, prioritisation in risk assessment is necessary.

The thesis strengthens the empirical evidence on the relationship between psychosocial hazards and musculoskeletal disorders and sickness absence. By presenting the theoretical and methodological steps necessary to implement the risk matrix approach, the thesis demonstrates that it is possible to assess psychological risks using this approach and provides initial evidence of its validity. In addition, the thesis showed that direct or mediated non-clinical health indicators of well-being are particularly promising outcomes to assess psychosocial risk. To consider which other health-related outcomes may be relevant for risk assessment, further research on additional outcomes should be intensified. In addition, further studies to assess methodological quality and applicability of the risk matrix approach should be considered. Finally, research on non-linear and dose-response relationships is needed to further develop psychosocial risk assessment.

1 Introduction

Excluding weekends and absences due to holidays, most working people spend half of their lives at their workplace (Kompier, 2005). This illustrates how working conditions can affect psychological and physical behaviour of the work force. This influence continues to affect employees after the work period itself. There have been numerous changes in working conditions over the past decades that can have an impact on the behaviour and experience of the workforce, but particularly on the health and safety. Identified key trends are increased internationalisation and competition, new technologies, changed configuration of workplace and flexibility, and organisational restructuring such as downsizing and outsourcing (e.g., Goudswaard & de Nanteuil, 2000; Kompier, 2006; Koukoulaki, 2010; National Institute for Occupational Safety and Health, 2002). Rapid advances in automation and artificial intelligence and the changing working conditions of industry 4.0, where people are forced to learn new, everyday tasks in combination with high-tech gadgets, also have an impact on the health and safety (Tay, Chuan, Aziati, & Ahmad, 2018). The projected development of the World Economic Forum (2020) show that the pace of technology adoption is expected to remain unabated and may accelerate in some areas. The future of work has already arrived for a large majority of online white-collar workforce, deepening existing inequalities between lower wage workers and high-paid professions. One consequence of this rapid development is an increase in working conditions with psychosocial effects and, associated with this, an increased prevalence of psychosocial risks (Niedhammer, Chastang, Sultan-Taïeb, Vermeylen, & Parent-Thirion, 2013; Russo et al., 2021).

While not all aspects of a changing work environment have evidence on direct effects on occupational safety and health there is growing evidence that certain aspects of the work environment can have a negative impact to health and safety (Koukoulaki, 2010). Above all, the studies on the effects of psychosocial hazards on mental and physical health are unambiguous. There is strong evidence that work-related psychosocial hazards are risk factors for a wide range of somatic and mental health outcomes, as well as safety outcomes like accident rates (e.g., Jain, Torres, Teoh, & Leka, 2022; Leineweber, Marklund, Aronsson, & Gustafsson, 2019; Leka & Jain, 2010; Niedhammer, Bertrais, & Witt, 2021; Taouk, Spittal, Milner, & LaMontagne, 2020). To ensure a safe working environment, prevent possible accidents and health impairments and maintaining work ability is essential for employees and employers (Burr et al., 2022) as the impact of existing psychosocial risks on workforce health is immense. Hassard, Teoh, Visockaite, Dewe, and Cox (2018) estimated the cost of lost productivity due to of work-related stress between 221 million and 187 billion US dollars across identified studies from different regions of the world.

Employers are therefore expected to systematically assess psychosocial risks and reduce them as much as possible (Antoni, Beck, & Schütte, 2022). To address challenges arising from psychosocial hazards, several policies for the integration of psychosocial risks into laws have been implemented at the international, regional, and national levels (ILO – International Labour Organization, 2016). Studies examine the effects of policies indicate that the presence of national stress legislation is associated with more enterprises having a work-related stress action plan (Jain et al., 2022). But while the assessment of physical risks (e.g., toxins, noise, or heat) is a well-established measure, the survey data show that the assessment of psychosocial hazards is only insufficiently implemented (Eurofound and EU-OSHA, 2014; Schuller, 2019).

Explanations about the changing nature of work and the increasing relevance of psychosocial risks are not entirely new and have been addressed in numerous publications. Legislation and research results have contributed to the fact that the topic is receiving more attention. However, despite the research findings and legislation, the implementation of psychosocial risk assessment is still inadequate. Even though there has been a considerable increase in knowledge there is still little empirical evidence on what and how companies do in this regard and the challenges and problems they encounter (Antoni et al., 2022). A major barrier in conducting psychosocial risk assessment still seems to be a lack of methodological expertise, the sensitivity of the issue, lack of resources and lack of training (Eurofound and EU-OSHA, 2014; European Agency for Safety and Health at Work, 2010; Leka, Jain, Widerszal-Bazyl, Żołnierczyk-Zreda, & Zwetsloot, 2011). Due to ambiguous conceptualizations and approaches, uncertainties arise during implementation (Bamberg & Mohr, 2016; Ferreira & Vogt, 2022; Schuller, 2019). Nevertheless, there is a great demand for individuals, society and companies not only to maintain but also to improve physical and mental health by preventing psychosocial risks (Ferreira & Vogt, 2022).

1.1 Aims of this Dissertation

To address the described research gap, this thesis provides guidance for improving psychosocial risk management in theory and practice. In the theoretical part of the thesis (Chapter 1), the terminology related to psychosocial risk assessment is classified, as existing inconsistencies lead to difficulties in understanding and comparability between different disciplines and within occupational psychology. The risk assessment process is then described, and the methodological particularities of psychosocial risk assessment are discussed. Detailed knowledge of the methodological challenges helps to ensure that they can be better addressed. The empirical part of the dissertation (Chapter 2), consisting of three papers, firstly examines an overarching empirical

review to increase knowledge of the risk effects of psychosocial hazards on musculoskeletal disorders, sickness absence and work-related accidents conducting a systematic literature meta-review. In this way, additional hazards can be identified that may not have been considered in the risk assessment so far because there is a risk to previously less researched health-related outcomes. From an occupational safety and health perspective, the priority is to identify specific hazards that are associated with a health risk at all. In this way, it can be determined which hazards-harm relationships are empirically well established and should therefore be the focus of the risk assessment.

The following two contributions (Chapter 2.2 & 2.3) address the risk evaluation of psychosocial hazards. How to evaluate the likelihood of a health-risk occurring from psychosocial hazards and how results can be translated into actionable information is still scarcely researched (Gaskell, Hickling, & Stephens, 2007; Hudson, 2016; Metzler, Groeling-Müller, & Bellingrath, 2019; Taibi, Metzler, Bellingrath, Neuhaus, & Müller, 2022). Numerous approaches and associated instruments are available to both assess and evaluate psychosocial hazards. This variety affects the possibilities in risk reduction, the critical step in which the transition from analysis to action is made. Incorrect evaluation can lead to overestimation or underestimation of health risk, and it is precisely an underestimation of risk that leads to potentially health-endangering working conditions not being adjusted. To support researchers and practitioners it is necessary to examine the validity of different risk estimators. Understanding how risk evaluation can be conducted in a more standardized way is important to improve psychosocial risk management. The thesis aims to promote both health and well-being by focusing on the crucial stage of risk evaluation of psychosocial hazards. Therefore, an overview and a crude quality assessment of existing approaches to risk evaluation will be conducted first (Chapter 1.3.2). Based on this, the risk matrix, a previously established but scarcely investigated and used approach for psychosocial risk assessment, is theoretical developed and empirical examined (Chapters 2.2 & 2.3). The thesis shows that the risk matrix approach can be used for psychosocial risk assessment and offers advantages over previously established approaches. Therefore, this thesis provides an approach on how risk evaluation of psychosocial hazards can be best performed.

In summary, the focus of this thesis lies on the examination and assessment of established approaches to risk evaluation and to explore further possibilities for validly evaluating the health risk of psychosocial hazards. Given the low implementation rate, mainly due to a lack of methodological knowledge, the thesis aims at providing a guidance for improving psychosocial risk management in theory and practice with focus on risk evaluation. As this thesis is publication-based, each analysis is presented in the style of a manuscript for publication with its own

introduction, results, and discussion section. The last part of this thesis provides a general discussion linking the findings and implications of all three analyses. Furthermore, implications for applied science, discussing the impact of the analyses and research opportunities are presented. A conclusion outlines the future relevance of the topic.

1.2 Theory of occupational stress

The field of occupational stress research concludes a variety of differing constructs and a wide ranged terminology. The succeeding subsections first addresses the used terminology in this field. Second the theoretical framework of the interdependencies between psychological hazards and possible health-, organisational- and personality-related effects will be presented. This is to enhance understanding of necessary steps conducted in psychosocial risk management.

1.2.1 Terminology

The terminology used in medical, sociological, psychological, and risk research led to inconsistent definitions and use of terms (e.g., Cox & Griffiths, 2010; Oesterreich, 2001; Ulich, 2005). As different terms are often used for similar issues and to provide an overview, the most common terms are briefly described below. Overall, a distinction must be made between indicators from the work environment (or predictors, causes) and associated effects (or outcomes) on the health and safety of employees. For indicators, the terms *psychosocial work characteristics*, *psychosocial factors*, *psychosocial working environment* or *psychosocial hazards* are used. *Psychosocial work characteristics* describe task- and/or organizational-level aspects of the work environment which effects can be explained by psychological processes (Taibi, Metzler, Bellingrath, & Müller, 2021). Whereas the definition for *psychosocial factors* in the Encyclopaedia of Occupational Health and Safety provides a more in-depth description:

> These conditions, which are commonly referred to as psychosocial factors, include aspects of the job and work environment such as organizational climate or culture, work roles, interpersonal relationships at work, and the design and content of tasks (e.g., variety, meaning, scope, repetitiveness, etc.). The concept of psychosocial factors extends also to the extra-organizational environment (e.g., domestic demands) and aspects of the individual (e.g., personality and attitudes) which may influence the development of stress at work. Frequently, the expressions work organization or organizational factors are used interchangeably with psychosocial factors in reference to working conditions which may lead to stress (Hurrell, Levi, Murphy, & Sauter, 2011).

The explanation shows the difficulty in defining the terms, as *psychosocial factors* are considered to be interchangeable with work organization, and also include individual aspects (Rugulies, 2019). Therefore, Rugulies (2019) proposes using the term *psychosocial working environment* instead, describing it „as an intermediate step in a causal pathway linking economic, social, and political structures with health and illness through psychological and psycho-physiological processes" (Rugulies, 2019, p. 3). In risk research, the term *psychosocial hazard* is used to describe indicators that potentially impairing employees' health and well-being (Cox & Griffiths, 2002). This may represent any *psychosocial work characteristic* or *psychosocial factor* as part of the *psychosocial work environment.* The WHO defines health as a state of complete physical, mental, and social well-being (World Health Organization, 2006). Therefore, when addressing the potential consequences of work indicators, a wide range of effects on the safety and health of workers must be considered.

To establish a substantive link to risk research and to summarize possible effects under one term, all adverse consequences of a *hazard* for the health and safety are defined as *harm*. For consistency of understanding, the term *psychosocial hazard* for potentially adverse indicators of the *psychosocial work environment* and *psychosocial harm* for health-related effects will be used uniformly in the further course of this thesis. These terms are commonly used in risk research and since the focus of this thesis lies on psychosocial risk management, the use of research-related terms is more suitable. Figure 1 illustrates the used terms within the *psychosocial work environment* using the framework proposed by Rugulies (2019). Therefore, *psychosocial work environment* is not limited to individual experiences but includes also macro- and meso-level structures that determine and shape the *psychosocial work environment* (Rugulies, 2019). The terms *hazard* and *harm* used in risk research have been assigned to the different elements of the framework for a better understanding of the terminology.

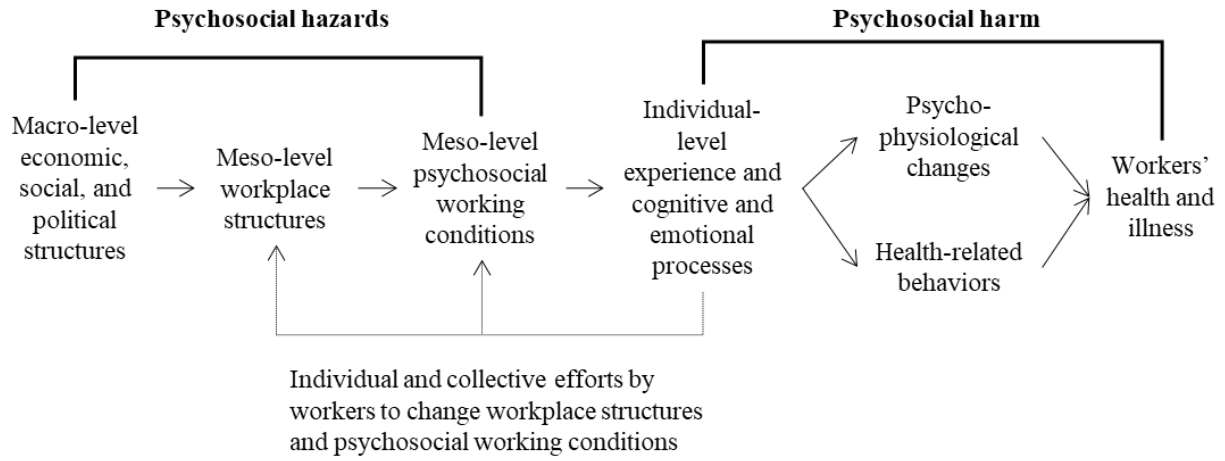

Figure 1. A conceptual framework for psychosocial work environment and health.
Adapted and modified from Rugulies (2019, p. 2). Mapping the terms *psychosocial hazard* and *harm* to psychosocial work environment has been added to facilitate understanding the terminology.

1.2.2 Acknowledged theories on work stress and work design

In work and organisational psychology research, various models have been established that examine psychosocial hazards and certain combinations of these hazards regarding effects on the health and personality of the workforce, including the consequences for performance. The significant impact of these models, especially on health, is meanwhile scientifically undisputed. Jain et al. (2022) summarised empirical studies that found evidence of effects on cardiovascular disease (e.g., Eller et al., 2009; Kivimäki et al., 2012), musculoskeletal disease (e.g., Rau & Buyken, 2015; Taibi et al., 2021) depression and anxiety (e.g., Madsen et al., 2017), and mortality (e.g., Taouk et al., 2020). Furthermore, effects have been found for sickness absenteeism (e.g., Amiri & Behnezhad, 2020; Russo et al., 2021), presenteeism (e.g., Navarro, Salas-Nicás, Moncada, Llorens, & Molinero-Ruiz, 2018) and early retirement due to disability (e.g., Leineweber et al., 2019). Currently, it is assumed that the relationship between psychosocial hazards and health-related outcomes is not direct but mediated or moderated by intervening variables such as coping mechanisms (e.g., Cox, Griffiths, & Rial-Gonzalez, 2000). For a better understanding of these mechanisms, the most established models are briefly explained in more detail.

The *job demands-resources model* (Demerouti, Bakker, Nachreiner, & Schaufeli, 2001) considers that occupational risk factors can be classified in job demands and job resources. Job demands refer to aspects that require physical and/or psychological effort (e.g., high work pressure, unfavourable physical environment, or emotionally demanding interactions). Job

resources refer to physical, psychological, social, or organizational aspects of the job that contribute to the achievement of work goals, reduce job demands or promote personal growth (Bakker & Demerouti, 2007). The model assumes two psychological processes for the development of job strain and motivation. The first is a health impairment process promoted by chronic job demands. This leads to an exhaustion of psychological and physical resources and therefore to health impairments. The second is a motivational process that constitutes that job resources have motivational potential and lead to high work engagement, low cynicism, and high work performance. Empirical studies of the model show significant positive effects for job demands on burnout and job resources on work engagement (Bakker & Demerouti, 2007). The basic structure of the model is maintained even when it is applied in different national and occupational contexts, when different methods of data collection are used, and when different measures are used to assess key variables (Llorens, Bakker, Schaufeli, & Salanova, 2006). Since job demands and resources can basically be identified in all occupational settings, the *job demands-resources model* can be regarded as an overarching model that can be applied in various contexts, regardless of the respective requirements (Llorens et al., 2006). Depending on which model is used, the operationalization of demands and resources as well as the cause-effect relationship and the outcomes considered differs.

The *job demands-control model* (Karasek, 1979) for example considers the extent of job demands and the degree of a decision-making latitude as a resource for dealing with these demands. Employees who are exposed to high quantitative demands (e.g., high time pressure) without having sufficient control and decision-making autonomy over the execution of their tasks are at particular risk to their health (high-strain jobs). Activities with high demands and high levels of job control are supposed to have a positive effect on employees, as they promote development potential. The model was enlarged to the *job demands-control-support model* (Johnson & Hall, 1988). According to this model, the lack of social support can increase the health risk (iso-strain: high demands-low control-low social support), or social support can reduce the detrimental effect on health. Although the literature gives considerable empirical support for the effects of high-strain and iso-strain, support for the moderating influence of job control and social support is less consistent (van der Doef & Maes, 1999).

Another relevant work-related health model is the *effort-reward imbalance model* (Siegrist, 2009). The model focuses on the imbalance between the effort expended and the rewards received. Rewards as a resource include not only wages or salary, but also opportunities for promotion, job security, and non-material recognition and appreciation by significant others (especially supervisors). The imbalance can also be reinforced and maintained by factors inherent in the

working person if the professional coping behaviour is determined by an excessive willingness to expend effort. In terms of stress theory, the disappointed reward expectations highlighted in the model address the central psychological need for social recognition in the context of performance. The model implies the assumptions that high efforts in combination with low rewards increase the risk of poor health, a high level of overcommitment may increase the risk of poor health, and employees reporting an extrinsic effort-reward imbalance and a high level of overcommitment have an even higher risk of poor health (van Vegchel, Jonge, Bosma, & Schaufeli, 2005). Empirical findings of a review (van Vegchel et al., 2005) support the assumption that high efforts in combination with low rewards increase the risk of poor health. Results for overcommitment remain inconsistent and the moderating effect of overcommitment has been scarcely examined (van Vegchel et al., 2005).

According to the *stress-strain concept* (Rohmert, 1986) the term stress is applied to all external influences which lead to changes in behaviour and well-being and is affected by work task, work environment (e.g., climate, noise), and social or psychological factors (e.g., leadership, personal relations, communication). The term strain characterizes immediate effects arising from these influences in consideration of characteristics, abilities, and skills of the individual. Stress can lead to different levels of strain depending on individual abilities or skills and cannot be determined only by the consideration of a specific stressor. The concept was evaluated in different empirical settings with different operationalizations of stress, strain, and job or health related outcomes. It could be shown, for example, that stress (e.g., work overload, low social support, or role conflicts) has a positive effect on exhaustion and exhaustion a negative effect on job satisfaction (e.g., Islam et al., 2018; Koeske & Koeske, 1993; Um & Harrison, 1998).

The *job characteristics model* (Hackman & Oldham, 1976) proposed that the five core job dimensions (autonomy, feedback, skill variety, task identity, and task significance) affect personal and work-related outcomes. According to the model increasing the five core dimensions leads to a stronger experience of meaning, responsibility and knowledge and therefore result in higher job satisfaction, work motivation, and better work performance. The model is an important contribution for work design as it summarizes numerous previous studies by indicating the main characteristics of workplaces that affect the attitudes and behaviour of employees (Wall, Clegg, & Jackson, 1978). Empirical review of the model shows strong empirical support for the relationships between job characteristics and personal outcomes (higher job satisfaction and work motivation) but fails to support the relationship to work outcomes (performance) (Boonzaier, Ficker, & Rust, 2001). A further meta-analysis indicates that job characteristics are related both to psychological and behavioural outcomes (Fried & Ferris, 1987).

The *organisational justice model* (Judge & Colquitt, 2004) states that subjective perceptions of unfair procedures in organisations can lead to health impairments of employees. These subjective perceptions are described as critical psychosocial work characteristics in three areas. Distributive injustice as unfair distribution of relevant resources among organisational members (e.g., unfair distribution of work services). Procedural injustice as unfair treatment in procedural matters in organisations (e.g., complaints from one are taken seriously, dismissed by another) and interactional injustice as experienced injustices regarding manners between organisational members. Empirical analysis show, that high procedural or distributive injustice are associated with increased morbidity (Kivimäki, Vahtera, Elovainio, Virtanen, & Siegrist, 2007).

The *concept of emotion work* refers to the quality of interactions between employees and any person who interacts with an employee (e.g., patients, children, customers, passengers, or guests) (Zapf, 2002; Zapf, Seifert, Schmutte, Mertini, & Holz, 2001). Employees do not only have to perform mental and physical labour but are also required to manage their emotions as a part of their job (Zapf, 2002). Morris and Feldman (1997) defined emotional work as the effort, planning, and control needed to express organizationally desired emotions. That implies that desired emotions are required in situations that do not correspond to actual emotions (e.g., staff must be friendly when they feel exhausted, and the interacting person is rude). Empirical studies so far show that emotion work has negative effects on health when an emotional dissonance exists between inner feelings and the outer expression which persists during the interaction (Zapf, 2002).

The *Challenge-hindrance model of occupational stress* (Cavanaugh, Boswell, Roehling, & Boudreau, 2000) indicates that work-related outcomes are positively or negatively related depending on the stressor being evaluated. Challenge-related self-reported stress (demands that individuals think they can overcome,) is positively related to job satisfaction and negatively related to job search. In contrast, hindrance-related self-reported stress (demands that are more likely to interfere with personal goals and development) is negatively related to job satisfaction and positively related to job search and turnover. Empirical analyses based on the model shows effects for organizational citizenship and counterproductive work behaviour (Rodell & Judge, 2009) or workplace safety (Clarke, 2012). Meta-analyses found significant relationships for work performance and motivation (LePine, Podsakoff, & LePine, 2005) and job attitudes (Podsakoff, LePine, & LePine, 2007).

A relevant theory in the investigation of psychosocial work characteristics is the *action regulation theory* (Hacker, 2003). The meta-theory explains individuals' goal-directed behaviour and its antecedents and consequences in work and organizational contexts (Zacher & Frese, 2017). Task-related workloads can lead to an impairment of action regulation and thus constitute

occupational strain and lead to a loss of well-being. Relevant is especially the completeness of an activity, which is composed of the activity sequence and cognitive functional levels. Several studies on occupational strain and well-being have been conducted based on action regulation theory (Zacher & Frese, 2017). Zijlstra, Roe, Leonora, and Krediet (1999) showed that interruptions lead to a decrease in well-being and employees experience higher levels of effort after interruptions. On the other hand, a diary study showed that problem solving demands were positively related to fatigue, and action regulation strategies mitigated this relationship (Schmitt, Zacher, & Frese, 2012). Yet studies of occupational stress and well-being based on action regulation theory are still relatively scarce (Zacher & Frese, 2017).

1.3 Risk assessment

Risk assessment is a systematic process to combat potential hazards at work and combines three elements: *hazards, harm, and risk* (Clarke, S. & Cooper, C., 2004). As described in Chapter 1.2.1, a psychosocial *hazard* is any psychosocial work characteristic that has the potential to impair the health and well-being of employees (Cox & Griffiths, 2002). The detrimental consequence of a hazard for the health and safety of an employee is defined as *harm*. Based on this approach *risk* can be described as the probability that a *hazard* will cause *harm*, and the severity of that *harm* (Glendon & Clarke, 2018). The systematic assessment of physical risks (e.g., toxins, noise, or heat) is an established measure in occupational safety and health and has contributed to a significant decrease in the incidence of accidents at work (Andersen et al., 2018; Tompa et al., 2016). Explicitly taking psychosocial hazards into consideration within the framework of risk assessment, on the other hand, is relatively new. Different authors or institutions describe how the process of risk assessment needs to be conducted (Clarke, S. & Cooper, C. L., 2004; Health and safety executive, 1997; Joint German Occupational Safety and Health Strategy [GDA], 2022; Nielsen, Randall, Holten, & González, 2010; Rick & Briner, 2000). It should be noted that the German Occupational Health and Safety Act has special regulations for psychosocial risk assessment regarding the terminology used. Despite the definition of the terms at national, European, and international level in DIN EN ISO 10075-1 (International Organization for Standardization, 2015), the used terminology is not uniformly understood and described (Ferreira & Vogt, 2022). The concept differences between *mental stress* as external influences affecting the person mentally and *strain* as a reaction of the individual. Factors influencing *mental stress* are external to the individual and the reaction to *mental stress* take place within the individual as a *strain* reaction. The specification that the term *mental stress* can be equated with *hazard* and *strain* with *harm*. This can ensure consistent use and better comprehensibility of terminology for this thesis.

The implementation of the psychosocial risk assessment is based on the same principles as the general risk assessment, which can be described by the following steps (see Figure 2). As psychosocial hazards vary according to the specific type of occupation or depending on work conditions in the organisational area, it is necessary to form units for assessment at the level of occupation or organisational area. The first step is therefore to identify work areas and/or job profiles with comparable exposure rates for which a risk assessment will be carried out. For example, work areas might be production or human resources, and job profiles might be a crane operator or a sales manager. To determine the likelihood and severity of a health risk to employees, the third step is to assess, based on the available screening results, whether the manifestation of a particular psychosocial hazard constitutes a health risk and whether appropriate risk-minimising measures needs to be taken. In the fourth step, risk-minimising measures for the identified hazards are defined and implemented. In the fifth step, the effectiveness of the implemented measures is verified. Finally, the actuality of the risk assessment must be reviewed at regular intervals and revised if necessary.

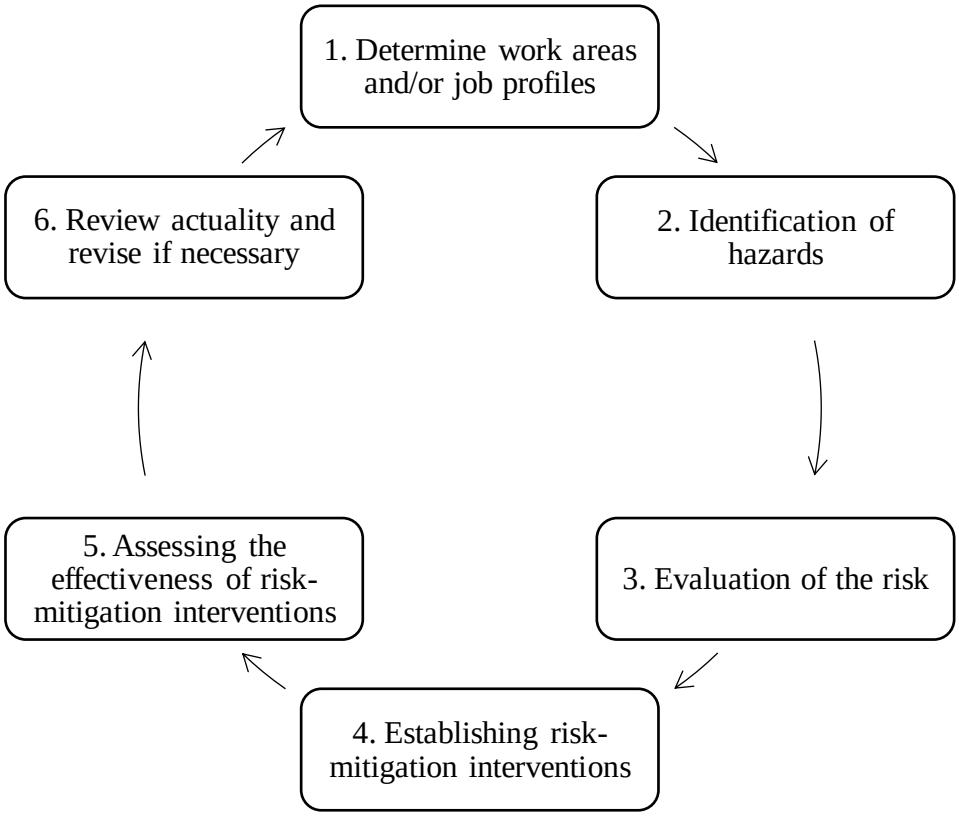

Figure 2. Providing information on procedural steps to be planned for a risk assessment
Own illustration based on the summary of different guidelines (Clarke, S. & Cooper, C. L., 2004; Health and safety executive, 1997; GDA, 2022; Nielsen et al., 2010; Rick & Briner, 2000).

1.3.1 Approaches for hazard identification

The identification of hazards refers to the assessment of working conditions (indicators) and not to the measurement of health-related effects. However, some instruments additionally allow the assessment of health-related effects. In German-speaking regions alone, *N*=89 risk assessment instruments have been identified which provides practitioners with a wide range of different tools (Kersten et al., 2022). In general, three methodological approaches have been established that can be used individually or in combination (Gilbert, Kirmse, Pietrzyk, & Steputat-Rätze, 2020). (1) an employee survey, (2) workplace observation by an expert and (3) assessment by a steering committee. Each method is related to different organisational requirements and is associated with different advantages and disadvantages. The selection of the appropriate method must therefore be made against the background of specific requirements within the organisation. Number of employees, staff capacity and planning, participation of employees, and derivation of measures are aspects that can function as important decision criteria when selecting a suitable method (Gilbert et al., 2020).

The available approaches can be categorized into objective-conditional and subjective-conditional methods (Rau, 2010). The terminology objective and subjective refers to the extent to which the workplace occupant can consciously or unconsciously influence the quality of the assessment (Frese & Zapf, 1994; Kasl, 1998). When surveyed about their perception of psychosocial hazards, the research subject may be influenced by e.g. attitudes, cognitions or motivations of the workplace occupant (Rau, 2010). In contrast, procedures in which psychosocial risks are observed and assessed by an expert are free from the influence of the workplace owner, but may be influenced by the subjective bias of the observer (Böckelmann & Seibt, 2011). The term condition-related refers to the fact that the external work situation, the work organisation, or the task content of an activity has to be assessed when psychosocial hazards are identified and not person-related factors such as cognitive capabilities or coping strategies (Rau, 2010; Richter & Hacker, 1998). There is ongoing debate about the validity of the available approaches, and which should be preferred (e.g., Theorell & Hasselhorn, 2005). Self-report measures are often criticised for problems of common method variance, which can lead to biased correlations or predictions (Buchanan & Bryman, 2011). As alternative to self-reports objective approaches like workplace observations are advertised. However, Kompier (2005) argues that objective methods are not necessarily more valid and therefore not necessarily preferable. For example, workplace observations are not free from individual bias and measurement error. It has also been shown that observer ratings and self-assessments provide comparable results and that both methods are

reliable assessment strategies in the context of psychosocial risk assessment (Schneider, Mädler, & Lang, 2019). Instead of relying on objective methods, the validity of questionnaire instruments can instead be improved by formulating condition-related items (e.g., Spector & Fox, 2003).

A common subjective-condition-based approach to identify psychosocial hazards are (1) employee surveys such as the Copenhagen Psychosocial Questionnaire (COPSOQ; Burr et al., 2019; Pejtersen, Kristensen, Borg, & Bjorner, 2010) or the HSE Management Standard Indicator (Marcatto, Colautti, Larese Filon, Luis, & Ferrante, 2014). Employees rate psychosocial hazards based on pre-formulated items. As there is no single overall value for all psychosocial hazards combined (Hacker, 1995; Nachreiner, 2002; Ulich, 2005), methods assess different aspects of the psychosocial work environment. There is a wide range of survey instruments for assessing the risk of psychosocial hazards. Depending on the questionnaire method used, the characteristics examined either refer to individual models or theories (see Chapter 1.3.2), such as the Job Content Questionnaire (Karasek et al., 1998), which is based on the job-demand-control model (Karasek, 1979). Or a broad measurement approach is taken, combining different theories and models, such as the COPSOQ or the Work Design Questionnaire (Morgeson & Humphrey, 2006). Most legislation and international standards do not specify which hazards should be considered, only that all occupational health and safety risks should be assessed (Leka et al., 2011). As questionnaire methods allow for the participation of all employees and the identification of a wide range of psychosocial hazards, the method is particularly suitable for providing an overview and identifying the most significant areas of psychosocial hazards. Disadvantages arise from the response rate required to maintain anonymity and to obtain reliable results. Furthermore, deriving appropriate risk-mitigating measures, e.g., through moderated workshops, must follow, as the results of the survey initially only provide an overview.

An objective-conditional approach for hazard identification is a (2) workplace observation. Known methods are e.g., Healthy Workplace Screening (Tomaschek, Lanfer, Melzer, Debitz, & Buruck, 2018) or the Instrument for Stress-Oriented Task Analysis (Irmer, Kern, Schermelleh-Engel, Semmer, & Zapf, 2019). Observing employee behaviour and interactions can provide valuable information about psychosocial hazards in the workplace. This can include observing work practices and physical environment, as well as listening to employees' conversations and interactions. One advantage is an independent assessment from the employees' experience. In addition, depending on the method, an exact description of the hazard situation can be implemented. Due to the high time demands, this method is particularly useful for homogeneous job profiles. In larger companies with heterogeneous occupational activities, it can be assumed that the implementation is time-consuming.

A mixed approach is the assessment by (3) a steering committee (see Düsseldorfer Modell, Schröer & Reinhold, 2011). The members of the steering committee are usually employees of the organisational unit, direct managers, safety experts, the works council, and a medical officer. The structure is intended to establish a bridge between the knowledge of the employees and the medical-ergonomic knowledge of the occupational safety and health experts. The committee should identify the psychosocial hazards and derive appropriate measures. The advantage of this approach is that it draws on a wide range of expertise and promotes acceptance of the measures and solutions developed. A disadvantage is that the dynamics of the group discussion may lead to bias.

1.3.2 Approaches for risk evaluation

An important step in the risk assessment process is the evaluation of identified hazards in relation to a potential health risk for the workforce (step 3, Figure 2). Based on screening results, it must be decided whether the manifestation of a certain hazard causes a health-risk and therefore appropriate risk-minimising measures needs to be derived. Evaluation of the data obtained from the risk assessment include the calculation of risk factors and understanding the association between hazard and harm (Clarke, S. & Cooper, C. L., 2004). International or national legislations do not specify how the risk must be evaluated. In addition, there are only a few studies available that provide an overview or examine a comparison of established approaches for risk evaluation. Based on the studies of Dettmers and Stempel (2021), Hudson (2016), Metzler et al. (2019), and Taibi et al. (2022) the following established approaches can be summarized, which will be discussed in more detail in the following section:

1. Uniform cut-off value approach – uniform scale score indicating the probability for all measured hazards as a cut-off value
2. Cut-off value approach – empirical thresholds that distinguish between individuals who reach a critical value of a health-related outcome
3. Reference value approach – Comparison with reference values from internal or external databases
4. Risk-based approaches – such as the Clark & Cooper approach (Clarke, S. & Cooper, C. L., 2004) or the risk matrix approach (e.g., Duijm, 2015; Ni, Chen, & Chen, 2010), which link hazard and harm either quantitatively or qualitatively.

Risk evaluation criteria are important for defining the format of parameters used for the decision making. They define how risks are evaluated and which level of risks are acceptable and

at what point risk-minimizing measures are required (Safedor, 2005). The approaches presented have different advantages and disadvantages for use in risk assessment. It is therefore important to be able to assess whether the used approach meets certain quality criteria. The following quality criteria are proposed for the assessment of the methodological quality:

a) Validity – Risk analyses are necessary when hazards are associated with certain probabilities and consequences. A fundamental requirement for approaches to evaluate the risk of psychosocial hazards to be of sufficient quality is the consideration of the risk definition, which is the probability that harm will be caused by a hazard (see Chapter 1.3). Common theories and empirical findings (as described in Chapter 1.2.2) provide a solid overview of the hazards and harms that need to be considered within the risk assessment. But it is not sufficient to consider hazards that have only theoretical legitimacy or empirical evidence without reviewing direct health effects within the work situation or sample (Clarke, S. & Cooper, C. L., 2004). Therefore, it must also be evaluated whether and to what extent health-related effects found at the population level are also valid for a specific work situation. Thus, the approach must consider possible health-related effects and identifies this relationship validly.

b) Completeness – Psychosocial hazards are often associated with multiple harms, only occur in the context of a specific combination of hazards or health-related effects are time-delayed (see Chapter 1.3.3). These complex mechanisms highlight the need for a differential consideration of various indicators and health-related effects within the risk assessment. The effectiveness of the approach depends on whether the most important hazard-harm combinations are addressed. Not considering these combinations can lead to an underestimation of the risk. To be able to assess the health-risk comprehensively, a systematic evaluation of the effects across different indicators and health-related outcomes is important (Taibi et al., 2022). In this context, the distinction between short-, medium-, and long-term health impairments allows the classification into marginal (i.e., immediate strain), moderate (e.g., medium-term fatigue symptoms), and severe (e.g., long-term clinically diagnosed diseases) outcomes. Which hazards and harms are assessed depends on the chosen hazard identification tool (see Chapter 1.3.1). However, the risk evaluation approach must allow the calculation and integration of different effects.

c) Transparency – The aim of a risk evaluation tool is to ensure a transparent and clear decision process, that is based on best empirical knowledge and reflects the understanding of all involved stakeholders (Duijm, 2015). These stakeholders are generally a risk analyst (expertise provided by, for example, occupational safety specialists, occupational psychologists, or company doctors) decision makers (employers, or managers) and the involved workforce. For decision makers it is important to understand, how the risk was evaluated to clarify the rational basis for

the decision to implement risk-minimising interventions. Thus, the decision maker can accumulate experience with the criteria and which type of risk control options are necessary (Safedor, 2005). Moreover, it is essential to involve the workforce in the process. On the one hand, the risk assessment is often based on employees' assessment of working conditions (e.g., in employee surveys, see Chapter 1.3.1). On the other hand, the workforce will be affected by the changes in working conditions in the form of derived risk-minimising interventions.

d) Execution economy – Depending on the approach, a different degree of know-how, data material and resources is required for establishment and application. Particularly for small and medium-sized enterprises, where fewer resources are likely to be available, the effort must be within reasonable and achievable limits.

In the following section, the presented approaches are explained in more detail and related to the quality criteria for discussing methodological advantages and disadvantages. Table 1 shows an overview of the quality assessment of the examined approaches.

(1) The uniform cut-off approach is based on existing theoretically plausible and empirically proven relationships between hazards and health-related effects. Therefore, it can be anticipated that a risk factor is present if a mean value indicates a high level of tension, amount, pressure, or frequency regarding this hazard. A uniform cut-off value is then set for all hazards, and when exceeded, a need for risk-minimising interventions is indicated. The more employees report an exposure, the greater the probability of that given hazard, with a moderate frequency representing an unacceptable level of risk. Setting the same threshold for all hazards bias the assessment of variables with strong health-related effects even at lower scorings (Metzler et al., 2019) and ignoring varying relationships between different hazards and health-related effects. The values only indicate that there is a health risk, but the cut-off value does not relate to a health-impairment making it meaningless to the actual health risk of employees (Dettmers & Stempel, 2021). Mean values do not provide information on severity of exposure and ignoring direct health-related effects within the work situation. Therefore, the criteria validity and completeness can only be assessed as insufficiently fulfilled. By contrast, the approach does not involve complex calculations and the risk assessment is easy to understand and transparent. Especially if the classification of the values is carried out in analogy to a traffic light system as in ergonomic approaches (Clarke, S. & Cooper, C. L., 2004; Cousins et al., 2004). Therefore, a sufficient execution economy can be expected, and organisational implementation can be expected without major barriers.

(2) The cut-off value approach calculates empirical thresholds in relation to clinically approved health-related measures that differentiate between individuals who reach a critical value

of that outcome. The values indicate the threshold where imminent or chronic adverse health effects are expected for certain psychosocial hazards. For example, ROC analysis can be used in the development of criterion-related cut-off values (e.g., Diebig & Angerer, 2020; Mustapha & Rau, 2019; Zeike et al., 2018). The goal is to determine a threshold that represents an optimal ratio between true-positive rate and false-positive rate to predict a health impairment. This allows the estimation of empirical cut-off values, for example for questionnaire data.

The approach establishes a direct reference to a health-related outcome and thus makes it possible to determine an individual value for all hazards above which a health risk exists. The approach thus enables valid evaluation of the risk, including for a specific work situation. The limitations of this approach in terms of completeness are that the thresholds are often related to only one specific harm (e.g., depression). Previous studies have so far only considered a small number of possible outcomes (e.g., Diebig & Angerer, 2020; Mustapha & Rau, 2019; Zeike et al., 2018). As a result, there may be hazards that have no risk effect on the investigated but on an antecedent harm. Therefore, cut-off values would have to be calculated for all possible hazard-harm combinations or by using an index value combining multiple outcomes. The approach indicates good transparency, as the rules for risk evaluation are based on a simple and comprehensible basis for decision-making. As soon as a value is exceeded, there is a health risk for the corresponding health outcome and risk-minimising interventions need to be derived. Basic statistical knowledge and a comprehensive data material are required for the calculation, especially if numerous cut-off values must be calculated. Therefore, it is to be expected that the implementation is associated with a lower execution economy.

(3) To establish reference values, population-based median or mean values of psychosocial hazards are calculated across different occupational groups and / or sectors in the same company or comparable other companies (e.g., the database of the Copenhagen Psychosocial Questionnaire; Nübling et al., 2011). To apply the reference value-based approach, the concordance of the values with the individually reported exposure rates is compared. Using defined rules for the deviation of the organisational results from the reference value (e.g., a deviation of more than 3 points), psychosocial hazards are selected for which risk-minimising interventions must be derived.

This approach does not provide a theoretical or empirical justification for the evaluation based on deviations of the mean from a reference sample (Rau, 2022). Provided that the database used is established on a valid hazard identification instrument, the hazards investigated are theoretically and/or empirically justified. However, the indication of a health hazard based on a deviation from the reference value is not theoretically justifiable. Furthermore, the use of reference values can lead to wrong conclusions. If the benchmark already indicates hazardous working

conditions the comparison would not indicate any peculiarities, leading to the underestimation of the risk. Therefore, the approach does not fulfil the criterions validity and completeness. As with uniform cut-off values, however, the approach is transparent since rules for the decision to implement risk-minimising interventions are well comprehended. If there is no need to develop a separate database because it is, for example, provided with the used hazard identification tool, sufficient execution economy can be expected. (4) Risk-based approaches like the Clarke and Cooper approach (CCA) or the risk matrix approach (RMA) consider direct health-related effects within the risk assessment by including health-related outcome variables. This allows the calculation of effects between the level of a hazard and a related outcome for a particular sample. The CCA directly incorporates the relationships between hazards and harm, by including the frequency or level of a hazard and the correlation between each hazard and associated health-related outcomes (Clarke, S. & Cooper, C. L., 2004). The RMA divides two dimensions into different levels that represent ascending probabilities or frequency of the hazard and different levels of severity of a harm (Markowski & Mannan, 2008; Ni et al., 2010). The matrix is then displayed as a table that systematically combines different levels of probability or frequency of a hazard with different levels of severity of a harm. The output risk index is calculated by multiplying the two dimensions and each cell of the table shows a specific degree of a risk that indicates the urgency for the derivation of risk-minimising interventions (Cox, 2008).

Both approaches allow for a valid evaluation of risk by considering health-related effects. By classifying different levels of probability and severity, the RMA enables the integration of different hazards and outcomes and thus fulfils the criterion of completeness. The CCA, as with the cut-off value approach, so far refers only to individual outcomes and thus requires the calculation of different combinations or the use of an index value in which several outcomes are combined. Due to the correlative approach, CCA values only allow comparison with other hazards within the sample and does not provide thresholds when there is an obligation to derive measures. In this way the method does not provide a statement about the absolute health risk of a certain hazard (Dettmers & Stempel, 2021). As a result, the method shows deficiencies regarding transparency. The RMA enables a transparent risk assessment due to its tabular and intuitive graphical structure and the classification into different risk levels and the respective necessary instructions for action. Both approaches require sound statistical and expertise knowledge. Extensive data material is required for the calculation, and issues with data privacy may arise when collecting health-related outcomes. Therefore, the execution economy for both approaches can be considered as low.

Table 1

Quality assessment of methodological approaches to evaluate psychosocial risks

	a) Validity	b) Completeness	c) Transparency	d) Execution economy
1) Uniform cut-off	-	-	+	+
2) Cut-off value	+	o	+	o
3) Reference value	-	-	+	+
4.1) Clark and Cooper	+	o	o	-
4.2) Risk matrix	+	+	+	-

Note. +: Fulfils the criterion. o: Partially meets the criterion. -: Does not fulfil the criterion.

1.3.3 Methodological challenges in psychosocial risk assessment

Although the prevalence and impact of psychosocial risks on health and safety of employees is widely acknowledged, there remains resistance in prioritizing psychosocial risk assessment both in business and policy making (Leka, van Wassenhove, & Jain, 2015). As a result, the state of implementation at national and EU level remains insufficient (Beck, 2019; Eurofound and EU-OSHA, 2014; Schuller, 2019). As mentioned in Chapter 1, the primary reasons are methodological difficulties in assessing and prioritising psychosocial hazards and the associated implementation of suitable risk-minimising interventions. Decision-makers are faced with complex assessment and management problems, which leads to the fact that psychosocial hazards cannot simply be integrated into existing physical risk assessment routines (Beck, 2019; Rick & Briner, 2000). Challenge arises from the differences between psychosocial and physical hazards (Rick & Briner, 2000) leading in the following issues:

1) Missing evidence-based threshold values
2) Complex cause-effect relationship
3) Time latency
4) Inverted U-shaped relationships
5) Internal conflicts of goals and interests

While it is possible to identify the level of exposure at which a physical factor (e.g. noise or toxins) becomes hazardous, it is difficult to identify the level at which, for example, role conflict might cause specific harm (Rick & Briner, 2000; Taibi et al., 2022). Research on the calculation of cut-off values is limited so far (see Chapter 1.3.2., cut-off value-based approach). This results

in (1) missing evidence-based threshold values, that allow a valid evaluation of the health risk (Rau, 2022; Taibi et al., 2022). In addition, psychosocial hazards are associated with (2) multiple harms, as the effect of a hazard is often mediated indirectly via psychological processes resulting in a complex cause-effect relationship. Psychosocial hazards sometimes occur only in the context of a specific combination of working conditions (e.g., high demands and low control, Karasek, 1979). For example, it is difficult to specify cause-effect relationships in the interaction of work quantity, task complexity, working time, qualification, and decision-latitude (Beck, 2019; Stab & Schulz-Dadaczynski, 2017). Therefore, it is often not clear which hazard-harm relationship should constitute the criterion for a risk evaluation. Another aspect is the (3) time latency and duration of exposure before psychosocial hazards have an adverse effect on health (e.g., Jonge et al., 2001; Koslowsky, 2008). Whereas effects such as fatigue or irritation occur relatively short-term, the development of mental, cardiovascular, or musculoskeletal diseases is associated with long-term exposure (e.g., Ford et al., 2014; Ulich, 2005). Also, psychosocial hazards do not necessarily have a linear adverse effect on health but (4) inverted u-shaped relationships such as between workload and performance (Anderson, 1976; Bruggen, 2015; Cohen, 1980) or between job control and eldercare workers' work-related well-being (Kubicek, Korunka, & Tement, 2014). It could be assumed, for example, that for low quantitative demands, the health risk increases because employees are underchallenged. The assessment of psychosocial hazards can finally cause (5) conflicts of objectives and interests, as the design of work intensity, for example, influences issues of company performance policy (Kratzer & Dunkel, 2011).

2 Research Paper

The theoretical part presented so far aimed to provide an overview of established terminology and theory in occupational stress research. In addition, the approach and challenges of psychosocial risk assessment were presented, as well as the associated economic implications. The empirical part consists of three papers that examine different aspects of psychosocial risk management and are thematically linked to each other.

The first paper aims to increase the understanding of the effects of psychosocial hazards on health-related outcomes in form of a systematic literature review of reviews and meta- analyses. International research focuses predominantly on systematic findings of psychosocial hazards on mental and cardiovascular health outcomes (e.g., Fishta & Backé, 2015; Harvey et al., 2017; Niedhammer et al., 2021; Nielsen & Einarsen, 2018; Rivera, Akanbi, O'Dwyer, & McHugh, 2020). The contribution of the meta-review of this thesis was therefore to specifically summarise the effects of psychosocial hazards on the less studied outcomes of musculoskeletal disorders, sickness absence and work-related accidents. In this way, additional hazards can be identified that may not have been considered in the risk assessment so far because there is a risk to previously less researched health-related outcomes.

How to evaluate the likelihood of a health-risk occurring from psychosocial hazards and how results can be translated into actionable information is still scarcely researched. Established approaches for risk evaluation show methodological disadvantages. Against this background, the second paper contributes a theoretical development of the risk matrix approach that enables the risk assessment of psychosocial hazards. The risk matrix approach is a traditional hazard analysis technique, but despite the current relevance of the issue, risk matrices for the assessment of psychosocial risks are still scarcely researched. The contribution advances the risk matrix approach as a framework that allows for assessing the relation between psychosocial hazards and harm disregarding which theory of work stress is applied or which tool is used for hazard identification.

The third paper follows the theoretical conception and empirically investigates the risk matrix approach for the risk assessment of psychosocial hazards based on a sample of employees of a large German steel manufacturing company. In the paper the procedure to build a risk matrix approach for assessing psychosocial risks and the advantages against other established methods are discussed. Additionally, the application in an organisational context for selecting and prioritizing psychosocial hazards to further derive risk-minimising interventions is considered.

As this thesis is publication-based, the following analyses have already been published or are currently in the submission or review process. They are presented in the style of a scientific

research manuscript, each comprising a theoretical introduction, an analysis, and results, as well as a discussion section. In accordance with the overarching objective of this work - to develop a practical approach to improve psychosocial risk assessment within the context of applied science - the manuscripts comprise interrelated contributions to the overall process.

2.1 A systematic overview on the risk effects of psychosocial work characteristics on musculoskeletal disorders, absenteeism, and workplace accidents

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Abstract

The present article provides a systematic overview on the relationship between psychosocial work characteristics and musculoskeletal disorders, absenteeism, and workplace accidents. The study identified and reviewed the findings of 24 systematic reviews or meta-analysis and 6 longitudinal studies. Publications were systematically searched in several databases from 1966 to January 2021. To summarize the level of evidence, a best evidence synthesis was performed, and the quality of included studies was rated.

High job demands, high job strain, high effort/reward-imbalance and low social support showed strong evidence to increase the risk for musculoskeletal disorders. In addition to job demands and job strain, low perceived fairness proved to be a risk factor of absenteeism with strong evidence. Due to the small number of studies, no reliable evidence assessment for workplace accidents was possible. The summarized findings can improve risk assessment methods, by providing a systematic estimation of the potential risk severity of psychosocial work characteristics and assist practitioners in further developing the psychosocial risk assessment.

Key words: Psychosocial work characteristics, Risk assessment, Stress

2.1.1 Introduction

From the perspective of occupational safety and health (OSH), it is essential to guarantee a safe working environment. To maintain health and working ability of employees the risk assessment of the work characteristics is indispensable. Risk assessment is a systematic process to address potential hazards arising from work and comprises the three main phases of analysis, assessment, and reduction (Clarke, 2004). During the last years, risk issues became more complex and the need for guidelines to provide a framework for risk assessment more apparent (Jardine et al., 2003). In addition, work characteristics have changed considerably in many occupational fields and the investigation of the risk potential of psychosocial work characteristics is becoming increasingly relevant. High psychosocial work demands or chronic work-related burdens without opportunities for recovery or coping can result in stress and exhaustion and in the long term increase the risk of chronic illness (Demerouti et al., 2001a; Demerouti et al., 2000; Rau and Buyken, 2015; Semmer, 1984).

From the OSH point of view, it is primarily relevant to identify specific work characteristic that are associated with a health risk at all. This focus differs from the epidemiological perspective that aims to determine any cause that increase the risk of a specific disease. To be able to assess the health-risk of specific psychosocial work characteristics comprehensively, a systematic evaluation of the effects across different health-related outcomes is important.

2.1.1.1 Choice of health-related outcomes

Previous studies already provide comprehensive reviews on the empirical evidence of the risk effects of psychosocial work characteristics on mental illness, cardiovascular disease, and diabetes (Rau and Buyken, 2015). From an OSH perspective, it is important to identify further psychosocial work characteristics that are risk factors for major health-related outcomes and are therefore imperative to consider in a comprehensive risk assessment. Musculoskeletal disorders, accidents, and absenteeism are relevant and available key figures for companies to estimate the health and safety of their employees.

Musculoskeletal disorders are injuries or dysfunctions affecting muscles, bones, nerves, tendons, ligaments, joints, cartilages, and spinal discs and are one of the main causes of absenteeism worldwide (Luttmann et al., 2003). Empirical findings conclude that the development of musculoskeletal disorders does not only result from the impact of physical exposures at the workplace but is also associated with psychosocial work characteristics (e.g. Bongers et al., 1993; Feuerstein, 1996; Kraatz et al., 2013; Lang et al., 2012). Widanarko et al. (2014) indicate that

physical and psychosocial factors independently influence musculoskeletal disorders, and that both factors interact. Current models suggests that psychosocial work characteristics impacts musculoskeletal disorders through increases in muscle tension; changes in endocrine, immune, neurological, and vascular systems or higher cognitive processes that alter the perception and evaluation of symptoms (Faucett, 2005).

OSH researchers have recognized the importance of examining the association between psychosocial work factors and accident outcomes. According to the job demands-resources model for example, high job demands lead to a limited capacity for physical and cognitive demands and affect the safety performance of employees (Nahrgang et al., 2011). Thus, adverse psychosocial work characteristics can increase the incidence of accidents. Johnston (1995) reported a four times higher injury rate for people working in stressful conditions and Nahrgang et al. (2011) found a meta-analytic correlation between job demands and occupational accidents, reporting small effect sizes.

In addition, absenteeism is an indicator to assess the well-being of employees and a predictor for health consequences (Marmot et al., 1995). Although the presence of job demands has been linked to increased employee absenteeism (Bakker and Demerouti, 2007) the causes of absenteeism are complex and can be multidimensional. However, empirical evidence shows that psychosocial characteristics can play an important role for higher rates of absenteeism (e.g., Bowling et al., 2015).

2.1.1.2 Aim of this study

The aim was to provide a systematic overview of the available evidence regarding the relationship between psychosocial work characteristics and musculoskeletal disorders, absenteeism, and workplace accidents, to enlarge the knowledge on the risk effects of psychosocial work characteristics. Due to the large variety of data generated by individual studies, the article focuses mainly on available meta-analyses and systematic reviews as these study types present more reliable and precise estimates (Centre for Reviews and Dissemination, 2009) and includes individual studies only after 2017. This restriction ensures a current focus and that several empirical findings on the respective association are available and comparable.

2.1.1.3 Work-related health models

We define psychosocial work characteristics as task- and/or organizational-level aspects of the work environment which effects can be explained by psychological processes. To specify health relevant psychosocial work characteristics, the most acknowledged concepts and theories

on work stress and work design were considered (see for example Parker et al., 2017): the job characteristics model (Hackman and Oldham, 1976), the job demands-control model (Karasek, 1979), and the job demands-resources model (Demerouti et al., 2001b). The job characteristics model states that a high level of work motivation can only arise if a work task considers the characteristics of skill variety, task identity, task significance, autonomy, and feedback. According to the job demands-control model, mental strain is caused by an interaction between (high) job demands and (low) job decision latitude. The job demands-resources model classifies work characteristics into job demands and job resources, with each category triggering a separate process. Job demands initiate a health impairment process and job resources initiate a motivational process.

Other relevant work-related health models are the effort-reward imbalance model (Siegrist, 2009) and the challenge-hindrance model of occupational stress (Cavanaugh et al., 2000). Siegrist (2009) stated that strain is a result of the imbalance between the effort (demands) and reward (resources) one perceives at work. The challenge/hindrance approaches assume that employees perceive work demands as a challenge, or a hindrance and that this subjective assessment determines the health relevance of a work characteristic.

Another relevant theory in the investigation of psychosocial work characteristics is the action regulation theory (Hacker, 2003). Task-related workloads can lead to impairment of the regulation of actions and thus represent a risk of strain. Relevant is especially the completeness of an activity, which is composed of the activity sequence and cognitive functional levels.

Further important concepts are the concept of emotion work (Zapf et al., 2001) and organizational justice (Judge and Colquitt, 2004). Emotional work means that a certain emotional behavior must be shown when working with customers, clients, or patients. Organizational justice describes the individual's and the group's perception of the fairness of treatment received from an organization and their behavioural reaction to such perceptions (Aryee et al., 2002).

2.1.2 Methodology

Before the data extraction started, a protocol was registered at PROSPERO (ID CRD42020154306). PROSPERO is an international database of prospectively registered systematic reviews in health care. The protocol was submitted in November 2019 and finally registered in May 2020. To indicate changes in our search strategy (expansion of the database and inclusion of additional study designs), we updated the protocol in March 2021.

2.1.2.1 Search strategy

To examine the relationship between psychosocial work characteristics and health-related outcomes a systematic literature search was conducted in the four databases PubMed, PsycINFO, PSYNDEX, and the database of the International Labour Organisation (ILO) for studies published between 1966 and January 2021. Additionally, the reference lists of identified studies were subsequently searched. Health-related outcomes were categorized in musculoskeletal disorders (e.g., neck pain, back trouble), absenteeism (e.g., duration of absence) and workplace accidents (e.g., number of accidents). The search strategy was similar in all databases and combined four blocks. The first block was related to psychosocial work characteristics, the second to the selected health outcomes, the third to the work environment, and the last to study design. Appendix A provides the full search strings.

2.1.2.2 Inclusion criteria

Initially, titles and abstracts were screened to articles eligible for further review. The studies were retained for full-text screening if they were fulfilling the following inclusion criteria. All studies had to be conducted in a work-related environment. To ensure the theoretical soundness of research, the psychosocial work characteristics under investigation had to refer to the described models in section 1.3. The measurement included self-reported or observed psychosocial work characteristics. Included outcomes were musculoskeletal disorders, absenteeism, and workplace accidents. The relevant population were employees who are currently working and aged between 18 to 65 years. The study design had to be a meta-analysis or a systematic review and had to be published in peer-reviewed scientific journals written in English or German. This search strategy resulted in N = 5,798 citations. Most of the publications was found in PubMed (N = 5,145), N = 587 were detected in PsycINFO and N = 66 in PSYNDEX. A rerun in July 2020 led to another N = 970 (PubMed), N = 40 (PsycINFO) and N = 6 (PSYNDEX) publications.

Slightly less than half (43%) of the available systematic reviews or meta-analyses that met the inclusion criteria were published between 2000 and 2010 and were therefore older than 10 years. The remaining 57% are from 2010 to 2017. To ensure a more current focus, the methodological framework was expanded. In addition to systematic reviews and meta-analyses, we included case-control, cohort, or longitudinal studies from 2017 onward. Following the recommendations of the National Health and Medical Research Council, only studies with a design that allows a well-founded evidence assessment have been considered (NHMRC, 2000). The additional strategy resulted in N = 7,970 citations (PubMed N = 6,350; ILO N = 1,538; PsycINFO

N = 81; PSYNDEX *N* = 1).

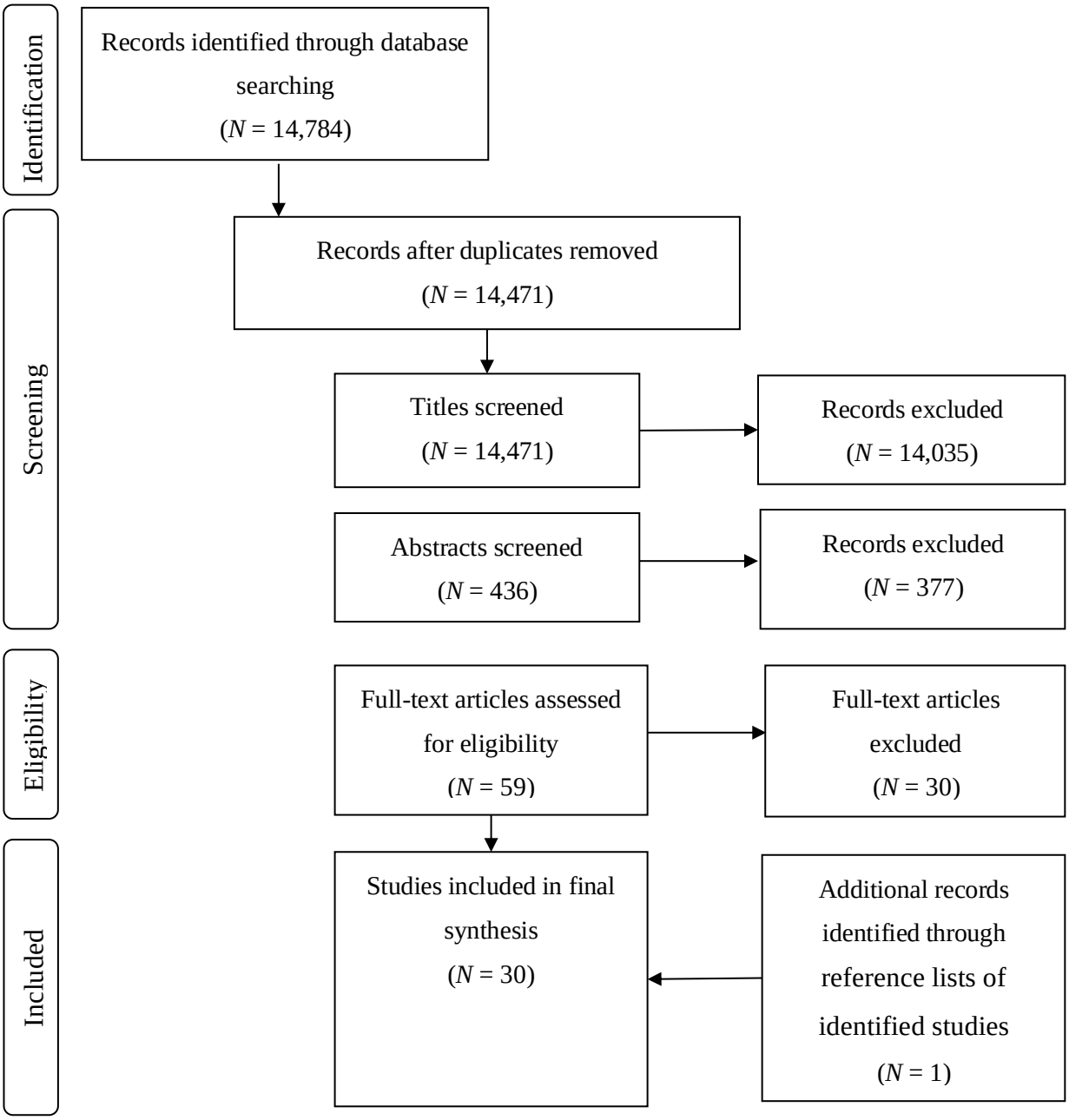

Figure 1. Flow chart of the inclusion process of included studies.

2.1.2.3 Data extraction

The literature search was conducted electronically and manually using above-mentioned databases. Records from these searches were checked for duplication. All titles and abstracts were screened initially and studies that met the inclusion criteria were further screened by obtaining and examining the full study reports. From each study, year of publication, research design, sample size, measurement of psychosocial work characteristics, outcome measures, main findings and effect size information were extracted.

2.1.2.4 Quality assessment

A validated and frequently used instrument for evaluating meta-analysis and systematic reviews is the AMSTAR checklist (Shea et al., 2009; Shea et al., 2007b; Shea et al., 2007a). The checklist is a methodologically advanced version of the OQAW (Overview Quality Assessment Questionnaire; Oxman and Guyatt, 1991) and the checklist of Sacks et al. (1987). The instrument comprises eleven guiding questions with the answer options yes, no, can't answer and not applicable. The quality of case-control, cohort, or longitudinal studies was rated by using the quality assessment tool for observational cohort and cross-sectional studies from the National Institutes of Health (National Institute of Health, 2021). The tool includes fourteen questions with the answer options yes, no, and other (cannot determine; not applicable; not reported). Appendix B provides an overview of the included instruments. To make a difference between high- and low-quality studies the number of positive evaluated criteria was added and divided by the total number of items (without the not applicable items) to create a methodological quality score of each article. The cut-off point between high-quality and low-quality studies was a priori set at 50% of the relative score. Studies with a method score > 50% were considered as high-quality studies. Table 2 and 3 shows the method score of all included articles.

Table 2

Methodological quality assessment of systematic reviews and meta-analysis (AMSTAR)

Study		1	2	3	4	5	6	7	8	9	10	11	Total	Score (%)	Quality
1	Bongers et al. (2002)	+	+	+	-	+	+	+	+	NA	NA	-	7	78	high
2	Bowling et al. (2015)	+	CA	-	-	-	-	-	-	+	-	+	3	27	low
3	Duijts et al. (2007)	+	+	+	-	-	+	+	+	+	-	-	7	64	high
4	Brborović et al. (2017)	+	+	+	-	+	+	+	+	NA	NA	+	8	89	high
5	Clarke (2012)	+	+	+	-	-	-	-	-	+	-	-	4	36	low
6	Côté et al. (2008)	+	-	-	-	+	CA	+	+	NA	NA	-	4	44	low
7	da Costa et al. (2010)	+	+	+	-	+	+	+	+	NA	NA	-	7	78	high
8	Darr et al. (2008)	+	+	+	+	-	-	-	-	+	+	-	6	55	high
9	Hauke et al. (2011)	+	CA	+	-	+	+	+	+	+	-	-	7	64	high
10	Koch et al. (2014)	+	+	+	-	+	+	+	+	NA	NA	-	7	78	high
11	Kraatz et al. (2013)	+	+	+	-	+	+	+	+	NA	NA	+	8	89	high
12	Lang et al. (2012)	+	+	+	-	-	+	+	+	+	+	+	9	82	high
13	Nahrgang et al. (2011)	+	+	+	+	-	-	-	-	+	-	-	5	45	low
14	Nielsen et al. (2016)	+	CA	+	-	-	+	+	+	+	+	-	7	64	high
15	Nixon et al. (2011)	+	+	+	+	+	-	+	+	+	-	-	8	73	high
16	Pindek et al. (2016)	+	+	+	+	-	CA	-	-	+	-	+	6	55	high
17	Robbins et al. (2012)	+	+	+	+	-	+	-	-	+	-	-	6	55	high
18	van der Molen et al. (2017)	+	+	+	-	+	+	+	+	+	+	+	10	91	high
19	van der Windt et al. (2000)	+	+	+	-	+	+	+	+	NA	NA	-	7	78	high
20	van Rijn et al. (2009)	+	-	+	-	+	+	+	+	NA	NA	+	7	78	high
21	van Rijn et al. (2010)	+	-	+	-	+	+	+	+	NA	NA	-	6	67	high
22	Hoogendoorn et al. (2000)	+	+	+	CA	-	+	+	+	NA	NA	-	6	67	high
23	Ariëns et al. (2001)	+	-	+	-	+	+	+	+	NA	NA	-	6	67	high
24	Amiri et al. (2020)	+	+	+	+	+	+	+	+	+	+	+	11	100	high

Note. "+" = Yes, "-" = No, CA: Can't answer, NA: Not applicable. 1-11: Question number of the AMSTAR Checklist (see Appendix B).

Table 3

Methodological quality assessment of longitudinal studies (NIH)

Study		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total	Score (%)	Quality
25	Baidwan et al. (2019)	+	+	NR	+	-	+	+	+	+	+	+	NA	+	+	11	85	high
26	Leineweber et al. (2017)	+	+	NR	+	-	-	+	+	+	+	+	NA	-	+	9	69	high
27	Mortensen et al. (2017)	+	+	+	-	-	CD	+	+	+	-	+	NA	+	+	9	69	high
28	Mutambudzi et al. (2019)	+	+	+	+	-	+	+	+	+	+	+	NA	+	+	12	92	high
29	Andersen et al. (2019)	+	+	+	+	-	-	+	+	+	+	+	-	-	+	10	71	high
30	Prakash et al. (2017)	+	-	+	-	-	-	+	+	+	+	+	NR	-	+	8	57	high

Note. "+" = Yes, "-"= No, CD: Cannot determine, NA: Not applicable. NR: Not reported. 1-14: Question number of the NIH Checklist (see Appendix B).

2.1.2.5 Assessment scheme

The considered studies show a large heterogeneity in relation to the included study population, the psychological work characteristics, and the assessment of the outcomes. To summarize the level of evidence of the association between psychological work characteristics and outcomes, best evidence synthesis was performed according to the following scheme:

- **Strong evidence:** generally consistent findings in at least two high-quality studies.
- **Reasonable evidence:** generally consistent findings in one high-quality study or multiple low-quality studies.
- **Insufficient evidence:** inconsistent findings in multiple studies or clear superiority of qualitatively good studies with negative or ambiguous evidence or only one low-quality study available.

The evidence evaluation scheme is based on comparable studies (Hoogendoorn et al., 2000; Kraatz et al., 2013). The best evidence synthesis integrates the quantification of effect sizes and a systematic study selection process (Slavin, 1986). Consistent findings implied that the results of at least 75% of the studies investigating the effect of a work characteristic on a certain outcome

pointed in the same direction. For a positive result, the association reported in meta-analytic studies must be statistically significant. Included systematic reviews reported the number of positive associations for a certain outcome without any risk estimates. For a positive result, the number of studies with a positive association had to be higher than the number of studies with a negative or no association.

2.1.3 Results

Tables 4, 5, and 6 provide the descriptions of all included studies. In total 14 from 30 studies (47 %) examined the effect of psychosocial work characteristics on musculoskeletal disorders and six studies (30 %) on absenteeism. Since only four studies (13 %) investigated the effects of accidents and injuries, the outcome was excluded for further evidence assessment. The number of studies is insufficient for a reliable risk assessment.

Table 4

Descriptive characteristics of included meta-analyses

Study		*k*	*N*	Psychosocial work characteristics	Outcome measures	Result
2	Bowling et al. (2015)	16	5,859	Workload	Absenteeism	ρ = .07*
3	Duijts et al. (2007)	5		Job control	Sick leave	OR = 1.28*
		2		Work time control	(> 3 days)	OR = 1.15*
		9		Psychological job demands		OR = 1.15*
		2		Job strain		OR = 1.27
		2		Decision authority		OR = 1.49*
		4		Decision latitude		OR = 1.33*
		11		Social support		OR = 1.08
		1		Fairness		OR = 1.30*
4	Brborović et al. (2017)	1	877	Patient-associated work overload	Short spells absenteeism	RR = 1.44*
				Patient-associated work overload	Long spells absenteeism	RR = 1.49*
		1	1,793	Job strain	Short term leave	IDR = 1.20*
				Job strain	Certified all	IDR = 1.09
				Job strain	Mental	IDR = 1.24
		1	1,793	Social support	Short term leave	IDR = 1.26*
				Social support	Certified all	IDR = 1.27*
				Social support	Mental	IDR = 1.78*
5	Clarke (2012)	16	19,442	Occupational stressors	Injuries	ρ = .02
		7	17,052	Challenge stressors		ρ = .001
		13	3,731	Hindrance stressors		ρ = .19*
8	Darr and Johns (2008)	56	18,630	Work strain	Absenteeism	r = .145*
9	Hauke et al. (2011)	51		Social support	Musculoskeletal disorders	r = 1.16*
		43		Job demands		r = 1.19*
		26		Job control		r = 1.21*

		11		Decision authority		r = 1.56*
		20		Skill discretion		r = 1.24*
		23		Job satisfaction		r = 1.28*
		22		Job strain		r = 1.35*
		4		Job insecurity		r = 1.12
12	Lang et al. (2012)	16	47,447	Job demands	Lower back symptoms	OR = 1.32*
		14	45,680	Job control		OR = 1.3*
		13	7,190	Job strain		OR = 1.38*
		14	39,472	Social support		OR = 1.42*
		6	10,228	Supervisor support		OR = 1.37*
		5	3,907	Coworker support		OR = 1.19
		9	38,908	Job satisfactionLang et al., 2012		OR = 1.27
		8	11,817	Job security		OR = 1.43*
		7	3,734	Monotonous work		OR = 1.66*
		28	43,030	Job demands	Neck and/or shoulder symptoms	OR = 1.17*
		26	26,017	Job control		OR = 1.27*
		12	8,716	Job strain		OR = 1.33*
		18	21,078	Social support		OR = 1.15*
		7	4,993	Supervisor support		OR = 1.17*
		7	4,994	Coworker support		OR = 1.13
		12	6,273	Monotonous work		OR = 1.22*
		8	8,765	Job demands	Upper extremity symptoms	OR = 1.18*
		9	9,279	Job control		OR = 1.33*
		7	8,363	Social support		OR = 1.23
		6	7,059	Monotonous work		OR = 1.57*
		5	1,916	Job control	Lower extremity symptoms	OR = 1.14
		5	1,919	Social support		OR = 1.62*
		5	1,820	Monotonous work		OR = 1.25
13	Nahrgang et al. (2011)	18	24,104	Job demands (physical demands)	Accidents and injuries	r_c = .09*
		5	1,190	Job demands (complexity)		r_c = .11*
14	Nielsen et al. (2016)	10		Workplace bullying	Sickness absence	OR = .58*
15	Nixon et al. (2011)	6	2,853	Interpersonal conflict	Backache (upper back, lower back, shoulders, and neck)	w_r = .19*
		13	5,556	Lack of control		w_r = .13*
		29	7,226	Organizational constraints		w_r = .16*
		5	971	Role ambiguity		w_r = .05
		4	487	Role conflict		w_r = .16*
		30	7,894	Work hours		w_r = - .10
		40	11,086	Workload		w_r = .12*
16	Pindek and Spector (2016)	4	1,355	Organizational constraints	Absenteeism	r_c = .27*
17	Robbins et al. (2012)	14	10,148	Perceptions of Unfairness	Absence	ρ = .08*
18	van der Molen et al. (2017)	3	50,841	Job demands	Soft tissue shoulder disorders	OR = 1.12*
		2	13,439	Decision latitude		OR = 1.08
		1	37,402	Job control		OR = 1.22

		1	725	Job security		OR = 1.12
20	van Rijn et al. (2009)	1		Job demands	Lateral epicondylitis (elbow disorder)	OR = 0.9
		1		Job control		OR = 2.2*
		1		Social support		OR = 1.8*
21	van Rijn et al. (2010)	1		Job demands	Tendinitis of the biceps tendon, rotator cuff tears, subacromial impingement syndrome (SIS)	OR = 3.19*
		1		Job control		OR = 1.83
		1		Social support		OR = .91
		1		Job demands		OR = 1.7
		1		Decision latitude		OR = .55
		1		Job satisfaction		OR = .61
		1		Job security		OR = .56
24	Amiri and Behnezhad (2020)	18		Job strain	Sick leave	RR = 1.44*

Note. *k* = Number of included studies. *N* = Sample size. * p < .05 (95% confidence intervals did not include one or zero). OR: odds ratio. ρ: weighted mean correlation corrected for unreliability. RR: relative risk. IDR: incidence density ratio. r: pooled estimate of effect sizes. r_c: weighted mean r corrected for unreliability. w_r: weighted effect size.

Table 5

Descriptive characteristics of included systematic reviews

Study		*k*	Psychosocial work characteristics	Outcome measures	Result
1	Bongers et al. (2002)	28	Quantitative job demands	All upper extremity	9/15
			Qualitative job demands		2/5
			Low stimulus from work		5/11
			Job control		8/14
			Social support		8/14
			Few rest break opportunities		3/7
6	Côté et al. (2008)	109	Job Strain	Neck Pain	8/11
			Social Support		4/6
			Job Security		1/1
7	da Costa and Vieira (2010)	63	Social Support	Work-related musculoskeletal disorders	7/7
			Efford/Reward-Imbalance		1/1
			Job Control		1/1
			Job Demands		5/5
			Job insecurity		1/1
			Job Strain		3/4
			Monotony		1/1
10	Koch et al. (2014)	19	Efford/Reward-Imbalance	Musculoskeletal disorder	13/19
11	Kraatz et al. (2013)	18	Job demands	Neck and shoulder disorders	6/7
			Job control		3/3
			Job Strain		4/4
			Low Support		5/6
14	Nielsen et al. (2016)	17	Workplace bullying	Sickness absence	16/17
19	van der Windt et al. (2000)		Psychological work demands	Shoulder Pain	8/14
			Job control		6/11
			social support at work		3/12
22	Hoogendoorn et al. (2000)	13	Work Pace	Back Pain	1/3
			Qualitative Demands		2/0
			Job Content		0/4
			Job Control		0/1
			Social Support in the Workplace		4/5
23	Ariëns et al. (2001)	29	Quantitative job demands	Neck Pain	9/10
			Social support at work		8/9
			Supervisor support		3/4
			Coworker support		2/2
			Conflicts at work		1/2
			Job control		5/6
			Job strain		2/3
			Job security		1/1
			Rest break opportunities		1/4

Note. *k* = Number of included studies. Column "Results" shows the ratio between studies with statistically significant correlations and the total number of studies.

Table 6

Descriptive characteristics of included longitudinal studies

Study		*k*	*N*	Psychosocial work characteristics	Outcome measures	Result	
25	Baidwan et al. (2019)	1	3,305			Male	Female
				Work demands	Work-related injury events	IRR = 2.63*	IRR = 1.68*
				Work control		IRR = 1.48	IRR = .94
				Work-related strain		IRR = 1.65	IRR = 1.73*
				Support at the work		IRR = 2.48*	IRR = 2.47*
				Effort-reward imbalance		IRR = 1.91*	IRR = 1.78*
26	Leineweber et al. (2017)	1	19,493	Interpersonal justice	Long sickness absence	RR = 1.18*	
					Frequent sickness absence	RR = 1.14*	
				Informational justice	Long sickness absence	RR = 1.21*	
					Frequent sickness absence	RR = 1.16*	
27	Mortensen et al. (2017)	1	26,800			Male	Female
				High job strain	Long term sickness absence	HR = 1.09	HR = 1.09*
28	Mutambudzi et al. (2019)	1	2,183	High job strain	Long term sickness absence	HR = 1.28*	
29	Andersen et al. (2019)	1	2,080	Support from colleagues	Back injury	OR = 3.16*	
30	Prakash et al. (2017)	1	4,534			Male	Female
				High strain	Back MSDs	RR = 1.30*	RR = 1.33*
					Degenerative MSDs	RR = 1.23*	RR = 1.24

Note. *k* = Number of included studies. *N* = Sample size. * p < .05 (95% confidence intervals did not include one or zero). OR: odds ratio. HR: Hazard ratio. RR: relative risk. IRR: incidence rate ratios.

2.1.3.1 Evidence assessment

Table 7 and 8 show the evidence assessment of the includes studies. In the following sections, the reference numbers of the studies from Tables 2 and 3 are given in parentheses. For a better readability, the results are divided into task-related and organizational job characteristics.

Task-related factors included aspects related to the execution of the work task. Organizational factors included work characteristics that concern the interaction within the organization.

Table 7

Analysis of studies on the relationship between psychosocial work characteristics and absenteeism

	Absenteeism					
	References [a]				Result [b]	Level of evidence
	High-quality		Low-quality			
	Yes [c]	No [d]	Yes	No		
1) Task-related						
Job control	3				1/1=100%	reasonable
Job demands	3, 4		2		3/3=100%	strong
Job strain	4, 24, 27, 28	3			4/5=80%	strong
2) Organizational						
Work time control	3				1/1=100%	reasonable
Social support	4	3			1/2=50%	insufficient
Workplace bullying	14				1/1=100%	reasonable
Hindrance stressors	16				1/1=100%	reasonable
Organizational fairness / justice	3, 17, 26				3/3=100%	strong

Note. [a] Reference numbers of studies from Table 2 and 3. [b] Consistency of positive findings.

[c] Association between psychosocial work characteristics and outcome is significant.

[d] Association between psychosocial work characteristics and outcome is not significant.

Table 8

Analysis of studies on the relationship between psychosocial work characteristics and musculoskeletal disorders

	Musculoskeletal disorders					
	References [a]				Result [b]	Level of evidence
	High-quality		Low-quality			
	Yes [c]	No [d]	Yes	No		
1) Task-related						
Effort/reward-imbalance	7, 10				2/2=100%	strong
Job control	1, 7, 11, 12, 15, 19, 23	18, 21, 22			7/10=70%	insufficient
Job demands	1, 7, 11, 12, 15, 18, 19, 21, 22, 23	20			10/11=91%	strong
Job strain	7, 11, 12, 23,30		6		6/6=100%	strong
Monotonous work	7, 12	1, 22			2/4=50%	insufficient
Work pace		22			0/1=0%	insufficient
2) Organizational						
Work hours		15			0/1=0%	insufficient
Few rest break Opportunities		1, 23			0/2=0%	insufficient
Social support	1, 7, 11, 12, 22, 23	19, 21	6		7/9=78%	strong
Hindrance stressors	15				1/1=100%	reasonable
Role ambiguity		15			0/1=0%	insufficient
Role conflict	15				1/1=100%	reasonable
Low job security	7, 12, 23	18, 21	6		4/6=67%	insufficient
Interpersonal conflict	15				1/1=100%	reasonable

Note. [a] Reference numbers of studies from Table 2 and 3. [b] Consistency of positive findings.

[c] Association between psychosocial work characteristics and outcome is significant.

[d] Association between psychosocial work characteristics and outcome is not significant.

2.1.3.1.1 Task-related work characteristics

Job control. One high-quality study (3) reported a significant odds ratio of 1.28. Application of the rating system shows reasonable evidence of an effect of low job control on absenteeism.

Ten studies investigated the association between job control and musculoskeletal disorders. Six high-quality studies (1, 7, 11, 12, 19, and 23) and one low quality study (15) reported a significant negative relationship. Two high-quality studies (18, 21) could not observe any significant association and one high-quality systematic reviews (22) reported inconsistent results. Application of the rating system shows insufficient evidence of an effect of low job control on musculoskeletal disorders.

Job demands. One low-quality (2) and two high quality studies (3, 4) investigated the effects of high job demands on absenteeism and all studies reported significant effects. Based on the results, it is concluded that the evidence for the relationship is strong.

Eleven studies investigated the effects of high job demands on musculoskeletal disorders. The results of ten studies (1, 7, 11, 12, 15, 18, 19, 21, 22, and 23) pointed in the same direction and only one high quality meta-analysis (20) showed an opposite result. Application of the rating system shows strong evidence of an effect of high job demands on the risk of musculoskeletal disorders.

Job strain. Five studies (3, 4, 24, 27, and 28) examined the influence of high job strain on absenteeism. Four high quality studies (4, 24, 27, and 28) reported significant effects and one study (3) calculated a non-significant result. Application of the rating system shows strong evidence of an effect of high job strain on absenteeism.

Altogether six studies investigated the effect of high job strain on musculoskeletal disorders (6, 7, 11, 12, 23, and 30) and all studies reported significant results. The results support the notion of a strong evidence.

Effort/reward-imbalance. Two high-quality systematic reviews (7, 10) assessed the effects of effort-reward imbalance on musculoskeletal disorders, and both reported a significant positive relationship. Application of the rating system shows strong evidence of an effect of high effort/reward-imbalance on an increased risk of musculoskeletal disorders. We identified no reviews or meta-analyses that assessed the association between high effort/reward-imbalance and absenteeism.

Monotonous work. Four studies assessed the association between monotonous work and musculoskeletal disorders. One high-quality meta-analysis (12) and one high-quality systematic

review (7) provided significant results. Two high quality systematic reviews (1, 22) reported no association. The evidence for the relationship is insufficient. We identified no reviews or meta-analyses that assessed the association between monotonous work and absenteeism.

Work pace. One high quality study (22) investigated the relationship between high work pace and musculoskeletal disorders. The systematic review examined three studies and one of them showed a significant association. Application of the rating system shows insufficient evidence. We identified no reviews or meta-analyses that assessed the association between work pace and absenteeism.

2.1.3.1.2 Organizational work characteristics

Work hours. Since only one low quality study (15) assessed the relationship, high work hours show insufficient evidence as a risk factor for musculoskeletal disorders. We identified no reviews or meta-analyses that examined the relationship between work hours and absenteeism.

Few rest break opportunities. Two of the included studies (1, 23) provided information on the effects of few rest break opportunities associated with the risk of musculoskeletal disorders. Both studies reported a non-significant association. Based on the results, it is concluded that the evidence is insufficient. We identified no reviews or meta-analyses that examined the relationship between rest break opportunities and absenteeism.

Work time control. One high-quality study (3) assessed the association between low work time control and absenteeism. The results support a reasonable evidence base. We identified no reviews or meta-analyses that assessed the association between work time control, and musculoskeletal disorders.

Social support. Of nine studies (1, 6, 7, 11, 12, 19, 22, 21, and 23) that reported results on the relationship between social support at work and musculoskeletal disorders seven studies stated a significant relationship (1, 6, 7, 11, 12, 22, and 23). Application of the rating system shows strong evidence of an effect of low social support on the risk of musculoskeletal disorders.

Two high quality studies (3, 4) investigated the relationship between social support and absenteeism. The results show insufficient evidence for an effect of low social support on absenteeism.

Workplace bullying. One high-quality meta-analysis investigated the effect of workplace bullying on sickness absence (14). The authors reported a significant result. Application of the rating system shows reasonable evidence. We identified no reviews or meta-analyses that assessed the association between workplace bullying and musculoskeletal disorders.

Hindrance and challenge stressors. Two studies assessed the association between hindrance stressors and absenteeism (16) or musculoskeletal disorders (15). Based on the results of the high-quality studies, the evidence for the effect on absenteeism and musculoskeletal disorders is reasonable.

Nixon et al. (2011) reported a weighted effect size of .16 between organizational constraints and backache. As one high-quality study is available, the evidence for an effect of high hindrance stressors on musculoskeletal disorders is reasonable.

Perceived unfairness. Three high-quality studies examined the effect of high-perceived organizational unfairness or injustice on absenteeism (3, 17, and 26). All studies reported significant results and the findings demonstrate strong evidence. We identified no reviews or meta-analyses that investigated the effects between perceived unfairness and musculoskeletal disorders.

Role ambiguity, role conflict and interpersonal conflict. One high-quality study (15) examined the effects of role ambiguity, role conflict and interpersonal conflict on musculoskeletal disorders. The authors found significant mean correlations of .16 for role conflict and of .19 for interpersonal conflict and backache. The association between role ambiguity and backache with a value of .05 was non-significant. Application of the rating system shows insufficient evidence for high role ambiguity and reasonable evidence for high role conflict and high interpersonal conflict. We identified no reviews or meta-analyses that investigated the effects between role ambiguity, role conflict or interpersonal conflict and musculoskeletal disorders.

Low job security. Six studies investigated the relationship between low job security and musculoskeletal disorders. One high-quality meta-analysis (12) reported a significant odds ratio of 1.43 between job insecurity and lower back symptoms. Two high quality studies (18, 21) did not find any significant results. Three systematic reviews (6, 7, and 23) each examined one study for the effects and reported significant results. Application of the rating system support a reasonable evidence base for the effects of low job security. We identified no reviews or meta-analyses that assessed the association between job security and absenteeism.

2.1.3.2 Risk assessment

To expand the current state of knowledge of the risk effects of psychosocial work characteristics, we complement previous overview studies that focused on mental illness, cardiovascular disease, and diabetes (Rau and Buyken, 2015). Table 9 shows the summarized findings on the relationship between psychosocial work characteristics and the health-related outcomes. The results indicate strong evidence that the combination of low job control and high job demands (job strain) is a risk factor for a broad range of health problems as well as absenteeism.

Moreover, both studies agree that also job demands alone, workplace bullying, and social support also reveal strong evidence to be risk factors for health. Most other show evidence that they are risk factors for at least one health related-outcome and should therefore be part of a risk assessment. In addition, we were able to show that there is strong evidence that perceived fairness and reasonable evidence that work time control should also be included in a risk assessment.

Table 9

Risk assessment of psychosocial work characteristics by expanding the results with the study of Rau & Buyken (2015)

	Rau & Buyken (2015)							
	Absen-teeism	MSD	De-pression	Anxiety	Psych. imp.	CVD	Diabetes	Risk
1) Task-related								
Job Control	+	o	+ +		+	+		2.5
Job demands	+ +	+ +	+ +		+	o		3.5
Job strain	+ +	+ +	+ +	+	+	+ +	+	5.5
Monotonous work		o						0.0
Effort/reward-imbalance		+ +	+		+	+		2.5
Work pace		o						0.0
2) Organizational								
Work time control	+							0.5
Work hours		o			+ +			1.0
Few rest break Opportunities		o						0.0
Social support	o	+ +	+		+	+		2.5
Workplace bullying	+		+ +	+ +	+ +			3.5
Hindrance stressors	+	+						1.0
Challenge stressors								0.0
Fairness	+ +							1.0
Role ambiguity		o						0.0
Role conflict		+	+	+ +				2.0
Low job security		o			+ +	+		1.5
Interpersonal conflict		+						0.5

Note. ++ = strong evidence. + = reasonable evidence. o = insufficient evidence. CVD = cardiovascular disease. MSD = musculoskeletal disorders. Psych. imp. = psychological impairments. Risk = sum of relationships that showed evidence for risk potential. Insufficient or no evidence was counted with zero, reasonable evidence was counted with .5 and strong evidence with 1.0. **Note:** Rau & Buyken (2015) used different acronyms to describe the strength of evidence and separated the evaluation between systematic reviews and meta-analyses. “A / D ++” was used for strong and “B / D +” for reasonable evidence.

2.1.4 Discussion

The aim of this article was to summarize the evidence for significant relationships between theoretically well-founded psychosocial work characteristics and three important health outcomes, i.e., musculoskeletal disorders, absenteeism, and workplace accidents. Strong evidence to be a risk factor for musculoskeletal disorders and absenteeism was found for the following work characteristics: High job demands, high job strain, high effort/reward-imbalance, low social support, and low perceived fairness. Low job control, low work time control, high workplace bullying, high hindrance stressors, high role conflict, and interpersonal conflicts show reasonable evidence to be a risk factor. For monotonous work, number of work hours, few rest break opportunities, work pace, challenge stressors, low job security and role ambiguity we could identify only insufficient evidence. Finally, there is insufficient evidence that psychosocial work characteristics are related to an increased risk for accidents, as only a few studies were available so far. Previous overview studies focused on mental illness, cardiovascular disease, and diabetes (Rau and Buyken, 2015). To examine whether additional psychosocial work characteristics need to be included in the risk assessment when considering additional major health-related outcomes, we pooled the results of the two studies. As an addition to the study of Rau & Buyken (2015), we were able to show that perceived fairness, work time control and interpersonal conflicts should also be included in a risk assessment.

In the assessment of psychosocial work characteristics, it is essential to know how the risk can be assessed. Metzler et al. (2019) examined and compared established methods for risk evaluation and found the approach of Clarke and Cooper (2000) to be most promising. In this approach, the risk is calculated by multiplying the probability that an undesirable event will occur (exposure to a psychosocial work characteristic that is a health risk) and the severity of its outcomes (consequences in terms of a health-risk) for a given period (Glendon and Clarke, 2017). The summarized findings in Table 9 can inform such risk assessment methods, by providing a very crude but systematic estimation of the potential risk severity when workers are exposed to specific psychosocial work characteristics. Knowledge of the health-related effects of psychosocial work characteristics is critical to derive targeted interventions and thus reduce the risk. Holman and Axtell (2016) assessed a multiple mediator–multiple outcome model and showed that job redesign interventions influence a broad range of employee outcomes by making changes to multiple job characteristics.

From a practical point of view, it is important to use instruments for risk assessment that refer to different theories and different types of work characteristics and are not only limited to

one specific model (e.g., COPSOQ; Burr et al., 2019). Moreover, it is difficult to design work characteristics separately since most are acting simultaneously. The present study may therefore guide researchers and companies in selecting suitable instruments that cover psychosocial work characteristics that show strong evidence to be a health risk. Thus, targeted risk assessments and interventions can be developed to minimize the health-risks for employees.

Models describing psychosocial risk factors for musculoskeletal disorders assume that certain work characteristics initially increase the probability of the development of symptoms (Bongers et al., 1993; Feuerstein, 1996). If the symptoms persist, there are few possibilities for recovery and behaviour patterns and pain continues. In the interplay between individual factors (e.g., personality type or coping styles) and psychosocial work characteristics, negative risk dynamics can thus arise. This leads initially to a disorder and in the long-term to chronic diseases or work disability. These models illustrate that individual psychosocial factors may also be relevant to the development of health-related outcomes; however, the OSH management has reduced control regarding individual factors. Therefore, psychosocial work characteristics that initially trigger dynamic risk processes should be prevented by appropriate interventions.

Psychosocial work characteristics may be associated with various outcomes for individuals through different mechanisms. For example, it is known that the occupational choice of individuals can be related to the personal risk-avoidance. Workers with a high risk-avoidance tend to make occupational choices for safer jobs (DeLeire and Levy, 2004; Grazier and Sloane, 2008). Employees in high-risk professions may have a higher likelihood of injury without necessarily being at increased health risk for musculoskeletal disorders or absenteeism. The findings of our study do not consider specific mechanisms that link psychosocial work characteristics to health impairments. Nevertheless, certain psychosocial work characteristics may increase or exacerbate the risk for specific health-related outcomes within a professional group. Employees who accept a higher risk of injury can still have a higher risk for musculoskeletal disorders due to the lack of social support. From the perspective of occupational safety and health, it is important to know the psychosocial work characteristics that could potentially be related to an increased risk of major health impairments and should be included in a risk assessment.

2.1.4.1 Limitations

When interpreting the results, several aspects and limitations must be considered. To be able to carry out a comprehensive risk assessment, the present study referred to common concepts and theories of work-related health models. Consequently, our study did not include work characteristics that were either not covered by these models or did not met our inclusion criteria.

Montano et al. (2017) for example show the importance of leadership as an occupational health factor but this dimension does not appear in our overview. The included work characteristics should therefore not be interpreted as an exhaustive list.

Some of the examined psychosocial work characteristics are captured on a very abstract level and can therefore cover quite different aspects of work. For example, job demands might include aspects such as temporal demands, task complexity, or task variety. These aspects may also differ between different professions or industries, making a common assessment more difficult. To assess the differences in major categories between professions or industries further meta-analysis or systematic reviews will be required that uses a fine-grained classification of working characteristics.

The restriction to include only systematic reviews and meta-analysis resulted in limited availability of recent studies summarizing the association between psychosocial work characteristics and health-related outcomes. Several included studies are already older than ten years and possible changes in culture, technology, workforce, or personal health make it difficult to compare the included studies. To examine whether the results are biased, we considered differences in the evidence assessment. Excluding all studies published before 2010 results in an identical evidence assessment of most psychosocial work characteristics. Therefore, we did not exclude any studies based on the date of publication. To ensure a more current focus we also included longitudinal studies from 2017 onward. Thus, different study designs are included in the evidence assessment and the results of the longitudinal studies access smaller datasets. Both study designs are nevertheless methodologically justifiable, and the results of the longitudinal studies point in the same direction as the included reviews. To assess the evidence of changing working conditions in recent years further meta-analyses or systematic reviews are needed.

A further limitation is the lack of systematic studies for the health effects of time-related working conditions and for the association between psychosocial work characteristics and accidents. When interpreting our study, it is important to note that in this case insufficient evidence does not mean that there is a low risk. A low risk can only be assumed if consistent findings in high-quality studies show that there is no correlation between a work characteristic and adverse health effects. However, we have not observed such consistently negative findings for any of the working conditions considered. Research results may already be available on the missing topics but are not considered in this risk assessment. To assess the risk, further research in form of meta-analyses or systematic reviews is necessary for accidents and time-related work characteristics.

A publication bias of our findings cannot be eliminated. In total, five out of the 24 included systematic reviews and meta-analysis searched for reports regardless of their publication type and

included unpublished literature. In only one study, a publication bias was statistically assessed, and the test provided no evidence. Most of the included studies only considered published literature and our search strategy also did not include any unpublished studies. Future research could include unpublished literature or investigate statistically the possibility of a publication bias.

2.1.5 Conclusion

Our results demonstrated that there is strong or reasonable evidence that low job control, high job demands, high job strain, high effort/reward-imbalance, low work time control, low social support, high workplace bullying, high hindrance stressors, low perceived fairness, high role conflict, low job security, and interpersonal conflicts are risk factors for heterogeneous adverse effects. The results can inform risk assessment methods, by providing a systematic estimation of the potential risk severity of psychosocial work characteristics. With that, our study provides recommendations for the necessary but not necessarily sufficient content of the risk assessment of psychosocial work characteristics. In this way, targeted interventions can be derived and working conditions improved in the long term.

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Conflict of interest

None.

2.1.6 References

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2.1.7 Appendix A: Search strings

2.1.7.1 Search strings PubMed

#1 psychological stress [MeSH Terms]
#2 Stress, psychological [MeSH Major Topic]
#3 psychological strain [MeSH Terms]
#4 ((stress*[Title/Abstract]) OR stress*[Text Word]))
#5 ((occupational strain OR occupational stress OR job stress OR psychosocial work factors OR distress OR job strain OR work strain OR work stress OR occupational exposure OR working conditions))
#6 ((job demand OR job characteristics OR work demand OR high demand))
#7 ((work load OR work-load OR workload OR time pressure OR work overload))
#8 ((social stressors at work OR emotional labour OR emotional demands OR interpersonal relation))
#9 ((social support OR support system OR emotional support))
#10 ((low control OR lack of control OR work control OR job control demand resource))
#11 ((effort reward OR reward at work OR organizational rewards OR social recognition))
#12 ((organizational justice OR organizational injustice OR organisational justice OR organisational injustice))
#13 ((risk factor OR risk assessment OR psychological risk))
#14 ((role ambiguity OR role conflict OR role clarity))
#15 (#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14)
#16 ((absenteeism [Mesh Terms] OR absence OR sickness absence OR long-term absence OR cost of sickness OR absence from work OR sick leave OR leave of absence))
#17 ((accident OR work accident OR workplace accident OR occupational accident OR workplace safety OR safe behavior OR safe behaviour OR safety performance OR safety climate OR safety culture OR injury rates OR injury severity OR injur* OR safety events OR error* OR unsafe behavior OR unsafe behaviour))
#18 ((musculo-skeletal disease OR musculo-skeletal disorder OR musculoskeletal disorder))
#19 (#16 OR #17 OR #18)
#20 ((workplace [Mesh] OR work-place [Mesh] OR occupation*[Mesh]))
#21 ((work OR work environment OR occupational environment OR working condition OR occupation OR job OR employ* OR occupational safety OR occupational health))

#22 (#20 OR #21)
#23 (meta-analysis OR metaanalysis OR systematic review)
#24 (#15 AND #19 AND #22 AND #23)
#25 (((((#24) NOT (mental illness OR mental health OR psychiatric disorder*))) NOT (depression OR major depression OR dysthymic disorder OR affective disorder OR depressive disorder)) NOT depress*[Title/Abstract]) NOT (anxiety OR anxiety disorder)) NOT (cardiovascular disease OR cardiovascular mortality OR high blood pressure OR hypertension OR hypertonia OR arterial hypertension OR myocardial infarct OR coronary heart disease) Filters: Meta-Analysis, Review, Systematic Reviews, Humans

2.1.7.2 Search strings PsychINFO and Psyndex

#1 psychological stress.ab. or psychological stress.ti. or psychological stress.sh. or psychological stress.tw.
#2 psychological strain.ab. or psychological strain.ti. or psychological stress.sh. or psychological strain.tw.
#3 psychological stress.mp. or exp Psychological Stress/
#4 psychological strain.mp.
#5 stress*.ab. or stress*.ti. or stress*.sh. or stress*.tw.
#6 (occupational strain or occupational stress or job stress or psychosocial work factors or distress or job strain or work strain or work stress or occupational exposure or working conditions).ab. or (occupational strain or occupational stress or job stress or psychosocial work factors or distress or job strain or work strain or work stress or occupational exposure or working conditions).ti. or (occupational strain or occupational stress or job stress or psychosocial work factors or distress or job strain or work strain or work stress or occupational exposure or working conditions).sh. or (occupational strain or occupational stress or job stress or psychosocial work factors or distress or job strain or work strain or work stress or occupational exposure or working conditions).tw.
#7 (job demand or job characteristics or work demand or high demand).ab. or (job demand or job characteristics or work demand or high demand).ti. or (job demand or job characteristics or work demand or high demand).sh. or (job demand or job characteristics or work demand or high demand).tw.
#8 (work load or work-load or workload or time pressure or work overload).ab. or (work load or work-load or workload or time pressure or work overload).ti. or (work load or work-load or workload or time pressure or work overload).sh. or (work load or work-load or workload or time pressure or work overload).tw.

#9 (social stressors at work or emotional labour or emotional demands or interpersonal relation).ab. or (social stressors at work or emotional labour or emotional demands or interpersonal relation).ti. or (social stressors at work or emotional labour or emotional demands or interpersonal relation).sh. or (social stressors at work or emotional labour or emotional demands or interpersonal relation).tw.

#10 (social support or support system or emotional support).ab. or (social support or support system or emotional support).ti. or (social support or support system or emotional support).sh. or (social support or support system or emotional support).tw.

#11 (low control or lack of control or work control or job control demand resource).ab. or (low control or lack of control or work control or job control demand resource).ti. or (low control or lack of control or work control or job control demand resource).sh. or (low control or lack of control or work control or job control demand resource).tw.

#12 (effort reward or reward at work or organizational rewards or social recognition).ab. or (effort reward or reward at work or organizational rewards or social recognition).ti. or (effort reward or reward at work or organizational rewards or social recognition).sh. or (effort reward or reward at work or organizational rewards or social recognition).tw.

#13 (organizational justice or organizational injustice or organisational justice or organisational injustice).ab. or (organizational justice or organizational injustice or organisational justice or organisational injustice).ti. or (organizational justice or organizational injustice or organisational justice or organisational injustice).sh. or (organizational justice or organizational injustice or organisational justice or organisational injustice).tw.

#14 (risk factor or risk assessment or psychological risk).ab. or (risk factor or risk assessment or psychological risk).ti. or (risk factor or risk assessment or psychological risk).sh. or (risk factor or risk assessment or psychological risk).tw.

#15 (role ambiguity or role conflict or role clarity).ab. or (role ambiguity or role conflict or role clarity).ti. or (role ambiguity or role conflict or role clarity).sh. or (role ambiguity or role conflict or role clarity).tw.

#16 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15

#17 (musculo-skeletal disease or musculo-skeletal disorder or musculoskeletal disorder or back or neck or shoulder or forearm or wrist or hand).ab. or (musculo-skeletal disease or musculo-skeletal disorder or musculoskeletal disorder or back or neck or shoulder or forearm or wrist or hand).ti. or (musculo-skeletal disease or musculo-skeletal disorder or musculoskeletal disorder or back or neck or shoulder or forearm or wrist or hand).sh. or (musculo-skeletal disease or musculo-skeletal disorder or musculoskeletal disorder or back or neck or shoulder or forearm or wrist or hand).tw.

#18 exp Employee Absenteeism/ or absenteeism.mp.

#19 (absenteeism or absence or sickness absence or long-term absence or cost of sickness or absence from work or sick leave or leave of absence).ab. or (absenteeism or absence or sickness absence or long-term absence or cost of sickness or absence from work or sick leave or leave of absence).ti.

#20 (accident or work accident or workplace accident or occupational accident or workplace safety or safe behavior or safe behaviour or safety performance or safety climate or safety culture or injury rates or injury severity or injur* or safety events or error* or unsafe behavior or unsafe behaviour).ab. or (accident or work accident or workplace accident or occupational accident or workplace safety or safe behavior or safe behaviour or safety performance or safety climate or safety culture or injury rates or injury severity or injur* or safety events or error* or unsafe behavior or unsafe behaviour).ti.

#21 17 or 18 or 19 or 20

#22 (workplace or work-place or occupation*).ab. or (workplace or work-place or occupation*).ti. or (workplace or work-place or occupation*).sh. or (workplace or work-place or occupation*).tw.

#23 (work or work environment or occupational environment or working condition or occupation or job or employ* or occupational safety or occupational health).ab. or (work or work environment or occupational environment or working condition or occupation or job or employ* or occupational safety or occupational health).ti. or (work or work environment or occupational environment or working condition or occupation or job or employ* or occupational safety or occupational health).sh. or (work or work environment or occupational environment or working condition or occupation or job or employ* or occupational safety or occupational health).tw.

#24 22 or 23

#25 (meta-analysis or metaanalysis or systematic review*).ab. or (meta-analysis or metaanalysis or systematic review*).ti. or (meta-analysis or metaanalysis or systematic review*).sh. or (meta-analysis or metaanalysis or systematic review*).tw.

#26 16 and 21 and 24 and 25

#27 limit 24 to (human and peer reviewed journal and (english or german))

2.1.7.3 Search strings ILO

#1 occupational stress, psychological stress, work stress, work strain, occupational strain, job strain

OR

#2 psychosocial work factors, job demands, job control, job characteristics, working conditions

OR

#3 work load, work-load, workload, time pressure, work overload, work hours

OR

#4 social stressors at work, emotional labour, emotional demands, interpersonal relation, role ambiguity, role conflict, role clarity

OR

#5 effort reward, reward at work, organizational rewards, social recognition, organizational justice, organizational injustice, organisational justice, organisational injustice

AND

#6 musculo-skeletal disease, musculo-skeletal disorder, musculoskeletal disorder, absenteeism, sickness absence, work accident, workplace accident, occupational accident

2.1.8 Appendix B: Quality assessment of the included studies

2.1.8.1 A measurement tool to assess systematic reviews (AMSTAR)

1. Was an ‘‘a priori’’ design provided? The research question and inclusion criteria should be established before the conduct of the review.
   - □ Yes
   - □ No
   - □ Can’t answer
   - □ Not applicable

2. Was there duplicate study selection and data extraction?
   There should be at least two independent data extractors and a consensus procedure for disagreements should be in place.
   - □ Yes
   - □ No
   - □ Can’t answer
   - □ Not applicable

3. Was a comprehensive literature search performed?
   At least two electronic sources should be searched. The report must include years and databases used (e.g., Central, EMBASE, and MEDLINE). Key words and/or MESH terms must be stated, and where feasible, the search strategy should be provided. All searches should be supplemented by consulting current contents, reviews, textbooks, specialized registers, or experts in the particular field of study, and by reviewing the references in the studies found.
   - □ Yes
   - □ No
   - □ Can’t answer
   - □ Not applicable

4. Was the status of publication (i.e., grey literature) used as an inclusion criterion?
   The authors should state that they searched for reports regardless of their publication type. The authors should state whether or not they excluded any reports (from the systematic review), based on their publication status, language etc.
   - □ Yes
   - □ No
   - □ Can’t answer
   - □ Not applicable

5. Was a list of studies (included and excluded) provided?
   A list of included and excluded studies should be provided.
   - □ Yes
   - □ No
   - □ Can’t answer
   - □ Not applicable

6. Were the characteristics of the included studies provided?
   In an aggregated form, such as a table, data from the original studies should be provided on the participants, interventions, and
   - □ Yes
   - □ No

	outcomes. The ranges of characteristics in all the studies analyzed, e.g., age, race, sex, relevant socioeconomic data, disease status, duration, severity, or other diseases should be reported.	□ Can't answer □ Not applicable
7.	Was the scientific quality of the included studies assessed and documented? ''A priori'' methods of assessment should be provided (e.g., for effectiveness studies if the author(s) chose to include only randomized, double-blind, placebo-controlled studies, or allocation concealment as inclusion criteria); for other types of studies, alternative items will be relevant.	□ Yes □ No □ Can't answer □ Not applicable
8.	Was the scientific quality of the included studies used appropriately in formulating conclusions? The results of the methodological rigor and scientific quality should be considered in the analysis and the conclusions of the review, and explicitly stated in formulating recommendations.	□ Yes □ No □ Can't answer □ Not applicable
9.	Were the methods used to combine the findings of studies appropriate? For the pooled results, a test should be done to ensure the studies were combinable, to assess their homogeneity (i.e., Chi-squared test for homogeneity, I2). If heterogeneity exists, a random effects model should be used and/or the clinical appropriateness of combining should be taken into consideration (i.e., is it sensible to combine?).	□ Yes □ No □ Can't answer □ Not applicable
10.	Was the likelihood of publication bias assessed? An assessment of publication bias should include a combination of graphical aids (e.g., funnel plot, other available tests) and/or statistical tests (e.g., Egger regression test).	□ Yes □ No □ Can't answer □ Not applicable
11.	Was the conflict of interest included? Potential sources of support should be clearly acknowledged in both the systematic review and the included studies.	□ Yes □ No □ Can't answer □ Not applicable

2.1.8.2 Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies (NIH)

	Criteria	Yes	No	Other (CD, NR, NA) *
1.	Was the research question or objective in this paper clearly stated?			
2.	Was the study population clearly specified and defined?			
3.	Was the participation rate of eligible persons at least 50%?			
4.	Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?			
5.	Was a sample size justification, power description, or variance and effect estimates provided?			
6.	For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?			
7.	Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?			
8.	For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?			
9.	Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?			
10.	Was the exposure(s) assessed more than once over time?			
11.	Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?			

12. Were the outcome assessors blinded to the exposure status of participants?
13. Was loss to follow-up after baseline 20% or less?
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?

* CD = cannot determine. NA = not applicable. NR = not reported.

2.2 Applying risk matrices for assessing the risk of psychosocial hazards at work

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Abstract

Although wide-ranging amendments in health and safety regulations at the European and national level oblige employers to conduct psychosocial risk assessment, it is still under debate how psychosocial hazards can be properly evaluated.

For psychosocial hazards, an epidemiological, risk-oriented understanding similar to physical hazards is still missing, why most existing approaches for hazard evaluation insufficiently conceive psychosocial risk as a combination of the probability of a hazard and the severity of its consequences (harm), as found in traditional risk matrix approaches (RMA).

We aim to contribute to a methodological advancement in psychosocial risk assessment by adapting the RMA from physical onto psychosocial hazards. First, we compare and rate already existing procedures of psychosocial risk evaluation regarding their ability to reliably assess and prioritize risk. Second, we construct a theoretical framework that allows the risk matrix for assessing psychosocial risk. This is done by developing different categories of harm based on psychological theories of healthy work design and classifying hazards through statistical procedures.

Taking methodological and theoretical considerations into account, we propose a 3x3 risk matrix that scales probability and severity for psychosocial risk assessment. Odds ratios between hazards and harm can be used to statistically assess psychosocial risks. This allows for both risk evaluation and prioritizing to further conduct risk-mitigation.

Our contribution advances the RMA as a framework that allows for assessing the relation between psychosocial hazards and harm disregarding which theory of work stress is applied or which tool is used for hazard identification. By this, we also contribute to further possible developments in empirical research regarding how to assess the risk of workplace stress. The risk matrix can help to understand how psychosocial hazards can be evaluated and organizations can use the approach as a guidance to establish a suitable method for psychosocial risk evaluation.

Keywords: Risk evaluation, Risk matrix approach, Occupational stress, Occupational safety, Work design, Mental health

2.2.1 Introduction

To ensure a safe working environment and to prevent possible accidents and health impairments, systematically assessing risk factors of the work environment is essential. Risk assessment is a systematic process to combat potential hazards at work and combines three elements: hazards, harm, and risk (Clarke & Cooper, 2004). Hazard is defined as a work characteristic that has the potential to cause harm. Harm is a possible detrimental consequence of a hazard for the health and safety of an employee. The risk is then defined as the chance that a harm will be caused by a hazard (Rick & Briner, 2000). Based on this approach, risk is often described as a product of probability and consequences (Campbell, 2005), i.e., the probability that a hazard will cause harm, and the severity of that harm (Glendon & Clarke, 2018). The systematic assessment of physical hazards (e.g., toxins, noise, or heat) is nowadays an established measure in occupational safety and health (OSH) and has contributed to a significant decrease in the incidence of accidents at work in many industrialized countries (Andersen et al., 2019; Tompa et al., 2016). However, profound changes in the nature of work like increasing digitalization, or the substantial rise of service work, result in an increasing importance of psychosocial hazards at work (Bliese, Edwards, & Sonnentag, 2017). Consequently, health and safety regulations require companies to also include psychosocial hazards within risk assessment (EU Directive 89/391/EEC, 1989).

Although there is robust empirical evidence that specific psychosocial work characteristics, such as low social support or high job demands, can impair the mental and physical health of employees (e.g. Amiri & Behnezhad, 2020; Anwer, Li, Antwi-Afari, & Wong, 2021; Rau & Buyken, 2015; Taibi, Metzler, Bellingrath, & Müller, 2021), the question of how psychosocial hazards should be evaluated in the context of risk assessment is still under debate and the systematic assessment of psychosocial risks has so far been insufficiently implemented (Beck & Lenhardt, 2019; Ertel et al., 2010). While numerous tools for hazard identification have been published in recent years, research has shown that different methods for risk evaluation produce differing results in risk assessment (Metzler, Groeling-Müller, & Bellingrath, 2019). It is surprising that this crucial fact has not been addressed more intensively by applied science, because it implies that following measures of risk-mitigation and work re-design could fail at promoting health and well-being of the workforce to an unknown extent (Metzler, Neuhaus, Taibi, Bellingrath, & Müller, 2022) which is a core principle of OSH.

Challenges arise from the lack of comparable threshold values as reference data, or from the fact that psychosocial hazards sometimes occur only in the context of a specific combination of working conditions (e.g., high demands and low control, Karasek, 1979). In addition,

psychosocial hazards are often associated with multiple harms, as the effect of a hazard is often mediated indirectly via psychological processes and furthermore occurs with a time lag (e.g., Jonge et al., 2001; Koslowsky, 2008). But there is also a conceptual shortfall that possibly results from the understanding of a psychosocial hazards as being determined on a population-based level (Semmer, McGrath, & Beehr, 2005). Many tools for hazard identification exclude the assessment of health-related variables in favor of evaluating hazards according to statistical measures of location, instead of directly associating hazard and harm. In addition, it seems unclear which health-related variables, or outcomes more in general, are best suited for this purpose because of the wide variety in the relation of psychosocial hazards and outcomes. However, it should not be forgotten that this complexity likewise applies to associations between physical work factors and health.

Against this background, we want to contribute to the methodological development of psychosocial risk analysis. In particular, we want to present an adequate calculation of risks based on psychosocial hazards as a necessary precondition to prioritize preventive steps in the risk management process. For this purpose we propose an advanced theoretical conceptualization of the risk matrix approach (RMA) as a method that can enhance the validity of risk analysis, discuss the avantages of the RMA against other established methods and propose a procedure to build a RMA for assessing psychosocial risks.

2.2.1.1 Study objectives

The main objective of our study is to conceptually enhance the RMA for assessing the risk of psychosocial hazards. With that, our contribution combines the approach as an established and proven method for assessing risks related to physical hazards with psychological theories of healthy work design (e.g., Demerouti, Bakker, Nachreiner, & Schaufeli, 2001; Hackman & Oldham, 1976; Karasek, 1979). First, we compare and rate existing procedures of psychosocial risk evaluation regarding their ability to reliably assess and prioritize risk. Second, we construct a matrix for specifically assessing psychosocial risk. To be able to use the matrix for risk evaluation, we discuss the theoretical and methodological steps necessary to scale the probability and severity of the approach. Based on our considerations, we finally present a graphical representation of a 3x3 risk matrix that uses odds ratio between psychosocial hazards and harms to statistically assess psychosocial risks. Using the constructed matrix, we provide recommendations for the development and application of the matrix in the organizational context and finally, we address possible challenges during RMA development.

Thereby, we aim to contribute to the development of a theoretical sound, empirically proven and practically useful assessment method for the risk assessment of psychosocial hazards. The proposed risk matrix can provide a conceptual framework for further empirical research. Organizations can use the approach as a guidance to establish a method for psychosocial risk assessment that is understandable by all stakeholders.

2.2.1.2 Methodological approaches for the risk assessment of psychosocial hazards

Psychosocial risk assessment is a multi-stage process that includes the steps preparation, screening, action planning, implementation, and evaluation (Nielsen, Randall, Holten, & González, 2010). In the screening phase psychosocial hazards are identified that are associated with a health risk to derive risk-reducing measures in the action-planning phase. Subsequently, the measures are implemented and evaluated regarding their effectiveness. A critical point in the process of psychosocial risk assessment is the transition from the screening to the action-planning phase. Based on screening results, it has to be decided whether the manifestation of a certain work characteristic causes a health-risk and therefore appropriate measures have to be derived. But how to assess the likelihood of a health-risk occurring from psychosocial work hazards and how results can be translated into actionable information is still scarcely researched (Gaskell, Hickling, & Stephens, 2007; Hudson, 2016; Metzler et al., 2019).

For the implementation of the EU Directive on psychosocial risk assessment, international standards were published (EN ISO 10075, 1991). The international standard proposes the framework of a stimulus-organism-reaction model and refer to the terms *mental stress* and *mental strain* (Nachreiner & Schultetus, 2002). According to this concept factors influencing mental stress are external to the individual and the reaction to stressors take place within the individual as a strain reaction. Therefore, as part of risk analysis, working conditions needs to be assessed and adjusted. The international standards apply an ergonomic rather than an individual-centered clinical design approach. For the design of working conditions, the main advantage of this approach is that the responsibility for managing psychosocial risks is not shifted to employees, e.g., through behavioural preventive approaches for dealing with health-related problems. The aim is to design adequate working conditions and not to change employees. The approach leads to the fact that legal requirements for assessing psychosocial risks demand that working conditions affecting the employees have to be documented, but not the effects itself (Nachreiner, 2002). Risk is generally calculated as the combination of hazard and harm (Glendon & Clarke, 2018). Methods for assessing psychosocial risks often do not fulfil this requirement, as the effects, e.g., in form of health-related outcomes, are not considered. For a complete risk calculation, the consideration of

possible health-related effects of identified hazards are missing. For workplace design it is still important to refer to an ergonomic approach. Health problems should not be individualized to the detriment of workers, but a necessary and important parameter should be considered within the framework of risk assessment.

The RMA considers both factors when calculating risk and can thus be regarded as a suitable method. Before addressing the potential benefits of RMA for psychosocial risk assessment in more detail, we first consider the advantages and disadvantages of existing approaches. The studies (Dettmers & Stempel, 2021; Hudson, 2016; Metzler et al., 2019) examined the following approaches, which we will look at in more detail in the next section:

a) The uniform cut-off procedure, where a uniform mainly theoretically derived scale score for all measured work characteristics is used as a cut-off value.

b) The value-based cut-off approach calculates empirical thresholds via ROC (receiver operating characteristic) analysis in relation to clinically approved health-related measures that differentiate between individuals who reach a critical value of a health-related outcome. The goal is to determine a risk factor threshold that represents an optimal ratio between true-positive rate and false-positive rate to predict a health impairment i.e., a harm. This allows the estimation of empirical cut-off values, for example for questionnaire data.

c) The reference value-based approach compares data with available reference values from previous risk assessments in the same company or comparable other companies. Through defined rules for the deviation of organizational results from the reference value, psychosocial work characteristics are selected for which measures must be derived.

d) The Clark and Cooper approach (CCA; Clarke & Cooper, 2000) calculates a risk using a combination of the frequency of a hazard and the correlation between each hazard and the relevant harm.

2.2.1.3 Discussion of the quality of existing approaches for assessing psychosocial risks

To discuss the quality of methodological approaches presented in section 1.2, it must be clarified that we differentiate between the instrument used to measure hazards (e.g., questionnaire) and the procedure used to assess the risk based on identified hazards (e.g., reference value-based approach). We generally require that instruments used to measure psychosocial hazards are based on established theories and fulfil methodological quality criteria like reliability, validity, and utility (Kompier, 2005).

We assume that methodological quality of approaches to assess the risk of psychosocial hazards can be assessed using three criteria: (1) Criterion validity: A fundamental requirement for

a sufficient quality of approaches to assess the risk of psychosocial hazards is that they must comply with the risk definition, defined as the chance that a harm will be caused by a hazard. For this, there must be a sufficient criterion validity of the approach to predict possible harms of psychosocial hazards. Thus, the approach must consider possible health-related effects and identifies this relationship validly. (2) Completeness: Another quality characteristic that can be used is how comprehensively health-related effects are considered. For example, does the procedure only refer to specific harms or are a wide range of possible effects considered. A comprehensive assessment of possible health outcomes is relevant, otherwise the risk may be underestimated. To be able to assess the health-risk comprehensively, a systematic evaluation of the effects across different health-related outcomes is important. (3) Clarity: The aim of a risk evaluation tool is to ensure a transparent and clear decision process, that is based on best empirical knowledge and reflects the understanding of involved stakeholders (Duijm, 2015). For this purpose, the methodology should be able to identify the risk in a comprehensible and understandable way. Table 10 shows a summary of the approaches regarding the chosen evaluation criteria, which we explain in more detail in the following section.

Table 10

Quality evaluation of methodological approaches to psychosocial risk assessment

	Criterion validity	Completeness	Clarity
a) Uniform cut-off procedure	-	-	+
b) Cut-off value	+	-	-
c) Reference value	-	o	+
d) Clark and Cooper Approach	+	+	-

Note. +: Fulfils the criterion completely. o: Partially meets the criterion. -: Does not fulfil the criterion.

a) The uniform cut-off procedure is based on the logic that for a work characteristic - not necessarily for the specific operationalization of this work characteristic - theoretically plausible and empirically proven relationships to health impairments exist and that it can therefore be assumed ex-ante that if a mean score of a work unit in a screening indicates a high level of this work characteristic, a risk factor is present. A uniform cut-off value is then set for all hazards, above which a need for action is indicated. Ergonomic measures in particular use this approach and suggest a moderate need for action in analogy to a traffic light system (Clarke & Cooper, 2004; Cousins et al., 2004; EU-OSHAS, 2007). It is assumed that the probability of a hazard is greater

the more employees report an exposure, and a moderate frequency represents an unacceptable level of the risk. Even if the instrument used has a strong theoretical foundation, a uniform cut-off value across work characteristics is difficult to justify, as different stressors are very likely to have different threshold values for different health impairments (Dettmers & Stempel, 2021). The authors state, that the scale scores are arbitrarily defined and meaningless to the actual risk for employee health impairment. Thus, the approach does not fulfil the necessary requirement of criterion validity, as it does not consider specific associations across different possible health impairments, as the same value is assumed for each work characteristic (Dettmers & Stempel, 2021). Since no different health-related effects per hazard are considered, the approach does not comprehensively assess the health-risk. Notwithstanding this criticism, the use of a traffic light system makes the risk assessment understandable and comprehensible.

b) Cut-off scores are specific values of questionnaires that determine when a test result is positive or negative, e.g., the occurrence of depression. In the context of risk assessment, this value indicates whether there is a health risk for a specific scale. When developing criterion-related cut-off values for questionnaires, ROC analysis can be used to predict health-related outcomes respective harms. Empirically calculated correlations between hazards and harms are also taken into account in this approach, so satisfactory criterion validity can be assumed. The determined cut-off scores indicate a health-risk for a specific scale value and a health-related outcome.
Disadvantages of this approach are that cut-off values are only related to a specific harm (e.g., depression) and previous studies only consider a small set of possible outcomes (Dettmers & Stempel, 2021; Diebig & Angerer, 2021; Zeike et al., 2018). Thus, it is possible that no risk effect has been identified for a working condition related to health impairment A, but this does not exclude the existence of a risk effect related to health impairment B. However, in the context of risk assessment, the evaluation of risk effects that are based on single outcomes is not sufficient. To be able to assess the health-risk of psychosocial work characteristics comprehensively, a systematic evaluation of effects across different harms is important (Taibi et al., 2021). It would therefore be necessary to calculate cut-off values for different hazards with a wide range of health-related outcomes. Moreover, clarity of the risk assessment may be limited because there are no rules to prioritize the selection of hazards for risk-mitigating measures when many hazards exceed the cut-off value.

c) To establish reference values, population-based median or mean values of psychosocial work characteristics are calculated across different occupational groups and / or sectors (see for example Milner et al., 2016). To assess health-related effects, the concordance of values with individually reported exposures is compared. Risks are therefore identified at a population level,

which are then considered in the risk assessment. For a variety of psychosocial work characteristics, the explanatory power of health-related effects due to the profession or occupation is low (Nübling, Vomstein, Haug, & Lincke, 2017). Kroll (Kroll, 2011) notes that the approach is suitable for physical but not for psychosocial hazards. Satisfactory criterion validity is therefore not given due to low explanatory power. In addition, it must be noted that risks determined at the population level do not necessarily apply in an organization-specific risk assessment. Reference values represent a relative assessment criterion. If an organization has lower values than a reference population that is already associated with high risks, it cannot be concluded that no risks exist in the organization.

The approach does not comprehensively assess possible health effects for certain hazards, but it can be assumed that a comparison of hazards with a representative population sample reflects the understanding of involved stakeholders, risk assessment becomes comprehensible, and the approach thus satisfies the criterion of clarity.

d) Unlike previous approaches, the CCA directly incorporates the relationships between hazards and harm, by using a combination of the frequency of a hazard and the correlation between each hazard and theoretically founded harms. This allows different risk effects of psychosocial work characteristics to be included. It can therefore be assumed that the criterion validity is sufficient, as the relationship between hazard and harm is taken into account. Furthermore, comprehensive health effects are considered, as correlations between hazards and theoretically established harms are considered.

However, the procedure does not provide thresholds when there is an obligation to derive measures. Instead, all measured work characteristics are ranked for prioritization. In this way the method does not provide a statement about the absolute health risk of a certain psychosocial work characteristic and no statement can be made about the number of acceptable questionnaire values (Dettmers & Stempel, 2021). As a result, the method shows deficiencies with regard to clarity.

2.2.1.4 Risk matrix approach

Generally, risk assessment can be divided into qualitative, semi-quantitative and quantitative methods (Ni, Chen, & Chen, 2010). While quantitative methods use numerical values to describe the extent of damage and/or frequency, qualitative methods present the results as non-numerical estimates in the form of descriptions or recommendations. The semi-quantitative method combines the procedure of the two methods. Among others, assessing physical risks by an RMA is a frequently used semi-quantitative method (Levine, 2012) and a traditional hazard analysis technique to specify risks. Risk matrices are widely used, and national and international

standards have promoted the introduction of risk matrices (Cox, 2008). The approach calculates the risk as a combination of the likelihood of an adverse event (hazard) and the negative consequences (harms) (Duijm, 2015). The matrix is often illustrated as a table that systematically contrasts different categories of probability of occurrence of a hazard in rows (or columns) with different categories of severity of harms in columns (or rows, respectively). Accordingly, each cell of the table shows a specific degree of urgency with respect to the derivation of measures (Cox, 2008, see Figure 4). The calculation process of the RMA is represented with the formula $r = p \; x \; c$, where *p* is the probability of hazard and *c* is the severity of a harm (Markowski & Mannan, 2008). To apply values to cells in the matrix, point values must be assigned to the axes. Figure 4 shows a possible representation of the approach where we have assigned the points one to three to the axes in ascending order. The risk score is obtained by multiplying the two axes. Based on the risk score, threshold values can be defined above which a need for action exists. For example, a critical harm degree [3] with the probability "always" [3] has a risk score of nine and thus a high urgency to reduce the risk with appropriate interventions. The grid is usually divided into fewer risk categories and summarized by colors, such as green, yellow, and red, to represent low, medium, and high risk (Duijm, 2015).

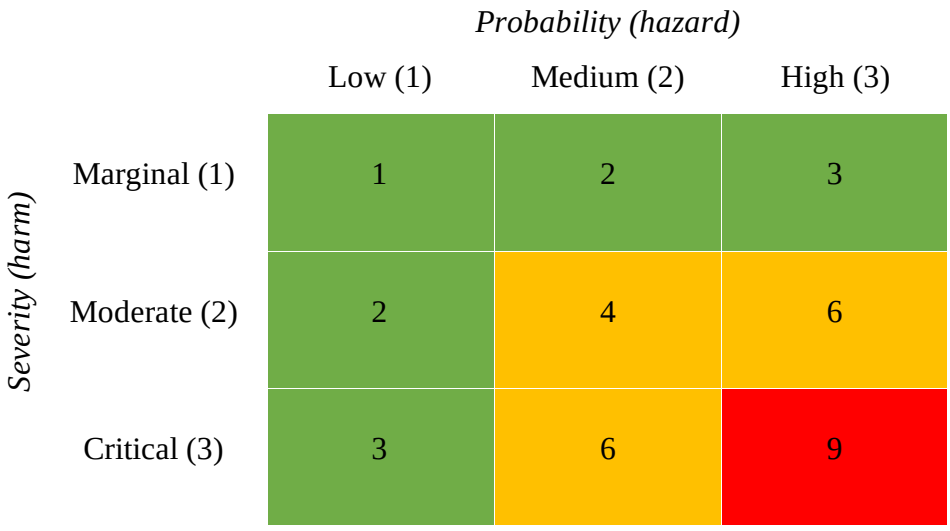

Figure 4. Exemplary illustration of a risk matrix.

Note. The numbers in cells quantify the risk for a harm by multiplying the two axes. The grid is divided into three different risk categories. Green indicates a low, yellow a medium and red a high risk.

2.2.1.5 Possible Advantages of the RMA

In the following section we discuss the advantages of the RMA for the assessment of psychosocial risks in respect to the evaluation criteria presented in section 1.3. As the RMA assess risk as a combination of the likelihood of an adverse event (hazard) and negative consequences (harms), the approach considers possible health-related outcomes of hazards. Thus, the definition criteria of risk are met, and sufficient criterion validity can be assumed, provided that theoretically sound and empirically validated outcomes are considered in the development of the risk matrix. In the risk assessment it is necessary to clarify which negative consequences are relevant when looking at a multitude of possible consequences (Aven, 2017). The selection of relevant consequences can be determined based on empirical evidence of possible health-related effects of psychosocial work characteristics. The selection of these outcomes can be assigned to the harm categories of the matrix (see Figure 4) and summarized within the categories if they remain comparable (Duijm, 2015). Different types of severity, such as the impact on environment, human health, or economy, cannot be summarized within a category. The classification of outcomes into harm categories requires conceptual understanding and empirical validation of the severity of adverse outcomes (e.g., marginal: short-term reversible strain like fatigue, severe: chronic disease like depression). This enables risk matrix to include a broad range of different outcomes in the calculation. Thus, it can be assumed that the approach fulfils the criterion of completeness. Moreover, as the RMA enables a comparison of hazards across different severity levels, it becomes possible to make a statement about what kind of health risks are likely for a certain hazard, and thus allows a prioritization with respect to the development of measures. Furthermore, by dividing the grid into different risk levels, the risk matrix can provide threshold values above which a health risk exists, and risk-reducing measures must be derived.

Due to the intuitive graphical design of the approach and the presentation of different risk levels, the risk for specific hazards and the respective necessary instructions for action, the procedure allows for a clear and comprehensible risk assessment. This makes it well received in manufacturing, service work and other industries (Ni et al., 2010). Even though the assessment of physical hazards using the RMA is very common, we are not aware of any publication that examines the use of the RMA in the risk assessment of psychosocial risks. Before transferring the RMA approach to the assessment of psychosocial risks however, the points of criticism mentioned should be considered.

The RMA is not without limitations. Cox (Cox, 2008) criticizes the subjective interpretation of the input to matrices. Duijm (Duijm, 2015) also notes, that the a priori assessments

of probability and severity of adverse events are not always precise. Thus, to achieve an objectification of a risk assessment of psychosocial hazards based on the RMA, theoretically sound and empirically validated health models that that can validly explain the relationship between psychosocial work characteristics and possible health-related outcomes must be considered. A further potential disadvantage of the approach is an imprecise classification of the risk index, as the different risk levels are grouped into categories. This can lead to insufficiencies due to the complexity of assessment problems (Ni et al., 2010). The categorization also allows the same qualitative ratings to different quantitative risks, as there can be a wide range of risks within a single category (Levine, 2012). The disadvantage is evident when considering the risk levels in Figure 4. For example, the yellow category includes both critical and moderate harms, whose health-related effects may differ significantly, but are in the same risk category due to the calculation process. Finally, the approach neglects uncertainty in the probability and consequence assessments, which can result in errors in the decision process (Cox, 2008; Duijm, 2015; Goerlandt & Reniers, 2016; Levine, 2012).

In addition to the general advantages and disadvantages discussed, we want to answer the question to what benefit the RMA has compared to previously established approaches and how the points of criticism mentioned can be countered.

2.2.2 Methods

In the following section we want to propose a theoretical procedure to build a RMA for assessing psychosocial risks. Markowski and Mannan (Markowski & Mannan, 2008) propose four steps that are necessary to build a risk matrix: (1) categorization and scaling of the probability of adverse events (hazard) and the severity of negative consequences (harm), (2) categorization and scaling of an output risk index, i.e., the number of possible risk categories (3) build-up risk-based rules knowledge and (4) the graphical edition of the risk matrix. For a conceptual development of the RMA for the assessment of psychosocial risks, we transfer these steps on the illustration of a 3 x 3 matrix (see Figure 4). Two scenarios are conceivable for the development of RMA:

1) an organization creates and maintains a matrix based on internal available data, e.g., from employee surveys, task analyses or statistics on sick leaves. In this scenario a RMA with high ecological validity can be developed, i.e., a high validity for the specific organizational context. But a high level of methodological expertise and a large amount of time must be invested to create and maintain the RMA. In addition, the linking of different data sets can pose

data privacy issues within the organization. Moreover, the available data structure could possibly be unsatisfactory (e.g., if only cross-sectional data are available).

2) Instrument developers can aim to create matrices as an aid to interpretation. The advantage is that more resources are available to create and maintain large datasets. In addition, there are no conflicts with organizational data protection regulations, so that more clinical outcomes can be recorded if necessary and the collection of data sets can be scientifically monitored. A disadvantage, however, results from organization-specific risks that may not be identified when collecting data at a population level.

2.2.2.1 Categorization and scaling the risk matrix

To build the axes, the two dimensions probability (hazard) and severity (harm) needs to be scaled and categorized. The two axes must be divided into a number of categories, which finally determines the number of risk levels. Our example in Figure 4 shows three categories per axis and thus nine different risk levels. Duijm (Duijm, 2015) note that discrete categories for the risk matrix can be identified by nominal and textual labels (e.g., high, medium, low respective never, sometimes, always). We describe the scaling process in detail in the following two sections.

First, it is important to clearly define the two dimensions of the risk matrix. In our case we define hazards as the probability of occurrence of psychosocial work characteristics that have been empirically proven to be associated with negative health consequences. Harms can be defined as the corresponding clinical and non-clinical health impairments. In order to obtain an overview of hazards and harms that need to be considered in the RMA, we focus on psychosocial aspects of work characteristics by acknowledged concepts and theories on work stress and work design. Table 11 provides an overview of relevant hazards and associated outcomes. Even though environmental or ergonomic factors (e.g., noise, temperature, etc.) may also encompass a psychosocial component, established concepts and theories on work stress and work design refer to generic psychosocial work characteristics (e.g., the dimension job demands in the job content questionnaire (Karasek et al., 1998): "my job requires me to work hard"). Furthermore, these models also do not consider antecedents that cause work characteristics being classified as potential hazards. This has also been criticized for example by Parker, Wall, and Cordery (Parker, Wall, & Cordery, 2001), when emphasizing that work design theory often fails to consider antecedes of work stress. For example, organizational design (e.g., reward system, strategy), management style or technologies used in the organization have an influence on psychosocial work characteristics and therefore on potential hazards. Antecedents of psychosocial work

characteristics play an important role for the work design. However, they are initially negligible for the development of the RMA.

2.2.2.1.1 Scaling the probability (hazard)

The probability axis of the risk matrix, as with other physical risk assessment methods, refers to the probability or frequency of events occurring (e.g., how often someone fell during work). Psychosocial hazards can be defined as events (e.g., Copenhagen Psychosocial Questionnaire, COPSOQ: Do you have to do overtime? Burr et al., 2019), but also how permanent a specific work characteristic is (e.g., COPSOQ: Is your work emotionally demanding? Burr et al., 2019). In other words, usually the data refer either to the frequency or to the extent of the examined work characteristics.

The risk matrix must be interpreted differently if the *extent* of the hazard is measured compared to the *probability or frequency* of a hazard. If the extent of a hazard is measured (e.g., the level of time pressure), the risk must be classified as "high" when a hazard is associated with a critical outcome at a low level (e.g., when already a low level of time pressure is significantly associated with depression). In other words, if low level psychosocial work hazards are already linked to a critical outcome, risk-minimizing measures must be developed at low levels. Accordingly, if only high-level hazards show a relationship to health-related outcomes, this means that a health risk is only present at higher exposure levels of the hazard. In summary, this means that the content of the used instrument to evaluate the hazard has an impact on the calculation of the risk and the meaning of the cells of the risk matrix. Figure 4 and Figure 5 illustrate the classification of risk levels for the two cases described.

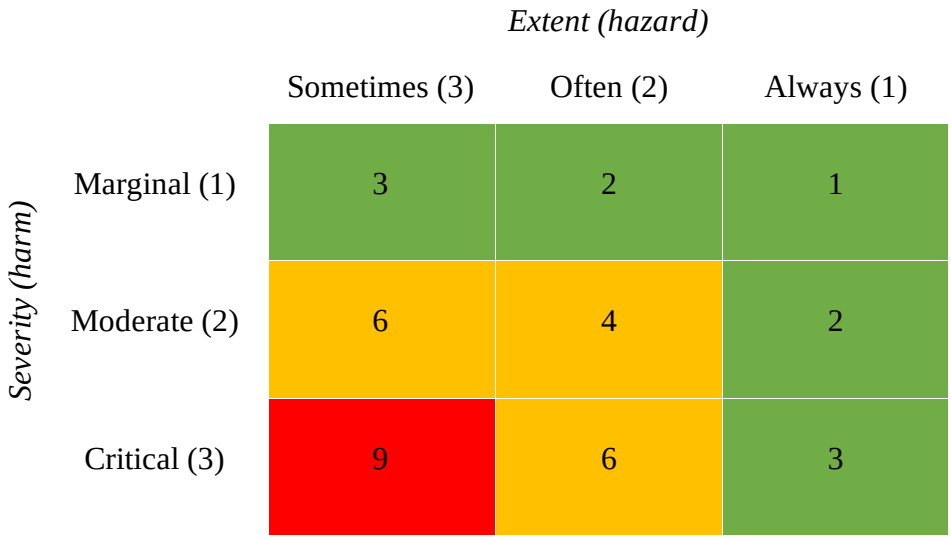

Figure 5. Exemplary illustration of a risk matrix with hazards as an extent score.

Note. The numbers in cells quantify the risk for a harm by multiplying the two axes. The grid is divided into three different risk categories. Green indicates a low, yellow a medium and red a high risk.

For the development of the matrix, it has to be determined which categories exist to capture hazards and the results from the risk assessment can be assigned to these categories. The axis for assessing hazards must therefore be built on the data of the used instrument and be oriented to the respective scaling. Either the scale levels of the instrument can be mapped directly as categories in the matrix or classification procedures can be used to assign the results of the instrument to the hazard categories of the matrix. Notelaers, Vermunt, Veldhoven, and Witte (Notelaers, Vermunt, Veldhoven, & Witte, 2003) for example recommend using the mean values of standardized questionnaires and applying statistical classification procedures. The questionnaire data can then be grouped using z-standardization. The aggregation reflects the categories of the matrix (e.g., sometimes, often, and always; see Figure 4) and associations between the categories and possible health-related outcomes can be used to calculate a risk score. For our illustration, we build a 3 by 3 risk matrix with a three-level scale (sometimes, often, and always) as an example (see Figure 4).

2.2.2.1.2 Scaling the severity of consequences (harm)

To scale the dimension of harm, it is necessary to consider theoretically sound and empirically validated results between psychosocial work characteristics and health-related effects. A brief summary is provided by the most recognized concepts and theories of work stress and work design (see for example Parker, Morgeson, & Johns, 2017). Additional outcomes were identified in the reviews Taibi, Metzler, Bellingrath, and Müller (Taibi et al., 2021) and Rau (Rau

& Buyken, 2015). Both studies summaries meta-analyses and systematic reviews and thus provide reliable information on possible consequences of psychosocial work characteristics.

Absenteeism and clinical health related outcomes such as depressive symptoms or nonclinical indicators of impaired wellbeing (such as exhaustion, monotony, or irritation) can be considered as outcomes, that might mediate the association between work characteristics and more severe health-impairments in terms of clinical diagnoses (Meijman, 1998). The consideration of non-clinical indicators can be used to identify more severe health-impairments at an early stage. Empirical evidence suggests that irritation (subjectively perceived emotional and cognitive strain; Mohr, Rigotti, & Müller, 2005, Mohr, 1986) is a preventive indicator for mental disorders (Dormann & Zapf, 2002). Consideration in the risk assessment can help prevent the development of more severe disorders based on early indicators.

To keep the subjective bias of the matrix as low as possible, a comprehensive consideration of possible health-related effects is necessary. Table 11 summarizes possible relevant outcomes across different work-related health models. The next step was to assign the identified outcomes to the categories of the matrix. Following Ni, Chen, and Chen (Ni et al., 2010) we created a 3 x 3 matrix with the degrees marginal, moderate, and critical to assess the level of harm.

Table 11

Relevant work characteristics and key outcomes across different work-related health models

Model	Work characteristics (hazards)	Key outcomes (harms)	Study
Job Characteristics Model	Skill variety Task identity Task significance	Sickness absence	Parker et al. (2017) (Parker et al., 2017)
Job Demands–Resources Model	Job demands Job resources (e.g., rewards, security)	Psychological strain Burnout	Parker et al. (2017) (Parker et al., 2017)
Challenge-Hindrance Model	Challenge demands: Workload	Burnout	Parker et al. (2017)

	Responsibility Hindrance demands: Role ambiguity Role conflict		(Parker et al., 2017)
Vitamin Model	Job complexity	(Emotional) exhaustion	Parker et al. (2017) (Parker et al., 2017)
Action regulation theory	Task variety Completeness of the work tasks	Fatigue Monotony Increased heart rate Increase in blood pressure Adrenaline release	Hacker and Sachse (2014) (Hacker & Sachse, 2014)
Job Demands–Control Model	Job demands Job control	Absenteeism (self-report and company registered) Accidents and injuries Burnout Depression Psychosomatic health complaints Psychological strain (General Health Questionnaire)	Schaufeli and Taris (2013) (Schaufeli & Taris, 2013)
Effort-Reward Imbalance Model	Effort: Physical load Time pressure Interruptions Reward: Esteem Security/career opportunities	Cardiovascular diseases Sickness absence (Psycho)somatic health symptoms Burnout	van Vegchel et al. (2005) (van Vegchel, Jonge, Bosma, & Schaufeli, 2005)

-	Work time control Social support	Absenteeism Musculoskeletal disorders	Taibi et al. (2021) (Taibi et al., 2021)
-	Work intensity Bullying Working hours Overtime Job strain	Depression Anxiety Psychological impairments Cardiovascular disease Diabetes	Rau and Buyken (2015) (Rau & Buyken, 2015)
-	Destructive leadership	Affective symptoms Burnout Stress	Montano et al. (2017) (Montano et al., 2017)

For the classification of health-impairments into the three categories, we refer to the proposed time until an impairment occurs after the occurrence of a hazard. According to international norms related to mental workload (EN ISO 10075, 1991) and work stress models such as the job demands-resources model (Demerouti et al., 2001; Schaufeli & Taris, 2013), we can distinguish between short-, medium-, and long-term health-impairments. A distinction can be found between synchronous stressor-strain effects that occur directly and chronic stressors that may have longer-term physical and mental effects and that take time to develop (Ford et al., 2014). Short-term health-impairments, such as fatigue, are usually not considered to be very serious and can usually be offset after normal recovery breaks or changes of work tasks (Geurts & Sonnentag, 2006). Even assuming adaptation effects, it is expected that psychological and psychosomatic dysfunctions usually increase with longer exposure to or stronger intensity of detrimental working conditions (Zapf, Dormann, & Frese, 1996). Thus, it can be assumed that an exposure to adverse psychosocial work characteristics over a longer period of time lead to more severe health-related outcomes. This is also associated with longer incapacity to work linked to the outcome. Thus, the degrees of harm can be mapped over the duration of the development. As a result, diagnosed diseases such as musculoskeletal disorders, cardiovascular diseases, depression, or diabetes that may take longer time to develop can be classified as harms with high severity. Effects such as fatigue, monotony or increased heart rate occur directly and can be classified as marginal (EN ISO 10075, 1991). Health-impairments that may develop in medium term, such as psychosomatic

health complaints, can be assigned as a medium severity degree. Table 12 shows the selected classification for the examined health-related outcomes.

Table 12

Possible classification of outcomes to consequences / severity

Severity level	Outcome
Marginal	Fatigue
	Monotony
	Increased heart rate
	Increase in blood pressure
	Adrenaline release
Moderate	Psychological strain
	(Psycho) somatic health symptoms
	Burnout
	Medium-term sickness absence
Critical	Depression
	Anxiety
	Cardiovascular disease
	Diabetes
	Musculoskeletal disorders
	Long-term sickness absence

2.2.2.2 Calculation and graphical edition of the risk matrix

In the next section, we discuss possible calculation methods that are necessary for the conceptual development of the RMA and enable a categorization and scaling of the output risk index. For the calculation and graphical representation of the approach, we propose the procedure presented in section 2.1:

a) Categorization and scaling hazards
b) Categorization and scaling harms
c) Empirical assessment of hazards and harms
d) Build-up risk-based rules
    d1) Binary logistic regression between "harms" and "hazards" with one degree of "hazards" as a reference category (e.g., never, see Figure 6).
        i. Calculation requires dichotomization of the "harms" into critical/non-critical values.
    d2) Statistically significant odds rations of different outcomes within a severity level are summarized.
    d3) Hazards with the calculated odds ratios are entered in the cells of the matrix.

a & b) As described in section 2.1.1 and 2.1.2, hazards are divided into different categories depending on the scaling or classification procedure. "Harms" are assigned to severity categories based on theoretical and empirical evidence.

c) An employee survey with a standardized and validated instrument is one suitable method for empirically assessing hazards (e.g., COPSOQ, Burr et al., 2019; HSE Indicator Tool, Edwards, Webster, van Laar, & Easton, 2008; Job Content Questionnaire, Karasek et al., 1998). To be able to assess the risk as comprehensively as possible, harms in all three severity categories should also be recorded. However, not every instrument used to record hazards is suitable for this purpose, as e.g., the HSE Indicator Tool and the Job Content Questionnaire do not record health-related outcomes. The COPSOQ, on the other hand, contains scales on health-related effects such as cognitive stress or burnout that can be used to measure harms. Nevertheless, the integration of other instruments is useful for measuring clinical characteristics such as musculoskeletal disorders (The Nordic Musculoskeletal Questionnaire; Crawford, 2007) depression (Patient Health Questionnaire; Kroenke, Spitzer, & Williams, 2001) or burnout (The Maslach Burnout Inventory; Maslach, Jackson, & Leiter, 1997). In addition, company data (e.g., sick leave) can be included to consider further outcomes of the different severity categories. Biological data such as increased hart rate or adrenaline release are less suitable for the implementation in the risk assessment.

d) An appropriate way of calculating a risk score is the multiplication of the numbers which were assigned to the different categories of the axes (Duijm, 2015). The calculated risk scores are then classified into different risk categories (e.g., low, medium, and high risk; Figure 4). However, the classification of the risk scores is influenced by a subjective assessment (Cox, 2008; Ni et al., 2010). To keep the subjective input as low as possible when using the approach for assessing the psychosocial risk and to consider the particularities of psychosocial work characteristics, we have assigned health-related outcomes to the different categories of harm. How to calculate risk scores for this approach is presented in the following section:

d1) Available systematic reviews and meta-analyses provide robust empirical evidence of the risk effects of psychosocial work characteristics on negative health consequences (da Costa & Vieira, 2010; Hauke, Flintrop, Brun, & Rugulies, 2011; Kraatz, Lang, Kraus, Münster, & Ochsmann, 2013; Lang, Ochsmann, Kraus, & Lang, 2012; Rau & Buyken, 2015; Taibi et al., 2021). Results of these meta-analyses are usually presented in the form of correlation coefficients. The coefficients are only indirectly suitable for the derivation of risk values since risk-based statements for the evaluation of hazards assess the probability of a negative event (Dettmers & Stempel, 2021).

In addition, it must be considered that organization-related data are often available in a multi-level structure and must therefore be analyzed with suitable methods. Otherwise, incorrect estimations will occur, because relationships among variables at one level do not necessarily are present at another level of the hierarchy (Croon & van Veldhoven, 2007; Snijders & Bosker, 2012). Besides the classic macro-micro multi-level structure (dependent and explanatory variable are measured at a lower level), organization-related data such as sickness rates are not available for each individual, but are only reported for organizational units (e.g., per department). This results in a micro-macro structure (dependent variables are measured at a higher level and have no variance at the lower level), for which there are only a few suitable analysis methods so far (Bennink, Croon, Kroon, & Vermunt, 2016; Croon & van Veldhoven, 2007).

To make risk-based statements, dichotomous variables are necessary and thus different calculation methods. In medical research, for example, the risk of health impairments or diseases between dichotomous predictors and outcomes is calculated by odds ratios (Bender & Grouven, 1997). The measure represents the odds that an outcome will occur given a particular exposure, compared to the odds of the outcome occurring in the absence of that exposure (Szumilas, 2010). This approach can be transferred to the calculation of the RMA if the outcomes considered are dichotomized. Dettmers and Stempel (Dettmers & Stempel, 2021) consider odds ratios as a solid basis for transparent decision making and as a basis for establishing rules on how to proceed during

the different stages of psychosocial risk assessment. Therefore, we propose a method that allows the calculation of odds ratios. For this purpose, a binary logistic regression between psychosocial hazards and harms can be used to predict the probability of the dichotomous outcome variable. For the calculation of the binary logistic regression, a reference category of the predictor (here a harm) must be selected. For a reasonable interpretation, either the highest or the lowest degree is suitable. In our example, we chose "never" as the reference category which refers to the degree when the probability of the psychosocial work characteristic is zero. This category can be selected for the calculation but is not used in the final graphical representation of the matrix.

d2) All significant odds ratios between one measured psychosocial hazard and all health-related outcomes within one category (see Table 12) are averaged. This score represents the average risk effect of a hazard on associated harms of a certain severity category (see Figure 6).

d3) Hazards with statistically significant odds ratios are entered in the cells. If, for example, the hazard "lack of social support" in the degree "often" shows a statistically significant association with psychosomatic health symptoms and burnout, “lack of social support” with the corresponding averaged odds ratio is entered in the cell of the column “often” and the row “critical”.

		Probability / extent (hazard)		
	Never *Reference category*	**Sometimes (P1)**	**Often (P2)**	**Always (P3)**
Severity (harm) **Marginal (S1)** (e.g., exhaustion, fatigue)		OR Hazards P1S1	OR Hazards P2S1	OR Hazards P3S1
Moderate (S2) (e.g., burnout, psychosomatic health symptoms)		OR Hazards P1S2	OR Hazards P2S2	OR Hazards P3S2
Critical (S3) (e.g., depression, cardiovascular diseases)		OR Hazards P1S3	OR Hazards P2S3	OR Hazards P3S3

Figure 6. Graphical edition of the RMA for psychosocial hazards. *Note*. OR = odds ratio.

2.2.3 Results

In the following section we want to propose recommendations for the development and application of the matrix in an organizational context. The proposed approach is a theoretical concept and has not yet been calculated using existing data. Our proposal is intended to support further empirical research. The prioritization of risk-mitigating measures in the risk management process using the RMA is based on the following four steps:

1. Assessing hazards with a suitable instrument (e.g., conducting an employee survey based on the COPSOQ)
2. Calculating the means of all hazards
3. Assessing the risk of each hazard by comparing the hazard means with the risk values in the cells of the risk matrix
4. Prioritize the development of measures according to the risk of the hazards

For the selection of risk-mitigating measures, hazards that indicate a statistically significant odds ratio in the association with a harm are relevant, as they indicate a risk for the health outcomes of the respective harm level.

Example based on Figure 7: In level P3, a risk was identified for high job demands and low social support, as significant correlations to corresponding health outcomes exist. If the risk assessment identifies a value for job demands that can be assigned to the category always (P3) there is risk of critical health impairment and measures must be implemented. If the value for job demands can be assigned to categories P2 or P1, no measures are required, as no health risk can be identified. For social support a risk is identified for every extent and therefore, risk-minimizing measures must be derived for this scale from level P1 onward. However, it must be kept in mind that for category P1 only a marginal health risk is evident. Therefore, within the framework of risk prioritization, it may make sense to derive measures only at higher severity categories.

Severity (harm)	*Extent (hazard)*		
	Sometimes (P1)	**Often (P2)**	**Always (P3)**
Marginal (S1) (e.g., exhaustion, fatigue)	Lack of social support 1.8		
Moderate (S2) (e.g., burnout, psychosomatic health symptoms)		Lack of social support 2.3	
Critical (S3) (e.g., depression, cardiovascular diseases)			Job demands 2.5 Lack of social support 3.6

Figure 7. Example of a risk matrix with fictional data for the selection of risk-mitigating measures. *Note*. The values represent averaged odds ratios between the measured hazards and all health-related outcomes within one category.

2.2.3.1 Limitation

The proposed method for assessing the risk of psychosocial hazards has a few methodological limitations that should be accounted for. Some of the suggested health-related outcomes are captured on an abstract level and can therefore cover heterogeneous aspects. Musculoskeletal or cardiovascular diseases include medical conditions that can have varying degrees of impact on personal health. A heart attack may have more severe effects than myocarditis, but both cases are grouped under cardiovascular disorders. Therefore, studies are needed that show the relationship between psychosocial work characteristics and possible effects, that uses a fine-grained classification of health-related outcomes.

A further disadvantage arises from the fact that the RMA can be insufficient due to the complexity of assessment problems (Aven, 2017). The two axes of the RMA represent complex interactions in reality. Therefore, the causes for the occurrence of risks may be disregarded. Instead of a non-numeric calculation process, the authors (Ni et al., 2010) propose an arithmetic extension of the risk matrix, which we have already partially considered in our development via the calculation of odds ratios. Other methods for assessing psychosocial risks have a similar problem, as previous approaches only consider one parameter of the risk definition and ignore health-related effects. The RMA goes one step further and, in addition to hazards, also considers harms. For the

practical development of the approach, it can be examined whether calculations from engineering-based approaches to risk assessment can be considered.

The performance of RMA to improve risk management decisions depends on the joint distribution of the attribute's probability and consequences. Since risk matrices are normally used when quantitative data is limited, the joint distribution is mostly uncertain (Cox, 2008). In order to adequately develop the RMA for the assessment of psychosocial risks, sufficient knowledge about the statistical joint distribution of probability and consequence is necessary. Whether the matrix is developed within an organization or by instrument developers, the joint distribution of probability and consequence should be checked before developing the RMA.

Another limitation arises from the necessary artificial dichotomization of health-related outcomes to calculate odds ratios. A transformation of continuous variables into dichotomous variables is accompanied by a loss of information. In addition, rules for categorizing outcomes into critical and non-critical values must be defined. In psychological research, outcomes are often measured using continuous variables. There are questionnaire procedures for the measurement of health-related outcomes that define threshold values (e.g., World Health Organization-Five Well-Being Index). In the medical context, a dichotomous classification is not uncommon, e.g., the detection of diabetes using the average blood sugar level (Mayfield, 1998). In the assessment of diseases, a distinction is made in most cases between present and absent and the degree of expression is not mapped using a continuous scale. For the calculation of the RMA, it must be considered that an operational guideline for dichotomization must be available for all included outcomes in order to be able to determine them as objectively as possible. Especially for psychological outcomes, which are increasingly available as continuous variables, thresholds must be defined.

2.2.4 Discussion

Due to changes in work requirements in many occupational fields, the importance of psychosocial risk factors increases. Health and safety regulations require companies to include psychosocial hazards in the risk assessment, but the systematic assessment has so far been insufficiently implemented. Existing approaches to assess psychosocial risks do not completely assess the risk in the understanding of the definition or do not provide a clear and comprehensible risk assessment. Since approaches to the analysis of physical hazards can only be transferred to the context of psychosocial risks to a limited extent, the main objective of our study was a conceptual advancement of the RMA to enable the risk assessment of psychosocial hazards with this method. The approach is proven in relation to other (e.g., physical) risk factors, but so far,

there are no risk matrices for the assessment of psychosocial risks. The assumed advantage of the RMA over other methods is that it calculates risk as a combination of the probability of an adverse event (hazard) and the negative consequences (harm). Furthermore, the method is transparent, and the graphical intuitive representation enables all participants to understand the risk assessment and prioritization for further risk-mitigating measures. To scale the probability, we classified hazards into different categories, either by transferring the scale of a used instrument onto the matrix or by applying statistical classification procedures. To scale the severity, we assigned harms into categories based on theoretical and empirical evidence. Odds ratios were calculated by logistic regression and hazards with significant results were entered into the cells of the matrix. To prioritize risk-mitigating measures, the risk is classified by comparing the values from the risk assessment with the hazards determined in the risk matrix. The RMA may provide critical values to prioritize different hazards, also regarding possible risk-mitigating measures to be derived. By designing the RMA, we contributed to the advancement of a theoretical sound, empirically proven and practically useful assessment method for the risk assessment of psychosocial work hazards. Our approach justifies the risk assessment based on a variety of empirically and theoretically founded health-related outcomes, and comprehensively includes the effects of psychosocial hazards.

It should be considered that the RMA has advantages over other methods in risk assessment of psychosocial hazards, but the development is more complex, time-consuming, and thus also more cost-intensive, as multi-layered data material and a wide range of possible health-related outcomes must be considered. Nevertheless, a well-founded risk screening is essential for the risk assessment since the selection of hazards for the derivation of risk-mitigating measures is based on these results. An insufficient screening can result in the development of measures that fail to reduce the health-endangering psychosocial work characteristics. This would miss the key objective and the health and safety of the employees cannot be guaranteed.

Two scenarios of RMA development are conceivable. First, authors developing instruments that assess psychosocial risks (e.g., Burr et al., 2019; Edwards et al., 2008; Karasek et al., 1998) may aim to create the RMA as an interpretive tool. Sufficient capacity can be created within research projects to generate large (long-term) data sets and use them for compilation. Another option is the development of a risk matrix within organizations. This results in a higher ecological validity, as the data is collected within the specific work situation. However, the development effort can be very high, especially for small and medium-sized enterprises, because either little expertise is available, or the data structure is insufficient for substantiated statements. In addition, clinically relevant outcomes may not be recorded due to company-specific data

protection guidelines and the data situation is insufficient for the assessment of higher severity levels. A possibility to reduce the effort is to limit the number of included health-related outcomes. Instead of recording all proposed outcomes, only a small selection per severity degree can be considered. Before development, it can be decided which outcomes are relevant in the risk assessment and the company limits itself to a smaller selection. It should be noted that the reduction of outcomes can reduce the validity of the risk assessment. Any relationship between hazard and harm that is not mapped can lead to hazards not being identified as a health risk.

It must, however, be kept in mind that the choice of health-related outcomes can influence the results of the risk assessment. During the last decades many studies have demonstrated that specific psychosocial work characteristics can impair the mental and physical health (da Costa & Vieira, 2010; Demerouti et al., 2001; Hauke et al., 2011; Kraatz et al., 2013; Lang et al., 2012; Larsman & Hanse, 2009; Rau & Buyken, 2015; Taibi et al., 2021). Particular attention should be paid to the role of leadership behavior. Especially destructive leadership is a factor that is negatively associated with the health of employees (Anna Nyberg & Peggy Bernin and Töres Theorell; Montano, Reeske, Franke, & Hüffmeier, 2017; Skakon, Nielsen, Borg, & Guzman, 2010). Furthermore, leadership style operates as a mediator. Communicative processes like feedback or availability of information can reduce other hazards (such as role, task, and interpersonal conflicts) and contribute to the formulation of efficient problem-solving strategies (Montano et al., 2017). A destructive leadership style, on the other hand, can encourage bullying and harassment (Einarsen, Aasland, & Skogstad, 2007). Leaders are influenced by the organizational structure and culture, but leaders also have a possibility to shape and change it (Anna Nyberg & Peggy Bernin and Töres Theorell). As the interaction has a great impact on the health of all employees, leadership behaviour must be considered in the risk assessment of psychosocial hazards. When assessing hazards, it may therefore be more appropriate to use instruments that refer to multifactorial models (e.g., Work Design Questionnaire, Morgeson & Humphrey, 2006; COPSOQ, Burr et al., 2019). These instruments cover a broad range of work characteristics and include individual factors such as environmental aspects or leadership, which are not captured by acknowledged concepts and theories on work stress and work design. The large number of inter-individual differences between studies in the assessment of psychosocial risks requires an epidemiological understanding similar to physical hazards, so that the question of which health-related effects certain hazards show is raised at a population-based level (Clarke & Cooper, 2004; Cox, Griffiths, & Rial-González, 2000; Semmer et al., 2005). The epidemiological perspective indicates risks associated with specific work characteristics at a population level without considering organizational or occupational specific effects in the risk

assessment (Nachreiner, 2002; Nachreiner & Schultetus, 2002). To verify whether specific hazards represent a health risk in the respective organizational context, it is important to consider health-related effects in the organizational risk assessment and not solely refer to epidemiological evidence. Thus, the scientific evidence of relevant hazards and related harms provides a basic framework for building up the RMA and the aspects that needs to be assessed, however it seems reasonable to use organization-specific data for the risk calculation. Such an approach, however, can only be implemented in large organizations.

One aspect in which psychological hazards differ from physical hazards is often the time interval between exposure and effect, because physical hazards usually have immediate effects, like an accident, whereas the effects of exposure to psychological hazards may remain latent for longer time (Rick & Briner, 2000). To account for this specificity, we assigned more severe health-related outcomes that take longer to develop across different degrees. However, long-term data are required to map time-related effects. Within the organization, only cross-sectional data are likely to be available because of the expense and company-related guidelines. Therefore, it must be considered that a time-related effect between hazard and harm cannot be determined in cross-sectional designs. Therefore, long-term data are more suitable for an optimal calculation of the approach.

In a standard risk assessment, probability of occurrence refers to the likelihood that a harm will occur. Observation instruments, workshops or questionnaire procedures should provide information on how often or to what degree psychosocial hazards occur. In our article, we point out, that the interpretation of the risk is different if the *extent* of the hazard is measured, which is often the case in the assessment of psychosocial work characteristics, compared to the probability or frequency. It should therefore be noted that the classical assessment of the matrix for categorizing the risk levels can be misleading in the context of deriving measures. One possibility for categorization can be the consideration of the strength of identified odds ratios. In order to decide what role, the level of odds ratios can play in risk categorization, it is first necessary to review the data situation.

A review of legal regulations shows that the implementation of the risk assessment of psychosocial hazards at EU level is still insufficient (Leka, Jain, Iavicoli, & Di Tecco, 2015). Furthermore, the study Langenhan, Leka, and Jain (Langenhan, Leka, & Jain, 2013) found that many organizations have practical difficulties in sufficiently understanding and incorporating psychosocial risks into strategic decision-making. The methodological guidance of the RMA can help organizations to bridge this gap. Most importantly, the RMA facilitates and provides comprehensible guidelines for decision-making that can be translated into a safety strategy.

Moreover, establishing the method can help to build a psychosocial safety climate (PSC). PSC is defined as policies, practices, and procedures for the protection of worker psychological health and safety (Hall, Dollard, & Coward, 2010). The theory assumes that psychological aspects are more important than productivity demands and that the management acts in the interest of employees' mental health (Loh, Dollard, McLinton, & Tuckey, 2021). To accomplish a PSC, measures to improve working conditions and mental health should be implemented in a coordinated approach that includes organizational communication, management involvement and commitment (Zadow & Dollard, 2016). By establishing a suitable, standardized, and comprehensible method for psychosocial risk assessment, management demonstrates that psychosocial risks and the health of employees are considered and thereby promotes the PSC. When developing and implementing the RMA, it should be ensured that data protection is observed when using health data, that the development and application of the RMA is transparent for all employees and that the prioritization of risk-mitigating measures based on the results is comprehensible.

2.2.4.1 Future research directions

For future research, it is necessary to calculate the RMA based on the conceptual development presented with available risk assessment data, either at the population-based level or in specific organizational settings. In the second case, objective data such as sick leave or accidents rates, which indicate serious harm and have a strong economic impact, are interesting.

To discuss the quality of existing approaches to psychosocial risk assessment, further methodological comparisons need to be conducted. For this purpose, the RMA and additional methods can be compared regarding their prognostic validity. The validity of the risk assessment can be determined by examining the extent to which psychosocial risks measured at baseline predict health-related outcomes measured after different time frames. Risk can be calculated between hazards and clinical health-related or non-clinical indicators of impaired well-being. Organizational data such as absenteeism or accident rates can be considered as outcomes.

Finally, the RMA can be evaluated in terms of utility and costs effectiveness in order to answer the question of how well the procedure can be implemented in organizations. It would be conceivable, for example, to conduct expert interviews with occupational safety and health decision-makers to be able to assess practicability or economic aspects such as costs. Another important aspect is the acceptance of the approach by employees, which can be assessed by means of large-scale employee surveys.

2.2.4.2 Conclusion

How psychosocial hazards should be properly evaluated is still under debate and most existing approaches do not sufficiently assess the risk, as health-related effects are not considered. The RMA can be regarded as a suitable method for psychosocial risk assessment, as it calculates risk as a combination of the likelihood of an adverse event (hazard) and the negative consequences (harms). In our study, we were able to present the theoretical and methodological steps necessary to realize the approach for psychosocial risk assessment. This is done by developing different categories of harm based on psychological theories of healthy work design and classifying hazards through statistical procedures. Our contribution advances the RMA as a framework that allows for assessing the relation between psychosocial hazards and harm disregarding which theory of work stress is applied or which tool is used for hazard identification.

The proposed risk matrix can provide a conceptual framework for further empirical research and help to understand how psychosocial hazards can be evaluated validly in the context of risk assessment. Organizations and researchers can use this guidance to establish the RMA and thus provide a valid method to assess the risk of psychosocial hazards that is understandable by all stakeholders and provides clear decision-making that can be translated into a safety strategy.

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2.3 Managing psychosocial hazards in the workplace: How to link Frequency and Severity using Risk Matrices

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Abstract

Introduction: The evaluation of psychosocial hazards in terms of the associated health risk still challenges scientists and practitioners. Most approaches for psychosocial risk evaluation do not consider direct health-related effects in the data at hand. The risk matrix approach (RMA) facilitates risk assessment by calculating risk as a combination of the likelihood of an adverse event (hazard) and negative consequences (harm) but has not been tested in psychosocial risk assessment yet.

Method: We construct the RMA for psychosocial risks by assigning stress and strain scales of the Copenhagen Psychosocial Questionnaire (COPSOQ) onto the axes of frequency and severity. To conceive severity, we categorize low, moderate, and high levels of health-related risk according to theory of healthy work design. Using a sample of a German steel company (N=7,242) the empirical hazard-harm relationship is calculated by logistical regression.

Results: Results are transferred to a 4 x 3 risk matrix that gradually associates levels of frequency with levels of harm. Most hazards show their level of risk to increase considerably with an increase in frequency. Strong effects are found for environmental conditions, work privacy conflict, and emotional demands in relation to personal burnout.

Conclusion: For further risk-mitigating interventions scales with significant health risk can be ranked according to severity level. This contribution advances the RMA as a framework by directly including health-related effects on a categorized level into psychosocial risk assessment. We enable future research and discussion in how to best evaluate and prioritize psychosocial risk for both scientists and practitioners.

Key words: Risk assessment, Risk evaluation, Psychosocial hazard, Occupational stress, Work stress, Job demands

2.3.1 Introduction

The detrimental effects of psychosocial work characteristics on employees' mental and physical health have been consistently proven in numerous studies (e.g., Kivimäki & Kawachi, 2015; Lang, Ochsmann, Kraus, & Lang, 2012; Rau & Buyken, 2015; Taibi, Metzler, Bellingrath, & Müller, 2021; Theorell et al., 2015). To maintain health and workability of employees, risk assessment of psychosocial work characteristics is essential. Risk assessment is a systematic process to combat potential hazards at work and combines three elements: *hazards, harm, and risk* (Clarke & Cooper, 2004). Considering an occupational context, a psychosocial *hazard* can be any psychosocial work characteristic that has the potential impairing employees' health and well-being (Cox & Griffiths, 2002). The detrimental consequence of a hazard for the health and safety of an employee is defined as *harm*. Based on this approach *risk* can be described as the probability that a hazard will cause harm, and the severity of that harm (Glendon & Clarke, 2018). Even though integration of psychosocial risks into laws have been established (e.g., EU Directive 89/391/EEC, 1989), risk assessment of psychosocial hazards is insufficiently implemented at national and international level (Beck & Lenhardt, 2019; Ertel et al., 2010; Eurofound and EU-OSHA, 2014). Most frameworks for psychosocial risk management refer to an epidemiological understanding of psychosocial hazards. The detrimental effects to health and well-being are hence assumed to be associated on a population-based and probabilistic scheme (Semmer, McGrath, & Beehr, 2005), instead of being assessed directly in the present data. Since *risk* is usually understood to be a product of frequency and severity under given circumstances (Ballard, 1992; Clarke & Cooper, 2000), not accounting for direct health effects in risk assessment might result in false assumptions, at every stage of the process from risk evaluation to mitigation (Taibi, Metzler, Bellingrath, Neuhaus, & Müller, 2022).

Psychosocial risk assessment is a multi-stage process and comprises the systematic assessment of hazards and the evaluation of the identified hazards in terms of their potential health risk. An overview of psychosocial hazard exposure is measured by suitable screening methods (e.g., employee surveys or observation interviews; DIN Standard, 2004). Based on existing screening results, it must be evaluated whether the manifestation of a certain psychosocial hazard causes a health-risk and therefore appropriate measures must be derived (Taibi et al., 2022). But it is not so much the assessment of psychosocial hazards (i.e., Are there any potential hazards, and if so, which?) that challenges organisations and scientists, but rather the risk evaluation of identified hazards (i.e., How likely, and severe is a health risk for the employees? Is it necessary to derive measures to reduce the harm and minimize the risk?). How to evaluate the likelihood of

a health-risk occurring from psychosocial hazards and how results can be translated into actionable information is still scarcely researched (Gaskell, Hickling, & Stephens, 2007; Hudson, 2016; Metzler, Groeling-Müller, & Bellingrath, 2019; Taibi et al., 2022). A major factor causing the insufficient implementation of psychosocial risk assessment is the lack of evidence-based threshold values, that allow a valid evaluation of the health risk (Rau, 2022; Taibi et al., 2022). Additionally, the effect of a hazard is often only indirectly mediated via psychological processes and occurs with a time lag (e.g., Jonge et al., 2001; Koslowsky, 2008) or psychosocial hazards are often associated with multiple harms. Therefore, it is often not clear which hazard-harm relationship should constitute the criterion for a risk evaluation.

To address these methodological challenges in the process of psychosocial risk assessment, the aim of our study is the adaptation of the risk matrix approach (RMA) for the evaluation of psychosocial hazards. With this approach, we want to evaluate psychosocial risks in a standardised way, independent of the used instrument for hazard identification. This allows a prioritisation of risks accounting for direct health effects in risk assessment. First, we discuss established risk evaluation procedures. Then we present methodological steps to adapt the RMA for a valid evaluation of psychosocial hazards and finally we present an empirical calculation based on existing data.

2.3.1.1 Established approaches for risk evaluation

We first provide an overview of established approaches to risk evaluation and their address methodological disadvantages. Most approaches to risk evaluation can be divided into three main types (Dettmers & Stempel, 2021; Metzler et al., 2019; Taibi et al., 2022): (1) uniform cut-off procedure, (2) reference value-based approach, and (3) cut-off value-based approach. The uniform cut-off procedure (1) sets a uniform cut-off value for all hazards, above which a need for action is indicated (e.g., there is the same cut-off value for the hazards time pressure, and work interruptions). The values are based on the logic that for a given work characteristic a theoretically plausible and empirically proven linear relationship with certain health impairments exist (e.g., Lang et al., 2012; Theorell et al., 2015). It is then assumed that the probability of a hazard is greater the more employees report an exposure. A legitimate critique of this approach is the arbitrary definition of scale values and with that also cut-off values. By doing so the approach ignores the actual empirical risk for an employee to suffer from a health impairment (Dettmers & Stempel, 2021). In addition, different hazards can have a different risk effect, but this is ignored by a unification of cut-off values (Dettmers & Stempel, 2021). The reference value-based approach (2) compares data with available reference values (e.g., database of the Copenhagen Psychosocial

Questionnaire; Nübling et al., 2011). Through defined rules for the deviation from the reference value, psychosocial hazards are selected as a risk. This approach is criticized because it does not provide a theoretical or empirical rational for the evaluation based on deviations of the mean from a reference sample (Rau, 2022). Furthermore, the use of reference values can lead to wrong conclusions. If the benchmark already indicates unfavourable working conditions the comparison would not indicate any peculiarities, even though the work characteristic show potentially a health risk.

The cut-off value-based approach (3) calculates empirical thresholds via ROC (receiver operating characteristic) analysis in relation to clinically approved health-related measures that differentiate between individuals who reach a critical value of a health-related outcome. Disadvantages of this approach are that cut-off values are often related to only one specific harm (e.g., depression). Previous studies have so far only considered a small number of possible outcomes (e.g., Dettmers & Stempel, 2021; Diebig & Angerer, 2021; Zeike et al., 2018). As a result, there may be hazards that have no risk effect on the investigated clinical harm but on an antecedent non-clinical harm. If these early indicators are neglected, important information for the derivation of preventive measures is missing. To be able to assess the health-risk of psychosocial hazards comprehensively, a systematic evaluation of effects across different health-related effects is important.

2.3.1.2 Methodological challenges

To be able to further develop the potential of psychosocial risk assessment, we transfer the RMA to the evaluation of psychosocial hazards. The risk matrix approach calculates risk as a combination of the probability or frequency of an adverse event (hazard) and its negative consequences (harm; Duijm, 2015). The two dimensions are divided into different levels that represent ascending probabilities or frequency of the hazard and different levels of severity of a harm (Ni, Chen, & Chen, 2010). The matrix is then displayed as a table that systematically combines different levels of probability or frequency of a hazard with different levels of severity of a harm (see Figure 8). The output risk index is calculated by multiplying the two dimensions and each cell of the table shows a specific degree of a risk that indicates the urgency for the derivation of measures (Cox, 2008).

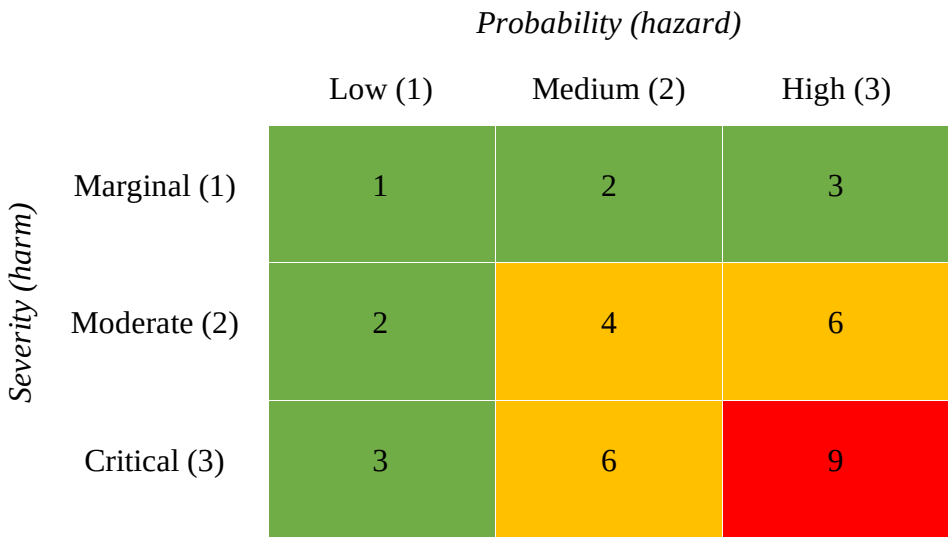

Figure 8. Exemplary illustration of a risk matrix.

Note. The numbers in cells quantify the risk for a harm by multiplying the two axes. The grid is divided into three different risk categories. Green indicates a low, yellow a medium and red a high risk.

The RMA addresses some major challenges in psychosocial risk evaluation that are not considered by the above described three established approaches: consideration of potential differential risk effects of hazards, consideration of different severity levels of harms and the consideration of direct health-related effects within risk assessment. The RMA enables the integration of health-related effects within the respective work situation and thus creates a reference point for the risk evaluation. The approach calculates risk as a combination of the probability of an adverse event and the severity of negative consequences and thus enables an empirical relationship between psychosocial hazards and health-related effects (Taibi et al., 2022). In this way, the RMA can moreover provide criterion-oriented thresholds for determining whether an exposure can be classified as critical or non-critical in terms of its health risk. In addition, the evaluation scheme of the matrix allows to calculate different cut-off values for different psychosocial hazards and integrate different health outcomes. Finally, the method is transparent, and the intuitive graphical representation enables all participants to understand the results of a risk assessment and the prioritization for further risk-mitigating measures. Hence, we assume that the RMA is a method that can enhance the validity of risk analysis, we want to investigate whether the approach that has been used so far for the assessment of physical hazard, can be applied for psychosocial risk analysis.

2.3.1.3 Study objectives

Against the here described theoretical background, the main objective of our study is the empirical investigation of the RMA for the risk assessment of psychosocial hazards using a sample of employees of a large German steel manufacturing company. For this we first present statistical calculations necessary to determine the actual risk potential based on the results of the risk assessment of psychosocial hazards. Subsequently, the results are transferred into the form of the risk matrix approach. We discuss the procedure to build a risk matrix approach for assessing psychosocial risks and the advantages against other established methods and. Additionally, we consider the application in an organisational context for selecting and prioritizing psychosocial hazards to further derive risk-minimising interventions. As we use existing results of a risk assessment of a steel manufacturing company, we figure out which pitfalls can arise when using organisational data. By improving risk evaluation and mitigation, we aim to advance psychosocial risk management in theory and practice to best comply with the overall aim of maintaining and promoting health and well-being of the workforce. The approach can provide a standardised evaluation, irrespective of the hazard identification tool used.

2.3.2 Materials and Method

2.3.2.1 Procedure and sample

The dataset derives from data collected during the psychosocial risk assessment in a large German steel manufacturing company between 2016 and 2021. To measure the risk of psychosocial work hazards the company established a standardized process and concluded a work agreement between the works committee and the management board to clarify and contract the procedure of psychosocial hazard analysis.

All employees have the possibility to evaluate the psychosocial work characteristics using the Copenhagen Psychosocial Questionnaire (COPSOQ; Burr et al., 2019). The questionnaire was filled out in the paper version in regular team meetings near the workstations and was accompanied by trained personnel. Written informed consent was obtained from all voluntary participating employees. The current sample includes N=7,242 employees and the total average response rate is 58%. Gender, age in groups, type of work (blue or white collar), type of working contract (being fixed term- or permanent employed), years of experience on the current job, workload and working hours were assessed as additional information in the psychosocial risk assessment and can be used as covariates. The basic characteristics of the sample are shown in Table 13.

Table 13

Basic characteristics of the sample

Variable	Per cent %	Variable	Per cent %
Gender		Type of work	
Male	88	Blue Collar	59
Female	8	White Collar	29
Missing	4	Missing	12
Age		Work experience	
Up to 24 years	6	Under 1 to 5 years	29
25 to 34 years	18	6 to 10 years	15
35 to 44 years	14	11 to 20 years	16
45 to 54 years	34	21 to 30 years	16
Over 55 years	22	More than 30 years	20
Missing	5	Missing	5
Type of contract		Working hours	
Fixed-term contract	10	24h Service	1
Permanent contract	86	Office Monday - Friday	28
Missing	4	Early shift	6
Working time		Full shift	50
Full-time	95	Two shifts	7
Part-time > 50%	2	Missing	8
Part-time < 50%	.3		
Missing	3		

Note. *N*=7,242.

2.3.2.2 Measures

The German standard version of the COPSOQ (Nübling, Stößel, Hasselhorn, Michaelis, & Hofmann, 2006) for conducting psychosocial risk assessment is applied in the process. The questionnaire contains the following dimensions to measure psychosocial hazards: demands (14 items, subscales: quantitative demands, emotional demands, demands for hiding emotions, work-privacy conflict), influence and development (19 items, subscales: influence at work, degree of freedom, possibilities for development, meaning of work, workplace commitment), interpersonal relations and leadership (16 items, subscales: predictability, role-clarity, role-conflicts, quality of leadership, social support, feedback, social relations, sense of community, bullying), additional

factors (18 items, subscales: trust and justice, job insecurity, environmental conditions; Metzler & Bellingrath, 2017). The COPSOQ measures effects of psychosocial hazards on employees as a function of individual conditions using different *strain* variables (24 items, subscales: intention to leave the job, job satisfaction, general health, personal burnout, cognitive stress symptoms, satisfaction with life). All items have a Likert-type scale on four, five or seven possible answers and the responses were transformed to a scale of 0 and 100 as recommended by Burr et al. (2019). All scales were calculated as average scores if at least half of the affiliated items are non-missing with high averages indicating increased exposure to hazards or experienced strain. Means, standard deviations and Cronbach's α of all scales can be found in Table A1 in the appendix.

For further analysis those COPSOQ scales were selected that represent psychosocial hazards that showed the most robust evidence for health-impairing effects according to recent reviews and meta-analyses (e.g., Anwer, Li, Antwi-Afari, & Wong, 2021; Rau & Buyken, 2015; Taibi et al., 2021): quantitative demands, emotional demands, demands for hiding emotions, degrees of freedom, influence at work social support, job insecurity, social relations, role conflicts, environmental conditions and work-privacy conflict (e.g. Anwer et al., 2021; Rau & Buyken, 2015; Taibi et al., 2021). Among the COPSOQ *strain* variables, general health, personal burnout, and cognitive stress symptoms are suitable for further analysis. These outcomes can be considered as nonclinical indicators of impaired wellbeing, that might mediate the association between hazards and more severe health-impairments in terms of clinical diagnoses.

2.3.2.3 Statistical analyses

All statistical analyses were conducted with the statistical software package SPSS 27. Of all cases, 33% contained missing data, but only 4.0% of all values were missing in general. Little's test (p=0.000) and graphical analysis showed the data not to be missing completely at random (MCAR). The data are missing at random (MAR) as the procedure in SPSS reveals a dependency of the type of work (blue vs. white collar) on the response behaviour. According to Schafer and Graham (2002), who argued that serious violations of MAR are relatively rare we used linear regression method in SPSS to impute the missing values.

2.3.2.4 Constructing the risk matrix

In the following section we want to propose the methodological steps to build the RMA for assessing psychosocial risks. To construct the risk matrix, first the two dimensions hazard and harm must be scaled. The risk score can then be calculated based on the two axes.

2.3.2.4.1 Scaling frequency and severity

A hazard refers to characteristics of the work environment which have the potential to induce adverse effects (Metzler et al., 2019). With increasing exposure to these work characteristics, the frequency of that given hazard and the probability that harm will occur is supposed to simultaneously increases. Scales of the COPSOQ questionnaire (demands, influence and development, interpersonal relations, and leadership) enable the assessment of precisely those work characteristics (e.g., "Do you have to do overtime?", "Is your work emotionally demanding?"; Burr et al., 2019) and the scaling of the COPSOQ is constructed in such a way that the frequency (response options: always, often, sometimes, seldom, never / hardly) or extent (response options: to a very large extent, to a large extent, somewhat, to a small extent, to a very small extent) is assessed. Therefore, the information provided in the questionnaire can be used to map the frequency of a given hazard. For this purpose, we categorize the frequency-scale of the risk matrix into five levels with value ranges 0 (never), 1-25 (seldom), 26-50 (sometimes), 51-75 (often), and 76-100 (always).

To scale the dimension harm, it is necessary to consider theoretically sound and empirically validated health-related effects of psychosocial hazards (e.g., clinical, or nonclinical indicators of impaired well-being; Taibi et al., 2022). There are several established theoretical models on psychosocial work characteristics which consider the influence of unfavourable working conditions on health-related outcomes (e.g., job demands-control model, Karasek, 1979; job demands-resources model, Demerouti, Bakker, Nachreiner, & Schaufeli, 2001; effort-reward imbalance model, Siegrist, 2009; stress-strain concept, Rohmert, 1986). Outcomes varying from direct effects like work-related stress (ILO – International Labour Organization, 2016), and long-term effects like cardiovascular diseases (e.g., Kivimäki & Kawachi, 2015), musculoskeletal disease (e.g., Lang et al., 2012) depression or anxiety (e.g., Madsen et al., 2017). Suitable scales of the COPSOQ to assess health-related effects that are consistent with the findings of health-related models and empirical findings are cognitive stress symptoms, personal burnout, and general health. We then divided the dimension into three levels and assigned one outcome to each level (marginal - cognitive stress symptoms, moderate - personal burnout, and critical – general health; see Table 14).

For the classification of health-impairments into these three levels, we refer to the proposed time span until an impairment occurs after the occurrence of a hazard and the time which is necessary for recovery (Ford et al., 2014; Geurts & Sonnentag, 2006; Zapf, Dormann, & Frese, 1996). Diagnosed psychosocial disorders that may take longer time to develop can be classified as

harms with high severity. Immediate strains such as fatigue, monotony or increased heart rate occur directly and can be classified as marginal whereas a medium severity degree can be assigned to health-impairments that may develop over a medium span, such as exhaustion or burnout symptoms. According to this approach, the outcomes personal burnout and cognitive stress symptoms can be categorised as mentioned above. The instrument does not provide a suitable scale for the high severity category "critical", but indirectly, the outcome "general health" can be used. As a valid instrument, general health is assessed with the EQ 5DL-VAS (Janssen et al., 2013; Scalone et al., 2013). Empirical results have shown that the VAS score for people with diseases such as diabetes, depression and musculoskeletal disorders is significantly lower than the mean score for healthy people (Huber, Felix, Vogelmann, & Leidl, 2017; Huber, Reitmeir, Vogelmann, & Leidl, 2016). This suggests that the global score for general health used in the COPSOQ is influenced by severe illnesses and is indicative of a critical health event.

2.3.2.4.2 Calculating the risk score

After both dimensions (i.e., psychosocial hazards and harms) have been scaled based on available data provided by the COPSOQ, the next step is calculating the risk score. Usually, risk scores are calculated by a multiplication of numbers assigned to the each of the two dimensions of the risk matrix to indicate increasing frequencies of a hazard or increasing probability of a risk. The description of the dimensions of the risk matrix depends on the subjective assessment of authors or users (Bao, Li, & Wu, 2022). The products are then classified into different risk categories (e.g., low, medium, and high risk; Duijm, 2015). Also, the classification of risks in certain categories such as low, medium, or high risk is often based on expert assessments and thus includes a subjective evaluation component in which different users may obtain different ratings of the same quantitative risks (Cox, 2008; Ni, Chen, & Chen, 2010), Therefore we use the calculation of odds ratios as a suitable measure for risk assessment (Dettmers & Stempel, 2021; Taibi et al., 2022). The odds ratios allow to predict the risk of health-related effects of one or more psychosocial hazards on different frequency levels. By empirically linking the two dimensions, the usual subjective component of risk assessment is reduced to a minimum. The risk assessment is intended to identify work characteristics that potentially cause a health risk. The health and economic consequences are higher if work characteristics are incorrectly identified as non-risky even though there is a health risk. Conversely, the consequences are marginal when work characteristics are wrongly assessed as risky even though there is no risk.

To calculate the empirical relationship between psychosocial hazards and health-related effects, we performed multiple logistic regression analyses with COPSOQ strain scales as the

dependent variable and all COPSOQ scales that measure psychosocial hazards as predictors. All covariates (see Table 13) were entered in Block 1 and all selected predictors were entered in Block 2. The dependent variables used were general health, personal burnout and cognitive stress symptoms dichotomised in critical and non-critical by median split. Thus, each of the three dependent health variables represents one of the three levels of the harm-dimension of the risk matrix (see Table 15).

The simultaneous inclusion of hazards in the models represents the synchronicity of several hazards in the execution of occupational tasks. However, when analysing the results, it is noticeable that several predictors that are considered as important psychosocial hazards in previous research do not reach significance in the overall models. Therefore, there is the possibility that this approach leads to a too low sensitivity of risk detection. Therefore, we used models with only individual hazards predicting health-relating effects. In terms of risk prevention, the use of effects of individual hazards for risk assessment seems therefore the preferable approach. For the calculation we divided the value range of the scales into five categories (0, 1 - 25, 26 - 50, 51 - 75, 76 – 100, see above) and use zero as the reference category, resulting in four dummy variables per hazard in the model. In this way, the five levels of each COPSOQ scale also represent the levels of the hazard-dimension of the risk matrix (see Table 15).

2.3.2.5 Preparatory moderator analyses

A methodological challenge studying the effects of psychosocial hazards is the consideration of heterogeneous samples regarding workplace characteristics or working conditions (Kristensen, 1995). The used sample is highly heterogeneous and consists of various occupational groups. Particularly, it can be assumed that there is a considerably difference in the occupational profiles of production workers (blue-collar workers) and administrative and management occupations (white-collar workers). In advance, we therefore checked whether the job profile (blue vs. white collar) moderates a relationship between psychosocial hazards and health-related outcomes and whether different risk matrices must be created for the respective job profile. For this purpose, moderation analyses (SPSS Process v4.1; Hayes, 2013) were calculated with COPSOQ hazard scales as predictors, strain scales as outcomes and type of work as moderator and tested for significant interaction effects. Since a total of N=33 moderations were calculated, we adjusted the significance level using the Bonferroni correction. Of all N=33 possible effects, the interactions between job type and "demands for hiding emotions" and "environmental conditions" on cognitive stress symptoms are statistically significant ($p < .05$). The effect is stronger for blue collar in both cases. Based on these results, we did not consider separate matrices for occupational

groups as necessary. An overview of the results of these preparatory analyses can be found in Table A2 in the appendix.

2.3.3 Results

We first present results of logistic regression analyses, aiming to calculate the risk score as described in Chapter 2.3.2.4.2. Beginning with *cognitive stress symptoms* as the first category of severity in the risk matrix (marginal) the model with all psychosocial hazards as predictors explains a substantial part of the variance (χ (19) = 1246.82, p = .000, R^2 = .23 (Nagelkerke), R^2 = .17 (Cox & Snell)). For *personal burnout* (moderate) the predictors also explain a substantial part of the variance (χ (19) = 2304.24, p = .000, R^2 = .40 (Nagelkerke), R^2 = .30 (Cox & Snell)). For the outcome *general health* (critical) the part of explained variance is smaller (χ (89) = 560.31, p = .000, R^2 = .11 (Nagelkerke), R^2 = .08 (Cox & Snell)).

Table 14 shows an overview of the odds ratios between individually considered predictors and associated health-related outcomes. The results show how much the probability of reaching a critical value for the health-related outcome increases on a certain level of the predictor compared to a reference category. No correction for alpha error accumulation was done for the calculated values, since in terms of risk prevention, false positive findings (overestimation of a risk) should be less important than false negative findings (underestimation of a risk). An overview of all model parameters is listed in Tables A3-A4 in the appendix.

The results show for all scales linear increasing odds ratios with higher frequencies of hazards within a strain category. The highest risk to experience cognitive stress symptoms occurs when detrimental environmental conditions (*OR*=24.30), work privacy conflict (*OR*=35.48), emotional demands (*OR*=9.33), and role conflicts (*OR*=9.24) are always present. For the outcome personal burnout, the most aversive hazards are detrimental environmental conditions (*OR*=37.62), work privacy conflict (*OR*=35.48), and emotional demands (*OR*=28.44). For impaired general health detrimental environmental conditions (*OR*=4.65), dysfunctional social relations (*OR*=3.71) and work privacy conflict (*OR*=3.09) are the most aversive hazards.

The lowest risk to experience cognitive stress symptoms occurs when dysfunctional social relations (*OR*=1.78), low influence at work (*OR*=4.11), and restricted degrees of freedom (*OR*=4.16) are always present. For the outcome personal burnout, the least aversive hazards are dysfunctional social relations (*OR*=2.06), job insecurity (*OR*=4.86), and restricted degrees of freedom (*OR*=5.56). For impaired general health job insecurity (*OR*=1.58), dysfunctional social relations (*OR*=1.78) and emotional demands (*OR*=3.09) are the least aversive hazards.

Table 14

Logistic regression with COPSOQ hazard scales as predictors and strain scales as outcomes

		Marginal Cognitive stress symptoms	Moderate Personal Burnout	Critical Impaired General health
	Category			
Quantitative demands	Seldom			
	Sometimes			
	Often	3.10*	3.18**	
	Always	4.65***	6.02***	
Emotional demands	Seldom	1.74***	1.96***	
	Sometimes	3.17***	4.42***	
	Often	5.70***	9.92***	1.58**
	Always	9.33***	28.44***	1.95***
Demands for hiding emotions	Seldom	1.80***	1.66***	
	Sometimes	2.99***	3.49***	1.54***
	Often	4.73***	6.23***	1.94***
	Always	7.53***	13.47***	2.23***
Work privacy conflict	Seldom	1.69***	1.74***	
	Sometimes	3.11***	4.38***	1.61***
	Often	5.92***	10.63***	2.05***
	Always	10.50***	35.48***	3.09***
Low influence at work	Seldom		2.96*	
	Sometimes	3.00*	3.21*	
	Often	4.32**	4.91***	
	Always	4.11**	6.54***	
Restricted degrees of freedom	Seldom	2.04*		
	Sometimes	2.60**	2.43*	
	Often	3.53***	4.03***	2.30**
	Always	4.16***	5.56***	2.78**
Role conflicts	Seldom			
	Sometimes	3.50***	2.27*	
	Often	5.36***	4.35***	1.91**
	Always	9.24***	9.82***	2.29**
Low social support	Seldom	1.79***	1.60***	1.38**
	Sometimes	2.88***	2.90***	2.04***
	Often	4.38***	5.52***	2.91***
	Always	4.57***	10.35***	3.71***
Dysfunctional social relations	Seldom			
	Sometimes	1.78***	1.80***	1.51***
	Often	1.89***	2.03***	1.58***
	Always	1.78***	2.06***	1.73***
Job insecurity	Seldom	1.55**		
	Sometimes	2.41***	1.93***	1.39***
	Often	3.26***	3.21***	1.47***
	Always	4.56***	4.86***	1.58***
Detrimental environmental conditions	Seldom	3.22*		2.31**
	Sometimes	7.08***	5.52***	3.10**
	Often	14.24***	14.44***	4.20***
	Always	24.30***	37.62***	4.65***

Note. COPSOQ value range: never = 0-0.5, seldom = 1-25, sometimes = 26-50, often = 51-75, always = 76-100. The category *never* is used as a reference category and is not presented in the table. * Significant a level of $p < .05$. ** Significant a level of $p < .01$. *** Significant a level of $p < .001$.

To use the results (Table 14) for the risk matrix approach, we transferred all statistically significant odds ratios between hazards and associated health-related outcomes into a 4 x 3 matrix (Table 15). Given that many of the examined hazards are significant we removed all values below 1.68, because odds ratios lower than this can be considered as a small effect (Chen, Cohen, & Chen, 2010). Next, we considered hazards with the highest risk, i.e., when a hazard on a higher severity level already indicates a significant health risk, all lower-level risks of the same hazard were removed. For example, a low frequency of detrimental environmental conditions and of social support already show a significant health risk for the most critical health risk, *impaired general health,* therefore all odds ratios of these scales in relation with the two less critical health impairments were removed.

Overall, odds ratios range between 1.7 and 9.9 and the strongest effects are found in relation to *burnout symptoms* (*emotional demands OR*=9.92, *quantitative demands OR*=6.02, and *low influence at work OR*=6.54). For *cognitive stress symptoms*, only *restricted degrees of freedom* show a significant effect at the lowest frequency. As the frequency of this scale increases, the relationship to outcomes in the higher harm categories also becomes significant. For *impaired general health*, significant effects are found especially in the high frequency levels *often* and *always*. As lower-level risks of a hazard were removed, when the same hazard indicates a significant health risk on higher severity levels, the strong effects for personal burnout (*emotional demands OR*=28.44, *work privacy conflict OR*=35.48 or *detrimental environmental conditions OR*=37.62) are not represented in the risk matrix.

If a risk assessment is carried out, the determined scale values of this assessment can be compared with the scores of the matrix. The cut-off value can be identified as a significant health risk between frequency and outcome. If the results of a risk assessment using the COPSOQ for example, shows a value of > 50 on the scale *quantitative demands*, there is a significantly increased risk for *burnout symptoms*. For a scale value of 51 and above, the frequency of *quantitative demands* must therefore be reduced by suitable interventions to reduce the risk. For the scale *demands for hiding emotions*, for example, there is a significant risk of *impaired general health* from a value of 51, so that suitable risk-minimising measures must be derived above this value.

Table 15

Graphical edition of the RMA for psychosocial hazards

		Frequency (hazard)							
		Seldom (1-25)		Sometimes (26-50)		Often (51-75)		Always (76-100)	
Severity (harm)	Marginal (Cognitive stress symptoms)	Restricted degrees of freedom	2.04						
	Moderate (Burnout symptoms)					Quantitative demands	3.18	Quantitative demands	6.02
		Emotional demands	1.96	Emotional demands	4.42	Emotional demands	9.92		
		Work privacy conflict	1.74						
		Low influence at work	2.96	Low influence at work	3.21	Low influence at work	4.91	Low influence at work	6.54
				Restricted degrees of freedom	2.43				
				Role conflicts	2.27				
				Job insecurity	1.93	Job insecurity	3.21	Job insecurity	4.86
	Critical (Impaired General health)							Emotional demands	1.95
						Demands for hiding emotions	1.94	Demands for hiding emotions	2.23
						Work privacy conflict	2.05	Work privacy conflict	3.09
						Restricted degrees of freedom	2.30	Restricted degrees of freedom	2.78
						Role conflicts	1.91	Role conflicts	2.29
				Low social support	2.04	Low social support	2.91	Low social support	3.71
								Dysfunctional social relations	1.73
		Detrimental environmental conditions	2.31	Detrimental environmental conditions	3.10	Detrimental environmental conditions	4.20	Detrimental environmental conditions	4.65

Note. The values represent odds ratios between with COPSOQ hazard scales as predictors and COPSOQ strain scales used as outcomes.

2.3.4 Discussion

Psychosocial risk assessment is a multi-stage process and includes identifying hazards with suitable instruments and evaluating these hazards in terms of their potential health risk. For this process a valid evaluation in terms of an actual health risk is essential. But how to evaluate the likelihood of a health-risk occurring from psychosocial hazards still challenges scientists and occupational safety and health experts, mainly because evidence-based threshold values are still missing.

Against this background the main objective of our study was an empirical investigation of the risk matrix approach (RMA) for a methodological improvement of the risk assessment of psychosocial hazards and to discuss the application in an organisational context for selecting and prioritizing psychosocial hazards. Our study indicates that the development of a risk matrix is achievable with suitable data material and provides several advantages over previously established approaches for risk evaluation. Using the RMA health-related effects can be directly considered within the respective work situation and not only in an epidemiological perspective. In this way, the method sets a reference point for psychosocial risk assessment. Another advantage is the possibility of integrating different health-related effects and degrees of severity by categorising the outcomes. The approach allows the assignment of hazards in relation to specific health-related outcomes. It is therefore not only possible to see that an actual health risk exists, but also in what manifestation this risk is present. Finally, the approach enables the calculation of threshold values, as the matrix indicates at which scale value of a hazard a significant health risk exists. Comparisons with other risk assessment methods (e.g., uniform cut-off procedure, cut-off value-based approach or reference value-based approach) show that the risk matrix allows a more fine-grained risk evaluation. For example, usually, the COPSOQ classifies scales as a health risk if there is a deviation from the reference value. For the scale *influence at work* for example this value is 58 (Nübling et al., 2011). Our results of the risk matrix, however, indicate an increased risk for burnout symptoms already at lower values and therefore indicates the need for risk-minimising measures already at lower exposure rates of psychosocial hazards.

An interesting aspect of our results is the linear increase in health risk for the workforce as the frequency of hazards increases. The results are in accordance with previous studies that examine the effects of psychosocial work characteristics on employees' mental and physical health (e.g., Leineweber, Marklund, Aronsson, & Gustafsson, 2019; Niedhammer, Bertrais, & Witt, 2021; Taouk, Spittal, Milner, & LaMontagne, 2020). This results also indicates that the RMA provides more information compared to other risk assessment approaches. Cut-off, uniform, and

reference value-based approaches do not make any statement about how the risk develops in relation to hazard frequency, but only whether a risk exists or not. What is not shown are inverted U-shaped relationships, such as between workload or perceived stress and performance (Anderson, 1976; Bruggen, 2015; Cohen, 1980). It could be assumed, for example, that for low quantitative demands, the health risk increases because employees are underchallenged. However, the studies on these relationships do not refer to health-related effects, but to effects on workforce productivity.

The strongest effects can be found in relation to *burnout symptoms* which represents the moderate severity category. This finding could be explained by the stability of included health-related outcomes, with smaller effects for unstable health impairments like cognitive stress symptoms. Cognitive stress symptoms are operationalised as self-reported difficulties at work in concentrating, thinking clearly, making decisions, and remembering in the past four weeks (Pejtersen, Kristensen, Borg, & Bjorner, 2010). These immediate effects might relate more to the daily work situation. The COPSOQ scales related to working conditions, however, represent the *usual* manifestation of a hazard over longer periods which might differ from the daily work situation. Burnout symptoms, one of the three modular subscales from the Copenhagen Burnout Inventory (Kristensen, Borritz, Villadsen, & Christensen, 2005), refers to fatigue and emotional or physical exhaustion, irrespective of a time period mentioned. In particular, the period to which employees are asked to refer in their assessment suggests that burnout symptoms tend to refer to a more stable condition. Our findings are in accordance with other studies that report a stronger effect for job demands on exhaustion than on stress symptoms (Rantanen, Lyyra, Feldt, Villi, & Parviainen, 2021). Similarly, the validation study of the COPSOQ III also reveals the strongest effects for burnout symptoms (Lincke et al., 2021). The general health scale, on the other hand, is a global indicator and is very likely to be influenced by other factors external to work, such as age or smoking behaviour (Whynes, 2008). An additional explanation can be provided by the healthy worker effect. This effect reflects that an individual must be relatively healthy to be employable, and both morbidity and mortality rates within the sample are usually lower than in the general population (Li & Sung, 1999). Thus, employees with critical health conditions could have already been dropped out because they are no longer employable. Therefore, effects on general health are smaller than effects for burnout or cognitive stress symptoms. These results illustrate the relevance of selecting suitable outcomes for risk assessment of psychosocial hazards. In general, the selection of outcomes should be based on theoretical and empirically proven findings. However, an extension to organisation-related effects such as sick leave data or accident indicators can be useful.

The RMA has two basic applications, one is deciding the acceptability of risks and the other is to prioritise which risk needs to be addressed first (Duijm, 2015). For assessment of risk acceptance usually applying a traffic light system is used by dividing the grid of the matrix in different colours (green, yellow, red) and each level represents a different grade of acceptance. Green usually indicates an acceptable risk, for yellow the risk should be reduced as low as reasonably practicable and red represents an unacceptable risk (Duijm, 2015). Different safety assessment strategies can be represented by using different risk tolerance limits (Markowski & Mannan, 2008). To follow a rigorous safety assessment strategy, for example, a red code can already be assigned for moderate levels of severity. This way, only low risks are accepted to keep the potential for health impairments as low as possible.

The assessment of risk acceptance is not the primary objective in the present matrix. This is mainly due to the justified criticism of this application. On the one hand, the division of the grid into different colour ranges requires a subjective assessment (Cox, 2008). Secondly, different hazards can end up with the same assigned risk category, even though the risk is actually different (so called risk ties, see Ni et al., 2010). Instead, we propose to use the RMA to prioritise hazards regarding the derivation of risk-mitigating measures. For this, hazards are ranked according to the severity and the likelihood of their risk and hazards with high severity and/or probability have a higher priority when deriving risk-mitigating measures (Cox, 2008). This requires comparing values from the risk assessment with scores of the risk matrix. Scales with significant health risk are ranked with the highest severity level at the top. Depending on the available organisational resources, it must then be reviewed how many hazards can be considered for further risk-mitigating measures. It should be noted that the health risk is higher with significant values for critical outcomes at low frequency levels, as risk-minimising measures must be developed even though employees are only rarely exposed to these hazards (Taibi et al., 2022). In summary, it can be stated that different approaches for application of the RMA in terms of prioritisation and derivation of measures are available. The presented approach is a first step and further research is needed to investigate possible applications of the risk matrix for the assessment of psychosocial hazards.

2.3.4.1 Limitations

The RMA in the context of psychosocial hazard evaluation has a few methodological and practical limitations that should be considered. To calculate risk in terms of its definition – the probability that a hazard causes harm, - the outcome must be a dichotomous variable, as harm refers to an event that may or may not occur. Therefore, the dependent variables had to be categorised in two categories, critical and non-critical, for the calculation of a binary logistic

regression. On the one hand, this leads to a loss of information for continuous variables, and, on the other hand, there are different approaches for dichotomisation available. The COPSOQ itself does not provide a value for the classification into critical or non-critical, so we dichotomised the variables using a median split. Despite being criticized for resulting in a loss of information and a reduction in power, the method can be useful to test categorical latent constructs (Iacobucci, Posavac, Kardes, Schneider, & Popovich, 2015). If, as in this case, no information is available for dichotomisation, the approach still allows for applicability in a present dataset. There are further approaches, such as using the deviation from the reference value or via z-transformation of outcome variables (Notelaers, Vermunt, Veldhoven, & Witte, 2003). It can be expected that different approaches may lead to varying results. Therefore, further research would be needed to compare the advantages and disadvantages of different methods for dichotomization and to standardise the approach.

Another methodological limitation is the possibility of a common method variance, i.e., a bias where variance is accountable to the method of measurement and not on the constructs that the measured variables are intended to represent (Buchanan & Bryman, 2011). In the context of organisational research, self-report questionnaires are repeatedly related to common method variance (Buchanan & Bryman, 2011). Furthermore, the measurements are only available as cross-sectional data. Cross-sectional studies suffer from a limited internal validity and longitudinal designs are needed to determine the directionality of causal relationships (Taris & Kompier, 2014; Zapf et al., 1996). Future research on the application of risk matrices could therefore conduct longitudinal studies and validate the results using different methods.

Practical limitations result from the complex design of the risk matrix approach in the organisational context. Extensive data material is required for the calculation, and issues with data privacy may arise when collecting health-related data. For small and medium-sized enterprises, the methodology can only be implemented to a limited extent, as it is highly likely that they lack corresponding know-how and suitable data material. At this point, developers of instruments for assessing psychosocial hazards are called to provide the proposed methodology. Another possibility is to pursue the RMA in higher-level research projects. For future research, the evaluation of usability, e.g., using expert interviews with occupational health and safety practitioners, is interesting in terms of practical implementation. In conclusion, it is also necessary to evaluate the quality of the RMA in comparison to other risk assessment approaches (e.g., reference value-based approach) regarding prognostic validity.

2.3.4.2 Conclusion

How psychosocial hazards should be evaluated still challenges scientists and practitioners. Most existing approaches do not sufficiently evaluate hazards, as direct health-related effects are not considered and only few instruments for identifying hazards provide evidence-based threshold values so far. The RMA can be regarded as a suitable method for evaluating psychosocial risks, as it calculates risk as a combination of the likelihood of an adverse event (hazard) and negative consequences (harm). In our study, we were able to present an empirical investigation of the RMA to evaluate psychosocial hazards. Our contribution advances the RMA as a framework that allows an empirical assessment of the relation between psychosocial hazards and harm for the respective work situation, disregarding which tool is used for hazard identification. In this way, health-related outcomes that can be considered according to different severity levels within the risk assessment and the classification of the risk matrix allow the calculation of empirically proven threshold values. The conceptual considerations and calculation presented can be used as a fundament for further empirical research. Additionally, the approach can help organizations and practitioners to establish a risk matrix and thus improving the assessment of psychosocial hazards.

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2.3.6 Appendix

Table A1

Means, standard deviations and Cronbach's α of COPSOQ scales

Scale	Mean (SD)	Ref.	Cronbach's α	N of Items
Quantitative demands	48 (18)	55	.73	4
Emotional demands	44 (21)	52	.81	3
Demands for hiding emotions	36 (25)	46	.76	2
Work privacy conflict	37 (26)	42	.91	5
Influence at work	59 (21)	58	.76	4
Degrees of freedom	52 (21)	47	.72	4
Possibilities for development	40 (20)	33	.78	4
Meaning of work	30 (20)	26	.81	3
Commitment	46 (20)	43	.74	4
Predictability	50 (21)	46	.72	2
Role clarity	30 (17)	27	.82	4
Role conflicts	48 (20)	44	.77	4
Quality of leadership	44 (22)	50	.89	4
Social support	33 (20)	36	.81	4
Feedback	52 (23)	58	.68	2
Social relations	42 (22)	48	.45	2
Sense of community	25 (19)	25	.85	3
Signs of bullying	28 (26)	21	-	1
Trust and justice	43 (17)	-	.78	4
Job insecurity	43 (25)	32	.77	4
Environmental conditions	44 (18)	16	.85	10
Intention to leave the job	16 (24)	16	-	1
Job satisfaction	37 (15)	37	.82	7
General health	24 (21)	29	-	1
Absenteeism	29 (24)	-	-	1
Personal burnout	43 (19)	42	.90	6
Presenteeism	32 (18)	-	.59	3
Cognitive stress symptoms	28 (20)	29	.88	4
Satisfaction with life	33 (17)	34	.87	5

Note. *N* = 7,242; Ref. = Reference values (Nübling et al., 2011).

Table A2

Hierarchical multiple regression analyses predicting COPSOQ strain variables from COPSOQ hazard scales and type of work (blue collar vs. white collar)

	Cognitive stress symptoms	Personal Burnout	General health
Quantitative demands	.057* (.002)	.004* (.000)	.007* (.001)
Emotional demands	.082* (.002)	.005* (.000)	.016* (.000)
Demands for hiding emotions	**.094* (.002*)**	.008* (.002)	.023* (.000)
Work privacy conflict	.143* (.002)	.006* (.000)	.028* (.002)
Influence at work	.016* (.001)	.002* (.000)	.004* (.000)
Degrees of freedom	.016* (.000)	.007* (.000)	.009* (.002)
Role conflicts	.075* (.000)	.003 (.000)	.011* (.000)
Social support	.055* (.001)	.011* (.000)	.028* (.000)
Social relations	.010* (.002)	.005* (.000)	.005* (.001)
Job insecurity	.055* (.000)	.003* (.001)	.005* (.001)
Environmental conditions	**.104* (.002*)**	.005 (.000)	.011* (.000)

Note. Total R^2 (ΔR^2: Increase in explained variance by including the interaction between psychosocial work characteristics and type of work). * Significant a level of $p < .05$ (Bonferroni correction).

Table A3

Results of the binary logistic regression between COPSOQ hazard scales and cognitive stress symptoms. For each predictor a separate model was calculated

								95% C. I	
	Category	B	S.E.	Wald	Df	Sig.	Exp(B)	Lower	Upper
Quantitative demands	Seldom	0.04	0.44	0.05	1	0.93	1.04	0.44	2.47
	Sometimes	0.59	0.44	1.97	1	0.18	1.81	0.76	4.31
	Often	1.13	0.44	7.12	1	0.01	3.10	1.30	7.40
	Always	1.54	0.44	12.36	1	0.00	4.65	1.95	11.10
Emotional demands	Seldom	0.56	0.16	13.27	1	0.00	1.74	1.27	2.40
	Sometimes	1.15	0.16	62.33	1	0.00	3.17	2.33	4.32
	Often	1.74	0.16	132.91	1	0.00	5.69	4.18	7.76
	Always	2.23	0.21	128.45	1	0.00	9.33	6.22	14.01
Demands for hiding emotions	Seldom	0.59	0.09	44.86	1	0.00	1.80	1.51	2.14
	Sometimes	1.09	0.09	162.67	1	0.00	2.99	2.49	3.59
	Often	1.55	0.10	241.23	1	0.00	4.73	3.88	5.77
	Always	2.02	0.15	202.37	1	0.00	7.53	5.62	10.07
Work privacy conflict	Seldom	0.52	0.11	24.25	1	0.00	1.69	1.35	2.11
	Sometimes	1.13	0.11	115.22	1	0.00	3.11	2.49	3.88
	Often	1.78	0.12	260.45	1	0.00	5.92	4.70	7.46
	Always	2.35	0.15	276.81	1	0.00	10.50	7.90	13.96
Low influence at work	Seldom	0.78	0.48	2.60	1	0.11	2.19	0.85	5.65
	Sometimes	1.10	0.47	5.35	1	0.02	3.00	1.19	7.60
	Often	1.46	0.48	9.57	1	0.00	4.32	1.70	11.02
	Always	1.41	0.48	8.83	1	0.00	4.11	1.61	10.50
Restricted degrees of freedom	Seldom	0.71	0.34	4.30	1	0.04	2.04	1.05	0.71
	Sometimes	0.95	0.34	7.86	1	0.00	2.59	1.34	0.95
	Often	1.26	0.34	13.73	1	0.00	3.53	1.81	1.26
	Always	1.42	0.34	16.81	1	0.00	4.16	2.12	1.42
Role conflicts	Seldom	0.44	0.31	1.99	1	0.15	1.56	0.85	2.86
	Sometimes	1.25	0.30	17.98	1	0.00	3.50	1.93	6.36
	Often	1.68	0.30	32.64	1	0.00	5.36	2.96	9.68
	Always	2.22	0.31	51.95	1	0.00	9.24	5.01	17.07
Dysfunctional social support	Seldom	0.58	0.13	21.94	1	0.00	1.79	1.39	2.31
	Sometimes	1.06	0.13	75.19	1	0.00	2.88	2.23	3.71
	Often	1.48	0.14	119.14	1	0.00	4.38	3.32	5.79
	Always	1.52	0.22	49.41	1	0.00	4.57	2.99	6.99
Social relations	Seldom	0.23	0.13	2.94	1	0.08	1.26	0.97	1.63
	Sometimes	0.58	0.12	21.48	1	0.00	1.78	1.40	2.27
	Often	0.63	0.13	23.04	1	0.00	1.89	1.46	2.44
	Always	0.57	0.17	11.65	1	0.00	1.78	1.28	2.46
Job insecurity	Seldom	0.44	0.13	11.77	1	0.00	1.55	1.19	2.02
	Sometimes	0.88	0.12	50.94	1	0.00	2.41	1.89	3.08
	Often	1.18	0.13	85.69	1	0.00	3.26	2.54	4.19
	Always	1.52	0.15	107.95	1	0.00	4.56	3.37	6.16
Detrimental environmental conditions	Seldom	1.17	0.47	6.78	1	0.01	3.22	1.28	8.12
	Sometimes	1.96	0.47	18.48	1	0.00	7.08	2.83	17.72
	Often	2.66	0.47	33.49	1	0.00	14.24	5.72	35.50
	Always	3.19	0.49	44.29	1	0.00	24.30	9.32	63.40

Note. COPSOQ value ranges of the categories: Reference category is never = 0 (not displayed in table), seldom = 1-25, sometimes = 26-50, often = 51-75, always = 76-100. S.E. = Standard Error. Df = Degrees of freedom. Sig. = p-Value. Exp(B) = odds ratio. C. I. = confidence interval.

Table A4

Results of the binary logistic regression between COPSOQ hazard scales and personal burnout. For each predictor a separate model was calculated

								95% C. I	
	Category	B	S.E.	Wald	Df	Sig.	Exp(B)	Lower	Upper
Quantitative demands	Seldom	-0.26	0.42	0.51	1	0.54	0.77	0.34	1.77
	Sometimes	0.40	0.42	0.95	1	0.35	1.49	0.65	3.42
	Often	1.16	0.42	8.00	1	0.01	3.18	1.39	7.24
	Always	1.80	0.45	17.62	1	0.00	6.02	2.50	14.47
Emotional demands	Seldom	0.67	0.16	16.89	1	0.00	1.96	1.42	2.70
	Sometimes	1.49	0.16	90.13	1	0.00	4.42	3.25	6.01
	Often	2.29	0.16	202.68	1	0.00	9.92	7.20	13.65
	Always	3.35	0.25	212.77	1	0.00	28.44	17.54	46.12
Demands for hiding emotions	Seldom	0.51	0.09	33.17	1	0.00	1.66	1.40	1.98
	Sometimes	1.25	0.09	211.94	1	0.00	3.49	2.94	4.15
	Often	1.83	0.11	321.87	1	0.00	6.23	5.05	7.69
	Always	2.60	0.16	259.94	1	0.00	13.47	9.77	18.58
Work privacy conflict	Seldom	0.55	0.12	23.50	1	0.00	1.74	1.37	2.20
	Sometimes	1.48	0.11	179.37	1	0.00	4.38	3.51	5.46
	Often	2.36	0.12	407.89	1	0.00	10.63	8.38	13.49
	Always	3.57	0.18	394.53	1	0.00	35.45	24.78	50.70
Low influence at work	Seldom	1.08	0.47	5.05	1	0.02	2.96	1.19	7.36
	Sometimes	1.17	0.46	6.10	1	0.01	3.21	1.29	8.00
	Often	1.59	0.46	11.61	1	0.00	4.91	1.98	12.13
	Always	1.88	0.46	16.18	1	0.00	6.54	2.63	16.27
Restricted degrees of freedom	Seldom	0.50	0.36	1.81	1	0.16	1.66	0.82	3.33
	Sometimes	0.89	0.35	6.08	1	0.01	2.43	1.22	4.86
	Often	1.39	0.35	15.29	1	0.00	4.03	2.01	8.08
	Always	1.72	0.37	22.34	1	0.00	5.56	2.69	11.48
Role conflicts	Seldom	0.08	0.26	0.11	1	0.76	1.08	0.65	1.82
	Sometimes	0.82	0.26	10.59	1	0.00	2.27	1.38	3.75
	Often	1.47	0.26	33.62	1	0.00	4.35	2.63	7.20
	Always	2.28	0.28	68.60	1	0.00	9.82	5.72	16.84
Dysfunctional social support	Seldom	0.47	0.12	14.77	1	0.00	1.60	1.26	2.04
	Sometimes	1.07	0.12	78.65	1	0.00	2.90	2.29	3.68
	Often	1.71	0.14	159.55	1	0.00	5.52	4.24	7.20
	Always	2.34	0.25	86.33	1	0.00	10.34	6.28	17.05
Social relations	Seldom	0.23	0.13	2.92	1	0.09	1.25	0.96	1.63
	Sometimes	0.59	0.13	22.75	1	0.00	1.80	1.41	2.30
	Often	0.71	0.13	29.20	1	0.00	2.03	1.57	2.62
	Always	0.72	0.16	19.49	1	0.00	2.06	1.50	2.84
Job insecurity	Seldom	0.22	0.13	3.13	1	0.09	1.24	0.97	1.60
	Sometimes	0.66	0.12	30.50	1	0.00	1.93	1.53	2.45
	Often	1.17	0.13	89.69	1	0.00	3.21	2.51	4.12
	Always	1.58	0.15	118.44	1	0.00	4.86	3.59	6.56
Detrimental environmental conditions	Seldom	0.91	0.47	4.44	1	0.05	2.48	0.99	6.24
	Sometimes	1.71	0.46	16.28	1	0.00	5.52	2.22	13.71
	Often	2.67	0.47	40.41	1	0.00	14.44	5.72	36.44
	Always	3.63	0.49	63.99	1	0.00	37.62	14.36	98.59

Note. COPSOQ value ranges of the categories: Reference category is never = 0 (not in the table), seldom = 1-25, sometimes = 26-50, often = 51-75, always = 76-100. S.E. = Standard Error. Df = Degrees of freedom. Sig. = p-Value. Exp(B) = odds ratio. C. I. = confidence interval.

Table A5

Results of the binary logistic regression between COPSOQ hazard scales and general health. For each predictor a separate model was calculated

								95% C. I	
	Category	B	S.E.	Wald	Df	Sig.	Exp(B)	Lower	Upper
Quantitative demands	Seldom	-0.12	0.45	0.22	1	0.79	0.88	0.36	2.16
	Sometimes	0.01	0.44	0.12	1	0.98	1.01	0.42	2.42
	Often	0.12	0.44	0.22	1	0.78	1.13	0.47	2.72
	Always	0.10	0.48	0.21	1	0.83	1.11	0.43	2.85
Emotional demands	Seldom	0.10	0.16	0.65	1	0.53	1.11	0.80	0.10
	Sometimes	0.29	0.15	4.52	1	0.05	1.33	1.00	0.29
	Often	0.46	0.15	10.92	1	0.00	1.58	1.17	0.46
	Always	0.67	0.19	13.17	1	0.00	1.95	1.35	0.67
Demands for hiding emotions	Seldom	0.15	0.09	3.20	1	0.11	1.16	0.97	1.38
	Sometimes	0.43	0.09	26.23	1	0.00	1.54	1.30	1.83
	Often	0.66	0.10	46.59	1	0.00	1.94	1.60	2.36
	Always	0.80	0.14	36.31	1	0.00	2.23	1.70	2.91
Work privacy conflict	Seldom	0.19	0.10	3.90	1	0.06	1.21	0.99	1.48
	Sometimes	0.47	0.10	22.53	1	0.00	1.61	1.32	1.96
	Often	0.72	0.11	46.99	1	0.00	2.05	1.66	2.54
	Always	1.13	0.13	75.96	1	0.00	3.09	2.40	3.99
Low influence at work	Seldom	-0.22	0.39	0.32	1	0.57	0.80	0.38	1.72
	Sometimes	-0.19	0.37	0.24	1	0.61	0.83	0.40	1.71
	Often	0.01	0.37	0.05	1	0.97	1.01	0.49	2.10
	Always	0.09	0.37	0.12	1	0.82	1.09	0.52	2.27
Restricted degrees of freedom	Seldom	0.37	0.36	1.08	1	0.30	1.45	0.71	2.96
	Sometimes	0.64	0.36	3.36	1	0.07	1.90	0.94	3.86
	Often	0.83	0.36	5.57	1	0.02	2.30	1.13	4.68
	Always	1.02	0.37	7.89	1	0.01	2.78	1.35	5.71
Role conflicts	Seldom	0.12	0.27	0.27	1	0.66	1.13	0.66	1.93
	Sometimes	0.45	0.27	3.27	1	0.10	1.56	0.92	2.64
	Often	0.65	0.27	6.65	1	0.02	1.91	1.13	3.23
	Always	0.83	0.28	9.57	1	0.00	2.29	1.32	3.95
Dysfunctional social support	Seldom	0.32	0.13	6.75	1	0.01	1.38	1.07	1.79
	Sometimes	0.71	0.13	32.13	1	0.00	2.04	1.58	2.63
	Often	1.07	0.14	59.97	1	0.00	2.91	2.21	3.84
	Always	1.31	0.23	36.89	1	0.00	3.70	2.36	5.82
Social relations	Seldom	0.22	0.14	2.36	1	0.13	1.25	0.94	1.65
	Sometimes	0.41	0.13	9.31	1	0.00	1.51	1.16	1.96
	Often	0.44	0.14	9.55	1	0.00	1.56	1.18	2.05
	Always	0.54	0.17	9.52	1	0.00	1.72	1.23	2.42
Job insecurity	Seldom	0.12	0.13	0.92	1	0.34	1.13	0.88	1.46
	Sometimes	0.33	0.12	7.28	1	0.01	1.39	1.10	1.76
	Often	0.39	0.13	9.23	1	0.00	1.47	1.14	1.90
	Always	0.46	0.15	9.95	1	0.00	1.58	1.18	2.11
Detrimental environmental conditions	Seldom	0.84	0.40	4.47	1	0.04	2.31	1.05	5.08
	Sometimes	1.13	0.39	8.36	1	0.00	3.10	1.43	6.69
	Often	1.43	0.40	13.67	1	0.00	4.20	1.90	9.29
	Always	1.54	0.42	13.80	1	0.00	4.65	2.02	10.71

Note. COPSOQ value ranges of the categories: Reference category is never = 0 (not in the table), seldom = 1-25, sometimes = 26-50, often = 51-75, always = 76-100. S.E. = Standard Error. Df = Degrees of freedom. Sig. = p-Value. Exp(B) = odds ratio. C. I. = confidence interval.

3 Summary of the results and general discussion

The current thesis aims to provide guidance for improving psychosocial risk management in theory and practise to best comply with the overall aim of maintaining and promoting the health and well-being of the workforce. The management of psychosocial risks provides a foundation for initiating effective measures for the humane design of work. Derived measures based on the risk assessment aim to improve working conditions and, thus, maintain and promote the health of all employees. To summarise the theoretical introduction and the findings obtained from the empirical analyses, a general discussion linking the results and conclusions as well as the theoretical and practical contributions is given. Possible implications for future research and applied science are presented. Moreover, a conclusion attempts to provide an underlying understanding of the social relevance and impact of the issue. To address the overarching research question of this thesis, the most important findings of the three included papers will be summarised and discussed against the theoretical background.

3.1 A systematic overview on the risk effects of psychosocial work characteristics on musculoskeletal disorders, absenteeism, and workplace accidents

One of the key issues raised is which hazards need to be considered when assessing psychosocial risk. International and national legislations do not specify which hazards must be covered, but there are guidelines at the national level, for example in Germany, which give an overview of the hazards to be included in risk assessment (Joint German Occupational Safety and Health Strategy, 2018). International research in the form of meta-reviews focuses predominantly on systematic findings of psychosocial hazards on mental and cardiovascular health outcomes (e.g., Fishta & Backé, 2015; Harvey et al., 2017; Niedhammer et al., 2021; Nielsen & Einarsen, 2018; Rivera et al., 2020). The contribution of the meta-review of this thesis was therefore to specifically summarise the effects of psychosocial hazards on musculoskeletal disorders, sick leave, and work-related accidents. In this way, additional hazards can be identified that may not have been considered in the risk assessment so far because there is a risk to previously less researched health-related outcomes. This involved identifying and reviewing the results of systematic reviews, meta-analyses, and longitudinal studies. Due to the large variety of data generated by individual studies, meta-reviews of available meta-analyses and systematic reviews are preferable, as these study types present more reliable and precise estimates (Centre for Reviews and Dissemination, 2009).

Overall, the results of the study are in accordance with the above-mentioned meta-reviews examining the health-related effects of psychosocial hazards. The review of this thesis found strong or reasonable evidence that high job demands, high job strain, high effort/reward imbalance, low social support, low perceived fairness, low job control, low control over working hours, long working hours, high workplace bullying, high obstructive stressors, and high role conflict are risk factors for musculoskeletal disorders or sickness absence. For monotonous work, work pace, work time control, few rest break opportunities, challenge stressors, role ambiguity, and interpersonal conflict, the review of this thesis found only insufficient evidence. In addition, the study shows that there is insufficient evidence that psychosocial hazards are associated with an increased risk of work-related accidents, because there have been few meta-analyses, systematic reviews, or longitudinal studies.

An additional finding that a particular hazard is also associated with accidents is not necessary, as the study identified that corresponding hazards are already considered in the risk assessment. However, the fact that the study identified insufficient evidence of an increased risk of accidents is important for accident prevention. To take the necessary interventions for accident prevention, it is relevant to know which specific hazards are related to an increased risk for work-related accidents. Further meta-analyses or long-term studies are needed to make a reliable statement about whether and which psychosocial hazards are associated with an increased risk for work-related accidents.

The summarised findings of the meta-review can inform risk assessment methods by providing a systematic estimation of the potential risk severity when employees are exposed to specific psychosocial hazards. Knowledge of the health-related effects of psychosocial hazards can be beneficial to derive targeted interventions and thus reduce the risk. The findings of the study confirm, to a large extent, existing results that are already available for other outcomes. There are no indications that additional hazards need to be included in the risk analysis.

3.2 Theoretical conceptualization of the risk matrix approach

In the second paper of this thesis, we conducted a theoretical and methodological development of the risk matrix approach (RMA) that enables the evaluation of psychosocial hazards. The risk matrix approach is a traditional hazard analysis technique, but risk matrices for the assessment of psychosocial risks are still scarcely researched. The study advances the approach as a framework that allows for assessing the risk between psychosocial hazards and health- or safety-related effects. With that, the RMA is geared towards overcoming the serious shortcomings of established frameworks for psychosocial risk evaluation (particularly reference value and

uniform cut-off value; see Chapter 1.3.2). The reference values do not provide any information on whether there is an absolute risk, but only on what the risk is in relation to other organisations or sectors. For example, labour intensity has been at a very high level across sectors in all EU countries for many years (Eurofound, 2019). Comparing the labour intensity of an organisation or a department with sectoral benchmarks would therefore lead to an underestimation of risk. The uniform cut-off value approach results in an arbitrary definition of the scale values and thus ignores the actual empirical risk of an employee suffering from a health impairment (Dettmers & Stempel, 2021). Thresholds calculated using the cut-off value approach are often related to only one specific harm (e.g.; Diebig & Angerer, 2020; Mustapha & Rau, 2019; Zeike et al., 2018); however, as shown in the first study of the thesis, psychosocial hazards have multiple health-related effects. As a result, there may be hazards that do not have a risk effect on the clinical harm being investigated but do have a risk effect on an antecedent non-clinical harm.

In summary, it is not only the extent of a hazard that matters, but also its effect on health-related outcomes that need to be considered. To be able to assess the health risk of psychosocial hazards comprehensively, a systematic evaluation of these effects across different health-related effects is important. The RMA calculates risk as a combination of the probability of an adverse event and the severity of its negative consequences. This incorporates empirical research findings by assigning severity levels to health-related outcomes based on theoretically sound and empirically validated findings on the relationship between psychosocial work characteristics and health-related outcomes. In this way, the RMA allows for the consideration of potential differential risk effects of hazards, the consideration of different levels of severity of harm, and the consideration of an empirical relationship between psychosocial hazards and health-related effects within the risk assessment. Thus, RMA can provide criterion-based thresholds for determining whether an exposure is critical or non-critical in terms of health risk. In addition, the evaluation scheme of the matrix allows for different cut-off values for different psychosocial hazards and the integration of different health outcomes. Understanding the risk effects can help identify and prioritise key actions to minimise risk by starting with the risk factor with the highest risk impact.

The study presented important theoretical and methodological steps necessary to realise the RMA for psychosocial risk assessment. This involved first classifying hazards into different categories, either by transferring the scale of an instrument used to the matrix or by applying statistical classification procedures. To determine their severity, harms were assigned to categories based on theoretical and empirical evidence. The empirical hazard-harm relationship was calculated using logistical regression, and hazards with significant results were entered into the cells of the matrix. To prioritise risk-mitigating measures, the risk is classified by comparing the

values from the risk assessment with the identified hazards in the risk matrix. Reflecting this development, the study indicates that the development of the RMA may be more complex, time-consuming, and thus also more cost-intensive than established approaches for risk evaluation. Particularly complex data material and a wide range of possible health-related outcomes must be considered. But the risk matrix can help us understand how psychosocial hazards can be evaluated.

3.3 Empirical investigation of the risk matrix approach

To test the conceptually developed risk matrix for further application, an empirical investigation of the RMA for the risk assessment of psychosocial hazards was carried out in the third study of this thesis (Chapter 2.3) using a sample of employees of a large German steel company. The aim of the study was to determine what statistical calculations are necessary to apply the RMA and what pitfalls can arise when implementing this approach in an organisational setting. The study demonstrates that the evaluation of psychological risks with the risk matrix approach is possible.

The study further indicates that, in line with our assumptions, the risk impact of the hazards differs, and therefore, prioritisation in risk assessment is necessary. The strongest effects are found for environmental conditions, work privacy conflicts, and emotional demands in relation to personal burnout. Practical challenges result from the complex design of the risk matrix approach in an organisational context. Extensive data material is required for the calculation, and issues with data privacy may arise when collecting health-related data. In the following chapters, aspects regarding validity, choice of appropriate criterion variables, methodological development and a critical reflection of the approach are discussed.

3.3.1 Validity of the risk matrix approach

The analysis of the study shows that expected hazards cause their level of risk to increase considerably with an increase in frequency. The results are consistent with theoretical assumptions that also postulate linear relationships between hazards and health-related effects (e.g., job demand resources model; Demerouti et al., 2001) and with empirical findings of meta-reviews that examine the effects of psychosocial hazards on employees' mental and physical health (e.g., Fishta & Backé, 2015; Harvey et al., 2017; Nielsen & Einarsen, 2018; Rivera et al., 2020).

Although the outcomes of the third and first studies (Chapters 2.1 and 2.3) are only comparable to a limited extent, the results can still provide valuable information on the validity of the RMA. The first study examined the effects on musculoskeletal disorders, absenteeism, and workplace accidents. The sample of the third study examines direct, non-clinical effects (cognitive

stress symptoms) and medium-term, non-clinical effects (burnout symptoms). The impaired general health allows for the closest comparison. Comparable are the predictors of job control (low influence at work), job demands (quantitative and emotional demands), working time control (limited degrees of freedom), low social support (low social support), role conflicts (role conflicts), low job security (job insecurity), and interpersonal conflicts (dysfunctional social relationships). The same predictors that show an increased risk for absenteeism or musculoskeletal disorders in the first study also show significant effects for personal burnout and poor general health in the third study. Even though different operationalisations of health risk were considered in the two studies, the results provide a first indication of the satisfactory validity of the RMA due to the concordance with previous research findings.

3.3.2 Choice of appropriate criterion variables in risk assessment

When choosing a risk evaluation approach that considers direct health-related effects in the risk assessment (e.g., RMA, CCA, see Chapter 3.2), one fundamental question is which outcomes need to be integrated. The strong effects of psychological hazards on burnout symptoms identified in this study illustrate the relevance of non-clinical health indicators for psychosocial risk assessment. The strong effects can be explained by the stability of health-related outcomes. Smaller effects can be expected for unstable or immediate health impairments like cognitive stress symptoms, which can vary in the daily work situation, and global indicators like impaired general health, which are likely to be influenced by external factors (Whynes, 2008). Burnout symptoms describe fatigue and emotional or physical exhaustion (Kristensen, Borritz, Villadsen, & Christensen, 2005). Like burnout symptoms, the period to which employees refer in their assessment of hazards relates to a more stable condition. An additional explanation can be provided by the 'healthy worker effect,' which reflects the fact that an individual must be relatively healthy to be employable and that both morbidity and mortality rates within the sample tend to be lower than in the general population (Li & Sung, 1999). Employees with critical health conditions may have already left the company because they are no longer employable. Therefore, the effect on general health is smaller than the effect on burnout.

Mediated non-clinical health indicators of well-being, such as burnout symptoms, may be promising outcomes for risk assessment. The outcomes have sufficient sensitivity to respond to the effects of hazards and are robust enough to represent lasting health-related effects. They are also not severe enough to cause permanent incapacity to work. These outcomes can also be suitable as they can act as early indicators in terms of prevention. A health impact is already measurable, but severe health impacts are still preventable through suitable interventions. If early indicators

are neglected, important information for the derivation of measures is missing. Psychosocial hazards can only be classified as health risks only after serious health impairments have already occurred. For example, burnout increases the risk for future absenteeism due to mental and behavioural disorders, diseases of the circulatory system, diseases of the respiratory system, and diseases of the musculoskeletal system (Toppinen-Tanner, Ojajärvi, Väänänen, Kalimo, & Jäppinen, 2005). Burnout additionally predicts permanent work disability and therefore could function as a risk marker for chronic health-related outcomes (Ahola et al., 2009). In this way, burnout can be integrated into the risk assessment as an early indicator of prevention.

When determining which outcomes to consider in risk assessment, it is useful to select those with a promising prognostic validity for clinically relevant health-related outcomes. For example, in addition to burnout, irritation could also be used as an outcome for lower levels of harm (marginal or low). Irritation is a subjectively perceived emotional and cognitive strain in an occupational context (Mohr, Rigotti, & Müller, 2005). The state acts as a mediator between stress and mental disorders, with good predictive validity for depressive symptoms if a time interval of at least two years lies between the assessments (Mohr et al., 2005). The results show that irritation can be used as a predictor in terms of prevention and is suitable as an outcome to be considered in risk assessment.

Similar to risk factors (hazards), it seems appropriate to calculate critical values for health-related outcomes as well. In this way, it is easier to decide which risks are acceptable or which risk needs to be addressed first. The approach is proposed for the RMA, but other procedures in risk evaluation also use classification according to different levels of severity (Gul, 2018). A classification for different degrees of severity could be determined based on the level of extent (e.g., by cut-off values for classification into low, average, and high; see Maslach Burnout Inventory; Schaufeli & van Dierendonck, 1995).

The development of a risk matrix within an organisation can result in higher ecological validity as the data is collected within the specific work situation. But not every organisation has the resources and the necessary know-how to record a wide range of different health-related outcomes. In addition, certain company stakeholders, such as the works council, may prevent the collection of specific data because employees' privacy rights are seen as being threatened. Therefore, in addition to validity, economic and data protection aspects must be considered. Mediated non-clinical health indicators of well-being have the advantage of economic measurement, e.g., via questionnaires and instruments such as the Copenhagen Burnout Inventory (Kristensen et al., 2005). Under the framework of data protection regulations, non-clinical

indicators can be measured rather than clinical outcomes, as the handling of clinical health data is more sensitive and subject to stricter regulations.

In summary, it can be concluded that mediated non-clinical health indicators of well-being are suitable for use in risk assessment based on conceptual and methodological considerations. From a conceptual point of view, they are sufficiently stable and have a sufficient level of predictive validity for health-related clinical outcomes. From a methodological point of view, they are economical to measure and allow classification into different severity levels using cut-off values.

3.3.3 Methodological steps of the development of the risk matrix

Study 3 identified important steps for developing the risk matrix. It is important to distinguish between the calculation of the risk values and the prioritisation of identified risks for the derivation of risk-mitigation measures. In the described calculation of risk values (see Chapter 2.3.2.4.2.), all psychosocial hazards can be included in the model at the same time using multiple logistic regression or a separate model is calculated for each hazard-harm relationship. The simultaneous inclusion of hazards represents the synchronicity of several hazards in the execution of occupational tasks in organisational reality. But if using multiple logistic regression, the results for empirically and theoretically validated psychosocial hazards partly showed no significance in the overall models. In an application-oriented focus, there is the possibility that this approach may lead to insufficient sensitivity of risk detection. These hazards would be ignored further within the framework of the risk analysis, regardless of their manifestation. In terms of risk prevention, considering effects of simple logistic regression for risk assessment seems therefore the preferable approach.

When applying the RMA, it is important to apply rules by which the identified risks are prioritised, and which risks can still be accepted. For the assessment of risk acceptance, matrices usually use a traffic light system by dividing the grid of the matrix into different colours (green, yellow, and red), and each level represents a different grade of risk acceptance. With increasing frequency and severity, a higher risk can be assumed, thus the need for risk-mitigation measures. The matrices can apply different risk tolerance levels and represent different safety assessment strategies depending on how the colours are assigned to levels of the matrix (Markowski & Mannan, 2008). If an unacceptable risk for example is already set for medium frequency or severity categories (red), a lower risk is tolerated. However, this approach ignores the fact that a higher health risk can be assumed if a significant health-related effect has already been identified at low-frequency rates. Instead of a colour scheme, it is therefore also possible to determine which

empirical thresholds represent an acceptable risk and at what cut-off value risk-minimising measures need to be derived.

In the present case for example (see Table 16), the highest health risk for role conflicts is at a value of 76 or higher, as this value indicates the strongest significant effect for the highest severity category. However, there is already an increased risk for cognitive stress symptoms and burnout symptoms from a score of 26 onwards. The empirical threshold above which risk reduction measures are required can be set (1) at the lowest frequency level, which indicates a significant effect regardless of severity. Or the threshold is set (2) at the value that indicates the highest health risk, where the need for risk-minimising interventions is most urgent.

Table 16

Exemplary representation in the development of the risk matrix

		Frequency (hazard)					
		Seldom (1-25)	Sometimes (26-50)		Often (51-75)		Always (76-100)	
Severity (harm)	Marginal (Cognitive stress symptoms)		**Role conflicts**	**3.50**	Role conflicts	5.36	Role conflicts	9.24
	Moderate (Burnout symptoms)		Role conflicts	2.27	Role conflicts	4.35	Role conflicts	9.82
	Critical (Impaired General health)				Role conflicts	1.91	**Role conflicts**	**2.29**

Note. The values represent odds ratios between with COPSOQ hazard scales as predictors and COPSOQ strain scales from the third study (Chapter 4.3.3). Values in bold indicate the two possible empirical thresholds.

The choice of risk evaluation method has an impact on risk management, as the derived risk mitigation measures are only implemented for those hazards that are assessed as risks (Metzler et al., 2019). The described possibilities for prioritizing the risk and determining the critical thresholds of the matrix can also have an impact on risk management as risks are being tolerated differently. Method 1 would be safer in terms of health risks. The approach is more sensitive because a risk is already indicated at lower levels of harm, and more hazards need to be reduced by appropriate measures. Thus, the derivation of measures is not always relevant to a serious health risk. However, it would also be more cost-intensive to implement, as this method would require significantly more interventions to reduce the identified risks. Method 2 would represent a matrix,

where the need for risk reduction may be lower. As hazards are identified as risks on the highest levels of harm, risk reduction measures are only taken when the health impact is already severe. On the other hand, the measures will have a more relevant impact on health. To prevent long-term, serious health consequences, it is recommended to use the more sensitive method 1. The considerations show that risk management is not always an empirical decision but also involves a discussion of organisational interests and norms. The decision as to what risk is still acceptable must therefore also be discussed between different company stakeholders (Beck, 2019; Semmer & Zapf, 2022).

Finally, the study show that some hazards indicate a significant health risk already at the lowest frequency level. Regardless which value is determined in the risk assessment, risk-mitigating measures would therefore always have to be derived for these hazards. The question arises as to how practicable these results are for the implementation of the risk assessment if measures must always be taken for certain hazards, regardless of the determined value. Hazards therefore need to be more differentiated or finer graded at the lower levels. Overall, further analysis is needed for the application and design of the matrix. This would help to determine which aspects are important and what an optimal design might look like. Chapter 3.4 discusses future directions for the use of thresholds and for usability research.

3.3.4 Empirical determination for critical values

According to the Joint German Occupational Safety and Health Strategy (2018), hazard identification tools must provide assistance for interpreting the results as a quality requirement. This should be provided by a fact-based and comprehensible evaluation, e.g., by guidance on the use of reference values, defined criteria, or threshold values. So far, only a few instruments for identifying hazards provide defined criteria or evidence-based threshold values (Ferreira & Vogt, 2022; Mustapha & Rau, 2019; Rau, 2022). Therefore, the third study of this thesis constitutes the risk matrix as an approach that enables the calculation of empirically proven threshold values, regardless of the instrument used for hazard identification.

There are opinions that doubt whether threshold values in terms of a critical manifestation of psychosocial risks can be determined exclusively empirically. Semmer and Zapf (2022), for example, state that critical values cannot be determined only on the basis of empirical data but that social norms and interests also have an impact. The question of what risk is still acceptable is not only a question of exceeding a cut-off value; it is also a societal decision, and these decisions are often made by scientific committees. In addition, operational practise sets limits for using generic cut-off values for single hazards, as a multitude of hazards act simultaneously and the health effects

of hazards differ across individuals (Semmer & Zapf, 2022). Semmer and Zapf (2022) therefore propose the use of an overall hazard index. Based on the results, experts can determine whether the overall exposure determined is too high. The individual values of hazards with the most critical health effects should be examined if a certain overall hazard index is exceeded. These decisions can then be discussed, for example, by a local expert panel consisting of supervisors, safety officers, occupational psychologists, health managers, and an employee representative.

The argument illustrates the difficulties in risk evaluation and the establishment of scientifically determined cut-off values. Therefore, the above-described process proposed by Semmer and Zapf (2022) may also be transferred to the RMA. For this purpose, instead of considering separate hazards in the risk matrix, a sum score can be calculated for all hazards and divided into different frequency categories. The empirical hazard-harm relationship is then calculated by logical regression between the different frequency categories of the overall index and health-related effects. If the matrix identifies a health risk across all hazards, the values for the individual hazards can be considered.

Regardless of whether an overall index or individual hazards are considered, the ability to map different health effects with varying degrees of severity with the RMA may provide an understandable and differentiated platform for constructive discussion. In this way, it can be expected that a major obstacle in the implementation of risk assessment can be addressed. Beck (2019) identified that the organisation and implementation of psychosocial risk assessment involve the different views and interests of several companies' stakeholders. The assessment of which manifestation of a hazard constitutes a health risk is the result of discussion processes in which employees, managers, and experts should participate equally (Beck, 2019). The RMA can support this process with its intuitive graphical approach, presentation of different levels of risk and the necessary instructions for action (Ni et al., 2010; Taibi et al., 2022).

3.4 Limitations and implications for future research and applied science

As noted by Campbell and Wilmot (2017), a major goal of research in industrial, work, and organisational psychology is improving organisational effectiveness and individual well-being in work roles. The results presented in this thesis are a further step towards achieving these goals regarding psychosocial risk management. Nevertheless, further research is needed to advance this issue. Therefore, the following chapter will provide recommendations for future research and applied science based on the identified results.

The first study of this thesis (see Chapter 2.1) did not include the examination of psychosocial hazards that were not covered by acknowledged theories on work stress and work

design. Several studies show the importance of leadership as an occupational health factor (e.g., Cummings et al., 2018; Harms, Credé, Tynan, Leon, & Jeung, 2017; Montano, Reeske, Franke, & Hüffmeier, 2016) but this dimension does not appear in the meta-review. This indicates that the assessment of psychosocial hazards should therefore be enlarged to less studied factors, especially within the scope of meta-reviews, meta-analysis, or longitudinal studies. In this way, hazards that needs to be considered within the risk assessment can be validly identified. In addition, hazards that result from new forms of work (e.g., mobility, time flexibilisation, reduced boundaries between work and private life) should be examined. The risk factors considered so far are based on theories from either the 1970s or the early 2000s (e.g., the job characteristics model; Hackman & Oldham, 1976; job demands-control model; Karasek, 1979; or job demands-resources model; Demerouti et al., 2001). There have been changes in working conditions over the past several decades that have an impact on the health and safety of employees (see Chapter 1). Health-related effects of changes in working conditions therefore need further theoretical development and empirical research in the form of meta-analysis. Consequently, risk matrices also represent an approach that needs to be reviewed and developed on an ongoing basis.

The third study of this thesis shows the following major limitations regarding: (1) included health-related outcomes; (2) used instrument for assessing psychosocial hazards; (3) additive or interactive effects between psychosocial hazards and health-related outcomes; (4) empirical threshold values; and (5) research on the usability of the approach.

(1) First, only cognitive stress symptoms, burnout symptoms, and impaired general health were considered health-related effects. To consider what other health-related outcomes may be relevant to the risk assessment, additional research on further outcomes should be strengthened. For these outcomes, theoretical models should be developed to explain the causal pathways leading to different outcomes. This will help to determine which health-related factors are appropriate for consideration in the RMA or in risk assessment in general. In addition, the prognostic validity needs to be tested in relation to clinically relevant outcomes, and empirical thresholds need to be assessed that differentiate between individuals who reach a critical value for that outcome.

(2) Second, the RMA in Study 3 solely uses self-report questionnaires as the most common methodological approach to psychosocial risk assessment (Leka & Jain, 2010). Challenges arising from self-reported data include the common method variance as both psychosocial environment and health are assessed at the same time in a cross-sectional way (Buchanan & Bryman, 2011; Theorell & Hasselhorn, 2005). Thus, the relationship between variables may partly be accountable to the method of measurement and not to the constructs that the measured variables are intended to represent. The response behaviour of employees is assumed to be another source of bias in self-

report questionnaire instruments. Employees may cause inflated relationships either because they complain about everything (negative affectivity) or about nothing (denial) (Theorell & Hasselhorn, 2005). A workforce with a high percentage of denying participants leads to an underestimation of risk, and one with a high percentage of negative affectivity leads to an overestimation (Theorell & Hasselhorn, 2005). Additionally, different hazards may have varying measurement requirements. For example, aspects of social relations may be difficult to assess with observation methods. Or the assessment of leadership quality through questionnaires may be subject to social desirability. Further research on alternative assessment methods should therefore be expanded to compare different methods and provide information on reporting biases (Niedhammer et al., 2021).

In this way, an overview can be developed that allows an assessment of which instruments validly assess which specific psychosocial risks and, at the same time, considers economic and practical aspects such as complexity in implementation. The large number of identified instruments shows the relevance of selecting a limited, field- and quality-tested range of instruments (Kersten et al., 2022). Basically, there is a science-practitioner gap in the research of work-related psychosocial risks. If psychological risks are assessed under natural conditions in the framework of field studies, it must be considered that the assessment of organisational data can be challenging due to data protection and company-internal guidelines. Furthermore, testing other methodological approaches may also be difficult. Therefore, it should be noted that the use of subjective questionnaire instruments has its justification and can be accepted in the context of research. Theorell and Hasselhorn (2005) also note that none of the available methods has explicitly been proven to be incorrect, and as long as the study results are interpreted with adequate consideration, they can be used. The impact of hazard identification methods on risk assessment or the interaction between identification methods and the hazards to be assessed are not considered in the studies in this thesis. But it should be noted that the primary aim of the thesis was not to determine the exact risk effect of specific hazards, but to test the basic methodology of the RMA.

(3) The results of the study do not consider additive or interactive effects between psychosocial hazards and health-related outcomes (e.g., high demands and low control as in the job-demand-control model; Karasek, 1979). This results in the consideration of isolated main effects between psychosocial hazards and possible health and safety-related outcomes. The framework proposed by Rugulies (2019) (Chapter 1.2.1, Figure 1) and the complex cause-effect relationships (Chapter 1.3.3) illustrate that health-related effects can change depending on the interactions of different psychosocial hazards. For example, Holman and Axtell (2016) propose a multiple-mediator, multiple-outcome model and show that workplace redesign interventions affect a wide range of employee outcomes by making changes to multiple workplace characteristics.

Andersen et al. (2022) examined the association between combined psychosocial work characteristics and long-term sick leave. They found that scoring poorly on all nine examined psychosocial factors posed the highest risk and scoring favourably on several psychosocial factors outweighed the potentially negative effects of scoring poorly on one or two factors. The results of the studies illustrate that the entire psychosocial work environment and possible interactions must be examined. It is not sufficient to consider constellations such as high demands and low job control (Karasek, 1979) or high effort and low reward (Siegrist, 2009).

(4) The third study showed the importance of using empirical thresholds for the RMA to prioritise risks. Chapter 3.3.3 discussed two possibilities for setting an empirical threshold above which risk reduction measures are required (at the lowest frequency level or at the value that indicates the highest health risk). However, it has not been possible to verify which of the two described methods is more beneficial in minimising psychosocial risks in the long run. For example, in cluster-randomised trials, the two approaches can be compared in different subgroups regarding predictive validity in relation to risk minimisation.

(5) Finally, usability aspects of the approach should be addressed in further research. The methodological details in the elaboration of the matrix and transferring results into the cells are not primarily a statistical but an application-related question. Regardless of this, the design of the matrix for an operational application must be described precisely. If no precise instructions for operational practitioners are given, methodological uncertainty and, thus, a low implementation rate are to be expected. Since the RMA has not yet been widely applied in the assessment of psychosocial hazards, further studies regarding its applicability are particularly useful. For example, the design and acceptance of this approach can be investigated through surveys or expert interviews of employees, managers, and occupational safety and health practitioners. In addition, obstacles, and success factors in the implementation of the approach can be identified with the aim of deriving optimal design principles for the RMA.

One further limitation of the thesis is the absence of an empirical comparison of the different approaches to risk evaluation. The theoretical quality assessment presented in Chapters 1.3.2 and 2.2.1.3 should therefore be deepened in further methodological research. The aim should be to establish well-founded standards for quality assessment of the different approaches to risk evaluation. To realise this, the approaches should be compared regarding different quality requirements within one sample with a comparative hazard identification tool. On the one hand, common quality criteria for the assessment of psychological instruments such as criterion validity, interpretative objectivity, and reliability can be used. However, aspects of the test economy should also be considered a quality criterion for the operational application.

There is a lack of investigation of dose-response relationships in the studies in this thesis to better understand and assess the health effects of psychosocial risks. The dose-response relationship is a central concept in toxicology and provides a framework for conducting hazard assessment tests and deriving environmental regulations (Calabrese, 2014). Behind the concept lies the assumption that the toxicity of a substance arises as a function of the dose. Accordingly, the duration of exposure to a psychosocial hazard is expected to influence the severity of the health risk. A higher health risk can be expected if an employee is exposed to a certain psychosocial hazard for several years instead of only a few weeks. Only a few studies have focused on evaluating a dose-response relationship between psychosocial hazards and health-related effects (e.g., dose-response relation between work hours and cardiovascular disease risk; Conway, 2016). The study found that the risk of cardiovascular disease rises with increasing average weekly work hours. To estimate dose-response relations with sufficient detail, quantitative information on exposures to possible risk factors are necessary (Jansen, Morgenstern, & Burdorf, 2004). Especially, as differences in the risk profiles of part-time and full-time workers were observed with no association between work hours and cardiovascular disease risk for part-time workers. In addition, Jansen et al. (2004) found a time window of decreasing risk that may reflect the benefits associated with the occupation.

The consideration of non-linear relationships is also important in this context, as research on these relationships is lacking in this thesis. For example, the composition of the risk matrix indicates a higher health risk with increasing frequency and severity. This logic would only work to a limited extent in the case of non-linear relationships. In principle, the structure of the matrix would have to be designed differently for such relationships. Previous studies examining the effects of psychosocial hazards primarily considered linear relationships, whereas the examination of curvilinear dependencies was only carried out in a few cases. Kubicek et al. (2014) for example found curvilinear effects with higher and lower degrees of job control showing a higher tendency to depersonalise care recipients and a lower tendency to feel dedicated. Future research needs to clarify which psychosocial hazards show curvilinear effects and whether this effect is due to confounding variables that mask linear effects. Studies of time-related exposures and nonlinear relationships need to be expanded for a wide range of psychosocial hazards. In addition, it must also be kept in mind that in many occupations, exposure to hazards is not limited to one factor, but includes many different factors. Therefore, in addition to temporal exposure, consideration of combination effects is also crucial. Jansen et al. (2004) implicated that hierarchical regression models can have important advantages in the examination for covariates that are strongly interrelated.

The discussion illustrates the difficulties in evaluating the health risks from psychosocial hazards. Therefore, one focus of this thesis was to examine and assess previous approaches to risk evaluation and to explore further ways to validly evaluate the health risks of psychosocial hazards. In addition, the gap between research and operational implementation will be bridged within the framework of applied sciences. One of the difficulties with the insufficient implementation of psychosocial risk assessment is a lack of methodological expertise (see Chapter 1.3.3). A methodical advisory from occupational safety and health stakeholders should help to close this gap and increase the implementation rate. In general, risk assessment must find a compromise between complex analysis and practical application. The risk must be validly assessed but remain within the scope of possible realisation. This is especially the case for small and medium-sized companies, which have fewer resources available for this issue. There is sufficient empirical evidence in occupational psychology research for robust relationships between the manifestations of psychological hazards and health-related effects (Dettmers & Stempel, 2021). Major goals of theory, research, and practise in industrial, work, and organisational psychology are improving organisational effectiveness and individual well-being in work roles (Campbell & Wilmot, 2017). To this end, scientific results must be translated into operational guidance and, ultimately, into implementation. A solid integration between scientific advice and practical application is needed, especially for such an important but complex topic as psychosocial risk assessment.

3.5 Final conclusion

The thesis provides a theoretical part about occupational stress and risk assessment and, building on this, three studies that cover an important topic in work and organisational psychology. The first study strengthened the empirical evidence on the relationship between hazards, musculoskeletal disorders, and sickness absence. It also showed that research on the relationship between hazards and work-related accidents is still lacking. The assessment of psychosocial hazards should be extended to less studied factors, e.g., hazards arising from new forms of work, and further research is needed on the relationship between hazards and safety and health-related outcomes that can be used in risk assessment. Direct or mediated non-clinical health indicators of well-being are particularly promising.

As risk evaluation in relation to psychosocial hazards is still poorly understood, the thesis discussed the advantages and disadvantages of existing approaches and found that procedures that consider direct health-related effects in the assessment can be advantageous. The thesis presented the theoretical and methodological steps necessary to realise the risk matrix approach for psychosocial risk assessment, thus developing a new approach to risk evaluation. An empirical

study demonstrated the suitability of the approach and provided initial indications of its validity. Further studies to assess the quality and evaluate the usability should be considered. Additionally, research on non-linear and dose-response relationships is needed to further develop the methodology for assessing psychosocial risk.

The increasing speed of changes in working conditions requires a well-founded and efficient design of risk assessment as part of a continuous improvement process. Health is and remains the most valuable asset that must be protected. Most occupational activities involve risk in some way, and it is difficult to set criteria for what levels of risk are still acceptable. But only a substantiated risk assessment enables an effective work design. Risk mitigation usually comes at a price, and a compromise must be found between the acceptable level of risk and the cost of mitigating those risks. For occupational safety and health experts, this trade-off needs to be considered carefully and thoroughly.

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