Swedish Agency for Work
Environment Expertise

Physical Work Environment for Health, Well-being and Performance – a systematic review

REPORT 2020:4

PHYSICAL WORK ENVIRONMENT FOR HEALTH,
WELL-BEING AND PERFORMANCE – A SYSTEMATIC REVIEW
Government commission to summarize knowledge of factors
that create sound and healthy workplaces
A2018/01349/ARM REPORT 2020:4
ISBN 978-91-986142-0-6

Swedish Agency for Work Environment Expertise
Box 6051, SE-800 06 Gävle
Telephone: 00 46 26 14 84 00, Email: info@mynak.se
www.sawee.se

Physical Work Environment for Health, Well-being and Performance – a systematic review

REPORT 2020:4

This report is written by:

Cecilia Berlin
Maral Babapour Chafi

Foreword

In June 2018, the Swedish Government commissioned the Agency for Work Environment Expertise to summarize knowledge regarding factors that create sound and healthy workplaces (A2018/01349/ARM). According to this commission, particular attention should be paid to organizational and social work environments. To carry out this task, the Agency recruited researchers from various colleges and universities to produce literature reviews in four areas: the physical work environment, leadership, the organization of work and the psychosocial work environment.

In this report, we present the literature review concerning physical work environment. It was authored by Cecilia Berlin, PhD (Associate Professor) and Maral Babapour Chafi, PhD, at Chalmers University of Technology. Professor Mikael Forsman of the Royal Institute of Technology (KTH) conducted a quality appraisal of the literature review at the request of the Agency, and Malin Almstedt Jansson, PhD and research librarian at the University College of Gävle, assisted the authors in identifying and obtaining scientific literature for the review.

This literature review reports on research regarding the ways in which workplace design can promote and improve employee health, well-being and performance. The researchers present a number of design properties in the physical work environment that promote workplace well-being, and suggest that these factors influence a range of health outcomes, from well-being on the one hand, to performance and productivity on the other. The review outlines a number of different workplace interventions that have been shown to promote well-being. The importance of achieving a better understanding of employees' needs is also pointed out, as is the value of employee participation in the processes of designing both work tools and workplaces.

The authors of the literature review chose their own theoretical and methodological starting points, and are responsible for the results and conclusions presented in this report.

I wish to express my tremendous gratitude to our external researchers and quality reviewers, and to the Agency employees who contributed to the creation of this valuable literature review.

The literature review has been published on the Agency website, and in the Literature review series.

Gävle, February 2020

Nader Ahmadi
General Director

Our process model for systematic reviews

To support the researchers in their preparation of this literature review, the Swedish Agency for Work Environment Expertise developed a system for the systematic creation of literature compilations in its area of responsibility. It contains systems of preparation, literature search, relevance assessment, quality assurance and the presentation of studies and results. It also includes the Agency's process management and university library support, as well as external quality assurance.

At the Agency, Annette Nylund has served as the supervising process manager for preparing the literature review. Susanne Lind administered the process, while a team of communicators consisting of Pernilla Bjärne, Sverre Lundqvist, Liv Nilsson, Joakim Silfverberg and Camilla Wengelin has been responsible for the work of text management, layout, accessibility and the scheduling and planning of webinars and podcasts.

Summary

The purpose of this report is to provide a review of available research on implications of the Physical Work Environment for employee Health, Well-being and Performance. This literature review focuses on identifying the ways in which a sound and healthy workplace can be designed to provide favourable conditions for good job performance in parallel with a high level of well-being. The review intentionally excludes problem-focused research regarding injury risks, as well as health-promotion initiatives that require employees to take greater individual responsibility for increasing physical activity or changing their lifestyle. The focus is instead on workplace well-being outcomes that result from well-designed workplaces in terms of layout and technical solutions (such as equipment, furniture, etc.). The review consists mainly of literature from the ergonomics and design fields, to emphasize knowledge about the intentional design of the work environment and its components.

A systematic literature search was conducted in two databases, Scopus and Web of Science. Out of an initial 4,299 hits, 446 abstracts were selected for full text screening and quality appraisal. A total of 317 articles from the years 2000 to 2018 were ultimately included and sorted into two main themes: 196 empirical studies and literature reviews concerning physical loading and workplace design and 121 articles on design process considerations that guide, organize and offer advice about the design of a healthy and functional physical workplace. Structured quality appraisals were performed on all the included articles; empirical studies were appraised using the McGill Mixed Methods Appraisal Tool (MMAT), literature studies with the Critical Appraisal Skills Programme (CASP) template for literature reviews, while the design process literature was appraised using a specially customized template.

The included material covers different types of studies, methodological approaches, intervention objectives and occupational groups. The different types of empirical studies were: Field studies (n=134), laboratory studies (n=45), and questionnaire-based cross-sectional studies (n=53), as well as literature reviews (n=14) that reported empirical studies.

The findings outline various types of well-being and performance outcomes, e.g. health, satisfaction, recovery, comfort, commitment, productivity, efficiency, creativity, problem-solving and cooperation. Some "negatively" expressed outcomes can be considered indicators of physical workplace health when they are reduced, for example reduced physical loading, reduced stress, reduced risk of physical injury or reduced human error. Not all of these outcomes fall strictly within the (designed) physical work environment context; they concern cognitive and organizational workplace well-being as well.

The presented results are also grouped by occupational categories. The greatest share of the literature regarding workplace well-being factors derives from knowledge work in office environments (n=79), followed by studies from the healthcare sector (n=48), then the industrial sector including the construction industry (n=43). Some of the literature addressed multiple occupational categories simultaneously (n=9). Miscellaneous occupations that collectively did not amount to a cohesive category were simply categorized as "Miscellaneous" (n=22).

The design process literature offers a great deal of guidance in terms of how workplaces should be designed in general to improve employee well-being.

Most of the studies on design processes that offer recommendations for how the design work should proceed and be organized recommend a participatory approach in order to achieve a better understanding of employ-

ees' needs, and to foster employee involvement during the processes of designing work tools and workplaces. There are, however, some studies that indicate that participatory approaches do not always bring about the desired effects.Other valuable contributions from the design process theme pertain to the use of various simulation and assessment tools, as well as methods for assessing the suitability of a workplace design for a specific group of users. The literature has evaluated worksite design as well as technical solutions and tools for supporting workplace well-being. A few studies focused on evaluating work tools for various occupational categories, often from the perspectives of risk assessment and physical ergonomics to prevent musculo-skeletal disorders, but also with regard to other aspects such as satisfaction, preference and user-friendliness.

Other recurrent themes in the literature are reduction of sedentary (seated) work, work conditions for older employees, and recovery. Another emerging trend in the literature is the use of new technological advancements in design and evaluation processes. The report outlines three areas that could become increasingly prevalent: robots as work tools and how labour should be divided between robots and humans; the use of wearable technology or motion-tracking technology (such as sensors and cameras) for activity and/or biometric measurements and, finally, greater use of simulations like so-called digital twins for design and maintenance of workplaces. According to one category of studies, design modifications in the workplace should ideally be combined with training and education in order to promote behavioural changes among users of the workplace or work tools, and to achieve lasting impacts on health and well-being.

The design process literature offers rich guidance on various approaches, tools and methods that support the design of healthy workplaces. These studies offer recommendations from both an individual and macro perspective, i.e. the approaches in the articles cover different system levels and can guide various phases of a design and development process such as selection and evaluation of specific equipment and layouts, and give advice on how a participatory process that involves the employees should proceed. The tools described for such purposes include methods, analytical models, measurement equipment and simulation technology.

This literature review had a broad approach, which has entailed both strengths and weaknesses. It has been difficult to identify clear and general recommendations with regard to so many different work contexts with distinctly different purposes. Although studies with a design-related workplace well-being focus exist, we propose that multiple-outcome approaches are of greater interest and relevance for future research and development. To reach a deeper understanding of combinations of outcomes, the authors believe that it is beneficial to concentrate future reviews (or further syntheses of this review) to in-depth studies of a specific occupational category (e.g. industrial work, healthcare, or knowledge work).

Another recommended elaboration would be to focus on evaluation studies of work tools and equipment intended to reduce physical loading, particularly those with a view to guiding organizations, employers and designers in the process of selecting, procuring and implementing equipment and work tools.

One area for future research is concurrent evaluation of physical and cognitive (or mental) demands from the same job. This is difficult, but crucial to study. This review has also found few studies that address temporal factors (such as scheduling, rotations, etc.), which are presented as alternative strategies for achieving healthier levels of physical loading at work. One closely related aspect that would be of interest for future studies is physical loading caused by user interaction with digital interfaces, as the increased use of digital services is leading to more physical interactions with smart interfaces and hand-

held/wearable technologies, both at work and at home. In addition, the review identified few studies that discuss unsuccessful design processes.

Table of contents

Delimitations

The purpose of this literature review is to inform the process of designing the physical environment in workplaces, in order to promote work-related well-being and performance.

The search process excludes studies on (i) interventions aimed at behavioural changes, such as increasing physical activity, (ii) rehabilitation and return to work following work-related injuries, (iii) purely educational interventions and training, (iv) purely Indoor Environmental Quality/IEQ, psychosocial or organizational aspects, (vi) borderless/boundless work and/or working from home, and (v) purely theoretical articles. These aspects are addressed by other literature reviews, for example those by the Institute of Stress Medicine on stress and psychosocial factors (Lindegård, 2009), or health-promoting workplaces with a focus on organizational and psychosocial work environment factors (Hultberg et al. 2018), as well as reports by the Swedish Work Environment Authority on boundless/borderless work (Aronsson, 2018) or Indoor Environmental Qualities, e.g. natural light (Lowden, 2019). There is also a report from the Swedish Work Environment Authority that focuses on a combination of physical and psychosocial aspects that can define a good work environment among healthcare and knowledge workers (Lindberg & Vingård, 2012). In contrast to the latter report, this literature review focuses on the design of the physical environment in workplaces.

Nomenclature

The design and configuration of a workplace can influence many different outcomes in terms of well-being and performance. The basic unit for analysis is not just the individual employee, but rather (up to) the entire group/organization at the workplace. A number of key terms need to be defined to clarify how the authors have interpreted the terminology in the literature leading to the sample deemed relevant, as well as the reasoning in the review.

- **Health** is defined as a "state of complete physical, social and mental well-being" (WHO, 1998) that is created in environments where people learn, work and live. Health promotion, according to the Ottawa Charter, is "the process of enabling people to increase control over, and to improve, their health."
- **The salutogenic** perspective on well-being focuses on factors that promote health, as opposed to those that cause ill-health or diseases (Antonovsky, 1979). According to this view, three factors, conditions or circumstances in workplace settings contribute to a person's coherent sense of well-being:
  (i) comprehensibility, i.e. the ability to understand and make sense of the surrounding environment,
  (ii) manageability, i.e. having the resources to engage and cope with various situations in a constructive manner, and
  (iii) meaningfulness, i.e. having the motivation and the ability to put events into context and find what is meaningful at the individual level.
- **Design** (in this report) refers to both the process and the result of an intentional specification, configuration, development and/or adaptation (Lawson & Dorst, 2009) of, for example, workplaces in terms of the physical work environment, layout, equipment or tools intended to enable and support work.
- **Ergonomics/Human factors** are according to the International Ergonomics Association (IEA, 2000) two equivalent terms that are defined as: "the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance."

2. Method

The search for relevant literature was conducted using the review protocol presented in Appendix 1. The databases Scopus and Web of Science were used for literature searches to identify potentially relevant studies. The authors sought international peer-reviewed literature and limited the search field to results in English. The search strategy was developed based on the inclusion and exclusion criteria presented in Appendix 1. These criteria were developed based on the PEO framework (Population, Exposure, Outcome). A complete overview of the method used to collect and appraise the quality of the literature, including the search strings, is also provided in Appendix 1.

The database search resulted in a total of 4,299 abstracts. After screening for duplicates, the authors reviewed 3,225 abstracts. In the first inclusion stage, 446 abstracts were found relevant. The 446 included articles were divided up between the authors, with each article undergoing a full-text review by one of them. If anything was unclear with regard to how a result should be categorized, the matter was resolved through discussion between the two authors. This step led to exclusion of 120 articles that had the wrong focus, wrong population, wrong language or were of the wrong type (Appendix 3).

The 326 included articles were divided into two main themes: (i) empirical or literature studies (n=204) concerning work-related well-being related to physical loading, and (ii) design process articles (n=121) concerning various methods, tools, processes and approaches for planning, creating and assessing a workplace (with regard to its layout/architectural aspects and its technical solutions).

Once the quality of all articles had been appraised, an additional nine studies were excluded. The reasons for excluding eight of them are given at the start of Appendix 2A (Appraised empirical studies, Screened articles). The last excluded article was a design-process article that involved the wrong population. This process led to a total of 317 included articles (196 empirical or literature studies, and 121 design-process articles).

The authors would like to emphasize that this searching and screening method differs from what a "systematic review" normally entails. Our reasoning is that knowledge on why and how workplace design can lead to well-being outcomes cannot easily be quantified to individual exposure correlations. Work-related well-being is a systemic effect comprising many objective and subjective outcomes. Well-being outcomes related to workplace design are often contextual or system-dependent; therefore, workplace well-being outcomes cannot be studied fairly based solely on clinical trials. Consequently, qualitative and mixed-methods approaches are predominantly relevant to our research questions, and consequently of major interest. Furthermore, much of the literature from the design and ergonomics disciplines is based on qualitative or mixed-methods approaches, and exclusion of this relevant knowledge, simply because it cannot be quantified, would be an unfortunate loss of important perspectives. Therefore, this review includes studies with a broader methodological variation and a much larger number of studies than a typical systematic literature review.

Appraisal of the literature

Three tools were used for quality appraisal of the included literature, in terms of credibility, reliability, validity and generalizability/transferability.

First, because of our broadly inclusive approach and because a substantial portion of the design and ergonomics research applies a mixed-methods approach (a combination

of qualitative and quantitative approaches), we chose a tool that facilitates the appraisal of multiple study types, namely the McGill Mixed Methods Appraisal Tool (MMAT) to review the included empirical studies (Hong et al., 2018; Pluye & Hong, 2014; Pace et al., 2012). MMAT is intended for literature reviews aiming to gain deeper and more nuanced insights on health problems by including qualitative, quantitative and combined methodological approaches, i.e. "mixed methods". Using MMAT involves having (at least) two appraisers assess the quality of each full-text article. The first two questions in MMAT are intended to determine whether the study in question is truly an empirical study, thus eliminating the studies that are not. The next step involves determining the type of each study (see Figure 1), thereafter answering a specific set of questions concerning that particular study type, in order to assess the specific methodological quality of the included articles. The five study types that MMAT handles are:

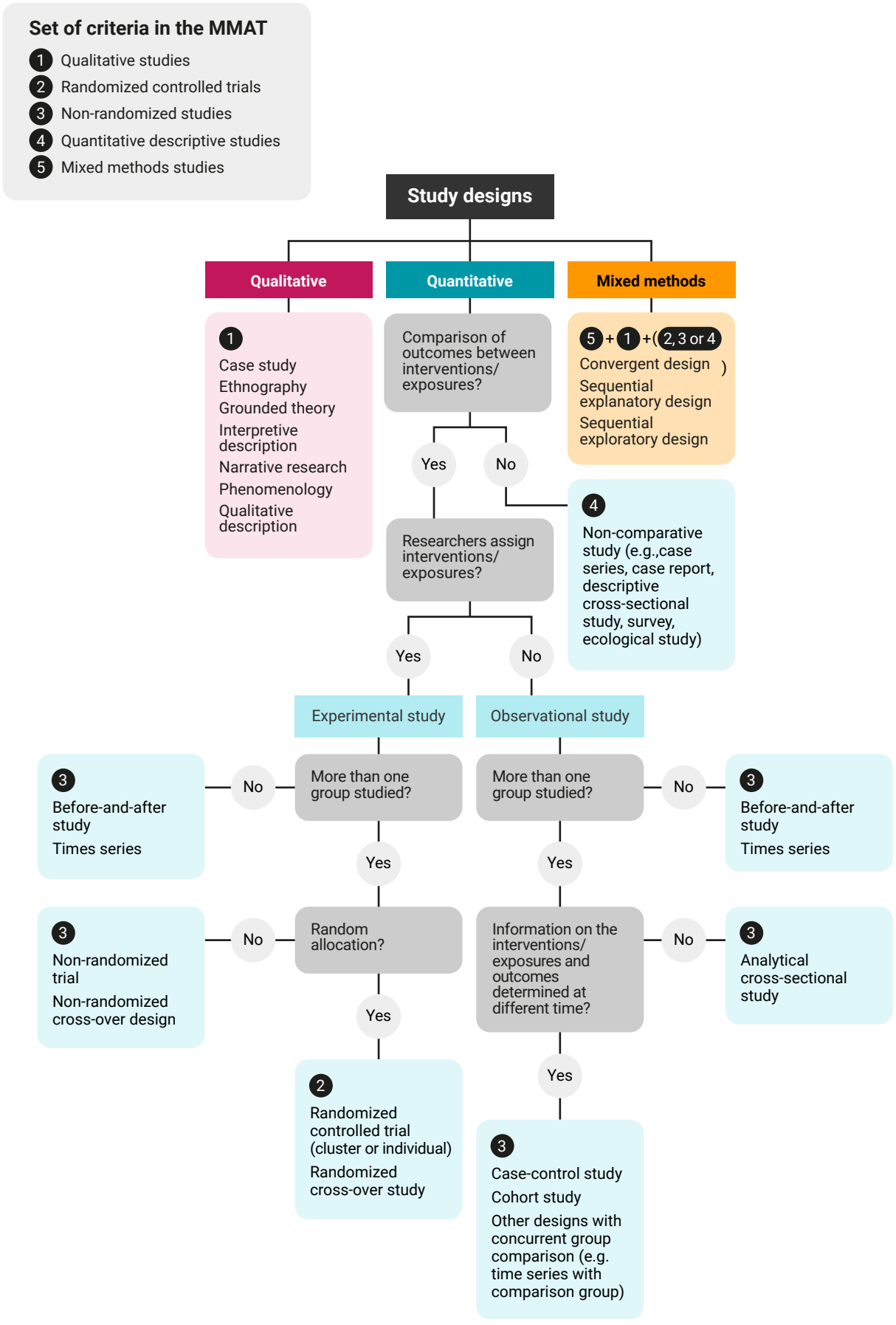
1. Qualitative studies
2. Randomized quantitative studies
3. Non-randomized quantitative studies
4. Purely descriptive quantitative studies, and
5. Mixed-methods studies, which, strictly defined, require a combination of (i) at least one qualitative and one quantitative method that (ii) are used with good disciplinary practice, and (iii) integration and synthesis of the methods to answer the research question (Pluye & Hong, 2014).

Pace et al. (2012) state that MMAT provides good support for facilitating the parallel appraisal of multiple study types. The inter-rater agreement among the authors in assessing the quality of the identified literature has ranged from fair to complete agreement, depending on the study type (with the greatest variation concerning qualitative and non-randomized quantitative studies).

Second, the tool from CASP (Critical Appraisal Skills Programme, 2018) was used for appraising the quality of the included literature studies, since the previous tool (MMAT) is not developed for appraising the quality of theoretical or non-empirical studies (Hong et al., 2018). CASP comprises ten questions divided into three sections with different purposes: Section A focuses on validity, Section B on reliability, clarity and precision of the results, and Section C on the generalizability or transferability of the results i.e. whether "the intervention" or exposure should be applied to other populations. CASP mainly targets systematic reviews with patient and treatment focus, which is evident in the questions posed in Section C. However, we applied CASP to all the studies that were categorized as literature reviews.

Third, due to difficulties in finding suitable established tools for appraising the quality of design-process articles, a simplified quality appraisal tool with customized questions was used (see overview in Chapter 3, and details in Appendix 2C). The lack of established quality appraisal tools for design-process articles is partly due to the guiding and advisory nature of these articles, often making them fall outside the framework of "evidence" studies.

Figure 1: Flow diagram of studies appraisable using MMAT criteria (from Hong et al., 2018)



3. Results

A complete overview of the reviewed full-text articles is provided in Appendices 2A, 2B and 2C (Articles with quality appraisals) and in Appendix 3 (Excluded articles). For easy referral to each specific article in this report, a code is used (presented in the appendices to the left of each table). The code consists of a prefix that indicates the type of the study and a serial number. In the case of empirical studies, the code indicates the type of study as identified with the MMAT tool, while a customized prefix is assigned for other articles (e.g. QL11 is a qualitative study, QN-N5 a quantitative non-randomized study, L6 a literature study and D77 a design process article). The articles under each study type are listed in an alphabetical order.

It is worth noting that the inclusion and exclusion criteria and the focus on well-being outcomes also resulted in a large share of literature focusing on injury risks (of which a subset are well-known contributions from Swedish authors). Most of these studies with a focus on injury risks had already been excluded at the abstract level. This is an important delimitation to consider, as musculo-skeletal injuries have been extensively documented and studied, mainly in "heavy" industry. Our review has not identified many results with a focus on promoting well-being from these "typical" sectors. Nevertheless, a share of risk assessment studies have been included, but this review is not intended to be comprehensive from a risk mapping perspective.

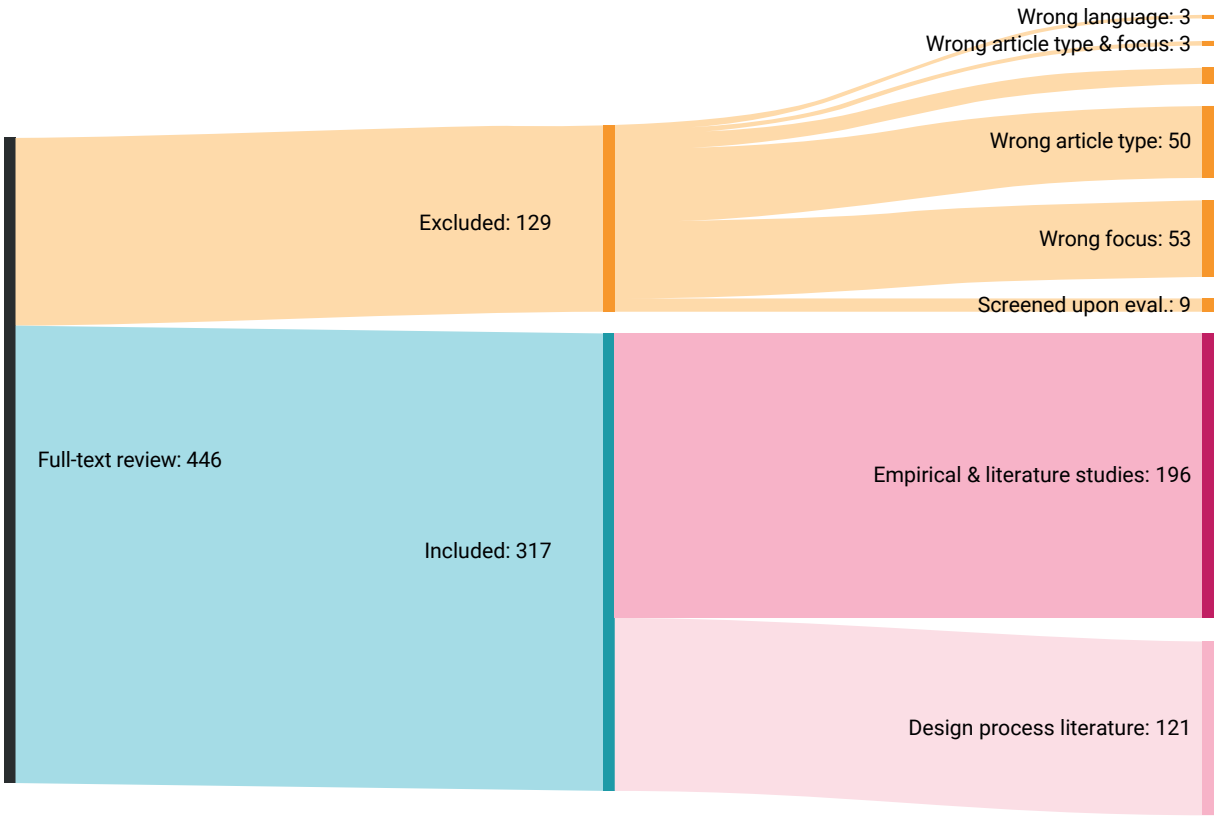
Overview of results – two distinct themes

Among the 317 included articles, we identified two main themes concerning work-related well-being in workplaces related to the physical work environment and physical loading. A great deal of empirical and literature studies were identified, which either examined injury risks and offered advice on injury prevention, or studied exposure to factors that influence outcomes in terms of health, well-being, satisfaction and performance. We refer to this theme as empirical and literature studies and present them in Chapter 4. The quality of these studies were appraised using the aforementioned MMAT and CASP tools (see Chapter 2).

We also identified a theme containing literature that described and elaborated various methods, tools, processes and approaches for use in workplace planning, design, configuration and evaluation, including the technical and architectural solutions it may involve. A number of these studies had to do with the development of design tools, processes and/or approaches, their application and evaluation in empirical and laboratory contexts. This theme is presented in Chapter 5. The overall breakdown of the identified literature is illustrated in Figure 2.

The full-text review phase led to the elimination of an additional nine empirical studies; the reasons why eight of them were screened are given at the start of Appendix 2A (Appraised empirical studies, Screened articles) , while one design-process article proved to involve the wrong population.

Figure 2: Flow diagram for reviewed articles



4. Empirical and literature studies – evidence on workplace well-being

This chapter presents studies that used an empirical approach (or literature reviews) to gather evidence on work-related well-being. The 196 articles that provided evidence on well-being with respect to physical loading consisted of literature reviews (n=14) or empirical studies (n=182). The latter studies were conducted either in a controlled laboratory environment, in the field (in a "real environment" where actual work was undertaken and contextual factors were allowed to impact the results), or in cross-sectional questionnaire studies targeting a specific occupational group. A few studies combined these approaches and could, for example, include both a laboratory environment and a field study (three studies), or they supplemented a field study with a cross-sectional study (e.g. QN-N22). Table 1 offers an overview of the identified study types.

Workplace well-being factors

There is no evident standard for measuring occupational well-being. In the large number of studies reviewed, we see a number of different constructs associated with well-being, including performance. Consequently, it is beneficial to consider a variety of terms and expressions for well-being in a workplace, consistent with our intention of emphasizing a holistic view on well-being and well-functioning work systems. Most of the identified well-being components are associated with job performance and workplace design, including the utility and user-friendliness of the physical equipment available to the employees.

Table 2 illustrates various constructs associated with well-being that have been identified, including examples of studies (see Appendices 2A and 2B). Attention has also been paid to a number of "negated" outcomes that relate to increased well-being, such as reduced discomfort, physical demand, stress, etc.

Recovery was identified as a trending theme in the literature, e.g. that access to nature, views and a pleasant environment can serve as a resource for recovery (QL11, QN-N40, L6, QN-N57), although all of these studies have been deemed "debatable" in terms of methodological quality. This type of study is most common in workplace studies related to knowledge work and office environments.

Another new trend is the use of wearables for assessing physical work demands, e.g. for measuring activity or pulse rate when evaluating interventions (QN-N16, QN-D14, QN-D19, MM10, MM45, D61, D118).

Worksite evaluations

A major part of the included literature concerns evaluations, pre-and post-occupancy comparisons, interventions, or other aspects involving a workplace as a whole. This includes comprehensive aspects of (physical) layout and configuration of worksites, consisting of multiple components that influence multiple individuals in such a way that the execution of work and the actual work arrangement becomes dependent upon the design of the workplace. This topic is identified in 74 empirical studies, most of which address knowledge work (n=40), healthcare (n=26), industrial work (n=16) or miscellaneous occupations (n=16). In addition, one literature review concerning activity-based offices was identified (L3). In the area of knowledge work, numerous studies involve office interventions in which the entire worksite layout and ways of working are altered and a group of employees are surveyed before and after

Table 1: Breakdown of study types and themes identified among the empirical and literature studies (some categories overlap)

Study types	Overview of the empirical studies
Field studies (N = 134) Primary data collected in a "real" work environment with ongoing activities and operations, where contextual factors are allowed to impact the results	The greatest share of field studies is found in Knowledge work (n=53), followed by Healthcare work (n=37), Industrial work (n=25) and Miscellaneous occupations (n=15). A large number of field studies concerned worksite evaluation (n=69) addressing worksites for Knowledge work (n=33), Healthcare (n=21) or Industry (n=6). Product evaluations in the field (24) are often concerning tools/products used in Knowledge work (n=12), followed by Industry (n=6) and Healthcare (n=3). Risk mapping (n=60) is another common theme, often in the form of questionnaires or observations targeting employees in Industry (n=20), Healthcare (n=17), Miscellaneous occupations (n=10) or Knowledge workers (n=9). Participatory design processes have been studied, often in the form of case studies of an intervention in which data is collected from the employees for designing and evaluating the intervention (n=6), or studies aiming at finding solutions to reduce musculo-skeletal injuries (n=10). Performance (n=46) is the most common outcome studied mainly in the contexts of Knowledge work (n=21), Healthcare (n=16) and Industry (n=7). Injury Prevention (n=37) is another common theme studied in the contexts of Knowledge work (n=15), followed by Healthcare (n=9), Industry (n=6) and Miscellaneous occupations (n=7). See complete results in Appendix 2A.
Laboratory (N = 45) Primary data collected in a clinical and "controlled" environment and not in an actual workplace, where contextual factors are restricted from impacting the results	The greatest share of laboratory studies is found in Knowledge work (n=18), followed by Industrial work (n=12), Healthcare (n=6), Multi-occupation (n=5) and Miscellaneous occupations (n=4). A few worksite evaluations are conducted in laboratory environments (n=6). The purpose of these studies is usually to assess or compare specific design solutions for a work environment with control variables (e.g. QL12, MM34, QN-N9, QN-N17). Product evaluations in laboratory environments (n=25) are mostly conducted in the context of Knowledge work (n=12) and concern evaluation of chairs, screens or keyboards; followed by Industry (n=5), usually with a focus on hand tools and risk mitigation; and Healthcare (n=4), with a focus on solutions for better ergonomics in surgery and diagnostics. Risk mapping (n=59) in laboratory environments is most often conducted in the context of Knowledge work (n=6), with a focus on body postures in connection with desk work; followed by Industry (n=4), where the focus is on risks of musculo-skeletal disorders in the construction industry or materials handling/assembly; and Multi-occupation (n=6), where much of the focus is on studying the body's limitations while performing various tasks. Performance outcomes (n=11) are studied in laboratory environments mainly in connection with product evaluation (n=6) or worksite evaluation (n=3), where the aim is to improve employees' interactions, cognitive performance or better physical posture while working. Injury Prevention (20) is studied in a laboratory environment in connection with product evaluation (n=15) or evaluations of body posture (e.g. arm angles, MM70) that may be harmful and should be avoided. See complete results in Appendix 2A.
Cross-sectional questionnaire studies (N = 53) Data collected via broad questionnaires to a specific occupational group	Often conducted for the purpose of risk mapping among specific occupations or interest groups (n=23), such as ageing knowledge workers (QL 15), computer users (QN-D2), construction workers (MM16), floor layers (MM23) or gynaecologists (QN-D3). There are a number (n=9) of field studies that have been combined with a cross-sectional survey (e.g. QN-N22, MM51, MM6, MM55). See complete results in Appendix 2A.
Literature studies (N = 14) Secondary data collected in order to map existing literature	Five literature studies (L1, L5, L7, L11 and L14) focus on Healthcare workers, four of which have the purpose of finding correlations between workplace design and well-being components. Three literature studies address Knowledge work (L3, L6, L12). Four literature studies are general: two studies examine correlations between the built environment and well-being (L2, L4); one addresses physical ergonomics coupled with hand/arm problems (L9), and one study reviews interventions with workplace design solutions used to increase the level of physical activity in sedentary work (L10). See complete results in Appendix 2B.

(or solely after) relocation to the transformed work environment. Occupation-specific worksite evaluations are outlined in Chapter 3.
A portion of the design process literature offers methodological or procedural guidance for worksite evaluations (n= 25 articles). Of these, 10 studies apply digital simulations for workplace evaluations (D8, D9, D12, D18, D42, D66, D22, D71, D100, D104), while 11 describe participatory processes for assessing (and in most cases influencing) a workplace design (D9, D59, D16, D65, D67, D22, D38, D84, D42, D85, D56).

Product evaluations

A number of studies (n=63) concerned the description, testing and/or evaluation of "products", i.e. various types of equipment, design modifications, working methods or technical solutions that serve as tools that mediate and facilitate work or reduce the risks of injury (including discomfort) associated with various work activities and operations.

Some studies compared two or more product solutions (e.g. QN-N53 and QN-N54), or assessed an intervention that combined a product with training (e.g. QN-N1, QN-N2). The latter studies found that combining adjustable/ergonomic equipment with training in how they are to be used entailed good (and more lasting) results in terms of reducing musculo-skeletal injury risks.

A categorization of product evaluation studies (most with a medium-high to high quality appraisal) is provided in Table 3. Some studies evaluated a product and found positive results in terms of well-being, others found both advantages and disadvantages of the tested solutions, and some compared two or more variants of a product to recommend which would lead to the best results in terms of well-being outcomes.

Ageing

A small share of the empirical and literature studies (n=4) address ageing in various occupational sectors, and how workplace design can meet the associated challenges. One literature study (L14), with 25 included articles, concludes that there is a lack of studies on how workplace design can support inclusion of an ageing workforce among nurses in the healthcare sector. The high physical demands in nursing can lead to chronic fatigue, and many nurses choose to continue working despite pain. The study found that workplace design that takes needs and pre-conditions of ageing nurses into account should support the retention of the competence of experienced nurses for longer.

Another study (QL 15) examined differences between older and younger knowledge workers' perceptions of supportive and impeding design factors in the workplace (equipment, lighting, storage, space, windows, accessibility of colleagues, etc.). No major differences were identified, concluding that there is no need for special design modifications specifically for older workers. Rather, the workplace design should meet the particular need for privacy that was identified among both groups, and this should be taken into account in designing attractive workplaces for knowledge workers.

Two studies from the construction industry (QL8 and MM16) examined the prerequisites for retaining older workers and found that the older, experienced construction workers are considered a valued resource, that the risks of physical injuries in the sector are still high, and that the experienced workers have many good ideas for interventions to facilitate work and reduce physical loading (MM16 provides 250 examples of potential improvements). Both of the studies offer a strong argument for using participatory approaches to improve workplaces for older workers in the construction sector.

The design process literature also contributes to this topic through e.g. stimulation

Table 2: Terms linked to workplace well-being, with examples from the studied literature

Well-being	Performance
Wellbeing or Well-being: MM16, QL7, L12, QN-D13, L11, QN-N57 Satisfaction: MM41, QN-N12, QN-N14, QN-N22, QN-N45, QN-D4, MM6, L1, L3, MM9, MM17 Recovery, Restorative or Relaxation: RC2, MM4, QL 18, RC7, QN-N20, MM41, L2, D77 Comfort or Reduced discomfort: D87, D17, QN-N22, QN-D21 Engagement: QN-N13 Reduced stress or Stress reduction: QN-N40, MM41, QN-N52 Reduced musculo-skeletal disorder risk, physical loading or the like: MM48, D35, D68 QN-N22, MM24, MM61 See complete results in Appendices 2A and 2B	Performance: MM41, QN-N13, QN-N45, QN-D20, MM9, MM15, MM36, MM49, MM54, MM59, MM62, D36, D89 Productivity: QN-N12, MM6, MM42, D4, D47, D86, QN-N17, QN-N2, QN-N31, QN-D10, QN-D13, MM19, MM20 Effectiveness or Efficiency: QN-N45, QN-N46, MM17 Creativity or Problem-solving: MM19, QN-N3, QN-N4 Collaboration or Teamwork: QN-N45, MM19, L3 Reduced errors: D90, D97 See complete results in Appendices 2A and 2B

Table 3: Breakdown of product evaluation studies

Furniture	Handheld tools	Industrial solutions	Miscellaneous products
Chairs RC4, QN-N1, QN-N2, QN-N53, MM52, QN-N30, QN-N49 – adjustable or dynamic/ activity-increasing chairs/ sitting solutions Storage D82 – medication cart	Hand tools MM61, MM69, D57, D68, D102, D106, MM7, MM61– hand tools, tools for woodworking shops **Computer equipment** RC1 – keyboard and trackpad Cleaning equipment MM72, MM67 – cleaning equipment **Medical technology** QN-N36 – microscope QN-N47 – hand tools, surgery MM21, D31, D109 – ultrasonic tools	**Industrial logistics** MM57 – material carrying cases Robots QN-D11, D2, D30 – human–robot collaboration Construction equipment MM3 – rebar installation QN-N33, QN-N38 – scaffolding and wall modules QN-N50, QN-N51 – visual reference for balance support	Multiple combined solutions MM26, D54 – various industrial solutions to improve ergonomics Support surfaces MM24, MM35, – work support surfaces for assembly or typing MM70 – arm support when typing **Wearable measurement devices** D118, D119 – wearable sensors that measure movements and physical activity

Table 4: Breakdown of empirical and literature studies by occupational category (see summaries of the studies in Appendices 2A and 2B)

Occupation	Description	Examples of studies* with high quality appraisals
Industrial work (N = 43)	E.g. factories, assembly, disassembly, process industry, construction sector, mining, textiles industry, etc.	QN-D1, MM3, MM7, MM42, MM69
Knowledge work (N = 79)	Workplaces (mainly office environments) in public and private sectors, e.g. engineering, academia, or administrative services	QL2, QL6, QL7, QL15, RC1, RC4, QN-D5, QN-D8, QN-D13, QN-D14, QN-N1, QN-N2, QN-N16, QN-N52, MM19, MM24, L3
Healthcare work (N = 48)	Healthcare and nursing environments, with focus on physicians, surgeons and/or nurses	QL3, QL12, QL16, QL18, QL23, RC6, QN-D9, QN-D22, MM4, MM15, MM18, MM38, MM41, L7, L14
Multi-occupation (N = 10)	Studies whose scopes intentionally include several different sectors and types of occupations	MM57
Miscellaneous occupations (N = 21)	E.g. cooks, vehicles, cleaning, fishing, military, maritime activities, commerce, handicrafts, libraries, teaching, etc.	QL5 (food service), QL17 (oil rig work), MM67 (cleaning)

* QL = qualitative study, RC = randomized control study, QN-N = quantitative non-randomized, QN-D = quantitative descriptive study, MM = mixed-methods study, L = literature study

of joint mobility among the elderly (D63), calculation of the injury risks among older workers in connection with manual handling (D35), and provision of a database for adapting workplace design to the elderly and their work capacities (D111).

Occupational categories

The majority of the studies concerned a specific occupational category. This section addresses an overall summary of the findings, based on the identified occupational categories. Specific studies are referred to by the codes found on the far left of the tables in Appendices 2A and 2B. The codes consist of a prefix for the study type and a serial number. We have identified both empirical and literature studies, as well as design process literature, from the various occupational categories. The main categories for empirical studies are presented in Table 4.

Industrial work

We found a total of 43 empirical or literature (and 57 design process related) articles concerned with industrial work. Some concern evaluations of work tools, i.e. technical solutions that facilitate work (n=11), while others cover worksite evaluations (n=9), usually aimed at exploring the possibilities for reducing physical loading and thereby the risk of injuries. The rest of the studies map risks tied to industrial work or analyse work in other ways, i.e. via field or laboratory studies (see Figure 3).

In the area of industrial worksite evaluation there are 15 studies, six of which concern the construction industry (MM71, MM23), the automotive industry (MM42, MM37, MM29) and the steel industry (MM68). Three studies (MM42, MM68, MM37) emphasised the importance of taking various work environment aspects of the workplace into account in such evaluations. Nine design process articles also reflect this topic. Five of these design process articles report on participatory processes (D42, D67, D84, D85, D91), with the first three reporting successful implementation of new solutions due to employee participation in the design process. Another recurrent theme concerns various forms of simulations for assessment of workplace ergonomics or injury risks (D18, D19, D42, D66, D71, D100, D104).

Knowledge work

We identified 79 empirical and literature studies addressing workplaces for knowledge work (see Figure 4). A large share of these studies concern worksite evaluations (n=39) or product evaluations (n=25), and there were three literature studies. We also identified five cross-sectional studies (QN-D2, QN-D4, QN-D10, QN-D16 and QL15) that examine the working conditions of knowledge workers through one-time measurements; the latter three studies draw conclusions on knowledge workers' performance. In addition, 17 design process articles were identified that address knowledge workers' workplaces.

Many articles that evaluate products associated with knowledge work concern prevention of physical injuries. We found 15 studies that evaluate interventions, a large share of which comprise product evaluations (n=9). The most prominent category of studies within knowledge work was "post-occupancy evaluation/POE" studies. In these studies, a drastic change in design of office environments was evaluated post-relocation (e.g. QL2, QL 7, QL 9, QN-N12, QN-N42, MM5, MM9). The results from these studies are mixed, but this is consistent with conclusions drawn from a corresponding literature review (L3).

A major trend in the literature on knowledge work concerns different types of offices, e.g. the implementation of activity-based offices (e.g. QL2, QN-D7, MM9, QL 9 and QN-D13) or open-plan, shared office landscapes (e.g. QN-D5 and QL7). These studies investigate correlations between office type and knowledge workers' well-being and performance. We found one systematic review (L12, 2017) that emphasizes that open-plan offices have negative effects on employee health, well-being and productivity. Another review (L3, 2019) states that activity-based offices have a mixed impact on employee performance in terms of improved interaction/collaboration and a sense of control on the one hand, and negative effects on concentration and privacy on the other hand.

One of the identified literature studies (L6, 2018) investigates the correlation between contact with nature and well-being in the workplace. The article concludes that contact with nature can be a resource for better stress management.

A large number of articles address sitting and standing (n=42) during office work. Here, we found mixed conclusions as to whether it is harmful to stand or sit. This category includes many product evaluations and interventions intended to study or reduce the time spent sitting at work (RC4, QN-N4, QN-N28). This has also been studied in laboratory environments disconnected from the office/knowledge work context (QN-N6, QN-N30, QN-N49, MM28). However, the results are mixed on different solutions for achieving posture variation or reducing sedentary work. One study (QN-N3) performed a laboratory-based analysis of standing knowledge work (as an alternative to sitting) and concluded that there are other risks of physical injury associated with prolonged standing work, and that cognitive performance can also be affected both negatively and positively.

Healthcare work

A total of 48 empirical and literature studies and 15 design process articles addressed healthcare work (see Figure 5). The largest share had to do with worksite evaluation (n=22), with some studies focusing on patients' or relatives' perceptions in parallel with the healthcare staff's work environment (QN-N23, QN-N24, L7, MM8, MM58, MM59). Product evaluation studies (n=7) were also identified, three of which related to medical equipment for surgery or treatment (MM21, QN-N47, QL13) and three to work equipment for other healthcare roles (QN-N22, MM53, MM25). We also identified five literature reviews (L1, L5, L7, L11, L14) on healthcare work and five cross-sectional studies with a focus on the physical work environments of physicians/surgeons (MM2, QN-D3, QN-D9), a mix of healthcare staff (MM38) and nurses (QN-D22).

Figure 3: Categorization of empirical studies relating to industrial work

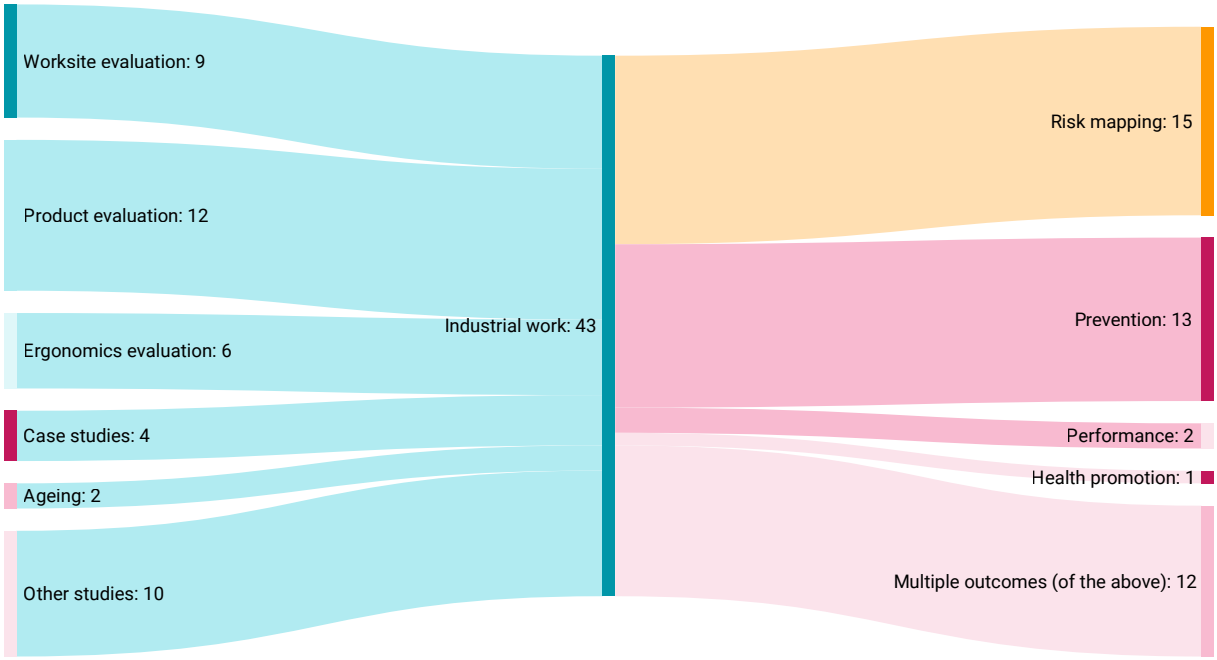
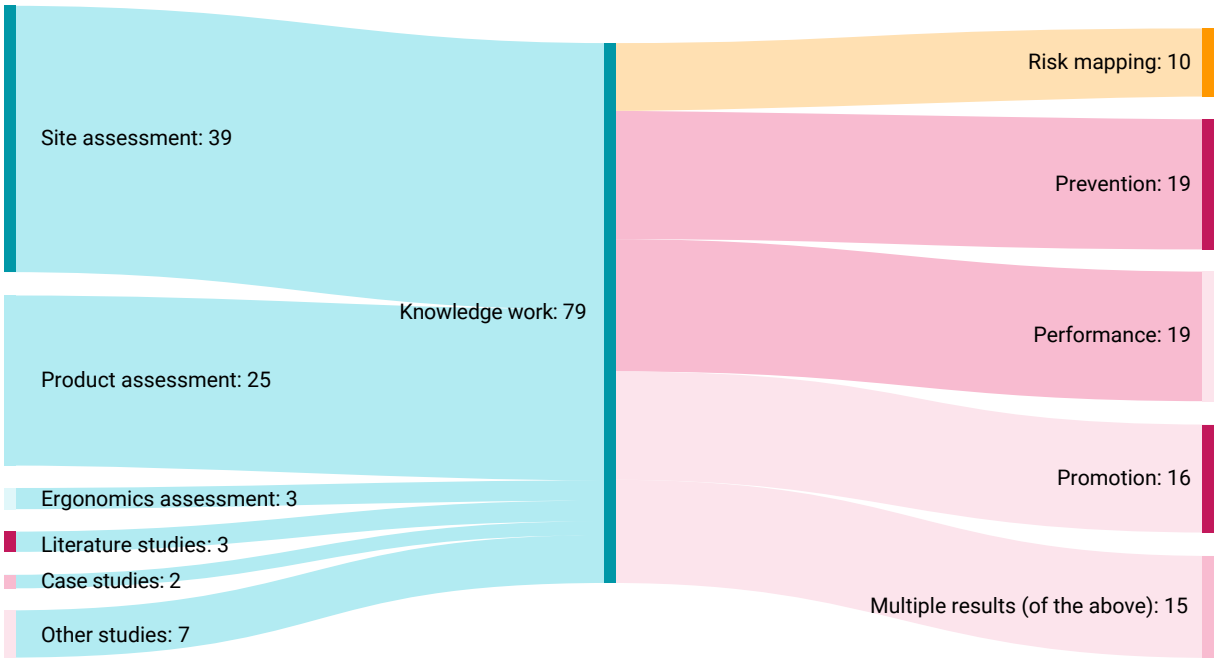


Figure 4: Categorization of empirical studies relating to knowledge work



A large number of worksite evaluation studies in healthcare environments focus on determining outcomes of workplace design on performance and quality of care, while most of the cross-sectional studies (five out of six) concern the mapping of injury risks. Relatively few studies focus on improved well-being for caregivers as an outcome, since the healthcare literature has mainly focused on patient-centred design (as discussed in L7, which reviews literature on "healing environments" and states that there is limited evidence concerning the staff). One study emphasizes that workplace design with positive results for caregivers can be achieved if ergonomics is taken into account early on (QN-N23). Other studies focusing on the impact of workplace design on caregiver well-being identify different significant design properties: QL18 identifies four properties of a workplace that enable older caregivers to feel that they are valuable, productive and safe, and that they belong in the workplace; QN-N7 describes how relocation to a new ward influenced nurses' perceptions of their work, the hospital and the building; MM54 studies workplace properties that provide "maximal health and performance" and concluded that these desirable workplace properties may vary depending upon gender and the type of healthcare work and context; and MM41 and D77 address the importance of partitioned rest areas where healthcare staff can recover while at work, which can lead to higher quality of care for the patients.

Studies of worksite evaluations in healthcare (22 empirical and 4 design process articles) concerned various design modifications affecting everything from the layout and structure of the entire built environment, from the perspective of the healthcare workers (QL16, QL20, QL23, QN-N7, QN-N14, QN-N23, QN-N24, QN-N48, MM17, MM38, MM56, MM58) to specific functional rooms/spaces (QL12, QN-N35) and specific work environment factors such as light (MM15), work tools in the healthcare context (QN-N9) or patient transport vehicles (MM8). In some cases, the healthcare work process and performance were studied in relation to the design of the work environment (QL4, QL18, MM54, MM59). Some studies also found that the design of hospital environments had a considerable impact on satisfaction and stress among healthcare workers, with one study (QN-N7) highlighting that this was to such an extent that it affected caregivers' decisions on whether to remain in the healthcare profession. The design process literature related to healthcare (n=14) included cases on participatory processes, in which the healthcare staff were engaged in suggesting design modifications (D2, D12, D9, D65, D72, D79, D82 and D90). In a number of cases, design concepts were reviewed in discussions with caregivers by presenting physical and virtual representations or models of the workplace concepts. Other design process studies concerned overall frameworks and processes (D5, D53, D64) or virtual or analytical methods and tools (D31, D109, D24) for supporting the process of designing healthcare workplaces.

Multi-occupation

We have characterized the literature regarding studies that included multiple occupational categories (n=9) as "multi-occupation". Within this category, we identified literature reviews with generally applicable contributions, for example a review of six interventions to reduce the risk of hand injury (L9), and a review on the design of non-powered hand tools to prevent the risk of injuries (L8), as well as a review on conceptual approaches to well-being associated with the built environment (L4). The remaining articles that cover multiple occupational categories concerned analyses of hand movements and/or physical loading related to hand tools, like pliers (QN-N17). The design process articles applicable to multi-occupations included discussions of how participatory design can be facilitated by design representations serving as a conversation starter between various stakeholders (D16) and offered checklists for facilitating design for well-being (D95).

Miscellaneous occupations

We identified 22 articles relating to varied occupations that did not amount to a distinct category, such as catering, vehicles, cleaning, fishing, the military, maritime activities, commerce, handicrafts, libraries, teaching, etc. Most of these articles were exploratory evaluations of a specific workplace (n=9), often with a focus on identifying specific challenges associated with that workplace and occupation (e.g. QN-N20; QL9, QL 17), or product evaluation (n=5) with a view to reducing ergonomic risk in connection to cleaning (MM67 and MM72), textile dyeing (MM47), tree grafting (QN-D11), and art restoration work (MM48). Furthermore, two articles reported on participatory workplace design processes in which the employees were involved (MM47 and MM48). We also found one literature review concerning maintenance work in the aviation industry (L13).

Most of the articles in this miscellaneous category concerned mapping of musculo-skeletal injury risks (n=14) and/or the prevention of such risks (n=9). Some of these articles with high quality appraisals investigated food service (QL5), dairy production (QN-N20), veterinary work (QN-D21), stable care (MM31), meat production (MM63) and cleaning (MM67).

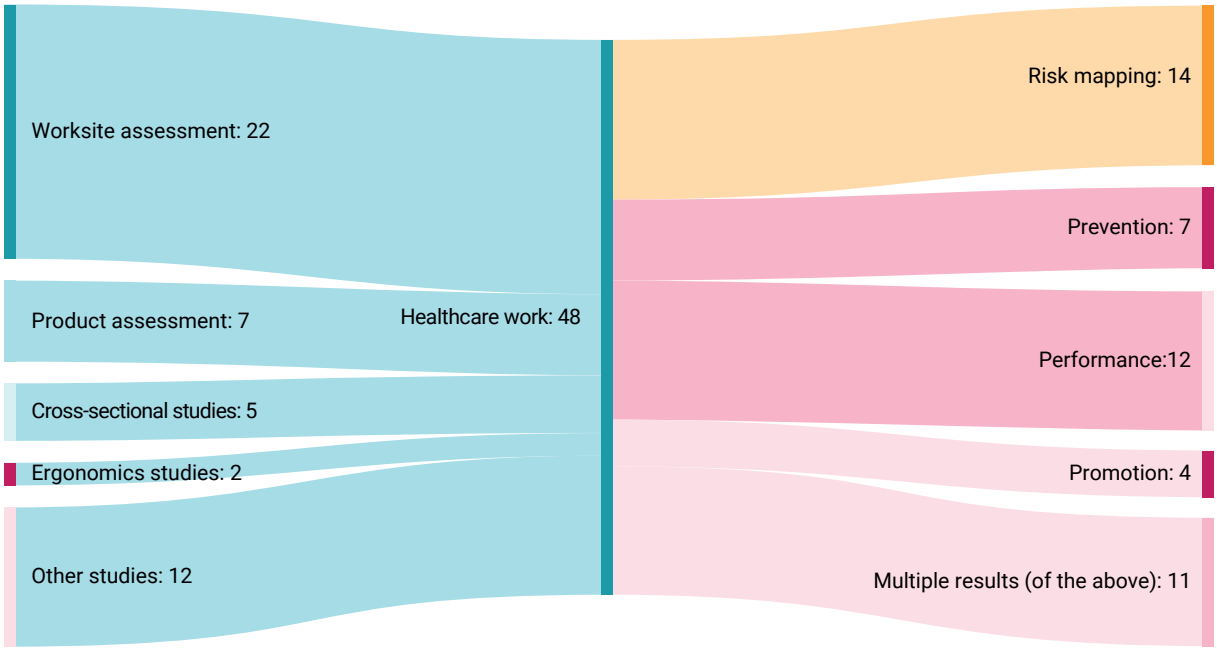
Quality appraisal of empirical and literature studies

The empirical studies comprised a wide variety of method types, which is why they were appraised using the McGill Mixed Methods Appraisal Tool/MMAT (Hong et al., 2018). MMAT was created specifically for reviews that combine qualitative, quantitative and combined (mixed-method) studies. Pace et al. (2012) recommend not converting MMAT appraisals into a numerical rating. Rather, non-fulfilment of the method-specific criteria should serve as potential grounds for exclusion, or further discussion of the contributions of the empirical study. It is also important to note that MMAT appraisal is focused on assessing methodological quality, i.e. the execution of the study, rather than its readability or the contents of its results.

The quality of the included literature studies was appraised using the CASP template (Critical Appraisal Skills Programme, 2018) for appraising literature reviews. A complete overview of the literature studies is provided in Appendix 2B. It is worth noting that the CASP template is intended for clinical studies and that it was not originally intended to address factors leading to well-being, which makes determining "the population to which the results apply" slightly awkward in terms of what is meant by "exposure". As a result, the questions in Section C of the CASP template (such as Question 10, "Are the benefits worth the harms and costs?") are difficult to answer and sometimes irrelevant.

The complete results of the quality appraisal are presented in Appendices 2A and 2B, but some of the studies with highest ranks (based mainly on the number of positive responses to the appraisal questions from MMAT or CASP) are used as illustrative examples in Table 4. One very distinct trend is that most of the studies with high quality appraisals are from the applications within knowledge work and healthcare.

Figure 5: Categorization of empirical studies relating to healthcare work



5. Design process articles – guidance for healthy workplace design

In this chapter we will address the other distinct theme in the literature, i.e. what we have categorized as design process-related literature, a total of 121 articles. They have been identified as offering methods, guidance, lessons-learned or evaluation criteria regarding how a workplace (or the technical solutions it contains) should be designed in order to support health at work. A complete overview of the articles in this category, including a (simplified) quality appraisal of them, is found in Appendix 2C.

Generally speaking, most of these methods, tools and proposed processes (55) are intended to lower the risk of physical injury at work. Some target multiple parallel health outcomes (33), chiefly the combined goals of lowering injury risk and enhancing work system performance. A large majority of the design process articles address workplace well-being at the individual level (81), while there are fewer that address improvement at the group or organizational (macro) level (31), although that group is also clearly present. A few articles focus solely on improving performance (3) or increasing well-being (4), while a large share had the more general purpose of supporting a structured design process (21).

We generally categorized the literature as design process-related if it chiefly addressed any of the following design-related content:

1. **Processes and Approaches**, i.e. a description or assessment of a proposed process or approach for designing or assessing workplaces. The majority of these articles concerned the participatory (collaborative) design or assessment of workplaces, i.e. the incorporation of knowledge directly from users and workers in the design or change process.
2. **Tools**, i.e. specifically described aids, methods or models used to structure and guide the task of designing, modifying and assessing workplaces.

Our choice to conduct a simplified quality appraisal means that this portion of the review falls within the framework of what could be termed a "Scoping review" according to Pham et al. (2014). Our decision to limit the included literature to "peer-reviewed, journal-published literature" is intended as a step towards quality-assuring the content.

Processes and approaches for healthy workplace design

These articles offer general process recommendations about how design work should proceed and be organized. A considerable share of the process literature (28) describes or recommends a participatory approach in order to secure a better understanding of the workers' needs and engagement during the design process. An important contribution from this literature consists of descriptions of specific methods and tools that support employee involvement and encourage active participation during the design process, for e.g. industrial workshops (D40), the use of different types of physical representations (D13, D15, D20, D60) and digital simulations (D79, D9) that enable reflection on the strengths and weaknesses of existing workplaces and work tools, or future scenarios. (A number of the previously mentioned empirical studies also follow up on participatory design processes that involve the cooperation of the employees in designing their workplace, four of which derive from healthcare, three from industry, one from knowledge work and five from miscellaneous occupations.

The majority of those studies report that participatory approaches lead to high acceptance of the changes and more lasting results, though not all the studies are longitudinal.)

However, some articles indicate that these participatory processes do not always lead to desired effects (e.g. D69, D85). There are obstacles and critical aspects to consider; for instance, participation is difficult to achieve if the organization or work group is overburdened, which means that the design process can lead to heavier demands and stress (D69). Nor does participation alone necessarily lead to well-designed and user-adapted workplace designs; rather, the right competence is a necessary condition to design and implement changes (D69), as are sufficient time, financial resources, information dissemination and the communication of process-related knowledge (D78). To achieve multiple parallel well-being outcomes, it is important to plan well-thought-out participatory design processes by selecting the right participants, securing engagement on the part of management, comprehensive analysis of the work, and critical risk assessment (D69, D85).

There are generally three types of articles about processes and approaches: one is at the macro level and concerns the design of the entire workplace, covering the entire design process from problem identification to execution and assessment, with the intention of addressing a number of workplace well-being factors (e.g. D1, D76). The second type is at the meso level and focuses on a particular, delimited phase in the design process (e.g. D18, D64) or a specific sub-section of the workplace, such as a functional space or workstation (D7, D13, D21, D56, D76, D77, D79, D97). The third type is at the micro level, and focuses on processes for designing tools and equipment, usually with a view to reducing injury risks; for example, D82 describes a needs inventory and requirement specification for designing medicine cupboards in healthcare environments.

Methods and tools for healthy workplace design

This review identified specifically described methods and tools for supporting a successful design process, such as: studies of ergonomic simulations using both physical models and digital and virtual tools (or similar) to streamline the design process (e.g. D72, D94, D100); compilations of standards and checklists for designing and/or assessing workplaces (D90, D96, D121); and the application of anthropometric data (body sizes for a specific population) as input data for designing user-centred workplaces and tools (D41, D99, D25).

A large share of the literature concerns methods and analytical calculation models assessing the risks of musculo-skeletal disorders (D34, D36, D65, D83, D88, D89, D97, D101, D101, D104, D105, D113, D115, D116). Those included here represent far from all of the assessment method variants that exist. There are, however, existing overviews that map, compare and assess such methods specifically, such as those of Palm et al. (2014) and Neumann (2006).

Some articles propose methods for determining or modelling the division of labour between humans and robots (D2, D30, D43). Because robots may be viewed as work tools that can enhance the performance of a work system and reduce the risks of individual injury, and have also drawn interest primarily in terms of their industrial applications, it is important to obtain a basis for decision-making when dividing tasks between humans and robots. However, this review includes only a few scientific articles that can offer such advice.

Because of rapid advancements in virtual technology, there is a considerable difference between simulation studies conducted before and after 2015. While more recent articles apply and point out new possibilities for how virtual simulation tools can help to assess workplaces (e.g. D10, D17, D22, D31, D33), earlier studies examined the potential of simpler statistical digital representations

and models (D6, D8, D19, D58, D94, D100). The differences lie in the greater interactivity, reliability and mobility found in the digital tools used in current simulation studies. One more recent term that appears in the literature is "digital twin", which is a type of virtual copy of a physical site and is used to simulate it so as to assess injury risks or performance in connection with design modifications (e.g. D62). There are also applications in which "capability" data, i.e. data concerning human work capacity, are combined with simulations in order to assess workplaces in relation to the capabilities of the older workforce (D63).

The process of designing a workplace may also involve choices of various work tools. Some of the design process-related literature concerns studies, methods and tools that can support appropriate selection of work tools during design processes, such as hand-held tools (D57, D68, D102, D106), computer mice and keyboards (D7, D17), software interfaces (D113) or ultrasonic healthcare equipment (D31, D109). In the long run, more articles of this type could support organizations in the procurement of such new work tools.

6. Synthesis and conclusions

This literature search and appraisal process led to a review of 317 articles published in peer-reviewed international scientific journals between 2000 and 2018. The review organizes the results into two distinct themes; firstly, a quality-appraised "mixed studies review" of empirical and literature studies of salutogenic factors associated with physical loading, and secondly a "scoping review" of design process-related articles, utilizing a simplified, customized quality appraisal.

The search for literature that generally addresses workplace well-being in the physical sense is an extremely comprehensive and varied task, to which strict exclusion criteria need to be applied if it is to be manageable. It is a challenge to draw any conclusive general recommendations, given the large spread of specialized contexts and varying purposes of the work systems in question. Therefore, one of our first recommendations to readers seeking to improve workplace health is to focus their knowledge search on workplace well-being studies from the specific occupational environment that they hope to improve, so as to obtain, in a more manageable way, results that are applicable and relevant to the types of physical loading and equipment that are typical of their particular workplace.

The subject area of "physical work environment with regard to musculo-skeletal disorders" has traditionally focused on avoiding and reducing pain/problems/risks and enhancing performance. The earlier (and plentiful) problem-focused literature has predominantly studied occupations classed as "heavy labour" (e.g. healthcare and industry), so the proportions in our results may surprise practitioners with good insight into the existing musculo-skeletal injury literature, particularly that originating from Sweden. It bears repeating that this review has targeted international (English-language) literature, and that its search strategy (Appendix 1) has decreased the focus on studies about problems and risks in favour of those about workplace well-being. Our review also excludes studies whose main focus is work-environmental factors (light, noise, vibrations, radiation, air quality, etc). Finally, a number of ergonomics methods (based on observation and measurement) to assess the risk of musculo-skeletal disorders have been included, but since this review has not actively sought out those particular methods, we cannot claim it to be comprehensive in mapping that knowledge area. Other authors (such as Palm et al., 2014; Neumann, 2006) have already contributed useful methods overviews towards this end. Thus, a lot more scientific literature regarding workplace physical loading is available than has been captured here.

As a rule, workplace well-being factors were interpreted in each respective study as specific outcomes considered to be of interest or importance. We found that these individual workplace well-being factors range broadly between well-being on the one hand, and work performance on the other. Specific outcomes include, for example, well-being, satisfaction, recovery, comfort, engagement performance, productivity, efficiency, creativity, problem-solving and collaboration.

Some "negatively" expressed outcomes can be considered indicators of physical workplace health when they are reduced, for example reduced physical loading, reduced stress, reduced risk of physical injury or reduced human error. As is evident, not all of these outcomes fall strictly within the (designed) physical work environment context; they concern cognitive and organizational workplace well-being as well.

One of the conclusions we draw from this is that even though etiological studies do exist of exposure to individual "health-promoting" factors, multiple-outcome-based approaches (such as those that study physical and mental loading combined) offer a much more interes-

ting and relevant path forward for future research and development. In order to go farther and deeper with such combined purposes, we propose that it can be a success factor to limit the scope to one specific occupational application at a time.

This review has made it clear that, within the literature on workplace well-being, the biggest proportion derives from the knowledge work sector (which is dominated by office studies), followed by studies from the healthcare sector (with some workplace studies also incorporating patients' and relatives' perspectives) and from industrial applications (including construction industry). A few studies address health promotion for multiple occupational categories. We have not found many cross-sectional studies in the field of workplace design. Those that do exist focus mainly on risk mapping within an occupational category, and do not necessarily contribute towards re-design of the physical workplace.

On the other hand, there is much good general advice to be obtained from the design process-related literature concerning how workplaces should be designed in general to improve workplace well-being. Most of the studies of design processes that offer process recommendations (as in how the design work should proceed and be organized) recommend a participatory approach, so as to foster a better understanding of the employees' needs and to encourage engagement during the process of designing both work tools and workplaces. However, some studies indicate that participatory processes do not always lead to the desired effects. These studies shed light on barriers and success factors in participatory design processes that are important to take into account. Other valuable contributions from this literature category pertain to the use of various simulation and assessment tools, as well as methods to assess the suitability of the workplace design for specific user groups.

On a more concrete level, this review includes a number of studies that assessed both worksite design and technical solutions to support well-being in the workplace. A few studies focused on assessing work equipment for various occupations, specifically with a view to supporting the choice of work tools during design processes. Furthermore, these types of articles can provide support to organizations in selecting and procuring new work tools and equipment. We also found more product assessments of chairs/keyboards related to knowledge work contexts than to healthcare settings. A possible explanation could be that healthcare products are often subject to stricter requirements owing to medical technical standards and rules; the fact that these constitute more specialized equipment may lead to them not being evaluated in scientific articles to protect the confidentiality of product specifications.

The use of new technological advancements represents another trend evident in the design and assessment process literature. We have shed light on three areas that could become increasingly prevalent. First is the use of robots as work equipment, and how the division of labour between robots and humans should be configured. The second trend is the use of wearables or motion-tracking technology (e.g. sensors and cameras) for measuring activity and/or making biometric measurements (pulse, joint angles, muscle activation) when assessing workplace interventions. Such approaches are becoming increasingly common, since workers' private mobile devices and smart watches have the potential for use in research studies, e.g. to measure sleep patterns, physical activity or screen time, which could also potentially increase the level of "citizen research" based on voluntarily donated data. However, it is important that such measurement methods be used in ways that are consistent with GDPR. Finally, the use of simulations like so-called "digital twins" may become more common tools for both designing and maintaining workplaces.

One category of studies (of which a portion was excluded at the abstract level) proposes that design-related workplace modifications should be combined with employee education, training and knowledge supple-

mentation in order to change the behaviour of the users of the workplace or work tools, in order to achieve the most impactful and lasting effects on health and well-being. In this review, we have only included interventions incorporating training and behavioural changes if they coincided with a physical modification of the work environment. This indicates that there exists additional literature concerning purely training-based interventions intended to reduce physical loading.

Identification of knowledge gaps

This review has taken a broad approach, with no specific limitations to specific occupational categories. One possible gap thus involves studies of "sound and healthy workplaces" that focus specifically (and in greater depth) on delimited occupational fields such as industry, healthcare, knowledge work, and other more specific application areas that have been lumped together in this overview (such as the military, transport industry, food and groceries, construction, etc.). Similar methodologies and decisions as in this study (e.g. to include design process-related literature) could benefit such occupation-targeting studies, but they should be conducted with a view to reaching critical mass in terms of identifying issues that are particularly relevant within each occupation.

Another elaboration would be to focus on assessments of physical load-reducing work tools, with the aim to offer guidance to organizations, employers and designers in the process of procuring, selecting and implementing equipment and work tools. Some of the literature can serve as a basis for impact analysis, support for user customization, and guidance for involving the right stakeholders in a participatory procurement process, so that the right kinds of demands can be made to promote workplace health (in terms of both well-being and performance).

It was difficult to draw conclusions in this study on whether there are enough high-quality studies that examine combinations of multiple salutogenic (or pathogenic) workplace factors.

In particular, what was found to be lacking were parallel assessments of physical and cognitive (or mental) workload from the same job. This is a difficult but very important topic for study, as many physical jobs have started to involve an increasing degree of decision-making and information processing, and because high levels of combined physical and mental strain may lead to increased employee aversion to the work, and likely to more complex health and recovery problems when things go wrong.

In some cases, the importance of temporal factors such as scheduling, rotations, etc. have been presented as strategies for achieving a healthier level of physical loading at work. Studies focusing on temporal factors have, however, been mostly excluded here, as such factors are seldom studied in conjunction with design aspects. This may represent a knowledge gap in terms of how time exposure combined with physical changes in the workplace can impact health and well-being. This could be of particular interest in scenarios where wearable technologies to alleviate physical loading are being considered, such as "exoskeletons" intended to off-load physical labour in areas such as the military, healthcare and the automotive industry (Exoskeleton Report, 2016).

One closely related aspect that would be of interest to study in greater depth is how user interaction with digital interfaces affects physical loading. This review found one study that focused on this topic, but given current technological advancements, it is highly likely that new types of problems regarding physical strain will arise as a result of modern people's frequent use of smart screens and handheld/wearable technologies, both at work and at home. Extensive interaction with glowing screens can also have effects on visual ability in the long term, aspects that have not been covered in this review.

We also found that we rarely encountered studies describing unsuccessful design

processes. There may be several prestige- or confidentiality-related reasons as to why such studies are limited, but it appears that there is a clear knowledge gap regarding what can instigate failure in the process of creating a healthy and highly functional workplace. Some studies in this review addressed the topic of participatory design processes – highlighting some problems associated with participation aspects in particular – but few studies are concerned with what can go wrong.

During the quality appraisals we found that there is a lack of suitable quality-appraisal tools that can handle the objectives and approaches encompassed by the ergonomics/human factors and design fields, whose contributions are often analytical and work with heuristics (rules of thumb) to quickly screen observed workplace risks. Therefore, these contributions provide analytical, abstracting and prescriptive (advisory) frameworks at the same time. The MMAT appraisal went a long way towards successfully classifying and evaluating a broad range of empirical studies, while analytical, risk-assessing contributions (such as the use of ergonomic evaluation methods, ergonomic simulations, participatory design processes, etc.) were difficult to categorize as any clear-cut type of empirical study as per the categories in the MMAT template. In other words, the potential exists to develop the MMAT further, or to create a different tool, which we propose should be based on the simplified appraisal template we have used for design process-oriented literature. However, we would point out that our own appraisal template is customized specifically for this literature review, and that there is room to improve its criteria. For example, the cited time frames from Question 6 should not be viewed as absolute terms for the relevance of the studies, but rather apply only to the relative span of years (2000–2018) from which we sought literature. We also found that the demarcation between the Individual–Group–Macro levels in Question 5 did not result in an ideal classification, as the "Group" level perspective was found in only one article out of 121.

Suggested utilization of the results

These results may be presumed to be of interest to a number of different roles and stakeholders. First and foremost, we believe that the results are of interest to practitioners who have means of influencing the design of physical workplaces; purchasers, users or other requirement-influencing stakeholders; policymakers; and educators in the fields of architecture, workplace design, product design, process preparation and/or production management.

Proposed ways of utilizing the results include:

- A handbook of general recommendations for physical workplace design that targets architects, site managers, purchasers, safety officers, and others.
- A video series with content corresponding to the aforementioned handbook.
- A training programme for professional ergonomists and work environment engineers that can integrate the content of this literature review, to support them in connection with proposals for design or adaptation of workplaces or equipment.
- Dissemination of the content on Swedish meeting platforms (both digital and physical) that have a pronounced work environment focus, such as Prevent.se, Sunt Arbetsliv [Healthy Work Life] and the annual Gilla Jobbet [Enjoy Work] conference.
- Dissemination to professional work environment and ergonomics networks and associations such as the Swedish Ergonomics and Human Factors Society (EHSS), Sweden's Registered European Ergonomists, the Swedish Association of Graduate Engineers, the Nordic Ergonomics and Human Factors Society (NES), etc.

References

Antonovsky, A. (1979). Health, stress, and coping: Jossey-Bass Publishers.

Bramer, W. M., Giustini, D., de Jonge, G. B., Holland, L., & Bekhuis, T. (2016). De-duplication of database search results for systematic reviews in EndNote. Journal of the Medical Library Association: JMLA, 104(3), 240.

Critical Appraisal Skills Programme (2018). CASP Systematic Review Checklist. Hämtad 23 sept 2019 från https://casp-uk.net/wp-content/uploads/2018/01/CASP-Systematic-Review-Checklist_2018.pdf

Exoskeleton Report (2016). The Exoskeleton Industry in 2016. Hämtad 22 jan 2020 från https://exoskeletonreport.com/2016/08/exoskeleton-industry-2016/

Hong, Q., Pluye, P., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M.-P., Griffiths, F., Nicolau, B., O'Cathain, A., Rousseau, M.-C., Vedel, I. (2018). Mixed Methods Appraisal Tool (MMAT) Version 2018: User guide. McGill, 1–11. Hämtad 16 dec 2019 från http://mixedmethodsappraisaltoolpublic.pbworks.com/w/file/fetch/127916259/MMAT_2018_criteria-manual_2018-08-01_ENG.pdf%0Ahttp://mixedmethodsappraisaltoolpublic.pbworks.com/

IEA, International Ergonomics Association. (2000). Definition and Domains of ergonomics. Hämtad 16 dec 2019 från http://www.iea.cc/whats/index.html

Lawson, B., & Dorst, K. (2009). Design expertise: Taylor & Francis Group.

Neumann, P. (2006). Inventory of tools for ergonomic evaluation. Stockholm, Sweden: Arbetslivsinstitutet, förlagstjänst. Hämtad 6 feb 2020 från https://www.ryerson.ca/content/dam/pneumann/research/documents/tool_inventory.pdf

Pace, R., Pluye, P., Bartlett, G., Macaulay, A. C., Salsberg, J., Jagosh, J., & Seller, R. (2012). Testing the reliability and efficiency of the pilot Mixed Methods Appraisal Tool (MMAT) for systematic mixed studies review. International Journal of Nursing Studies, 49(1), 47–53. https://doi.org/10.1016/j.ijnurstu.2011.07.002

Palm, P., Eliasson, K., Lindberg, P., & Hägg, G. (2014). Belastningsergonomisk riskbedömning -Vägledning och metoder. Hämtad 22 dec 2019 från http://www.ammuppsala.se/sites/default/files/rapporter/ammuppsala_rapport1_2014.pdf

Pham, M. T., Rajić, A., Greig, J. D., Sargeant, J. M., Papadopoulos, A., & McEwen, S. A. (2014). A scoping review of scoping reviews: advancing the approach and enhancing the consistency. Research synthesis methods, 5(4), 371-385.

Pluye, P., & Hong, Q. N. (2014). Combining the Power of Stories and the Power of Numbers: Mixed Methods Research and Mixed Studies Reviews. Annual Review of Public Health, 35(1), 29–45.

WHO (1998). Health promotion glossary. Hämtad 23 sept 2019 från http://www.who.int/healthpromotion/about/HPG/en/

These appendices constitute an expanded compilation (with article summaries) of the literature serving as the basis for the Swedish Agency for Work Environment Expertise's Literature Review 2020:4, authored by Cecilia Berlin and Maral Babapour Chafi.

The main report is available at http://www.sawee.se

Quality appraisal of the primary studies (based on MMAT)

The summary of the included articles and the results of the quality appraisals based on the McGill Mixed Methods Appraisal Tool (MMAT, Hong et al. 2018) are provided in alphabetical order, and categorised based on the study types in MMAT:

0) Screened articles
1) Qualitative studies
2) Randomized controlled studies
3) Quantitative non-randomized studies
4) Quantitative descriptive studies and
5) Mixed-methods studies

The MMAT review begins with two screening questions to which non-affirmative answers mean that the study may not be an empirical study and further appraisals may not be feasible. Based on these screening questions 8 articles were excluded (those are reported first). Each included study is assigned a reference code that indicates the study type, plus a serial number (in alphabetical order). Because all the appraisals were performed by two appraisers, some appraisal results with non-agreement required reconciliation, so based on a recommendation from Pace et al. (2012) we have consequently reported the lower appraisals given by the reviewers for each of the questions.

Pace et al. (2012) do not recommend converting the appraisals into quantitative point scores. Therefore, we have indicated, on a general level, the studies considered to be of high quality (based on the number of affirmative answers to the appraisal questions), and those considered to be studies of debatable quality (where the discussion of the study's contributions should address the purpose of the study, on the spectrum from providing exposure-related evidence to mapping more innovative initiatives). A number of studies are appraised as being of medium-high quality, wherein some or a few of the MMAT quality aspects are unfulfilled. Taking such studies into consideration in complex, real-life applications is justified by our purpose of deliberately seeking out this particular kind of knowledge.

We have also separately reported which studies were screened out early on in the review process due to having a debatable quality based on screening questions S1 and S2, as well as those whose types have been difficult to determine using the MMAT template. The latter situation occurs often because studies that have applied analytical methods for ergonomic assessments as a form of data collection do not fit unambiguously into the appraisal template, and could be interpreted as either mixed-methods (if the interpretation "quantification of qualitative data" is applied categorically, see Hong et al. 2018) or as some other study type, if the appraiser applied a stricter minimum requirement that the study must possess equal shares of combined qualitative and quantitative data collection and analysis.

0) Screened empirical studies based on the screening questions from MMAT (N=8)

The following studies did not fulfil the quality expected from the two screening questions S1 (Are there clear research questions?) and S2 (Do the collected data allow to address the research questions?). According to Hong et al. (2018), a non-affirmative answer indicates that the study may not be empirical, and the appraisers should then discuss whether it is to be included. The articles below were not included for further quality appraisals.

	Reference	Question S1	Question S2
S1	Abd El Megid, Z. M., & Hamdi, A. (2014). Design solutions to Address Garment Industry Issues in Egypt. Research Journal of Textile and Apparel, 18(4), 26–37.	Can't tell	Can't tell
S2	Bartlett, G. E., Hak, D. J., & Smith, W. R. (2011). Hang Them High: A Hands-Free Technique for Limb-Holding During Surgical Preparation. Journal of Orthopaedic Trauma, 25(7), 446–448.	No	Can't tell
S3	Costa, A. P. L., & Villarouco, V. (2012). Ergonomic analysis of the use of open-plan offices in Brazilian public sector offices. Work, 41(SUPPL.1), 3781–3787.	Yes	Can't tell
S4	Fernández, J. M. D., & Carbonell, L. M. P. (2012). Design and construction of a prototype of ergonomic pad controlled through electronic sensors to correct bad postures on office workers and its impact on productivity. Work, 41(SUPPL.1), 6054–6058.	Can't tell	No
S5	Fonseca, B. B., Aguilera, M. V. C., & Vidal, M. C. R. (2012). Conceptual design pattern for ergonomic workplaces. Work, 41(SUPPL.1), 797–803. https://doi.org/10.3233/WOR-2012-0243-797	No	Can't tell
S6	Guimarães, C. P., Cid, G. L., Zamberlan, M. C., Santos, V., Pastura, F. C., Oliveira, J., … Paranhos, A. G. (2012). Ergonomic Work Analysis Applied to Chemical Laboratories on an Oil and Gas Research Center. In V. G. Duffy (Ed.), Advances in Applied Human Modeling and Simulation (pp. 471–477).	No	Can't tell
S7	Koneczny, S. (2009). The operating room: Architectural conditions and potential hazards. Work, 33(2), 145–164.	Can't tell	Can't tell
S8	Vitello, M., Galante, L. G., Capoccia, M., & Caragnano, G. (2012). Ergonomics and workplace design: Application of Ergo-UAS system in Fiat group automobiles. Work, 41(SUPPL.1), 4445–4449.	No	Can't tell

1) Qualitative studies (N=23)

The appraisal questions are:
1.1. Is the qualitative approach appropriate to answer the research question?
1.2. Are the qualitative data collection methods adequate to address the research question?
1.3. Are the findings adequately derived from the data?
1.4. Is the interpretation of results sufficiently substantiated by data?
1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation?

	Reference	Occupational category	Content (n= no. of participants, if gender distribution is clearly stated: M=men/W=women)	Question 1.1	Question 1.2	Question 1.3	Question 1.4	Question 1.5	Quality
QL1	Araújo, A. P. de, Maia, M. do C. M., Lima, M. de M., Lopes, P. R. P. F., & Téjo, S. C. P. (2015). Ergonomic Analysis of Work in an Eyeglasses Store. Procedia Manufacturing, 3(Ahfe), 6052–6059.	Miscellaneous occupations	**Purpose:** to map activities in an optician/eyeglasses business and analyse associated ergonomic problems. Method: direct observations and interviews (n=2, 2M). Conclusions: lack of space entails physical discomfort, safety issues and flow problems.	No	Yes	No	Can't tell	Can't tell	Debatable
QL2	Babapour, M., Karlsson, M., & Osvalder, A.L. (2018). Appropriation of an Activity-based Flexible Office in daily work. Nordic Journal of Working Life Studies, 8(S3), 71–94.	Knowledge work	**Purpose:** to describe users' adoption of activity-based workplace. Method: shadowing observations (n=12, 7W/5M) for 6 months post-relocation. Conclusions: 3 types of use patterns were identified, and the variation depends on compatibility, complexity and the advantages perceived by the user.	Yes	Yes	Yes	Yes	Yes	High
QL3	Battisto, D., Pak, R., Vander Wood, M. A., & Pilcher, J. J. (2009). Using a Task Analysis to Describe Nursing Work in Acute Care Patient Environments. JONA: The Journal of Nursing Administration, 39(12), 537–547.	Healthcare	**Purpose:** to describe nurses' tasks in acute care. Method: nurses' work documentation, shadowing (n=10) for one day and 12 interviews (n=12). Conclusions: the most common tasks were documenting patient assessments and administering medications.	Yes	Yes	Yes	Yes	Yes	High
QL4	Bernardes, M., Trzesniak, C., Trbovich, P., & Mello, C. H. P. (2018). Applying human factors engineering methods for hazard identification and mitigation in the radiotherapy process. Safety Science, 109, 270–280.	Healthcare	**Purpose:** to identify risks and measures in radiotherapy. Method: indirect observations and heuristic analysis Conclusions: interactions between people, technology, tasks and the environment entail risks that can be mitigated by making changes at various system levels.	Yes	Yes	Yes	Yes	Can't tell	Medium-High

	Reference	Occupational category	Content (n= no. of participants, if gender distribution is clearly stated: M=men/W=women)	Question 1.1	Question 1.2	Question 1.3	Question 1.4	Question 1.5	Quality
QL5	Cann, A. P., MacEachen, E., & Vandervoort, A. A. (2008). Lay versus expert understandings of workplace risk in the food service industry: A multi-dimensional model with implications for participatory ergonomics. Work, 30(3), 219–228.	Miscellaneous occupations	**Purpose:** to compare understandings of injury risks experienced by the food industry workers and evaluated by experts. Method: telephone interviews (n=13). Conclusions: both groups had a multi-dimensional understanding of injury risks, but limited action space for reducing the risks. These risks were related to the conformation of the workplace to the physical requirements of the job, and to social and organizational aspects.	Yes	Yes	Yes	Yes	Yes	High
QL6	Cifuentes, M., Qin, J., Fulmer, S., & Bello, A. (2015). Facilitators and Barriers to Using Treadmill Workstations under Real Working Conditions: A Qualitative Study in Female Office Workers. American Journal of Health Promotion, 30(2), 93–100.	Knowledge	**Purpose:** to identify factors that impact use of workstations with treadmills. Method: a six-month evaluation study, with one interview per month (n=5, 5W). Conclusions: social interactions, lower perceived performance and problems with uneven floors were barriers for the use of the treadmills.	Yes	Yes	Yes	Yes	Yes	High
QL7	Cobaleda Cordero, A., Babapour, M., & Karlsson, M. A. (2019). Feel well and do well at work: A post-relocation study on the relationships between employee wellbeing and office landscape. Journal of Corporate Real Estate.	Knowledge work	**Purpose:** to explore the interrelations between the design of a combi-office and employee well-being. Method: interviews with employees (n=16, 11M/5W). Conclusions: the design had a positive impact for some users and negative impact for others in terms of control, satisfaction and social interactions.	Yes	Yes	Yes	Yes	Yes	High
QL8	Eaves, S. J., Gyi, D. E., & Gibb, A. G. F. (2015). Facilitating Healthy Ageing in Construction: Stakeholder Views. Procedia Manufacturing, 3, 4681–4688.	Industry	**Purpose:** to study factors affecting healthy ageing in the construction industry. Method: group interviews (n=18) from 3 different companies. Conclusions: the experience of older workers is highly appreciated in the construction industry, leading to a heavy workload among this group, without taking their physical capacity into account.	Yes	Yes	Yes	Can't tell	Can't tell	Debatable
QL9	Ekstrand, M., & Damman, S. (2016). Front and backstage in the workplace: An explorative case study on activity based working and employee perceptions of control over work-related demands. Journal of Facilities Management, 14(2), 188–202.	Knowledge work	**Purpose:** to study employee control over interactions and work processes in activity-based offices. Method: interviews with employees (n=29). Conclusions: zoning and opportunities to work in different environments increased employees' control over the physical environment.	Yes	Yes	Yes	Can't tell	Yes	Medium-high
QL10	Filgueiras, E., Rebelo, F., & Da Silva, M. (2012). Support of the upper limbs of office workers during a daily work journey. Work, 41(SUPPL.1), 676–682.	Knowledge work	**Purpose:** to quantify how physical support is used in office work. Method: video observations of office workers (n=30). Conclusions: use of arm supports was most common.	Yes	Yes	Yes	Can't tell	Can't tell	Medium-high

	Reference	Occupational category	Content (n= no. of participants, if gender distribution is clearly stated: M=men/W=women)	Question 1.1	Question 1.2	Question 1.3	Question 1.4	Question 1.5	Quality
QL11	Gray, T., & Birrell, C. (2014). Are Biophilic-Designed Site Office Buildings Linked to Health Benefits and High Performing Occupants? International Journal of Environmental Research and Public Health, 11(12), 12204–12222.	Knowledge work	**Purpose:** to study health benefits linked to green offices. Method: interviews and observations for 3 months after moving to an office designed with various types of greenery. Conclusions: greenery resulted in an increased perceived performance and provided better environments for social interaction.	Can't tell	Yes	Yes	Yes	Can't tell	Debatable
QL12	Hammond, A., Homer, C. S. E., & Foureur, M. (2017). Friendliness, functionality and freedom: Design characteristics that support midwifery practice in the hospital setting. Midwifery, 50, 133–138.	Healthcare	**Purpose:** to identify design attributes that support midwifery practice in hospital environments. Method: interviews with midwives(n=21). Conclusions: attributes that support the work of the midwives comprise functionality, perceived friendliness and flexibility.	Yes	Yes	Yes	Yes	Yes	High
QL13	Hu, C.-L., Yang, C.-Y., Lin, Z.-S., Yang, S.-Y., Kuo, C.-H., & Lin, M.-T. (2013). An interactive method for achieving ergonomically optimum conditions during laparoscopic surgery. Journal of Robotic Surgery, 7(2), 125–130.	Healthcare	**Purpose:** to achieve better postures during laparoscopic surgery. Method: observation of a procedure plus development and assessment of an device for adjustment of surgeons' standing height around a shared operating table. Conclusions: the new device resulted in better ergonomics, shorter time and fewer adjustments.	Yes	Yes	No	Can't tell	Can't tell	Debatable
QL14	Kim, S. L., & Lee, J. E. (2010). Development of an intervention to prevent work-related musculoskeletal disorders among hospital nurses based on the participatory approach. Applied Ergonomics, 41(3), 454–460.	Healthcare	**Purpose:** to develop a participatory intervention to prevent work-related musculoskeletal disorders among nurses. Method: participants (n=16) took part in various activities to produce checklists and recommendations, and to make improvements. Conclusions: the participatory approach led to positive changes and lower injury risks.	Yes	Yes	Can't tell	Can't tell	Can't tell	Debatable
QL15	Kupritz, V. (2001). Aging worker percep tions about design and privacy needs for work. Journal of Architectural and Planning Research, 18(1), 13–22.	Knowledge	**Purpose:** to study the compatibility of office environments with an ageing workforce. Method: interviews older and younger participants (n=24). Conclusions: no differences were identified in terms of needs for privacy or effects on performance.	No	Yes	Yes	Yes	Yes	High
QL16	Melo, S. (2018). The role of place on healthcare quality improvement: A qualitative case study of a teaching hospital. Social Science & Medicine, 202, 136–142.	Healthcare	**Purpose:** to study how the design of healthcare environments affects caregivers in terms of quality of care and patient safety. Method: interviews with 46 caregivers at a new hospital. Conclusions: contextual aspects such as infrastructure, patient flow and budget can have a negative effect on design quality and the quality of care.	Yes	Yes	Yes	Yes	Yes	High

	Reference	Occupational category	Content (n= no. of participants, if gender distribution is clearly stated: M=men/W=women)	Question 1.1	Question 1.2	Question 1.3	Question 1.4	Question 1.5	Quality
QL17	Mette, J., Velasco Garrido, M., Harth, V., Preisser, A. M., & Mache, S. (2017). "It's still a great adventure" – exploring offshore employees' working conditions in a qualitative study. Journal of Occupational Medicine and Toxicology, 12(1), 35.	Miscellaneous occupations	**Purpose:** to study working conditions of employees at an offshore wind-power plant. Method: telephone interviews with employees and experts (n=42) Conclusions: this group is exposed to physical demand, long working hours and being away from home, while the job resources are strong solidarity and a regular schedule.	Yes	Yes	Yes	Yes	Yes	High
QL18	Naccarella, L., Newton, C., Pert, A., Seemann, K., Williams, R., Sellick, K., & Dow, B. (2018). Workplace design for the Australian residential aged care workforce. Australasian Journal on Ageing, 37(3), 194–201.	Healthcare	**Purpose:** to study how design aspects of residential aged care affect caregiver performance, safety and sense of belonging. Method: group interviews with caregivers (n=9, 2M/7W) plus one interview with management. Conclusions: aspects that produced positive effects were a home-like environment, proximity to nature and the quality of the environment in terms of safety, openness and comfort.	Yes	Yes	Yes	Can't tell	Yes	High
QL19	Nasuto, S. M. A. Z., Yudistira, J., Gustiyana, T., & Sahroni, T. R. (2018). Ergonomic analysis of rig up wireline pressure control equipment (PCE) in well service activities. International Journal of Mechanical Engineering and Technology, 9(9), 441–459.	Miscellaneous occupations	**Purpose:** to assess injury risks in the oil industry. Method: observations and use of the PERA analysis method to assess body postures. Conclusions: categorization of tasks with high, medium-high and low associated injury risks.	Can't tell	Can't tell	Can't tell	Can't tell	Can't tell	Debatable
QL20	Rogers, B., Buckheit, K., & Ostendorf, J. (2013). Ergonomics and nursing in hospital environments. Workplace Health and Safety, 61(10), 429–439.	Healthcare	**Purpose:** to describe working conditions of nurses in hospital environments. Method: focus group interviews with 42 nurses (n=42) and walking tours at 5 different hospitals, plus interviews with experts from the corporate healthcare field affiliated with the hospitals. Conclusions: Design of the physical environment, organizational aspects such as high workload and heavy physical work created ergonomic problems.	Yes	Yes	Yes	Can't tell	Can't tell	Medium-high
QL21	Seif, M., Degiuli, N., & Muftić, O. (2003). Ergonomical valorization of working spaces in multipurpose ships. Collegium Antropologicum, 27(1), 391–402.	Miscellaneous occupations	**Purpose:** to assess body postures of ship crew. Method: interviews, observations and questionnaires. Conclusions: postures associated with high injury risks were mainly observed in the engine room.	Can't tell	Can't tell	Can't tell	Can't tell	Can't tell	Debatable

	Reference	Occupational category	Content (n= no. of participants, if gender distribution is clearly stated: M=men/W=women)	Question 1.1	Question 1.2	Question 1.3	Question 1.4	Question 1.5	Quality
QL22	Sugiono, S., Budiprasetya, A., & Efranto, R. (2019). Reducing musculoskeletal disorder (MSD) risk of wiring harness workstation using workplace ergonomic risk assessment (WERA) method. Przegląd Naukowy Inżynieria i Kształtowanie Środowiska, 27(4), 536–551.	Industry	**Purpose:** to assess body postures and injury risks of wiring harness activity, and to reduce those risks. Method: interviews with employees (n=9) and observations plus use of the WERA method for assessing body postures, and implementation of measures. Conclusions: postures associated with medium-high injury risk levels were identified and, through changes in the workstations, the risks of neck and shoulder injuries were reduced.	Can't tell	Can't tell	Yes	Yes	Can't tell	Debatable
QL23	VanHeuvelen, J. S. (2019). Isolation or interaction: healthcare provider experience of design change. Sociology of Health & Illness, 41(4), 692–708.	Healthcare	**Purpose:** to study how the design of a healthcare environment for neonatal intensive care unit affects caregivers. Method: interviews with caregivers (n=40) and observations over 13 Months. Conclusions: the new design did not match earlier ways of working individually and in groups.	Yes	Yes	Yes	Yes	Yes	High

2) Randomized controlled studies (N=8)

The appraisal questions are:
2.1 Is randomization appropriately performed?
2.2 Are the groups comparable at baseline?
2.3 Are there complete outcome data?
2.4 Are outcome assessors blinded to the intervention provided?
2.5 Did the participants adhere to the assigned intervention?

	Reference	Occupational category	Content (n=final no. of participants after all eliminations, if gender distribution is clearly stated: M=men/W=women)	Question 2.1	Question 2.2	Question 2.3	Question 2.4	Question 2.5	Quality
RC1	Dropkin, J., Kim, H., Punnett, L., Wegman, D. H., Warren, N., & Buchholz, B. (2015). Effect of an office ergonomic randomised controlled trial among workers with neck and upper extremity pain. Occupational and Environmental Medicine, 72(1), 6–14.	Knowledge work	**Purpose:** to study the effects of adjustable data input devices. Method: the study compared a control group with an intervention group that received adjustable keyboards/computer mouse for their dominant hand and touchpads for their non-dominant hand. Data were collected through structured observations (using the RULA method), measurements of muscular activity and a questionnaire study (n=113). Conclusions: the intervention led to more neutral body postures and more muscular activity in the hands.	Yes	Yes	Yes	No	Yes	High
RC2	Formanoy, M. A. G., Dusseldorp, E., Coffeng, J. K., Van Mechelen, I., Boot, C. R. L., Hendriksen, I. J. M., & Tak, E. C. P. M. (2016). Physical activity and relaxation in the work setting to reduce the need for recovery: what works for whom? BMC Public Health, 16(1), 866.	Knowledge work	**Purpose:** to identify suitable types of interventions for recovery among various office workers. Method: the study compared a social intervention and a physical workplace modification as health-promoting initiatives (n=329). Conclusions: the social intervention worked better for younger participants, and the workplace modification created opportunities for recovery.	Can't tell	Can't tell	Can't tell	Can't tell	Can't tell	Debatable
RC3	Haukka, E., Leino-Arjas, P., Viikari-Juntura, E., Takala, E.P., Malmivaara, A., Hopsu, L., … Riihimaki, H. (2008). A randomised controlled trial on whether a participatory ergonomics intervention could prevent musculoskeletal disorders. Occupational and Environmental Medicine, 65(12), 849–856.	Miscellaneous occupations	**Purpose:** to assess the efficacy of a participatory ergonomic intervention in an industrial kitchen. Method: the intervention included 402 modifications to the work environment associated with work-related musculoskeletal disorders and injury risks. In the assessment, questionnaire studies were conducted in 119 industrial kitchens (n=504) and a control group (n=60) three months before, three times during and one year after the intervention. Conclusions: the intervention made no difference in terms of physical strain.	Yes	Can't tell	Yes	Can't tell	Yes	Medium-high

	Reference	Occupational category	Content (n=final no. of participants after all eliminations, if gender distribution is clearly stated: M=men/W=women)	Question 2.1	Question 2.2	Question 2.3	Question 2.4	Question 2.5	Quality
RC4	Healy, G. N., Eakin, E. G., Owen, N., LaMontagne, A. D., Moodie, M., Winkler, E. A. H., … Dunstan, D. W. (2016). A Cluster Randomized Controlled Trial to Reduce Office Workers' Sitting Time: Effect on Activity Outcomes. Medicine and Science in Sports and Exercise, 48(9), 1787–1797.	Knowledge work	**Purpose:** to assess the effects of an intervention to reduce sedentary time in an office environment. Method: the study included 7 offices with the intervention and 7 control offices (n=231). The interventions involved organizational, physical and behavioural changes. Data collection included baseline plus 3 and 12 months follow-up using diaries and objectively measured activity durations. Conclusions: the intervention resulted in reduced sitting time both short and long term.	Yes	Yes	Yes	No	Yes	High
RC5	Jacobs, K., Foley, G., Punnett, L., Hall, V., Gore, R., Brownson, E., … Ing, A. (2011). University students' notebook computer use: lessons learned using e-diaries to report musculoskeletal discomfort. Ergonomics, 54(2), 206–219.	Knowledge work	**Purpose:** to assess the effects of ergonomic equipment for and training in laptop use. Method: questionnaire and diary studies with three intervention groups and one control group before (n=48) and after (n=40) intervention. Conclusions: the study identified reduced discomfort in the groups that received an ergonomic chair or laptop support.	Can't tell	Yes	Can't tell	No	Yes	Debatable
RC6	Jakobsen, M. D., Aust, B., Kines, P., Madeleine, P., & Andersen, L. L. (2019). Participatory organizational intervention for improved use of assistive devices in patient transfer: a single-blinded cluster randomized controlled trial. Scandinavian Journal of Work, Environment & Health, 45(2), 146–157.	Healthcare	**Purpose:** assessment of a participatory ergonomic intervention to improve use of assistive devices when moving patients. Method: 5 hospitals took part in the study (n=316). Data collection included log data from the use of assistive devices and questionnaires over 12 months. Conclusions: the frequency of use of assistive device, back problems and injuries were unchanged, but the intervention group generally increased the use of assistive devices and improved communication and guidance in the use of such devices.	Yes	Yes	Yes	No	Yes	High
RC7	Raanaas, R. K., Evensen, K. H., Rich, D., Sjøstrøm, G., & Patil, G. (2011). Benefits of indoor plants on attention capacity in an office setting. Journal of Environmental Psychology, 31(1), 99–105.	Knowledge work	**Purpose:** to assess the effects of indoor plants on attention capacity. Method: laboratory study measuring attention capacity. The study was conducted in two groups (n=34), one with and the other without indoor plants. Attention capacity was measured three times: upon arrival, after performing a cognitively challenging task, and after a 5-minute break. Conclusions: the group with plants exhibited higher performance from arrival time until having performed the task.	No	Can't tell	Can't tell	No	Yes	Debatable
RC8	Yang, Y., & Chan, A. P. (2017). Role of work uniform in alleviating perceptual strain among construction workers. INDUSTRIAL HEALTH, 55(1), 76–86.	Industry	**Purpose:** to evaluate a new work uniform for construction workers. Method: questionnaire study in a laboratory environment over one work day, with questionnaire data, pulse measurements and subjective assessment of heat-related strain (n=16). Conclusions: the new uniform resulted in increased comfort and lower perceived heat strain.	Can't tell	Can't tell	Yes	No	Yes	Debatable

3) Quantitative non-randomized studies (N=57)

The appraisal questions are:
3.1. Are the participants representative of the target population?
3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?
3.3. Are there complete outcome data?
3.4. Are the confounders accounted for in the design and analysis?
3.5. During the study period, is the intervention administered (or exposure occurred) as intended?

	Reference	Occupational category	Content (n=final no. of participants after all eliminations ; if gender distribution is clearly stated: M = men/W = women)	Question 3.1	Question 3.2	Question 3.3	Question 3.4	Question 3.5	Quality
QN-N1	Amick, B. C., Menendez, C. C., Bazzani, L., Robertson, M., DeRango, K., Rooney, T., & Moore, A. (2012). A field intervention examining the impact of an office ergonomics training and a highly adjustable chair on visual symptoms in a public sector organization. Applied Ergonomics, 43(3), 625–631.	Knowledge work	**Purpose:** to study the effect of a multi-intervention in an office to reduce visual symptoms. Method: pre-post study with three groups (n=161): one group received a highly adjustable chair and training in office ergonomics, one group received training only, and a third group served as the control group. A health questionnaire was given to the participants 2 months and 1 month before the intervention and 3, 6 and 12 months afterwards. Conclusions: office workers who were given a highly adjustable chair and ergonomics training experienced reduced visual symptoms, and the effect was still present 12 months after the intervention.	Can't tell	Yes	Yes	Yes	Yes	High
QN-N2	Amick, B. C., Robertson, M. M., DeRango, K., Bazzani, L., Moore, A., Rooney, T., & Harrist, R. (2003). Effect of Office Ergonomics Intervention on Reducing Musculoskeletal Symptoms. Spine, 28(24), 2706–2711.	Knowledge work	**Purpose:** to study the effect of an office intervention in reducing musculoskeletal symptoms and pain over the day. Method: pre-post study with three groups (n=161): one group received a highly adjustable chair and training in office ergonomics, one group received training only and a third group received training only at the end of the study. A brief daily symptom questionnaire was given to the participants for 5 days in a row; and data were collected 2 months and 1 month before the intervention and 2, 6 and 12 months afterwards. Conclusions: office workers who were given a highly adjustable chair and ergonomics training reduced the progression of musculoskeletal symptoms and pain over the day. No effect on symptoms growth was observed in the training group, but the pain level decreased in both intervention groups.	Yes	Yes	Yes	Yes	Yes	High

	Reference	Occupational category	Content (n=final no. of participants after all eliminations ; if gender distribution is clearly stated: M = men/W = women)	Question 3.1	Question 3.2	Question 3.3	Question 3.4	Question 3.5	Quality
QN-N3	Baker, R., Coenen, P., Howie, E., Lee, J., Williamson, A., & Straker, L. (2018). A detailed description of the shortterm musculoskeletal and cognitive effects of prolonged standing for office computer work. Ergonomics, 61(7), 877–890.	Knowledge work	**Purpose:** to study the health effects (in terms of discomfort, cognitive performance, muscle fatigue, movement, upper limb swelling and mental state) of prolonged standing during computer work. Method: laboratory study (n=20, 13W) in which participants carried out 2 hours of computer work while wearing biometric sensors. Measurements of health parameters were made every half-hour (total 5 times). The participants also filled out questionnaires. Conclusions: caution should be exercised when sitting work is to be replaced with prolonged standing, as this can lead to other problems. The discomfort increased over time throughout the entire body, concentration decreased, but creative problem-solving improved over time. Physical discomfort and prolonged standing correlated positively with deterioration in mental state.	Yes	Yes	Yes	No	Yes	Medium-high
QN-N4	Baker, R., Coenen, P., Howie, E., Williamson, A., & Straker, L. (2018). The Short Term Musculoskeletal and Cognitive Effects of Prolonged Sitting During Office Computer Work. International Journal of Environmental Research and Public Health, 15(8), 1678.	Knowledge work	**Purpose:** to study the health effects (in terms of discomfort, cognitive performance, muscle fatigue, movement and mental state) of prolonged sitting during computer work. Method: laboratory study (n=20, 13W) in which participants carried out 2 hours of computer work while wearing biometric sensors. Measurements of health parameters were made every half-hour (total 5 times). The participants also filled out questionnaires. Conclusions: prolonged sitting can lead to musculoskeletal discomfort and decreased cognitive performance. The discomfort increased over time and creative problem-solving was degraded, while long-term attention remained the same. Breaks from sitting are recommended.	Yes	Yes	Yes	No	Yes	Medium-high
QN-N5	Balasubramanian, V., Adalarasu, K., & Regulapati, R. (2009). Comparing dynamic and stationary standing postures in an assembly task. International Journal of Industrial Ergonomics, 39(5), 649–654.	Industry	**Purpose:** to study differences in fatigue levels between dynamic and stationary work postures in the assembly industry. Method: study subjects (n=9, 9M) were equipped with surface EMG sensors and, over 60 minutes, had to perform either stationary standing assembly tasks at 1 table or dynamic assembly tasks spread over 6 different tables. Each study subject performed both variants in random order on different days to allow for a considerable rest. Data collected with surface EMG and psychophysical analysis was analysed using regression analysis. Conclusions: muscle fatigue in legs and lower back was significantly higher for the stationary working posture. This was also consistent with the psychophysical assessments, as the study subjects reported greater discomfort in connection with stationary posture.	Can't tell	Can't tell	Yes	Can't tell	Yes	Debatable
QN-N6	Beach, T. A. C., Parkinson, R. J., Stothart, J. P., & Callaghan, J. P. (2005). Effects of prolonged sitting on the passive flexion stiffness of the in vivo lumbar spine. The Spine Journal, 5(2), 145–154.	Knowledge work	**Purpose:** to quantify temporal changes in passive flexion stiffness in the lower back as a result of prolonged sitting, and to determine whether there are gender differences with respect to prolonged sitting. Method: laboratory study in which participants (n=12, 6M/6W) performed sitting computer work for 2h with EMG sensors on their bodies. The range of motion was determined by measuring joint angles on a frictionless table. Conclusions: changes in passive flexion stiffness in the lower back can increase the risk of back injuries and may contribute to lower back pain while sitting. Some gender differences were identified with respect to sitting.	Yes	Yes	Can't tell	Can’t tell	Yes	Debatable

	Reference	Occupational category	Content (n=final no. of participants after all eliminations ; if gender distribution is clearly stated: M = men/W = women)	Question 3.1	Question 3.2	Question 3.3	Question 3.4	Question 3.5	Quality
QN-N7	Berry, L. L., & Parish, J. T. (2008). The Impact of Facility Improvements on Hospital Nurses. HERD: Health Environments Research & Design Journal, 1(2), 5–13.	Healthcare	**Purpose:** to study differences in nurses' perceptions of their jobs, hospital and building properties after moving to a new hospital. Method: pre-post assessment with questionnaires 6 months before (n=235, 87%W) and 6 months after a move in which 65 nurses moved (n=238, ≈ 86%W), plus focus groups after the second round of data collection. Conclusions: significant differences were found between the first and second data collections in terms of quality of patient rooms, safety, comfort, quality of workspaces, work stress, satisfaction and quality of services.	Yes	Yes	No	Can't tell	Yes	Debatable
QN-N8	Berthelsen, H., Muhonen, T., & Toivanen, S. (2018). What happens to the physical and psychosocial work environment when activity-based offices are introduced into academia? Journal of Corporate Real Estate, 20(4), 230–243.	Knowledge work	**Purpose:** to study how employees at a Swedish university perceived the physical and psychosocial effects of a move to activity-based offices. Method: pre-post assessment using web-based questionnaires 3 months before (n=217, 87%W) and 9 months after moving, n=200, 87%W). Because this was a two-part cross-sectional study, different people participated in each instance of data collection, and no causal links could be established. Conclusions: the majority used the same desk in the new environment, and worked from home more often. Negative impacts on the psychosocial environments and employee satisfaction were identified.	Yes	Yes	No	Can't tell	Yes	Debatable
QN-N9	Boyer, J., Lin, J. H., & Chang, C. C. (2013). Description and analysis of hand forces in medicine cart pushing tasks. Applied Ergonomics, 44(1), 48–57.	Healthcare	**Purpose:** to study hand force exertion in experienced nurses and nursing students when pushing a medicine cart in various phases of the activity. Method: 2 x 2 x 2 factorial experiment (n=22, 22W) in which the participants pushed the medicine cart along a path with different floor surfaces, lane congestion and precision requirements. Four different conditions were tested with 5 minutes of rest between the conditions. Analysis was conducted with descriptive statistics. Conclusions: differences in exertion of hand force were measured in the 4 different conditions (maximum 147N when turning on carpeted floor). The recommendation is to consider the changes in hand forces when remodelling healthcare facilities.	Yes	Yes	Yes	No	Yes	Medium-high
QN-N10	Burdorf, A., Windhorst, J., van der Beek, A. J., van der Molen, H., & Swuste, P. H. J. J. (2007). The effects of mechanized equipment on physical load among road workers and floor layers in the construction industry. International Journal of Industrial Ergonomics, 37(2), 133–143.	Industry	**Purpose:** to assess the load effects of different types of mechanized equipment on construction workers involved in road-laying, and to study the consequences in terms of musculoskeletal disorders and absenteeism due to illness. Method: 3 different pieces of equipment were tested on the personnel in different scenarios in the field. Observations and motion and force measurements were made in real time using accelerometers (n=described unclearly, probably max. 16 per scenario). Conclusions: the new equipment (hydraulic clamp & vacuum lift) changed the physical load (kneeling time, lifting frequency, time spent in inappropriate back postures) during the work tasks, the breakdown of work tasks and the organization of the work within the crew.	Yes	Yes	No	Can't tell	Yes	Debatable
QN-N11	Cai, H., & Li, L. (2016). How LED lighting may affect office ergonomics: The impact of providing access to continuous dimming controls on typing and colour-matching tasks performance. Light and Engineering, 24(2), 25–36.	Knowledge work	**Purpose:** to study the effect of providing young office workers individual with continuous dimming controls for LED lighting on their cognitive performance in terms of computer-based typing and colour-matching tasks. Method: experiment with video observation (n=30, 11M/19W). Conclusions: access to control over the LED lighting had no effect on the participants' subjective assessment of the difficulty of the typing task, or on their satisfaction with their performance. The participant's colour-matching ability was worsened.	Yes -	Can't tell	Can't tell	Can't tell	Yes	Debatable

	Reference	Occupational category	Content (n=final no. of participants after all eliminations ; if gender distribution is clearly stated: M = men/W = women)	Question 3.1	Question 3.2	Question 3.3	Question 3.4	Question 3.5	Quality
QN-N12	Candido, C., Thomas, L., Haddad, S., Zhang, F., Mackey, M., & Ye, W. (2019). Designing activity-based workspaces: satisfaction, productivity and physical activity. Building Research & Information, 47(3), 275–289.	Knowledge work	**Purpose:** pre-post assessment of a move from an open-plan office landscape to activity-based offices. Method: post-occupancy evaluation questionnaires in 10 workplaces (n=896), point measurements of the indoor environment quality (IEQ) plus step count monitoring in one case (n=20) before and after moving. Conclusions: activity-based office received higher ratings in terms of satisfaction with IEQ, perceived productivity and health. Office layout was also found to be a predictor of employees' overall sedentary time, but did not affect how many steps they took.	Yes	Yes	No	Can't tell	Yes	Debatable
QN-N13	Coffeng, J. K., Hendriksen, I. J. M., Duijts, S. F. A., Twisk, J. W. R., van Mechelen, W., & Boot, C. R. L. (2014). Effectiveness of a Combined Social and Physical Environmental Intervention on Presenteeism, Absenteeism, Work Performance, and Work Engagement in Office Employees. Journal of Occupational and Environmental Medicine, 56(3), 258–265.	Knowledge work	**Purpose:** to study the effectiveness of a combined social intervention (to stimulate physical activity) and work environment intervention with new work and resting zones. Method: 2 x 2 full-factorial comparison with control group (n=412). Data were collected for each group on presenteeism, absenteeism, performance and work engagement via questionnaires at baseline and after 6 and 12 months. Conclusions: implementing these interventions is not recommended. The combined intervention reduced contextual performance and engagement. The social intervention improved task performance, while the work environment intervention improved absorption in work.	Can't tell	Yes	No	Yes	Yes	Debatable
QN-N14	Copeland, D., & Chambers, M. (2017). Effects of Unit Design on Acute Care Nurses' Walking Distances, Energy Expenditure, and Job Satisfaction: A Pre–Post Relocation Study. HERD: Health Environments Research & Design Journal, 10(4), 22–36.	Healthcare	**Purpose:** to study a move from a hospital with centralized nursing stations to one with decentralized stations in relation to step counts and energy expenditure. Method: pre-post quasi-experiment. Free-text questionnaire and collection of pedometer data over 3 months, before and after the move (n=26 before, 2M/24W, n=35 after, 3M/32W). Conclusions: a number of sources of dissatisfaction were eliminated after the move. The nurses' energy expenditure decreased, as did the number of steps they took. Their previously high job satisfaction increased following the move, and accidents involving patient falls decreased by 55%.	No	Yes	Can't tell	Can't tell	Yes	Debatable
QN-N15	Dainoff, M. J., Cohen, B. G. F., & Hecht Dainoff, M. (2005). The Effect of an Ergonomic Intervention on Musculoskeletal, Psychosocial and Visual Strain of VDT Data Entry Work: The United States Part of the International Study. International Journal of Occupational Safety and Ergonomics, 11(1), 49–63. h	Knowledge work	**Purpose:** to assess long- and short-term effects of an ergonomic intervention for female computer workers in terms of musculoskeletal, visual and psychosocial strain. Method: measurement protocol for the variables was applied at the existing workplace before the intervention, then 1 year and 1 month after (n=26, 26W). The intervention consisted of optometric correction (as needed), reconfiguration of the physical workplace and a training programme. 435 variables were measured in the study. Conclusions: improvements were identified in terms of chair comfort, lighting, eye strain and sitting posture. Financial constraints prevented full implementation of the intervention, so the results are mixed.	Yes	Yes	Yes	No	Yes	Medium-high

	Reference	Occupational category	Content (n=final no. of participants after all eliminations ; if gender distribution is clearly stated: M = men/W = women)	Question 3.1	Question 3.2	Question 3.3	Question 3.4	Question 3.5	Quality
QN-N16	Decker, M., Gomas, K. A., Narvy, S. J., & Vangsness, C. T. (2016). The influence of a dynamic elastic garment on musculoskeletal and respiratory wellness in computer users. International Journal of Occupational Safety and Ergonomics, 22(4), 550–556.	Knowledge work	**Purpose:** to identify short-term effects of wearing an elastic posture garment (sweater) during computer use. Method: participants from one municipality (n=96, 34M/62W) wore the garment for 4 weeks and kept a log to track their use of the garment plus their perceived fatigue, productivity and energy level. After this period their physical posture, lung volume and grip strength were evaluated. Conclusions: the garment had a significant short-term effect on both subjective and objective ergonomic metrics. Wearing the sweater during sitting and standing computer use can improve body posture, lung function and perceived productivity, and also reduce fatigue.	Yes	Yes	Yes	Yes	Yes	High
QN-N17	Dempsey, P. G., McGorry, R. W., & O'Brien, N. V. (2004). The effects of work height, workpiece orientation, gender, and screwdriver type on productivity and wrist deviation. International Journal of Industrial Ergonomics, 33(4), 339–346.	General	**Purpose:** to study whether work height, workpiece orientation, gender and screwdriver type (2 types) play a role in productivity and wrist deviation in a repetitive screwdriving task. Method: experiment in which the participants (n=14, 7M/7W) performed a total of 90 screwdriving tasks under various combinations of conditions, in two sessions. The experiment included controlled breaks. Conclusions: no significant gender differences were observed, although women showed greater differences in performance (30%) between the two screwdriver types than did the men (10%). Productivity and wrist deviation were heavily affected by the combination of workpiece orientation and work height.	Can't tell	Yes	Yes	Can't tell	Yes	Debatable
QN-N18	Diaz-Zeledon, M., Lin, C. L., & Landau, K. (2007). Analysis of horizontal whole body-movements by transporting unstable objects. Occupational Ergonomics, 7(4), 247–263.	Industry	**Purpose:** to study how instability of an object and target position affect upper body movements during self-paced movement of the object in a seated position. Method: the participants (n=30, 15M/15W) sat in a height-adjusted workstation (adjustable chair + table) and moved a partially filled glass of water from one place to another. The time required for the hand movement and ranges of motion for the upper body, shoulder and elbow were measured during the test, as were muscular stress on selected muscle groups and mental stress. Conclusions: fluid level and target position have an effect on the physical and mental stress. The direction of the motion affects the range of motion, muscular activity and hand motion time.	Can't tell	Yes	Can't tell	Can't tell	Yes	Debatable
QN-N19	Dorsey, J., & Hedge, A. (2017). Reevaluation of a LEED Platinum Building: Occupant experiences of health and comfort. Work, 57(1), 31–41.	Knowledge work	**Purpose:** to re-evaluate building occupants' experiences of a LEED platinum-certified building and study current general experiences. Method: post-occupancy evaluation questionnaire (n=62, 74%W) was given out to building occupants on an American campus. The questionnaire measured indoor environment quality (IEQ) in relation to health, productivity and satisfaction. Conclusions: satisfaction with the office workstations and air quality had increased in the last 3 years in comparison with an earlier evaluation. However, physical symptoms had also increased in recent years. The study showed that control over the workstation features had a significant correlation with most of the outcomes.	Yes	Yes	No	No	Yes	Debatable

	Reference	Occupational category	Content (n=final no. of participants after all eliminations ; if gender distribution is clearly stated: M = men/W = women)	Question 3.1	Question 3.2	Question 3.3	Question 3.4	Question 3.5	Quality
QN-N20	Douphrate, D. I., Fethke, N. B., Nonnenmann, M. W., Rodriguez, A., Hagevoort, R., & Gimeno Ruiz de Porras, D. (2017). Full-shift and task-specific upper extremity muscle activity among US large-herd dairy parlour workers. Ergonomics, 60(8), 1042–1054.	Miscellaneous occupations	**Purpose:** to study full shift and task-specific muscle activity in upper extremities of dairy production personnel. Method: surface EMG sensors were applied to measure muscle activity of each participant (n=60, 100%M) during a full shift. Three types of dairy parlours were studied. Conclusions: of the three types of layouts used for dairy production, the "rotary" variant yielded more favourable muscle strain and greater recovery than the other two types ("herringbone" and parallel). The study draws the conclusion that the rotary type may offer both a favourable physical work environment and favourable organizational dynamics.	Yes	Yes	Yes	Can't tell	Yes	Medium-high
QN-N21	Duke, K., Mirka, G. A., & Sommerich, C. M. (2004). Productivity and Ergonomic Investigation of Bent-Handle Pliers. Human Factors: The Journal of the Human Factors and Ergonomics Society, 46(2), 234–243.	General	**Purpose:** to assess pliers with bent handles, which induce a more favourable wrist orientation in terms of productivity and ergonomics. **Method:** experiment in which the participants (n=16, 8M/8W) performed tasks using pliers while their productivity and shoulder and wrist orientations were measured. Four combinations of conditions were tested, wherein both the type of pliers and freedom in terms of how the pliers were to be held were varied. Conclusions: the results show that the advantages of the pliers with bent handles depend upon the type of task in question.	Can't tell	Yes	Yes	Can't tell	Yes	Debatable
QN-N22	Engst, C., Chhokar, R., Miller, A., Tate, R., & Yassi, A. (2005). Effectiveness of overhead lifting devices in reducing the risk of injury to care staff in extended care facilities. Ergonomics, 48(2), 187–199.	Healthcare	**Purpose:** before-and-after comparison of an intervention (overhead lifting device) and evaluation of its capacity to reduce injury risks when lifting patients. **Method:** a questionnaire (n=50) measured perceived risk of injury and discomfort, method preference in connection with patient handling, handling frequency, perceived physical demands, work organization and employee satisfaction. **Conclusions:** the staff preferred the overhead assistive device over manual or floor-based assistance for lifting and transporting patients. Significant reductions were identified in perceived injury risk and discomfort in the neck, shoulders, back, hands and arms. Costs associated with lifting and moving patients decreased by 68%. However, the advantages were not present in connection with repositioning of patients.	Yes	Yes	Can't tell	Can't tell	Yes	Debatable
QN-N23	France, D. J., Throop, P., Walczyk, B., Allen, L., Parekh, A. D., Parsons, A., … Deshpande, J. K. (2016). Does patient-centered design guarantee patient safety? Using human factors engineering to find a balance between provider and patient needs. Journal of Patient Safety, 1(3), 145–153.	Healthcare	**Purpose:** to study caregivers' impressions of a new family-centred hospital design for job functions, patient safety and personal well-being. Method: work environment questionnaires were given to clinical staff at a newly built paediatric hospital (n=270, ≈87%W). Conclusions: 87% rated the new hospital as better than the old one in terms of information flow, patient flow and overall efficiency.	Yes	Yes	Can't tell	Can't tell	Yes	Medium-high

	Reference	Occupational category	Content (n=final no. of participants after all eliminations ; if gender distribution is clearly stated: M = men/W = women)	Question 3.1	Question 3.2	Question 3.3	Question 3.4	Question 3.5	Quality
QN-N24	France, D., Throop, P., Joers, B., Allen, L., Parekh, A., Rickard, D., & Deshpande, J. K. (2009). Adapting to family-centered hospital design: Changes in providers' attitudes over a two-year period. Health Environments Research and Design Journal, 3(1), 79–96.	Healthcare	**Purpose:** to study how caregivers' attitudes towards a family-centred paediatric hospital and its effects on patients and staff changed over a two-year period. Method: a questionnaire was given out to healthcare personnel at the hospital (n=270 the first time, 544 the second time). Conclusions: the assessments were mainly positive in most areas, and had improved since the baseline measurement. However, the caregivers reported high mental and physical fatigue and a great deal of walking, as well as more noise, despite the improvements.	Yes	Yes	Can't tell	Can't tell	Yes	Debatable
QN-N25	Gallagher, K. M., Campbell, T., & Callaghan, J. P. (2014). The influence of a seated break on prolonged standing induced low back pain development. Ergonomics, 57(4), 555–562.	Knowledge work	**Purpose:** to assess effects of a seated break in the middle of standing work on the development of lower back pain, body posture and movement. Method: experiment in which the participants (n=20) stood for 45 minutes, sat down for 15 and repeated this while their lower back and upper body orientations were measured. Lower back pain was measured with subjective VAS scales. Conclusions: standing work can lead to lower back pain in some individuals, and alternative means of reducing prolonged standing should consequently be considered. 55% of the participants reported back pain, and the ratio of standing work to sitting breaks (3:1) did not provide sufficient recovery from pain development. Those who have pain end up in static postures that can exacerbate the development of pain.	Can't tell	Yes	Can't tell	Can't tell	Yes	Debatable
QN-N26	Goins, J., Jellema, J., & Zhang, H. (2010). Architectural enclosure's effect on office worker performance: A comparison of the physical and symbolic attributes of workspace dividers. Building and Environment, 45(4), 944–948.	Knowledge work	**Purpose:** to compare the effects of physical and symbolic attributes of architectural enclosures (i.e. workspace dividers) on work performance. **Method:** earlier questionnaire results were reused from a database (n=ca. 51,000) in which the respondents had rated various components of their offices. Conclusions: the symbolic attributes appear to be much more important for work performance than do the physical attributes. However, the symbolic attributes are not associated solely with workspace dividers.	Yes	Yes	Can't tell	Can't tell	Can't tell	Debatable
QN-N27	Gold, J. E., Driban, J. B., Yingling, V. R., & Komaroff, E. (2012). Characterization of posture and comfort in laptop users in non-desk settings. Applied Ergonomics, 43(2), 392–399.	Knowledge work	**Purpose:** to study average joint angles during brief tasks on laptop computers in 7 different postures. Method: observation of university students (n=20, 9M/11W) using infrared cameras and joint markers while they performed short-term computer tasks (typing and editing). Conclusions: work with prone postures (non-neutralized shoulder/elbows/wrists) was identified as a cause of major joint angle deviations and major bodily discomfort.	Yes	Yes	Yes	Can't tell	Yes	Medium-high

	Reference	Occupational category	Content (n=final no. of participants after all eliminations ; if gender distribution is clearly stated: M = men/W = women)	Question 3.1	Question 3.2	Question 3.3	Question 3.4	Question 3.5	Quality
QN-N28	Gorman, E., Ashe, M. C., Dunstan, D. W., Hanson, H. M., Madden, K., Winkler, E. A. H., … Healy, G. N. (2013). Does an 'Activity-Permissive' Workplace Change Office Workers' Sitting and Activity Time? PLoS ONE, 8(10), e76723.	Knowledge work	**Purpose:** to assess changes in activity level (e.g. standing and walking time) as well as health and work outcomes in office workers before and after moving from a conventional workplace to one that encourages physical activity. **Method:** natural pre-post study in which measurements were taken 4 months after the intervention with regard to the participants' (n=24, 75%W) physical activity in the workplace, health profile, job performance and satisfaction outcomes. Conclusions: the new activity-stimulating workplace led to a significant increase in standing work, probably at the expense of sitting rather than increased walking. No statistically significant differences were measured in terms of health or work outcomes.	Yes	Yes	3 drop-outs, risk of non-response bias	Can't tell	Yes	Debatable
QN-N29	Gravina, N., Lindstrom-Hazel, D., & Austin, J. (2007). The effects of workstation changes and behavioral interventions on safe typing postures in an office. Work, 29(3), 245–253.	Knowledge work	**Purpose:** to study the effectiveness of an intervention in which library staff were to adopt safer postures while typing on a computer. The intervention involved an adjustable workstation, testing of ergonomic input devices, peer observations and graphical feedback. Method: the postures of 6 different body segments were observed at repeated intervals among pain-free participants (n=5, 1M/4W), and a discomfort questionnaire was filled out by the participants following the measurements. Conclusions: each and every one of the interventions proved to have a beneficial effect on the posture of more than one body segment. The results indicate that interventions involving both workstation and behaviour changes can lead to maximum improvements in ergonomics.	Can't tell	Yes	Yes	No	Yes	Debatable
QN-N30	Grooten, W. J. A., Conradsson, D., Äng, B. O., & Franzén, E. (2013). Is active sitting as active as we think? Ergonomics, 56(8), 1304–1314.	Knowledge work	**Purpose:** to compare biomechanical properties of sitting on conventional office chair or standing or chairs without back support (intended to stimulate active sitting) with stable and unstable seats. Method: observation study in which the participants (n=13, 5M/8W) performed a 5-minute keyboard task under 5 different conditions in a randomised order. Muscle activity and body movements were measured during the test using motion capture, pressure plates and surface EMG. Conclusions: all the chairs intended for active sitting yielded a lower degree of swaying and muscle activation in the upper body than did a conventional chair or standing.	Yes	Yes	Yes	Can't tell	Yes	Medium-high
QN-N31	Haynes, B. P. (2008). Impact of productivity. Journal of Corporate Real Estate, 10(4), 286–302.	Knowledge work	**Purpose:** to study the effects of the office environment on perceived productivity of office workers with different working styles. **Method:** 2 data collections via questionnaires (n1=996, n2=422) measured how 27 different variables affected perceived productivity. The 4 styles that were compared were: individual work, group work, concentrated work and knowledge exchange. The other studied factors were comfort and office layout. Conclusions: interaction was the factor with the greatest positive effect on productivity, while distraction had the greatest negative effect. This indicates that behavioural components in the office work environment have the greatest impact on productivity.	Yes	Yes	53% response rate	Can't tell	Yes	Medium-high

	Reference	Occupational category	Content (n=final no. of participants after all eliminations ; if gender distribution is clearly stated: M = men/W = women)	Question 3.1	Question 3.2	Question 3.3	Question 3.4	Question 3.5	Quality
QN-N32	Helland, M., Horgen, G., Kvikstad, T.M., Garthus, T., & Aarås, A. (2011). Will musculoskeletal and visual stress change when Visual Display Unit (VDU) operators move from small offices to an ergonomically optimized office landscape? Applied Ergonomics, 42(6), 839–845.	Knowledge work	**Purpose:** to study whether a move from small offices to an ergonomically optimized office (including lighting and vision correction) has an effect on physical and visual stress and headaches among computer workers. Method: a case study (n=19) in which an intervention was implemented. The participants were monitored visually and given vision correction if needed. A questionnaire that measured the perceived quality of lighting environment and workload-related musculoskeletal disorders was completed just prior to the move and 9 months after. Conclusions: all participants reported improvements in the new office in terms of lighting, reduced glare, reduced visual discomfort and reduced headaches.	Yes	Yes	3 of 19 drop-out	No	Yes	Debatable
QN-N33	Hsiao, H., Hause, M., Powers, J. R., Kau, T.-Y., Hendricks, S., & Simeonov, P. I. (2008). Effect of Scaffold End Frame Carrying Strategies on Worker Stepping Response, Postural Stability, and Perceived Task Difficulty. Human Factors: The Journal of the Human Factors and Ergonomics Society, 50(1), 27–36.	Industry	**Purpose:** to identify working techniques with best effects on construction worker performance when lifting and carrying scaffold end frames. **Method:** laboratory test in which participants (n=18, 100% M) tested 3 carrying methods on 4 surfaces with 2 different frame weights and 3 ladder orientations. Conclusions: symmetrical lateral carrying was the best method for 22 kg frames. A frame weight of 9 kg could significantly reduce the risk of symptoms and injury when assembling and disassembling scaffolding.	Yes	Yes	Yes	No	Yes	Medium-high
QN-N34	Hua, Y., & Yang, E. (2014). Building spatial layout that supports healthier behavior of office workers: A new performance mandate for sustainable buildings. Work, 49(3), 373–380.	Knowledge work	**Purpose:** to study the effect of the physical environment on voluntary and imperative physical activity in an office environment. Method: participants (n=26, 8M/18W) wore accelerometers for 3 days in a row at work. Questionnaires were handed out to study satisfaction. Conclusions: the participants sat for ca. 80% of their work hours. Proximity to shared office resources correlated positively with step counts and satisfaction with the work.	Yes	Yes	No	No	Yes	Debatable
QN-N35	Hugine, A., Guerlain, S., & Hedge, A. (2012). User Evaluation of an Innovative Digital Reading Room. Journal of Digital Imaging, 25(3), 337–346.	Healthcare	**Purpose:** to evaluate a digital reading room for radiologists. Method: the workstations in the reading room were tested in a test bed where participants were interviewed to obtain feedback (n=30) and followed up with a questionnaire (n=7, 5M/2W) that determined satisfaction on Likert scales. Conclusions: overall, the users were pleased with the new reading room and its workstations. Design improvements were identified, e.g. with respect to the concierge functions and layout. The evaluation process in test beds can provide useful input for actual implementation to increase satisfaction and productivity among radiologists.	Yes	Yes	No	Can't tell	Yes	Debatable

	Reference	Occupational category	Content (n=final no. of participants after all eliminations ; if gender distribution is clearly stated: M = men/W = women)	Question 3.1	Question 3.2	Question 3.3	Question 3.4	Question 3.5	Quality
QN-N36	Jain, G., & Shetty, P. (2014). Occupational concerns associated with regular use of microscope. International Journal of Occupational Medicine and Environmental Health, 27(4), 591–598.	Knowledge work	**Purpose:** to map work-related problems associated with regular microscope use. Method: questionnaire study among professional lab workers and technicians (n=50, 17M/33W). Conclusions: lab workers with long experience (11–15 yrs) had the highest prevalence of musculoskeletal disorders. 62% of those surveyed reported work-related symptoms, primarily in their backs and necks. Other symptoms were tired eyes, aggravation of ametropia, headache, stress due to long working days and anxiety during or after microscope use.	Yes	Yes	Can't tell	Can't tell	Yes	Debatable
QN-N37	Kim, J.-Y., Chung, M.-K., & Park, J.-S. (2003). Measurement of physical work capacity during arm and shoulder lifting at various shoulder flexion and ad/ abduction angles. Human Factors and Ergonomics in Manufacturing, 13(2), 153–163.	Multi-occupation	**Purpose:** to study work capacity during arm and shoulder lifting at various flexion angles, and during adduction and abduction (lateral angles). Method: laboratory observation study in which the participants' (n=20, 20 M) maximum muscle contraction (MVC) was measured, after which the participants put an arm and shoulder into various combined lifting and lateral positions. Surface EMGs were measured. The results were compared with a 3D biomechanical model. Conclusions: the experiment offers guidance regarding particularly exposed shoulder positions. Based on the MVC comparison, 90° and 120° flexion (lifting), 30° adduction (inward) and 90° abduction (outward) are the most vulnerable angles.	Can't tell	Yes	Can't tell	Can't tell	Yes	Debatable
QN-N38	Kim, S., Nussbaum, M. A., & Jia, B. (2011). Low back injury risks during construction with prefabricated (panelised) walls: effects of task and design factors. Ergonomics, 54(1), 60–71.	Industry	**Purpose:** study of musculoskeletal strain risks during lifting and installation of wall panels in the construction industry. Method: experiment in which the participants (n=24, 19M/5W) installed prefabricated wall panels of two different weights, two different sizes in terms of panel length, and using five work techniques. Conclusions: high strain risks were identified in the work, e.g. limits for lower back pressure exceeded in 34% of the cases, and in 77% with regard to transverse force. Tasks that started from ground level or knuckle height resulted in the highest strain. Heavier panels increased the risk considerably, but with varying effects depending on the size and work task in question.	Can't tell	Yes	Can't tell	No	Yes	Debatable
QN-N39	Kothiyal, K., & Kayis, B. (2001). Workplace layout for seated manual handling tasks: an electromyography study. International Journal of Industrial Ergonomics, 27(1), 19–32.	Multi-occupation	**Purpose:** to study muscular exertion in relation to force generation and work tempo during seated material handling tasks. Method: experiment in which participants (n=10) used their dominant hand to move weights of 1 and 2 kg laterally over a distance of 38 cm at a rate of 10 and 20 movements per minute (guided by a metronome). The work was performed on an adjustable work surface of the proper height. EMG measurements were made on 5 muscles. Conclusions: the total muscular exertion depends on the direction of movement. The work pace had a greater effect on exertion than did the handled weight.	Can't tell	Yes	Can't tell	Can't tell	Yes	Debatable

	Reference	Occupational category	Content (n=final no. of participants after all eliminations ; if gender distribution is clearly stated: M = men/W = women)	Question 3.1	Question 3.2	Question 3.3	Question 3.4	Question 3.5	Quality
QN-N40	Largo-Wight, E., William Chen, W., Dodd, V., & Weiler, R. (2011). Healthy workplaces: The effects of nature contact at work on employee stress and health. Public Health Reports, 126(SUPPL. 1), 124–126.	Knowledge work	**Purpose:** to study the effects of nature contact in the workplace on employee health and stress levels. **Method:** cross-sectional study with a questionnaire filled out by office employees (n=503, 93%W). The data was analysed with multiple regression analyses. **Conclusions:** the study found that a higher degree of nature contact during the workday had a significant correlation with lower stress and fewer health problems.	Yes	Yes	No	Can't tell	Yes	Debatable
QN-N41	Malinowska-Borowska, J., Harazin, B., & Zieliński, G. (2011). The influence of wood hardness and logging operation on coupling forces exerted by lumberjacks during wood harvesting. International Journal of Industrial Ergonomics, 41(5), 546–550.	Industry	**Purpose:** to measure grip forces that lumberjacks apply to power saws, and to seek correlations between magnitude of force, the hardness of the wood and the type of forestry work. Method: field observations in which lumberjacks' (n=33 power saw operators and 19 trainees) force generation in hand grips was measured using a hydroelectric dynamometer during actual wood harvesting of various types of trees. In total, 193 cutting forces were measured for the tasks of felling, cross-cutting and limbing. Conclusions: the maximum transitory manual force was 275 N. The lowest cutting force, 27 N, occurred during limbing. The forces went up to ca. 50 N during felling and cross-cutting. As expected, greater force generation occurred during work on hardwoods, although the type and size of power saw affected manual force as well.	Yes	Yes	Yes	Can't tell	Yes	Medium-high
QN-N42	Meijer, E. M., Frings-Dresen, M. H. W., & Sluiter, J. K. (2009). Effects of office innovation on office workers' health and performance. Ergonomics, 52(9), 1027–1038.	Knowledge work	**Purpose:** to assess the implementation of an innovative office environment (open-plan layout, flexible workstations and paperless office) in terms of employee health and productivity. Method: longitudinal study in which participants (n=349, 185M/164W) filled out questionnaires at baseline and 6 and 15 months after the move Conclusions: no short-term differences were identified for the majority of items, except that the quantity of work decreased slightly. No significant differences were observed in the majority of items over the long term either, except for a general improvement in health and reduced symptoms involving the upper extremities (arms/shoulders). A clear increase in perceived productivity was measured after 15 months.	Yes	Yes	Can't tell	Can't tell	Yes	Debatable
QN-N43	Menéndez, C. C., Amick, B. C., Robertson, M., Bazzani, L., DeRango, K., Rooney, T., & Moore, A. (2012). A replicated field intervention study evaluating the impact of a highly adjustable chair and office ergonomics training on visual symptoms. Applied Ergonomics, 43(4), 639–644.	Knowledge work	**Purpose:** to compare the impact of two office interventions on visual symptoms in the private sector. Method: a quasi-experiment with implementation of either an adjustable office chair combined with ergonomics training or ergonomics training alone, plus a control group with no intervention. Data were collected via questionnaires (n=181, 90% W) and a health diary, 2 months and 1 month before and 2, 6 and 12 months after the interventions. Conclusions: both intervention types led to reduced visual symptoms after 12 months.	Yes	Yes	No	Yes	Yes	Debatable

	Reference	Occupational category	Content (n=final no. of participants after all eliminations ; if gender distribution is clearly stated: M = men/W = women)	Question 3.1	Question 3.2	Question 3.3	Question 3.4	Question 3.5	Quality
QN-N44	O'Sullivan, L. & Gallwey, T. J. (2002). Effects of gender and reach distance on risks of musculoskeletal injuries in an assembly task. International Journal of Industrial Ergonomics, 29(2), 61–71.	Industry	**Purpose:** to study differences in men's and women's elbow and shoulder angles during manual assembly tasks. Method: experiment in which the participants (n=10, 5M/5W) performed a simulated assembly task consisting of 17 steps with components at 3 different distances from the body. Electrogoniometers were used for the angle measurements. Conclusions: the men's elbow angles were, on average, smaller than the women's, but their shoulder angles were greater. Among women, the angle differences were greater the farther from the body the component was placed. Both direction of movement and original hand position affected the final angles of both elbows and shoulders.	Can't tell	Yes	Yes	Can't tell	Yes	Debatable
QN-N45	Robertson, M. M., & Huang, Y.-H. (2006). Effect of a workplace design and training intervention on individual performance, group effectiveness and collaboration: The role of environmental control. Work, (1), 3–12.	Knowledge work	**Purpose:** to assess an intervention (workplace modification plus ergonomics training programme) with regard to employees' perceived control over their work environment, satisfaction with the work environment, performance, efficiency and collaboration at the group level. Method: quasi-experimental field study with pre-post evaluation involving office workers from 3 companies (n=120, 57% M). No control group. Conclusions: the intervention had a significant positive impact on the workers' satisfaction with their work environment in terms of workstation layout and storage options, both of which correlated with individual performance, group cooperation and efficiency. Control over the work environment had a direct impact on individual performance and group cooperation.	Yes	Yes	Can't tell	Can't tell	Yes	Debatable
QN-N46	Robertson, M. M., Huang, Y.-H., O'Neill, M. J., & Schleifer, L. M. (2008). Flexible workspace design and ergonomics training: Impacts on the psychosocial work environment, musculoskeletal health, and work effectiveness among knowledge workers. Applied Ergonomics, 39(4), 482–494.	Knowledge work	**Purpose:** to study how a macro intervention in computer work in flexible office environments impacts the psychosocial work environment, musculoskeletal health and performance. Method: quasi-experimental non-randomized field study with pre–post assessment involving office workers (n=289) who were assigned either a flexible workplace, ergonomics training or a combination of a flexible workplace and ergonomics training, plus a control group. The measurements were taken 2 months before and 3 and 6 months after the intervention. Conclusions: both interventions had significant positive effects on workload-related musculoskeletal discomfort, control over the work, satisfaction with the work environment, sense of belonging, ergonomic climate, communication, cooperation and business process efficiency.	Yes	Yes	No	Can't tell	No	Debatable
QN-N47	Sancibrian, R., Gutierrez-Diez, M. C., Torre-Ferrero, C., Benito-Gonzalez, M. A., Redondo-Figuero, C., & ManuelPalazuelos, J. C. (2014). Design and evaluation of a new ergonomic handle for instruments in minimally invasive surgery. Journal of Surgical Research, 188(1), 88–99.	Healthcare	**Purpose:** to evaluate a new, ergonomically designed handle for laparoscopic surgical instruments. Method: experiment in which volunteer medical personnel (n=28) compared the new handle with a more conventional design while performing various tasks. The study subjects' muscle activation and hand, wrist and arm movements were studied using EMG and goniometers. Conclusions: the new handle both improved the ergonomics and increased efficiency by reducing the areas of high hand pressure and reducing extreme wrist movements.	Yes	Yes	Yes	Can't tell	Yes	Medium-high

	Reference	Occupational category	Content (n=final no. of participants after all eliminations ; if gender distribution is clearly stated: M = men/W = women)	Question 3.1	Question 3.2	Question 3.3	Question 3.4	Question 3.5	Quality
QN-N48	Schreuder, E., van Heel, L., Goedhart, R., Dusseldorp, E., Schraagen, J. M., & Burdorf, A. (2015). Effects of newly designed hospital buildings on staff perceptions: A pre-post study to validate design decisions. Health Environments Research and Design Journal, 8(4), 77–97.	Healthcare	**Purpose:** to study how newly built nonpatient-related buildings at a Dutch university hospital impacted staff perceptions, and to assess whether the design objectives were met. Method: pre–post evaluation with control group, using questionnaires that measured perceived levels of building performance (n=372, majority W). The questionnaires were filled out between 3 and 7 months before the move and between 5 and 8 months after. Longitudinal multi-level analysis was performed. Conclusions: the participants perceived improvements in indoor climate, perceived security, work environment, well-being, facilities, sustainability and general satisfaction. The study measured the performance of the new buildings and validated the design decisions.	Yes	Yes	No	Can't tell	Can't tell	Debatable
QN-N49	Schult, T. M., Awosika, E. R., Schmunk, S. K., Hodgson, M. J., Heymach, B. L., & Parker, C. D. (2013). Sitting on Stability Balls: Biomechanics Evaluation in a Workplace Setting. Journal of Occupational and Environmental Hygiene, 10(2), 55–63.	Knowledge work	**Purpose:** to compare sitting on stability balls, a stability ball chair fixed in a frame and conventional office chairs (as control group). Method: crossover study in which three groups of participants (n=159, 84.5% W) took turns sitting on the three variants over one month at a time, with subsequent rotation. Questionnaire concerning health and performance results was filled out after the testing. Conclusions: stability balls were perceived to improv posture and energy levels compared to the office chairs, and the same applies to the stability ball chairs, with the addition that users experience improved balance. Using stability balls reduced the likelihood of reporting pain.	Can't tell	Yes	Can't tell	Can't tell	Yes	Debatable
QN-N50	Simeonov, P. (2001). Height, surface firmness, and visual reference effects on balance control. Injury Prevention, 7(90001), i50–53.	Industry	**Purpose:** to assess the effects of height and surface structure on the sense of balance in the construction industry. Methods: measurement of standing balance in construction workers (n=24) while they performed standing tasks at different heights and on different types of surfaces. Conclusions: height and soft surfaces have a negative effect on balance.	Yes	Yes	Can't tell	Can't tell	Yes	Medium-high
QN-N51	Simeonov, P., Hsiao, H., & Hendricks, S. (2009). Effectiveness of vertical visual reference for reducing postural instability on inclined and compliant surfaces at elevation. Applied Ergonomics, 40(3), 353–361.	Industry	**Purpose:** to assess the effects of visual references on balance in the construction industry. **Methods:** measurement of standing balance in construction workers (n=24) while they performed standing tasks upright, on inclined or compliant surfaces. Conclusions: inclined and compliant surfaces have a negative effect on balance, but a reference/object in visual proximity can support one's balance.	Yes	Yes	Can't tell	Can't tell	Yes	Medium-high
QN-N52	Swanson, N. G., & Sauter, S. L. (2006). A multivariate evaluation of an office ergonomic intervention using longitudinal data. Theoretical Issues in Ergonomics Science, 7(1), 3–17.	Knowledge work	**Purpose:** to evaluate a keyboard intervention and its effects on physical and psychosocial stress and physical symptoms. Method: questionnaire data was collected before and after the intervention. The participants were divided into one group with a traditional keyboard (n=95) and one group with a keyboard with an alternative design (n=94). Conclusions: the participants with the alternative keyboard reported fewer musculoskeletal symptoms in their left hands/shoulders and an increase in co-worker support than did the participants with traditional keyboards.	Yes	Yes	Yes	Can't tell	Yes	High

	Reference	Occupational category	Content (n=final no. of participants after all eliminations ; if gender distribution is clearly stated: M = men/W = women)	Question 3.1	Question 3.2	Question 3.3	Question 3.4	Question 3.5	Quality
QN-N53	Synnott, A., Dankaerts, W., Seghers, J., Purtill, H., & O'Sullivan, K. (2017). The effect of a dynamic chair on seated energy expenditure. Ergonomics, 60(10), 1384–1392.	Knowledge work	**Purpose:** to compare a dynamic and a traditional office chair in terms of energy expenditure and discomfort. Method: the participants (n=15, 9M/6W) watched a 1-hour video sitting on dynamic and traditional office chairs in two sessions. Data collection included biometric data on energy expenditure, questionnaire data and subjective discomfort ratings. Conclusions: The dynamic chair led to greater discomfort and energy expenditure, although the level of energy expenditure was close to the levels of the traditional chair while sitting still .	Can't tell	Yes	Yes	No	Yes	Debatable
QN-N54	Szeto, G. P. Y., & Sham, K. S. W. (2008). The effects of angled positions of computer display screen on muscle activities of the neck–shoulder stabilizers. International Journal of Industrial Ergonomics, 38(1), 9–17.	Knowledge work	**Purpose:** to assess the effects of angled screens on muscle activity in the neck and shoulders. Method: subjective discomfort rating and biometric data on muscle activity among participants (n=20, 10M/10W) who performed 20-minute typing tasks in 3 different sessions in which 3 screen angles were tested. Conclusions: angled screens led to greater muscle activity and were perceived as more uncomfortable than centred screens.	Yes	Yes	Yes	No	Yes	Medium-high
QN-N55	Szeto, G. P. Y., Chan, C. C. Y., Chan, S. K. M., Lai, H. Y., & Lau, E. P. Y. (2014). The effects of using a single display screen versus dual screens on neck-shoulder muscle activity during computer tasks. International Journal of Industrial Ergonomics, 44(3), 460–465.	Knowledge work	**Purpose:** to assess the effects of single screens versus dual screens on muscle activity. Method: subjective discomfort ratings and biometric data regarding muscle activity were collected among participants (n=22, 11M/11W) who performed 15-minute typing tasks in 2 different sessions to assess single screens and dual screens. Conclusions: dual screens encouraged posture variety and movement compared to single screens.	Yes	Yes	Yes	No	Yes	Medium-high
QN-N56	Van Der Molen, H. F., Kuijer, P. P. F. M., Hopmans, P. P. W., Houweling, A. G., Faber, G. S., Hoozemans, M. J. M., & Frings-Dresen, M. H. W. (2008). Effect of block weight on work demands and physical workload during masonry work. Ergonomics, 51(3), 355–366.	Industry	**Purpose:** to study the effects of block weight on performance and physical workload among stonemasons. Method: observations and biometric data were collected while stonemasons (n=15, 3 groups) worked a full working day using 3 different block weights (14, 16 and 18 kg). Conclusions: the weight of the blocks had no effect in performance or physical workload.	Yes	No	Yes	Can't tell	Yes	Debatable
QN-N57	van Esch, E., Minjock, R., Colarelli, S. M., & Hirsch, S. (2019). Office window views: View features trump nature in predicting employee well-being. Journal of Environmental Psychology, 64, 56–64.	Knowledge	**Purpose:** to identify aspects of window views in office environments that impact well-being. Method: the first questionnaire study (n=151) examined whether different images of nature affected participants' psychological, emotional and cognitive reactions and work. The second questionnaire study (n=303) examined the effects of exposure to views of nature on well-being. Conclusions: the quantity of views of nature affected recovery and job satisfaction. Views that allowed for coherence, privacy and openness had the greatest effects on well-being.	Can't tell	Yes	No	Can't tell	Yes	Debatable

4) Quantitative descriptive studies (N=22)

The appraisal questions are:
4.1. Is the sampling strategy relevant to address the research question?
4.2. Is the sample representative of the target population?
4.3. Are the measurements appropriate?
4.4. Is the risk of nonresponse bias low?
4.5. Is the statistical analysis appropriate to answer the research question?

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 4.1	Question 4.2	Question 4.3	Question 4.4	Question 4.5	Quality
QN-D1	Abd Rahman, M. N., Aziz, F. A., & Yusuff, R. M. (2010). Survey of body part symptoms among workers in a car tyre service centre. Journal of Human Ergology, 39(1), 53–56.	Industry	**Purpose:** to study the prevalence (incidence and frequency) of injury and discomfort symptoms in various body parts due to standing work among employees at a service centre for car tyre maintenance in Malaysia. Method: questionnaire and interviews (n=12). Conclusions: the article recommends various risk-reducing measures at different administrative and engineering control levels.	Yes	Yes	Yes	Yes	Yes	High
QN-D2	Ahmed, I., & Shaukat, M. Z. (2018). Computer users' ergonomics and quality of life – evidence from a developing country. International Journal of Injury Control and Safety Promotion, 25(2), 154–161.	Knowledge work	**Purpose:** to assess workplace ergonomics and quality of life among computer users at various insurance companies in Pakistan. Method: questionnaire data was collected (n=235, 205M/30W). Conclusions: the ergonomics in several workplaces were found to be poor, and a strong correlation was found between this and low quality of life (in terms of both physical and mental illness).	Can't tell	Yes	Yes	Can't tell	Yes	Medium-high
QN-D3	Alleblas, C. C. J., Formanoy, M. A. G., Könemann, R., Radder, C. M., Huirne, J. A., & Nieboer, T. E. (2016). Ergonomics in gynecologists' daily practice: A nationwide survey in The Netherlands. Work, 55(4), 841–848.	Healthcare	**Purpose:** to study the prevalence (incidence and frequency) of physical symptoms and ergonomic limitations in gynaecology work in the Netherlands. Method: questionnaire with 52 questions from Dutch Musculoskeletal Questionnaire (n=227, 65% W). Conclusions: 89.4% of the respondents had had some form of physical symptom related to a body part in the last 12 months. Over 60% responded that their means of assuming neutral work postures (primarily in surgical work) were affected by limited work space, instrument design or patient size.	Yes	Yes	Yes	Can't tell	Yes	Medium-high
QN-D4	Baričič, A., & Salaj, A. T. (2014). The impact of office workspace on the satisfaction of employees and their overall health – Research presentation. Zdravniski Vestnik, 83(3), 217–231	Knowledge work	**Purpose:** to test two hypotheses that link built-environment factors to employee health and level of satisfaction in the white-collar sector. Method: questionnaire with 163 questions (n=1,036). Conclusions: factor analysis showed a strong link between various built-environment factors (workplace cleanliness, lighting, orientation, means of regulating lighting and climate) and employee satisfaction, as well as a strong link between employee satisfaction and employee health.	Can't tell	Can't tell	Yes	Can't tell	Yes	Debatable

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 4.1	Question 4.2	Question 4.3	Question 4.4	Question 4.5	Quality
QN-D5	Bergström, J., Miller, M., & Horneij, E. (2015). Work environment perceptions following relocation to open-plan offices: A twelve-month longitudinal study. Work, 50(2), 221–228.	Knowledge work	**Purpose:** to study how moving from individual office cells to an open-plan solution affects self-perceived health, the work environment and self-rated productivity. Method: three departments at the same company with similar job tasks were studied. Questionnaire data was collected one month before plus follow-up questionnaires 3, 6 and 12 months after the move (n=54 for fourth questionnaire, of which 42 in open-plan solution, 31% W). Conclusions: self-perceived employee health, job satisfaction and performance had deteriorated after 12 months.	Yes	Yes	Yes	Can't tell	Yes	High
QN-D6	Boynton, T., & Darraghb, A. R. (2008). Participatory ergonomics intervention in a sterile processing center: A case study. Work, 31(1), 95–99.	Healthcare	**Purpose:** to study a series of participatory ergonomic interventions (evaluation, training, redesign of the departmental configuration and changes in work process and tools over a 2.5-year period at an American hospital. Method: case study with ergonomic assessments, questionnaires and observations of work (n=30, 4M/26W). Conclusions: after the 2.5 years, the 30 employees reported no new work-related injuries compared to 19 injuries as the initial value. This success has resulted in the intervention being continued on a quarterly basis.	Yes	Can't tell	Yes	Yes	Can't tell	Medium-high
QN-D7	Brunia, S., De Been, I., & van der Voordt, T. J. M. (2016). Accommodating new ways of working: lessons from best practices and worst cases. Journal of Corporate Real Estate, 18(1), 30–47.	Knowledge work	**Purpose:** to identify factors taht explain high or low percentages of (dis-/)satisfied employees in activity-based offices in a Dutch public organization. Method: descriptive and explorative comparison of surveys among four cases (n=930). Two cases had high percentages of satisfaction and two had considerably lower satisfaction percentages. Focus group interviews were also included in each of the cases. Conclusions: the differences between the best and worst cases have to do with employee satisfaction with interior design, the openness and level of enclosure of the spaces, number and diversity of workstation types and the accessibility of the building. However, satisfaction was also affected by the introduction process and satisfaction with the organization.	Yes	Yes	Yes	Can't tell	Yes	Medium-high
QN-D8	Bruno Garza, J. L., Eijckelhof, B. H. W., Johnson, P. W., Raina, S. M., Rynell, P. W., Huysmans, M. A., … Dennerlein, J. T. (2012). Observed differences in upper extremity forces, muscle efforts, postures, velocities and accelerations across computer activities in a field study of office workers. Ergonomics, 55(6), 670–681.	Knowledge work	**Purpose:** to measure whether there are differences in biomechanical workloads between different computer-based occupations. Method: continuous measurements for 2h of movements of office workers using wireless wearable technology (n=118, 32M/86W) who were recruited at a university in the Netherlands. Conclusions: there were differences in almost all measured forces, muscle efforts, velocities and accelerations among activities involving keyboards and mouse and in a passive state. It is believed that some of these stress levels could contribute to musculoskeletal disorders (MSD).	Yes	Yes	Yes	Yes	Yes	High

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 4.1	Question 4.2	Question 4.3	Question 4.4	Question 4.5	Quality
QN-D9	Cavanagh, J., Brake, M., Kearns, D., & Hong, P. (2012). Work environment discomfort and injury: an ergonomic survey study of the American Society of Pediatric Otolaryngology members. American Journal of Otolaryngology, 33(4), 441–446.	Healthcare	**Purpose:** to study work-related discomfort and injuries among American ENT doctors and determine their familiarity with ergonomic principles. Method: cross-sectional study, questionnaire sent to members of the American Society of Pediatric Otolaryngology (n=100, 85M/15W). Conclusions: nearly two-thirds of the respondents had experienced pain or discomfort which they associated with surgical activities. Only a minority were familiar with ergonomic principles.	Yes	Yes	Yes	Yes	Yes	High
QN-D10	Chadburn, A., Smith, J., & Milan, J. (2017). Productivity drivers of knowledge workers in the central London office environment. Journal of Corporate Real Estate, 19(2), 66–79.	Knowledge work	**Purpose:** to identify productivity drivers in the physical and social environment of knowledge workers. Method: questionnaire data was collected from employees at 8 different consulting, financial and media firms based in central London (n=213). Conclusions: drivers behind high personal productivity were found to be comfort, cosiness, IT connections, good design and working on deadline. High-performing knowledge workers prefer flexible workplaces that can stimulate open and collaborative work as well as private, calm places without distractions and noise.	Yes	Yes	Yes	Can't tell	Yes	Medium-high
QN-D11	Chiu, Y. C., Chen, S., Wu, G. J., & Lin, Y. H. (2012). Three-dimensional computer-aided human factors engineering analysis of a grafting robot. Journal of Agricultural Safety and Health, 18(3), 181–194.	Miscellaneous occupations	**Purpose:** to perform an experimental human-factors analysis of a grafting robot using 3D simulation. Method: simulation of work with the grafting robot using human models from the 95th percentile, 50th percentile and 5th percentile in terms of size for both men and women (n=6) from a Taiwanese population. Physical loading were analysed using Lower Back Analysis and Rapid Upper Limb Assessment methods. Conclusions: the experiment showed that it was ergonomically beneficial to provide more leg room for the workers beneath the robots.	Can't tell	Yes	Yes	Yes	Can't tell	Debatable
QN-D12	Cohen, H. H., & Cohen, J. (2004). Employee participation in a hospital hazard management system. Ergonomics in Design, 12(3), 13–18.	Healthcare	**Purpose:** to describe a participatory process in which employees at an American hospital (with over 1,800 employees) took part in identifying and mitigating health and safety risks in the workplace. **Method:** case study involving a series of different participatory steps, including questionnaires, reporting initiatives, attitude questionnaire and participatory design. Conclusions: the study found that participatory ergonomics offered a successful strategy for identifying and reducing work-related injury risks.	Yes	Yes	Yes	Can't tell	Yes	Medium-high
QN-D13	Haapakangas, A., Hallman, D. M., Mathiassen, S. E., & Jahncke, H. (2018). Self-rated productivity and employee well-being in activity-based offices: The role of environmental perceptions and workspace use. Building and Environment, 145, 115–124.	Knowledge work	**Purpose:** to assess four activity-based offices in the public sector 12 months after implementation. Method: questionnaire 12 months after moving in (n=239, 46% W) with descriptive statistical analysis. Conclusions: satisfaction with the physical environment, privacy and communication correlated strongly with self-rated high productivity and well-being. Frequent switching between workstations could be tied to higher perceived productivity, while misspent time for searching for a workstation reduced the sense of productivity and well-being.	Yes	Yes	Yes	Yes	Yes	High

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 4.1	Question 4.2	Question 4.3	Question 4.4	Question 4.5	Quality
QN-D14	Jancey, J. M., McGann, S., Creagh, R., Blackford, K. D., Howat, P., & Tye, M. (2016). Workplace building design and office-based workers' activity: a study of a natural experiment. Australian and New Zealand Journal of Public Health, 40(1), 78–82.	Knowledge work	**Purpose:** to study how moving from a 30-year-old building to a new "activity permissive" building affected employees' physical activity and sedentary behaviour. Method: opportunistic natural case study before and after move. Accelerometers were used for 5 days to track motion, while anthropometric and demographic data were collected via a computerized questionnaire (n=42, 17M/27W). Conclusions: the move to the new building led to an increased physical activity level and decreased sedentary behaviour, although not to the desired extent.	Yes	Yes	Yes	Yes	Yes	High
QN-D15	Korhan, O., & Mackieh, A. (2011). An empirical investigation of the detrimental effects of the intensive use of computers in the business world. African Journal of Business Management, 5(3), 656–665.	Knowledge work	**Purpose:** to study musculoskeletal injury (MSD) risks due to intensive computer use among knowledge workers in Cyprus. Method: questionnaires were given to knowledge workers with high shares of computer work (n=84, 58.33% W), supplemented with a mathematical model. Conclusions: factors such as gender, psychosocial factors, physical office ergonomics (e.g. access to footstools and adequate lighting) had significant effects on occurrence of work-related MSDs.	Can't tell	Can't tell	Yes	Can't tell	Yes	Debatable
QN-D16	Lee, S. Y., & Brand, J. L. (2010). Can personal control over the physical environment ease distractions in office workplaces? Ergonomics, 53(3), 324–335.	Knowledge work	**Purpose:** to study whether control over various physical aspects of the workplace can reduce negative effects on job performance due to distractions in open-plan office environments. Method: analysis of questionnaires from 3 industrial companies (n=384, 38% W) with structural equations. Conclusions: employee perceptions of control over the physical work environment affected the relationship between perceived distractions and performance outcomes.	Can't tell	Can't tell	Yes	Can't tell	Yes	Debatable
QN-D17	Levchuk, I., Schäfer, A., Lang, K. H., Gebhardt, H., & Klussmann, A. (2012). Needs of ergonomic design at control units in production Industries. Work, 41(SUPPL.1), 1594–1598.	Industry	**Purpose:** to study usability and user-friendliness of CNC machines and potential ergonomic improvements. Method: questionnaires were given to CNC trainees at a German training centre (n=112, 112M). Conclusions: ergonomic optimization of the CNC machine's design was possible and desirable, particularly of its control panel. This applied to the placement, appearance and physical operation of controls and touchscreens. Adjustable screen height was recommended.	Yes	No	Can't tell	No	Can't tell	Debatable
QN-D18	Lin, J. D., Loh, C. H., Lai, C. Y., Lo, Y. T., Lu, H. L., Yen, C. F., … Chu, C. (2008). Perceived adverse occupational health effects in hospital personnel: An exploration of the effects of the workplace environment. Journal of Medical Sciences, 28(6), 227–232.	Healthcare	**Purpose:** to study the prevalence (incidence and frequency) and types of undesired effects on healthcare staff's physical health, and to study their relationship to the hospital's work environment. Method: cross-sectional study with structured questionnaire targeting healthcare staff at a hospital in Taipei (n=649, 154M/495W). Conclusions: common symptoms were reported in the shoulders/neck area, including tiredness, lower back pain, headache, eye and throat irritation, etc. Multiple logistic regression analysis showed that the staff perceived themselves as being exposed to a poor work environment, and noted degraded health status.	Yes	Yes	Yes	Can't tell	Yes	Medium-high

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 4.1	Question 4.2	Question 4.3	Question 4.4	Question 4.5	Quality
QN-D19	Lindberg, C. M., Srinivasan, K., Gilligan, B., Razjouyan, J., Lee, H., Najafi, B., … Sternberg, E. M. (2018). Effects of office workstation type on physical activity and stress. Occupational and Environmental Medicine, 75(10), 689–695.	Knowledge work	**Purpose:** to study the link between office type and objective measurements of physical activity and stress among knowledge workers in the public sector in the US. Method: observational study using wearable sensors given to office staff in 4 buildings (n=231, 116M/115W) for 3 days in a row, supplemented with entry and exit questionnaires plus a digital questionnaire each work hour. Conclusions: personnel in open workstations had higher physical activity and lower perceived stress than did colleagues in cubicles or office cells. The higher level of physical activity could in turn be tied to lower physiological stress outside the office (based on heart rate measurements).	Yes	Yes	Yes	Can't tell	Yes	Medium-high
QN-D20	Riaz, A., Shoaib, U., & Shahzad, M. (2017). Workplace Design and Employee's Performance and Health in Software Industry of Pakistan. International Journal of Advanced Computer Science and Applications, 8(5), 542–548.	Knowledge work	**Purpose:** to study the impact of workplace design (incl. noise, temperature, lighting, layout, equipment and furniture choices) on employee health and performance in the software industry in Pakistan. Method: questionnaire (n=193). Conclusions: regression analysis showed that good workplace design in terms of the aforementioned factors has a strong negative correlation with employee discomfort, and a weak positive correlation with their performance.	Yes	Yes	Yes	Can't tell	Yes	Medium-high
QN-D21	Scuffham, A., Firth, E., Stevenson, M., & Legg, S. (2010). Tasks considered by veterinarians to cause them musculoskeletal discomfort, and suggested solutions. New Zealand Veterinary Journal, 58(1), 37–44.	Miscellaneous occupations	**Purpose:** to describe veterinarians' perceptions of what causes work-related musculoskeletal disorders (MSD) and to collect their suggestions for improvement measures in New Zealand. Method: questionnaire (n=828, 417M/411W). Conclusions: systematic content analysis of the free-text responses showed that the veterinarians believe that the causes of MSD involve mainly physical demands rather than psychosocial ones. The most common causes were lifting, surgery, rectal palpation and animal handling. They proposed improvements in terms of workplace design and training.	Yes	Yes	Yes	Can't tell	Yes	Medium-high
QN-D22	Vieira, E. R., Kumar, S., Coury, H. J. C. G., & Narayan, Y. (2006). Low back problems and possible improvements in nursing jobs. Journal of Advanced Nursing, 55(1), 79–89.	Healthcare	**Purpose:** to assess workloads that lead to the development of lower back injuries among nurses at orthopaedic and intensive care departments at a Canadian hospital. Method: retrospective study with validated questionnaire (n=47, 4M/43W). Conclusions: there were differences between the two types of nurses studied, but overall the workload scored high in terms of the development of lower back pain, the heaviness of the handled weights and the extent of exertion required by the work. The questionnaires were found to be a good tool for assessing and planning design modifications in hospital environments.	Yes	Yes	Yes	Yes	Yes	High

5) Mixed-methods studies (N=72)

The appraisal questions are:
5.1. Is there an adequate rationale for using a mixed methods design to address the research question?
5.2. Are the different components of the study effectively integrated to answer the research question?
5.3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted?
5.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?
5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 5.1	Question 5.2	Question 5.3	Question 5.4	Question 5.5	Quality
MM1	Abdol Rahman, M. N., & Ahmad Zuhaidi, M. F. (2018). Exposure level of Ergonomic Risk Factors in Grocery Retail Industries. Journal of Engineering and Applied Sciences, 13, 6354–6358.	Industry	**Purpose:** to map injury risks in grocery stores. Method: questionnaire, participatory observations (n=60, 46M/16W) and use of the analysis methods WERA and REBA to assess body postures. Conclusions: the study identified high to medium-high injury risks to the back, arms and legs.	Can't	Can't	Can't	Can't	Yes	Debatable
MM2	Aghilinejad, M., Ehsani, A. A., Talebi, A., Koohpayehzadeh, J., & Dehghan, N. (2016). Ergonomic risk factors and musculoskeletal symptoms in surgeons with three types of surgery: Open, laparoscopic, and microsurgery. Medical Journal of the Islamic Republic of Iran, 30(1).	Healthcare	**Purpose:** to map injury risks among surgeons. Method: questionnaire study (n=81) and use of the WERA analysis method to assess body postures in three types of surgery. Conclusions: the study identified injury symptoms in the neck, hands and back, and recommended remedial measures.	Yes	Yes	No	Can't tell	No	Debatable
MM3	Albers, J. T., & Hudock, S. D. (2007). Biomechanical Assessment of Three Rebar Tying Techniques. International Journal of Occupational Safety and Ergonomics, 13(3), 279–289.	Industry	**Purpose:** to assess injury risks among iron workers associated with use of three different tools. Method: biometric data and video observations (n=8, 8M). Conclusions: use of electric tools with an extended handle resulted in minimized unergonomic positions.	Yes	Yes	Yes	Yes	Yes	High
MM4	Alomari, A., Wilson, V., Solman, A., Bajorek, B., & Tinsley, P. (2018). Pediatric Nurses' Perceptions of Medication Safety and Medication Error: A Mixed Methods Study. Comprehensive Child and Adolescent Nursing, 41(2), 94–110.	Healthcare	**Purpose:** to describe safety culture associated with dispensing medications in paediatric care. Method: observations, focus group interviews (n=20) and log data from the dispensing of medications. Conclusions: workload, frequent interruptions and deficiencies in the design of the physical environment constitute barriers that hinder the safe dispensing of medications.	Yes	Yes	Yes	Yes	Yes	High

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 5.1	Question 5.2	Question 5.3	Question 5.4	Question 5.5	Quality
MM5	Appel-Meulenbroek, R., Groenen, P., Janssen, I. (2011). An end- user's perspective on activity-based office concepts. Journal of Corporate Real Estate, 13(2), 122–135.	Knowledge work	**Purpose:** to research the interplay between the design of activity-based offices and the use of those offices. Method: questionnaire study (n=182) from 4 offices plus participatory observations. Conclusions: the study points to incorrect use of different zones due to a deficient design process. Incorrect use led to degraded productivity and dissatisfaction.	Yes	Yes	No	Can't tell	No	Debatable
MM6	Arundell, L., Sudholz, B., Teychenne, M., Salmon, J., Hayward, B., Healy, G., & Timperio, A. (2018). The Impact of Activity Based Working (ABW) on Workplace Activity, Eating Behaviours, Productivity, and Satisfaction. International Journal of Environmental Research and Public Health, 15(5), 1005.	Knowledge work	**Purpose:** to study the impact of activity-based offices on physical activity, performance, satisfaction and eating habits. Method: pre–post data collection using accelerometers and questionnaires (n=76 intervention group; n=59 control group) and interviews (n=21). Conclusions: significant positive results in terms of physical activity, eating habits and satisfaction, and minimal degradation of performance compared to the control group	Can't tell	Yes	Yes	Can't tell	Yes	Medium-high
MM7	Bhardwaj, S., & Khan, A. A. (2018). Ergonomics investigation for orientation of the handles of wood routers. International Journal of Occupational Safety and Ergonomics, 24(4), 592–604.	Industry	**Purpose:** to improve body postures in router use (carpentry). Method: 7 tool variants were tested (n=10) using biometric data (EMG), hand vibration measurements and subjective data. Conclusions: The more ergonomic handles had angles of 30° and 60° compared to the previous 90°.	Yes	Yes	Yes	Yes	Yes	High
MM8	Byran, E., & Gilad, I. (2012). Design Considerations to Enhance the Safety of Patient Compartments in Ambulance Transporters. International Journal of Occupational Safety and Ergonomics, 18(2), 221–231.	Healthcare	**Purpose:** to analyse functions and behaviours in an ambulance environment in terms of patient safety. Method: questionnaire data (n=31), interviews (n=10) and observations over one working day. Conclusions: design recommendations were drafted to enhance comfort and safety in ambulance environments.	Yes	Yes	Can't tell	Can't tell	No	Debatable
MM9	Candido, C., Chakraborty, P., & Tjondronegoro, D. (2019). The Rise of Office Design in High-Performance, Open-Plan Environments. Buildings, 9(4), 100.	Knowledge work	Purpose: to identify workplace well-being factors in open-plan office landscapes. Method: questionnaire data from 18 offices (n=1,949). Conclusions: identified workplace well-being comprised user-centred office design, availability of work-supporting surfaces, and greenery.	Yes	Yes	Yes	Can't	Can't	Medium-high
MM10	Capodaglio, E. M. (2017). Occupational risk and prolonged standing work in apparel sales assistants. International Journal of Industrial Ergonomics, 60, 53–59.	Miscellaneous occupations	**Purpose:** to analyse activities and body postures among sales assistants in clothing retail. Method: structured ergonomics observations (RULA, REBA, Strain Index, OCRA) and data from activity bracelets (n=70) from 9 clothing shops. Conclusions: the study identified injury risks associated with long-term standing postures.	Yes	Yes	Can't tell	Can't tell	No	Debatable

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 5.1	Question 5.2	Question 5.3	Question 5.4	Question 5.5	Quality
MM11	Chaiklieng, S., & Krusun, M. (2015). Health Risk Assessment and Incidence of Shoulder Pain Among Office Workers. Procedia Manufacturing, 3, 4941–4947.	Knowledge work	**Purpose:** to study injury risks and symptoms associated with the shoulders of office workers. Method: observations (using the ROSA assessment method), questionnaires (n=231) and log data concerning pain and treatment. Conclusions: the study identified medium-high risk for shoulder symptoms.	Yes	No	No	No	No	Debatable
MM12	Choi, S. D. (2010). Ergonomic assessment of musculoskeletal discomfort of iron workers in highway construction. Work, 36(1), 47–53.	Industry	**Purpose:** to assess injury risks associated with road construction work. Method: biometric data linked to hand grips, and body maps for subjective data collection (n=11, 11M). **Conclusions:** the study identified injury risks associated with hands and back.	Yes	Yes	No	No	Yes	Debatable
MM13	Chowdhury, N., Aghazadeh, F., & Amini, M. (2018). Ergonomic assessment of working postures for the design of university computer workstations. Occupational Ergonomics, 13(S1), 37–46.	Knowledge work	**Purpose:** to study the effects of office design with regard to work-related physical loading. Method: structured ergonomics observations (RULA, REBA, OSHA Checklist) and questionnaire data (n=72). Conclusions: the study identifies screen positioning as the most decisive design aspect that impacts physical loading among office workers.	Can't tell	No	Can't tell	No	No	Debatable
MM14	Coffeng, J. K., Hendriksen, I. J. M., van Mechelen, W., & Boot, C. R. L. (2013). Process Evaluation of a Worksite Social and Physical Environmental Intervention. Journal of Occupational and Environmental Medicine, 55(12), 1409–1420.	Knowledge work	**Purpose:** to evaluate the implementation process regarding changes in social and physical work environments in offices. Method: log data and documentation of activities, observations and questionnaires from three intervention groups (n=197). Conclusions: (i) engagement among employees and group leaders/ managers during the entire process, and (ii) a combination of changes in both social and physical work environments yield better results than individual interventions.	Yes	Can't tell	Yes	Yes	Can't tell	Medium-high
MM15	Dianat, I., Sedghi, A., Bagherzade, J., Jafarabadi, M. A., & Stedmon, A. W. (2013). Objective and subjective assessments of lighting in a hospital setting: implications for health, safety and performance. Ergonomics, 56(10), 1535–1545.	Healthcare	**Purpose:** to assess workplace well-being factors related to lighting conditions in a hospital. Method: questionnaire study (n=208) and light level measurements. Conclusions: glare/flickering and dark shadows were identified as deficiencies in the lighting conditions.	Yes	Yes	Yes	Yes	Yes	High
MM16	Eaves, S., Gyi, D. E., & Gibb, A. G. F. (2016). Building healthy construction workers: Their views on health, wellbeing and better workplace design. Applied Ergonomics, 54, 10–18.	Industry	**Purpose:** to study experiences regarding job-related health in the construction industry. Method: questionnaire study (n=80) and interviews. Conclusions: Most of the participants, particularly the older ones, had experienced injury symptoms connected to their work.	Yes	Yes	Yes	Can't tell	Can't tell	Medium-high

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 5.1	Question 5.2	Question 5.3	Question 5.4	Question 5.5	Quality
MM17	Fay, L., Carll-White, A., & Real, K. (2018). Emergency Nurses' Perceptions of Efficiency and Design: Examining ED Structure, Process, and Outcomes. Journal of Emergency Nursing, 44(3), 274–279.	Healthcare	**Purpose:** to study efficiency and satisfaction with the design of acute care among emergency nurses. Method: use of step counters (n=79), questionnaire study (n=78) and observations. Conclusions: work processes and the physical design impact satisfaction and perceived efficiency.	Yes	Can't tell	Yes	Can't tell	Can't tell	Debatable
MM18	Fethke, N. B., Schall, M. C., Determan, E. M., & Kitzmann, A. S. (2015). Neck and shoulder muscle activity among ophthalmologists during routine clinical examinations. International Journal of Industrial Ergonomics, 49, 53–59.	Healthcare	**Purpose:** to identify activities among ophthalmologists and their muscle activity in neck/shoulders. Method: observations and biometric data (n=15). Conclusions: computer work was the most common, but the most physically strenuous activities were associated with microscope use.	Yes	Yes	Yes	Yes	Yes	High
MM19	Fruchter, R., & Bosch-Sijtsema, P. (2011). The WALL: participatory design workspace in support of creativity, collaboration, and socialization. AI & SOCIETY, 26(3), 221–232.	Knowledge work	**Purpose:** to map knowledge workers' daily activities and identify factors conducive to productivity. Method: shadowing, questionnaire study (n=11) and interviews (n=2). Conclusions: the study emphasizes the importance of a central project visualization board that supports active participation of group members and social interaction.	Yes	Yes	Yes	Can't tell	Yes	High
MM20	Gangopadhyay, S., Das, T., Ghoshal, G., & Ghosh, T. (2006). Work organization in sand core manufacturing for health and productivity. International Journal of Industrial Ergonomics, 36(10), 915–920.	Industry	**Purpose:** to increase the efficiency of sand core manufacturing for better health and productivity. Method: Nordic questionnaire (n=30, 30M) and structured observations (OWAS). Conclusions: the study recommends changes in bench height and reorganization of the work.	Yes	Yes	Yes	No	Can't tell	Debatable
MM21	Ghasemi, M. S., Hosseinzadeh, P., Zamani, F., Ahmadpoor, H., & Dehghan, N. (2017). Ergonomic design and evaluation of a diagnostic ultrasound transducer holder. International Journal of Occupational Safety and Ergonomics, 23(4), 519–523.	Healthcare	**Purpose:** to develop and evaluate an ergonomically designed holder for an ultrasound transducer. Method: use of design principles for product development plus biometric data for muscle activities and subjective discomfort measurements on students (n=12, 7M/5W). Conclusions: the new design led to less uncomfortable wrist positions.	Yes	Yes	Yes	No	Can't tell	Medium-high
MM22	Gonen, D., Oral, A., & Yosunlukaya, M. (2016). Computer-Aided Ergonomic Analysis for Assembly Unit of an Agricultural Device. Human Factors and Ergonomics in Manufacturing & Service Industries, 26(5), 615–626.	Miscellaneous occupations	**Purpose:** to assess body postures associated with farming machinery assembly. Method: observations and simulation of the work. Conclusions: the study proposes changes in the organization of the work and the design of the physical environment so as to minimize injury risks.	Can't tell	Can't tell	Yes	No	No	Debatable

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 5.1	Question 5.2	Question 5.3	Question 5.4	Question 5.5	Quality
MM23	Jensen, L. K., & Kofoed, L. B. (2002). Musculoskeletal Disorders Among Floor Layers: Is Prevention Possible? Applied Occupational and Environmental Hygiene, 17(11), 797–806.	Industry	**Purpose:** to identify possible means of preventing injuries among floor layers. Method: questionnaire (n=102 experts, n=180 novices) and interviews (n=88 floor layers, n=16 other actors such as management, union representatives and training leaders). Conclusions: the most decisive change has to do with minimizing kneeling positions.	Yes	Yes	Yes	Can't tell	Yes	Medium-high
MM24	Kim, J. H., Aulck, L., Trippany, D., & Johnson, P. W. (2015). The effects of work surface hardness on mechanical stress, muscle activity, and wrist postures. Work, 52(2), 231–244.	Knowledge work	**Purpose:** to study the effects of softer table surfaces during computer work. Method: contact pressure, wrist position, perceived fatigue and comfort, biometric data on muscle activity and typing speed (n=18, 10M/8W) were measured in three experiments. Conclusions: softer surfaces resulted in lower contact pressure and fatigue, but no differences in terms of muscle activity or comfort. However, the study does recommend softer support surfaces.	Yes	Yes	Yes	Yes	Yes	High
MM25	Kluth, K., & Strasser, H. (2006). Ergonomics in the rescue service – Ergonomic evaluationof ambulance cots. International Journal of Industrial Ergonomics, 36(3), 247–256.	Healthcare	**Purpose:** to evaluate 3 ambulance cots. Method: biometric data and questionnaire (n=12, 12M). Conclusions: the study recommends solutions in terms of weight, design and positioning of the handle and height-adjusting mechanism.	Can't tell	Yes	Yes	Can't tell	Can't tell	Debatable
MM26	Kogi, K., Kawakami, T., Itani, T., & Batino, J. M. (2003). Low-cost work improvements that can reduce the risk of musculoskeletal disorders. International Journal of Industrial Ergonomics, 31(3), 179–184.	Industry	**Purpose:** to describe low-cost solutions that lead to lower physical loading in material-handling activities. Method: pulse measurements and biometric data on muscle activity at 20 small companies. **Conclusions:** examples of solutions included the use of aids for heavy lifting, tables and chairs of suitable height, and the introduction of breaks.	No	Can't tell	Can't tell	Can't tell	Can't tell	Debatable
MM27	Kumar, R., Chaikumarn, M., & Lundberg, J. (2005). Participatory Ergonomics and an Evaluation of a Low-Cost Improvement Effect on Cleaners' Working Posture. International Journal of Occupational Safety and Ergonomics, 11(2), 203–210.	Miscellaneous occupations	**Purpose:** to apply a participatory ergonomic intervention in order to identify problems associated with cleaning work. **Method:** a workshop (n=23, 23W) for identifying problems and solutions, plus evaluation of solutions using the OWAS analysis method (n=10, 10 W). Conclusions: implementation of low-cost solutions led to lower physical loading.	Yes	Yes	Yes	Can't tell	Can't tell	Medium-high
MM28	Kuster, R. P., Bauer, C. M., Gossweiler, L., & Baumgartner, D. (2018). Active sitting with backrest support: Is it feasible? Ergonomics, 61(12), 1685–1695.	Knowledge	**Purpose:** to study active sitting with back support during computer work. Method: motion tracking and questionnaire (n=8, 4M/4W) in a comparison of three chairs. Conclusions: active sitting with back support resulted in better posture and greater comfort.	Yes	No	Can't tell	Yes	No	Debatable

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 5.1	Question 5.2	Question 5.3	Question 5.4	Question 5.5	Quality
MM29	Landau, K., & Peters, H. (2006). Ergonomic demands in automotive component inspection tasks. Occupational Ergonomics, 6(2), 95–105.	Industry	**Purpose:** to assess and offer recommendations for more ergonomic work in the automotive industry. Method: observations using the Workplace Design Checklist tool at 5 subcontractors, development of solutions and training. Conclusions: the study proposed solutions to address problems in terms of long reach distances, a lack of organization in parts deliveries and associated difficulties in reaching parts for assembly.	Yes	Yes	Yes	No	Can't tell	Medium-high
MM30	Lee, Y.-H., & Su, M.-C. (2008). Design and validation of a desk-free and postureindependent input device. Applied Ergonomics, 39(3), 399–406.	Knowledge work	**Purpose:** to study physical loading and performance associated with the use of computer mice, trackpads and a new portable data input device worn on the thumb or index finger. Method: biometric data, subjective assessment plus time and number of errors associated with performing a test (n=20, 11M/9W). Conclusions: there was less physical strain on the neck and a more positive rating of the new device, but it reduced performance.	Yes	Can't tell	Yes	No	Yes	Debatable
MM31	Löfqvist, L., Osvalder, A.-L., Bligård, L.-O., & Pinzke, S. (2015). An analytical ergonomic risk evaluation of body postures during daily cleaning tasks in horse stables. Work, 51(4), 667–682.	Miscellaneous occupations	**Purpose:** to evaluate physical ergonomics in horse stable work. Method: structured observations in a lab environment using the HTA, HE and REBA analysis methods (n=1). Conclusions: the study identified risks associated with back, shoulders and wrists due to heavy lifting and inadequate tools.	Yes	Yes	Yes	Yes	Can't tell	Medium-high
MM32	Majumder, J., Shah, P., & Bagepally, B. S. (2016). Task distribution, work environment, and perceived health discomforts among Indian ceramic workers. American Journal of Industrial Medicine, 59(12), 1145–1155.	Industry	**Purpose:** to map work environment risks for ceramic workers in India. Method: temperature measurements, structured observations and questionnaire (n=329, 329M). Conclusions: The study identifies work environmental, physical, psychosocial and organizational deficiencies in the work environment.	Yes	Yes	Yes	Can't tell	Can't tell	Debatable
MM33	Malińska, M., Bugajska, J., Kamińska, J., & Jędryka-Góral, A. (2012). Analysis of Conditions and Organization of Work of Notebook Computer Users. International Journal of Occupational Safety and Ergonomics, 18(3), 443–449.	Knowledge work	**Purpose:** to assess working conditions associated with laptop use. Method: questionnaire (n=300) and observations of participants (n=53). Conclusions: the study identifies deficiencies in adjustability and adaptation of the workplace.	Yes	Yes	Yes	No	Yes	Medium-high
MM34	Mauro, C. L., Fisher, E., Korpan, D., & Medrano, P. A. (2015). Ergonomic Redesign of a Traditional Jewelry-Polishing Workstation. Ergonomics in Design: The Quarterly of Human Factors Applications, 23(1), 4–12.	Miscellaneous occupations	**Purpose:** to describe the user-centred creation of a new ergonomic work surface for jewellery polishing. Method: observations and analysis of body postures, creation and assessment of prototypes. Conclusions: the study proposed a more ergonomic solution than existing variants.	Yes	Yes	Can't tell	Can't tell	No	Debatable

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 5.1	Question 5.2	Question 5.3	Question 5.4	Question 5.5	Quality
MM35	Miguez, S. A., Hallbeck, M. S., & Vink, P. (2012). Participatory ergonomics and new work: Reducing neck complaints in assembling. Work, 41(SUPPL.1), 5108–5113.	Industry	**Purpose:** to assess proposed solutions for a physical stress-relieving assembly counter for mobile phone assembly. Method: participatory and iterative process for identifying problems and solutions, plus structured observations (RULA) and interviews before and after the change (n=28, 100% W). Conclusions: the new solutions brought lower injury risks and greater comfort.	Yes	Yes	Yes	Can't tell	Yes	Medium-high
MM36	Mitropoulos, P., & Memarian, B. (2013). Task Demands in Masonry Work: Sources, Performance Implications, and Management Strategies. Journal of Construction Engineering and Management, 139(5), 581–590.	Industry	**Purpose:** to map risks in masonry work. Method: subjective assessment of demands using NASA-TLX (n=22), interviews (n=44) and observations. Conclusions: the study recommends measures to enhance performance and safety tied to the minimization of delays, mistakes and re-work.	Yes	Yes	Yes	Can't tell	Can't tell	Medium-high
MM37	Moraes, A. S. P., Arezes, P. M., & Vasconcelos, R. (2012). From ergonomics to design specifications: Contributions to the design of a processing machine in a tire company. Work, 41(SUPPL.1), 552–559.	Industry	**Purpose:** to assess and further develop the design of a tyre replacement centre. Method: interviews and observations, creation of requirement specifications via a participatory process. Conclusions: the study emphasizes challenges associated with the implementation of ergonomic measures.	Yes	Yes	Yes	Can't tell	Can't tell	Medium-high
MM38	Mourshed, M., & Zhao, Y. (2012). Healthcare providers' perception of design factors related to physical environments in hospitals. Journal of Environmental Psychology, 32(4), 362–370.	Healthcare	**Purpose:** to study caregiver perceptions of a physical work environment. Method: questionnaire study at 2 hospitals (n=305, 110M/194W) and interviews (n=12). Conclusions: key aspects from the caregiver perspective were related to the physical work environment, and to maintenance.	Yes	Yes	Yes	Yes	Can't tell	High
MM39	Neeraja, T., Lal, B. I. A. S., & Swarandish, C. The factors associated with MSDs among construction workers. Journal of Human Ergology, 43(1), 1–8.	Industry	**Purpose:** to identify factors that lead to injuries in the construction industry. Method: questionnaire (n=220, 152M/68W). Conclusions: Improved work environment in terms of tools and the physical environment is needed to counteract injuries.	Yes	Can't tell	Can't tell	Can't tell	Can't tell	Debatable
MM40	Noad, N. H., Choobineh, A., Rahimifard, H., Haidari, H. R., & Reza Tabatabaei, S. H. (2013). Musculoskeletal Risk Assessment in Small Furniture Manufacturing Workshops. International Journal of Occupational Safety and Ergonomics, 19(2), 275–284.	Industry	**Purpose:** to study injury risks in the furniture industry. Method: questionnaire study (n=410) and preparation of a checklist for structured observations. Conclusions: material handling, deficient design of the physical environment and work organization led to risks for knee, back and hand/wrist injuries.	Yes	Yes	No	No	No	Debatable

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 5.1	Question 5.2	Question 5.3	Question 5.4	Question 5.5	Quality
MM41	Noati, A., Rodiek, S., & Shepley, M. (2016). The implications of high-quality staff break areas for nurses' health, performance, job satisfaction and retention. Journal of Nursing Management, 24(4), 512–523.	Healthcare	**Purpose:** to study the relationship between break areas and satisfaction, performance and health among nurses. Method: interviews (n=10) and questionnaire study (n=993). Conclusions: well-designed break areas bring higher satisfaction and performance.	Yes	Yes	Yes	Can't tell	Yes	High
MM42	Neumann, W. P., Winkel, J., Medbo, L., Magneberg, R., & Mathiassen, S. E. (2006). Production system design elements influencing productivity and ergonomics: A case study of parallel and serial flow strategies. International Journal of Operations and Production Management, 26(8), 904–923.	Industry	**Purpose:** to study how changes in the organization of assembly work affect health and productivity. Method: production data, interviews, structured observations and questionnaire (n=54, 49M/5W) before and after modified organization of the assembly work. Conclusions: both solutions brought high perceived pain. The study recommends a combination of solutions.	Yes	Yes	Yes	Can't tell	Can't tell	High
MM43	Ning, X., Huang, Y., Hu, B., & Nimbarte, A.D. (2015). Neck kinematics and muscle activity during mobile device operations. International Journal of Industrial Ergonomics, 48, 10–15.	General	**Purpose:** to assess muscle activity while working with mobile devices. Method: 3 scenarios were studied using biometric data (EMG) and NASA-TLX for subjective assessment (n=14, 10M/4W). Conclusions: long-term use of mobile devices leads to risks of back/neck injuries.	Can't tell	Can't tell	Can't tell	No	No	Debatable
MM44	Noro, K., Fujimaki, G., & Kishi, S. (2003). Evidence-Based Ergonomics. A Comparison of Japanese and American Office Layouts. International Journal of Occupational Safety and Ergonomics, 9(4), 527–538.	Knowledge	**Purpose:** to support the choice of an office design. Method: lab tests with eye movement measurements (n=3) as a measure of the need for concentration and interaction. Conclusions: places along a long table without separation can support work that requires interaction, while places around a cluster with separation screens can support work that requires concentration.	Can't tell	Yes	Can't tell	No	Yes	Debatable
MM45	Ohlendorf, D., Erbe, C., Hauck, I., Nowak, J., Hermanns, I., Ditchen, D., … Groneberg, D. A. (2016). Kinematic analysis of work-related musculoskeletal loading of trunk among dentists in Germany. BMC Musculoskeletal Disorders, 17(1), 427.	Healthcare	**Purpose:** to assess body postures during dental work. Method: measurement of body movements (n=21, 10M/11W) and structured observations (OWAS). Conclusions: the study identifies tasks associated with unergonomic positions and recommends design modifications and ergonomics training as remedial measures.	Yes	Yes	Yes	Can't tell	No	Medium-high
MM46	Panainte-Lehăduş, M., Nedeff, F., Petrovici, A., Telibaşa, G., Felegeanu, D. C., & Schnakovszky, C. (2016). Assessing the health and safety risks in the education sector. Environmental Engineering and Management Journal, 15(3), 563–572.	Miscellaneous occupations	**Purpose:** to assess injury risks at a Romanian technical college. Method: quantitative risk assessment with regard to staff (n=84) and students (n=2,385). Conclusions: the study identified the design of workplaces associated with computer work as posing a risk to staff. Risk factors among students were associated with workshops.	Can't tell	Yes	Can't tell	No	No	Debatable

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 5.1	Question 5.2	Question 5.3	Question 5.4	Question 5.5	Quality
MM47	Parimalam, P., Premalatha, M. R., Padmini, D. S., & Ganguli, A. K. (2012). Participatory ergonomics in redesigning a dyeing tub for fabric dyers. Work, 43(4), 453–458.	Miscellaneous occupations	**Purpose:** development and assessment of a new fabric dyeing tub via a participatory process. **Method:** iterative and participatory process for identifying needs and formulating proposals, plus performance measurements and discomfort assessment. Conclusions: the new solution reduced discomfort from high to medium-high, and increased productivity.	Can't tell	Yes	Can't tell	No	Can't tell	Debatable
MM48	Phillips, K., Bills, J., & Gare, J. (2016). Developing modified equipment and work practices to reduce the risk of workrelated musculoskeletal disorders from conservation treatment. AICCM Bulletin, 37(1), 42–48.	Miscellaneous occupations	**Purpose:** to study solutions for minimizing injury risks in conservation work. Method: participatory process for creating solutions and questionnaire study for assessment. Conclusions: solutions included adjustable work surfaces, neck support for prone work, and angled surfaces for sitting work involving textiles.	Can't tell	No	No	No	No	Debatable
MM49	Quemelo, P. R. V., & Vieira, E. R. (2013). Biomechanics and performance when using a standard and a vertical computer mouse. Ergonomics, 56(8), 1336–1344.	Knowledge work	**Purpose:** to compare muscle activity and performance when using 2 different computer mice. Method: questionnaire, biometric data on muscle activity and performance measurements (n=16). Conclusions: the vertical mouse entailed lower physical loading than the standard mouse, but also lower performance.	Yes	Can't tell	Can't tell	No	Can't tell	Debatable
MM50	Reinhold, K., Tint, P., Tuulik, V., & Saarik, S. (2008). Innovations at workplace: Improvement of ergonomics. Engineering Economics, 5(60), 85–94.	Multi-occupation	**Purpose:** to analyse injury risks associated with heavy lifting. Method: creation of a checklist and test in 7 different work environments (n=230, 16M/241W). Conclusions: the study identifies pain in the neck, back, shoulders, wrists, legs and knees.	Yes	Yes	Yes	Can't tell	Can't tell	Medium-high
MM51	Robertson, M. M., Huang, Y. H., & Lee, J. (2017). Improvements in musculoskeletal health and computing behaviors: Effects of a macroergonomics office workplace and training intervention. Applied Ergonomics, 62, 182–196.	Knowledge work	**Purpose:** to assess the effects of a flexible office and ergonomics training with respect to work-related musculoskeletal disorders. **Method:** 3 groups (control: n=42; flexible office: n=14; flexible office + training: n=26) took part in a longitudinal study that included questionnaires, observations (RULA) and testing of ergonomic knowledge. **Conclusions:** both interventions brought better body postures and less discomfort. The combination of training and a flexible office yielded better results.	Yes	Yes	Can't tell	Can't tell	Yes	Medium-high
MM52	Robertson, M., Amick, B. C., DeRango, K., Rooney, T., Bazzani, L., Harrist, R., & Moore, A. (2009). The effects of an office ergonomics training and chair intervention on worker knowledge, behavior and musculoskeletal risk. Applied Ergonomics, 40(1), 124–135.	Knowledge work	**Purpose:** to study the effects of ergonomics training and adjustable chairs on ergonomics knowledge and injury risk among office workers. Method: 3 groups (control: n=57; training: n=63; adjustable chair + training: n=96) took part in a longitudinal study involving questionnaires, observations (OEA, RULA) and testing of ergonomic knowledge. Conclusions: both interventions led to better body posture and lower injury risk, as well as greater control over the environment.	Yes	Yes	No	Can't tell	Yes	Medium-high

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 5.1	Question 5.2	Question 5.3	Question 5.4	Question 5.5	Quality
MM53	Randais, É., Atkinson, S., Guilbeault, M., & Bussières, J.-F. (2014). Nursing Perception of the Impact of Automated Dispensing Cabinets on Patient Safety and Ergonomics in a Teaching Health Care Center. Journal of Pharmacy Practice, 27(2), 150–157.	Healthcare	**Purpose:** to assess an automated dispensing cabinet from the nurses' perspective. Method: questionnaire (n=172) and a focus group interview (n=5). Conclusions: the cabinets facilitated the nurses' work and resulted in higher patient safety in connection with the dispensing of medications.	Yes	Yes	Yes	No	No	Debatable
MM54	Sagha Zadeh, R., Shepley, M. M., Owora, A. H., Dannenbaum, M. C., Waggener, L. T., & Chung, S. S. E. (2018). The Importance of Specific Workplace Environment Characteristics for Maximum Health and Performance. Journal of Occupational and Environmental Medicine, 60(5), e245–e252.	Healthcare	**Purpose:** to identify workplace well-being associated with workplaces in healthcare environments. Method: questionnaire study and open questions collected from 3 healthcare environments (n=174). Conclusions: the identified workplace well-being factorsnvaried depending on age, gender, the specific work and the context.	Yes	Yes	Yes	Can't tell	Can't tell	Medium-high
MM55	Sanjog, J., Patel, T., & Karmakar, S. (2019). Occupational ergonomics research and applied contextual design implementation for an industrial shop-floor workstation. International Journal of Industrial Ergonomics, 72, 188–198.	Industry	**Purpose:** to identify injury risks in the furniture industry and propose remedial measures. **Method:** questionnaire study (n=46), structured observations (OWAS/REBA) of work in plastic injection moulding, and simulations of new proposals. Conclusions: The study identified problems with reach as a contributing risk factor, and proposed remedial measures were analysed using simulations.	Can't tell	No	No	No	Can't tell	Debatable
MM56	Sheehan, B., Burton, E., Wood, S., Stride, C., Henderson, E., & Wearn, E. (2013). Evaluating the Built Environment in Inpatient Psychiatric Wards. Psychiatric Services, 64(8), 789–795.	Healthcare	**Purpose:** to develop performance metrics for the built environment for psychiatric care. Method: structured observations (Built environment checklist) in 98 healthcare environments, plus questionnaires (n=1,540). Conclusions: caregiver satisfaction was linked to non-corridor-based environments and private bathrooms for patients.	Yes	Yes	Can't tell	Can't tell	Can't tell	Debatable
MM57	Silva, L. C. C. B., Oliveira, A. B., Silva, D. C., Paschoarelli, L. C., & Coury, H. J. C. G. (2013). 30° inclination in handles of plastic boxes can reduce postural and muscular workload during handling. Brazilian Journal of Physical Therapy, 17(3), 307–318.	Industry	**Purpose:** to compare 7 types of boxes for material handling. Method: measurement of muscle activity (EMG) and subjective assessment (n=37, 37M). Conclusions: one of the boxes with a 30° handle resulted in a more neutral wrist position and lower muscle activity in the shoulders and arms, and garnered greater acceptance among users.	Yes	Yes	Yes	Yes	Yes	High
MM58	Smith, T. J. (2012). A comparative study of occupancy and patient care quality in four different types of intensive care units in a children's hospital. Work, 41, 1961–1968.	Healthcare	**Purpose:** to compare occupancy and quality in 4 intensive care units for children. **Method:** questionnaire study (n=67, 3M/64W), observations and task analysis. **Conclusions:** the study describes various healthcare tasks, along with success factors and deficiencies in the 4 environments associated with performance.	Yes	No	No	Can't tell	No	Debatable

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 5.1	Question 5.2	Question 5.3	Question 5.4	Question 5.5	Quality
MM59	Smith, T. J., Schoenbeck, K., & Clayton, S. (2009). Staff perceptions of work quality of a neonatal intensive care unit before and after transition from an open bay to a private room design. Work, 33(2), 211–227.	Healthcare	**Purpose:** to assess a move from an open-bay neonatal intensive care unit to private patient rooms. Method: questionnaire study before (n=79), 6 months (n=74) and 22 months (n=80) after the move, plus interviews before and after the move (n=33, 33W), and observations. Conclusions: the group and management were not prepared to work in the new environment, and consequently perceived no differences in the quality of the environment.	Yes	Yes	No	Yes	Can't tell	Medium-high
MM60	Spasojević Brkić, V. K., Klarin, M. M., & Brkić, A. D. (2015). Ergonomic design of crane cabin interior: The path to improved safety. Safety Science, 73, 43–51.	Industry	Purpose: to identify user needs among crane operators. Method: observations of 23 crane cabins and assessment based on anthropometric data from operators (n=74). Conclusions: crane cabins are not designed based on the users' needs in terms of anthropometrics.	Can't tell	Yes	Yes	Can't tell	Can't tell	Debatable
MM61	Spielholz, P., Bao, S., & Howard, N. (2001). A Practical Method for Ergonomic and Usability Evaluation of Hand Tools: A Comparison of Three Random Orbital Sander Configurations. Applied Occupational and Environmental Hygiene, 16(11), 1043–1048.	Industry	**Purpose:** to assess oscillating sanders based on ergonomics and usability. Method: comparison of three tools, biometric data on muscle activity, video observations of hands and hand movements, plus "think-aloud" observations and questionnaire for usability assessment (n=3). Conclusions: no significant differences in muscle activity were observed, but the participants did prefer one of the models.	Yes	Yes	Yes	Yes	No	Medium-high
MM62	Straker, L., Levine, J., & Campbell, A. (2009). The Effects of Walking and Cycling Computer Workstations on Keyboard and Mouse Performance. Human Factors: The Journal of the Human Factors and Ergonomics Society, 51(6), 831–844.	Knowledge work	**Purpose:** to assess performance at workstations with treadmills and cycles. Method: comparison of 6 types of workstations using standardized computer tasks and pulse measurements (n=39). Conclusions: performance was lower with treadmills and cycles than with office chairs.	Yes	Yes	Can't tell	Can't tell	Can't tell	Debatable
MM63	Vogel, K., & Eklund, J. (2015). On physiological demands and sustainability in meat cutting. Ergonomics, 58(3), 463–479.	Miscellaneous occupations	**Purpose:** to assess physiological work demands in the meat cutting industry. Method: biometric data (pulse measurements over one workday, RAS, BMI), interviews and observations (n=21, 21M). Conclusions: the study identified unsustainable demands in the meat cutting industry, which varied depending on the type of meat, employee experience, knives, tempo and working method.	Yes	Yes	Yes	Can't tell	Can't tell	Medium-high
MM64	Vujica Herzog, N., Vujica Beharic, R., Beharic, A., & Buchmeister, B. (2014). Ergonomic Analysis of Ophthalmic Nurse Workplace Using 3D Simulation. International Journal of Simulation Modelling, 13(4), 409–418.	Healthcare	**Purpose:** to study working conditions of ophthalmic nurses in terms of physical strain and stress. Method: structured observations and simulations (using OWAS and RULA analysis tools). Conclusions: the study identified back and neck strain.	Yes	Yes	Can't tell	No	Can't tell	Debatable

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 5.1	Question 5.2	Question 5.3	Question 5.4	Question 5.5	Quality
MM65	Wang, H., Hwang, J., Lee, K.-S., Kwag, J.-S., Jang, J.-S., & Jung, M.-C. (2014). Upper Body and Finger Posture Evaluations at an Electric Iron Assembly Plant. Human Factors and Ergonomics in Manufacturing & Service Industries, 24(2), 161–171.	Industry	**Purpose:** to assess body postures during assembly of electric irons. Method: video observations (n=17, 12M/5W). Conclusions: the study identified the tasks associated with the most and least physical strain.	Yes	Yes	Can't	Can't	No	Debatable
MM66	Wang, H., Kong, Y.-K., & Jung, M.-C. (2012). Postural Evaluation in a Poultry Farm for Broiler Chickens. International Journal of Occupational Safety and Ergonomics, 18(1), 67–75.	Industry	Purpose: to assess work associated with poultry production. Method: analysis of postures (n=5) during 9 steps in the production process. Conclusions: the study identified injury risks pertaining to the back, hands and legs due to deficient workplace design.	Yes	Yes	Can't tell	Can't tell	No	Debatable
MM67	Woods, V., & Buckle, P. (2005). An investigation into the design and use of workplace cleaning equipment. International Journal of Industrial Ergonomics, 35(3), 247–266.	Miscellaneous occupations	**Purpose:** to assess three types of cleaning equipment. Method: questionnaire study, observations and interviews (n=60), analysis of equipment in lab environment (n=10) plus two focus group interviews (n=21). Conclusions: pain and discomfort in back, neck and arms occurred among the participants. The study generated guidelines for the design and procurement of such equipment.	Yes	Yes	Yes	Can't tell	Yes	High
MM68	Yazigi, S., Yazigi, R., Porfiro, F. C., & Oliveira, R. C. de. (2015). Activities Triggered by Waste Generated in Steel Production: A Study from the Ergonomics Standpoint. Procedia Manufacturing, 3, 4517–4519.	Industry	**Purpose:** to map job tasks associated with metal recycling. Method: observations, interviews and ergonomic analysis of the workplace (using the EWA analysis tool). Conclusions: the design of the tools and the workplace entailed injury risks.	No	No	No	Can't tell	No	Debatable
MM69	You, H., Kumar, A., Young, R., Veluswamy, P., & Malzahn, D. E. (2005). An ergonomic evaluation of manual Cleco plier designs: Effects of rubber grip, spring recoil, and worksurface angle. Applied Ergonomics, 36(5), 575–583.	Industry	**Purpose:** to evaluate two variants of grip designs for pliers. Method: measurements of muscle activity (EMG), questionnaire and subjective discomfort assessment on a hand map (n=11). Conclusions: rubber grip and angling the work surface 60 degrees yielded the lowest muscle activity.	Yes	Yes	Yes	Yes	Yes	High
MM70	Zhu, X., & Shin, G. (2012). Shoulder and neck muscle activities during typing with articulating forearm support at different heights. Ergonomics, 55(11), 1412–1419.	Knowledge work	**Purpose:** to study the effects of forearm support height on discomfort and muscle activity in keyboard work. Method: performance of common keyboard work (n=24) with forearm support at three different heights and without forearm support, plus measurement of muscle activity (EMG) and subjective comfort assessment. Conclusions: keyboard work with forearm support at resting elbow height generated the least muscle activity, but caused greater strain at other heights than without forearm support.	Yes	No	Can't tell	Yes	Yes	Medium-high

	Reference	Occupational category	Content (n=final no. of participants after all eliminations; if gender distribution is clearly stated: M = men/W = women)	Question 5.1	Question 5.2	Question 5.3	Question 5.4	Question 5.5	Quality
MM71	Zunjic, A., Brkic, V. S., Klarin, M., Brkic, A., & Krstic, D. (2015). Anthropometric assessment of crane cabins and recommendations for design: A case study. Work, 52(1), 185–194.	Industry	**Purpose:** to assess crane cabin design in terms of anthropometrics. Method: anthropometric measurements and interviews (n=64, 64M) plus observations of 7 different cabins. Conclusions: the analysed cabins were not adapted for most operators.	Yes	Yes	Can't tell	Can't tell	No	Debatable
MM72	Öhrling, T., Kumar, R., & Abrahamsson, L. (2012). Assessment of the development and implementation of tools in contract cleaning. Applied Ergonomics, 43(4), 687–694.	Miscellaneous occupations	**Purpose:** to evaluate ergonomic cleaning equipment and its use in the cleaning service sector. Method: biometric measures of muscular activity, interviews and subjective assessment of exertion (n=13) was carried out in relation to two loading scenarios. Conclusions: the study showed that ergonomic equipment can improve work conditions, but organizational and contextual aspects must be considered to achieve desired effects.	Can't tell	Yes	Can't tell	Can't tell	No	Debatable

Quality appraisal of included literature reviews (based on CASP)

This appendix reports results from our quality appraisal of literature reviews, which were assessed by two appraisers. Good consistency between the appraisers' assessments and highest quality is noted for articles L3, L7, L10 and L14, based on CASP. In the absence of appraiser agreement we reconciled the responses from the appraisers through a discussion, as a rule adjusting toward the more severe appraisal. The comparison focuses on the first five questions from CASP, as those questions capture the methodological aspects of literature studies:

Question 1. Did the review address a clearly focused question?

Question 2. Did the authors look for the right type of papers?

Question 3. Do you think all the important, relevant studies were included?

Question 4. Did the review's authors do enough to assess the quality of the included studies?

Question 5. If the results of the review have been combined, was it reasonable to do so?

CASP Questions 6–10 reflect the original intention with the template, which is to appraise health sciences literature with a patient-focus and based on treatment efficacy, which has limited relevance to this literature review.

Questions 6 (What are the overall results of the review?) and 7 (How precise are the results?) are answered with * to indicate that they were answered in free text concerning the content of the article and the exactitude of that content, which is reported in the "Content" column.

Questions 8 (Can the results be applied to the local population?), 9 (Were all important outcomes considered?) and 10 (Are the benefits worth the harms and costs?) were answered in truncated fashion with Y=Yes, N=No or C= Can't tell.

	Reference	Occupational category	Content (n=final no. of included studies)	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	Question 9	Question 10	Quality
L1	Brambilla, A., Rebecchi, A., & Capolongo, S. (2019). Evidence Based Hospital Design. A literature review of the recent publications about the EBD impact of built environment on hospital occupants' and organizational outcomes. Annali Di Igiene, 31(2), 165–180.	Healthcare	**Purpose:** to study the most important built environment-related outcomes of evidence-based hospital building design, with regard to individuals and the organization. Method: systematic literature review in 2 databases (n=35, 2016–2018). Conclusions: the most important results pertain to the visual work environment (29%), acoustic environment (20%) and patient room design (20%). The build environment affects job satisfaction among staff and patient outcomes.	Yes	Yes	Can't tell	No	Yes	*	*	C	Y	C	Medium-high
L2	Burnard, M. D., & Kutnar, A. (2015). Wood and human stress in the built indoor environment: a review. Wood Science and Technology, 49(5), 969–986.	General	**Purpose:** to study how the material wood can be used in the restorative design of work environments to reduce individual stress. Method: a "critical" search in English quality-appraised literature yielded 4 journal articles and one doctoral thesis (n=5, 2002–2010). Several other books and articles were included as "support" for understanding recovery and stress. Conclusions: more studies are needed to examine psychophysical reactions to wood, but the material generally appears promising for restorative design. Suggestions for future experiments are offered.	No	Can't tell	No	No	Can't tell	*	*	C	C	C	Debatable
L3	Engelen, L., Chau, J., Young, S., Mackey, M., Jeyapalan, D., & Bauman, A. (2019). Is activity-based working impacting health, work performance and perceptions? A systematic review. Building Research & Information, 47(4), 468–479.	Knowledge work	**Purpose:** to study whether there is an evidence base in the literature for whether activity-based working impacts health, job performance and perceptions of the work environment. Method: a systematic literature review in 8 databases (n=17, 36,039 participants). A number of different study types were included. Conclusions: activity-based working promotes interaction, communication, control over time and space, and satisfaction, but is detrimental to concentration and privacy. The conclusions for physical and mental health are conflicting.	Yes	Yes	Yes	Yes	Yes	*	*	C	Y	C	High
L4	Hanc, M., McAndrew, C., & Ucci, M. (2019). Conceptual approaches to wellbeing in buildings: a scoping review. Building Research & Information, 47(6), 767–783.	General	**Purpose:** to present the most commonly occurring and insightful definitions and dimensions of well-being in buildings. Method: Scoping review in one database, Scopus (n=59, 2006–2016). Conclusions: an overview of how the term "well-being" is defined is offered, along with nine broad categories of well-being that are described as different "levels" of the built environment.	Yes	Yes	Yes	No	Yes	*	*	C	C	C	Medium-high

	Reference	Occupational category	Content (n=final no. of included studies)	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	Question 9	Question 10	Quality
L5	Hedge, A., James, T., & Pavlovic-Veselinovic, S. (2011). Ergonomics concerns and the impact of healthcare information technology. International Journal of Industrial Ergonomics, 41(4), 345–351.	Healthcare	**Purpose:** to study whether computerized healthcare information technology (HIT) leads to work-related musculoskeletal disorders (WMSD). Method: the process for gathering articles is not described explicitly; the article is purely descriptive on the topic (n ≈ 45?) and primarily has an American perspective. Conclusions: evidence is presented indicating that current HIT patterns may increase the risk of WMSD. A number of ergonomic principles plus standards and recommendations for seated computer work are offered.	Can't tell	Can't tell	Can't tell	No	Can't tell	*	*	C	C	C	Debatable
L6	Hui, F., & Aye, L. (2018). Occupational Stress and Workplace Design. Buildings, 8(10), 133.	Knowledge work	**Purpose:** to propose an improved model for how well-being, workplace design and contact with nature relate to one another. The basic perspective is demand–resource models from psychosocial work environment literature in English. **Method:** literature search using specified search terms in a database (Web of Science). An unspecified number of articles (n ≈ 80?) are included out of a search that yielded n=1,146 (1900–2018). Conclusions: a causal loop diagram showing the connections between natural environments and well-being outcomes (physical and psychosocial) is presented. Natural environments can serve as a work resource.	Can't tell	No	Can't tell	No	Can't tell	*	*	C	C	C	Debatable
L7	Huisman, E. R. C. M., Morales, E., van Hoof, J., & Kort, H. S. M. (2012). Healing environment: A review of the impact of physical environmental factors on users. Building and Environment, 58, 70–80.	Healthcare	**Purpose:** to map the evidence concerning the impact and healing effect of the physical built environment on patients with families, and its effects on working healthcare personnel. Method: structured review based on Cochrane methodology, in the JStor, PubMed and Scopus databases (n=65). Conclusions: success factors were identified for reducing errors, enhancing safety, comfort, control, privacy and comfort, and to promote family support, organization and technical support. The study found that there was a lack of literature addressing employee outcomes, therefore more research is needed regarding the needs of healthcare employees.	Yes	Yes	Yes	Yes	Yes	*	*	C	Y	C	High

	Reference	Occupational category	Content (n=final no. of included studies)	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	Question 9	Question 10	Quality
L8	Jain, R., Sain, M. K., Meena, M. L., Dangayach, G. S., & Bhardwaj, A. K. (2018). Non-powered hand tool improvement research for prevention of workrelated problems: a review. International Journal of Occupational Safety and Ergonomics, 24(3), 347–357.	Industry	**Purpose:** to map the literature concerning non-powered hand tool design according to ergonomics principles (incl. usability), and to tie this knowledge to low-to-middle-income countries, where much work is still done using totally manual tools. Method: structured search in the PubMed and EBSCOhost databases plus the publishers Taylor & Francis, Sage and Wiley-Interscience (n=58). Conclusions: a review of the majority of non-powered hand tool properties sorted by country and occupational sector is presented, along with their associated problem areas and design improvement variables. Very few articles originate from low-and-middle-income countries, except within the agricultural sector.	Yes	Yes	Can't tell	No	Yes	*	*	C	C	C	Medium-high
L9	Karuppiah, K., Abidin, E. Z., Alias, A. Tamrin, S & Shafiei, U. (2015). A systematic review of intervention to reduce musculoskeletal disorders: Hand and arm disorders. Jurnal Teknologi, 77(27), 105–111.	General	**Purpose:** to map the literature concerning interventions intended to reduce the risk of musculoskeletal disorders involving the hands and arms among workers in various occupations. Method: systematic search in the ELCOSH, PubMed, ScienceDirect, Google Scholar and OSHROM databases, plus grey literature (n=6). Conclusions: 6 interventions are described, all of which had extremely positive results (reduced musculoskeletal disorders) following implementation. The interventions came in the form of new training programmes, equipment or redesign of the workplace.	Yes	Can't tell	No	No	Can't tell	*	*	C	C	C	Debatable
L10	Podrekar, N., Kozinc, Ž., & Šarabon, N. (2019). Effects of cycle and treadmill desks on energy expenditure and cardiometabolic parameters in sedentary workers: review and metaanalysis. International Journal of Occupational Safety and Ergonomics, 1–9.	General	**Purpose:** to assess and meta-analyse how workstations with treadmills (for work while walking) or stationary cycles affect energy expenditure and cardiovascular and biochemical indicators in sedentary workers. Method: structured search in the PubMed,ScienceDirect, Scopus, Embase, Web of Science and PEDro databases (n=22). The studies were quality appraised using PEDro. Conclusions: both workstation types increased energy expenditure and pulse while decreasing blood glucose and insulin, but did not affect blood pressure or other biochemical indicators. These workstation types can have a positive effect in terms of suppressing the negative effects of sedentary work. However, there is major variation in terms of how energy expenditure is measured.	Yes	Yes	Can't tell	Yes	Yes	*	*	C	C	C	High

	Reference	Occupational category	Content (n=final no. of included studies)	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	Question 9	Question 10	Quality
L11	Rechel, B., Buchan, J., & McKee, M. (2009). The impact of health facilities on healthcare workers' wellbeing and performance. International Journal of Nursing Studies, 46(7), 1025–1034.	Healthcare	**Purpose:** to study how the design of healthcare environments impacts healthcare worker well-being and performance. Method: search in the PubMed database and on Google; grey literature was included (n=11). Conclusions: the study found that good healthcare environment design could yield many positive results. Six design factors that impact healthcare work are identified: geographical location, the hospital experience, access to personal privacy, choice of materials, a safe and secure environment and the incorporation of family-supporting functions, such as residential accommodations and childcare in or near the hospital area.	Can't tell	Yes	Can't tell	No	Yes	*	*	C	C	C	Debatable
L12	Richardson, A., Potter, J., Paterson, M., Harding, T., Tyler-Merrick, G., Kirk, R., … McChesney, J. (2017). Office design and health: A systematic review. New Zealand Medical Journal, 130(1467), 39–49.	Knowledge work	**Purpose:** to map research on how workplace design, particularly individual versus shared workplaces, impacts office worker health. Method: systematic search in the Medline, Embase, PsychInfo, Sociological Abstracts, Web of Science, Scopus, Education Source, EBSCO and Google Scholar databases (n=15). Conclusions: compared to individual offices, shared or open-plan offices do not promote employee health; on the contrary, the literature review found consistent evidence of detrimental effects on employee health, well-being and productivity. This was also consistent with earlier results.	Yes	Yes	Can't tell	No	Yes	*	*	Y	C	C	Medium-high
L13	Shanmugam, A., & Paul Robert, T. (2015). Human factors engineering in aircraft maintenance: a review. Journal of Quality in Maintenance Engineering, 21(4), 478–505.	Industry	**Purpose:** to provide an overview of the human factors-related literature in the area of aircraft maintenance. Method: a literature search with unspecified search terms in unnamed databases. Reports, conference presentations and standards at international, national and organizational levels were also included (n=not clearly stated, > 170 items). Conclusions: the literature is focused mainly on compliance with rules and regulations. 10 main categories of Human Factors areas relevant to aircraft maintenance are presented.	Yes	Can't tell	Can't tell	No	Can't tell	*	*	C	C	C	Debatable

	Reference	Occupational category	Content (n=final no. of included studies)	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	Question 9	Question 10	Quality
L14	Stichler, J. F. (2013). Healthy work environments for the ageing nursing workforce. Journal of Nursing Management, 21(7), 956–963.	Healthcare	**Purpose:** to describe the physical challenges faced by ageing nurses within their occupation, and which design factors in healthy care environments could motivate nurses to remain in the occupation. Method: searching in the databases ScienceDirect, Ovid, ProQuest, PubMED, CINAHL, PsychINFO, The Center for Health Design, Avery Index and Google Scholar. Government and organizational newsletters were included as well (n=25). Conclusions: given that older nurses possess a great deal of valuable knowledge, they are valuable as part of the workforce. Well-designed healthcare environments can support older nurses in facing challenges and optimizing their experiences.	Yes	Yes	Can't	No tell	Yes	*	*	C	C	C	High

Design process articles, with customized quality appraisal

This appendix offers a complete overview of the literature that is categorized as "Design process-oriented". These articles were identified on the basis that they described:

1) Processes and Approaches, i.e. a description or assessment of a proposed process or approach for designing and assessing workplaces. Several of these had to do with participatory design and evaluation of workplaces, i.e. the incorporation of knowledge directly from users and workers into the design or change process.

2) Tools, i.e. specifically described aids, methods or models for structuring and guiding the work of designing, modifying and assessing workplaces.

These articles have also been quality appraised using a simplified and specially customized appraisal template created by the report authors. Our choice to conduct a simplified quality appraisal means that this portion of the review falls within the framework of what might be termed a "scoping review", according to Pham et al. (2014). Our decision to limit the types of included publications to peer-reviewed, journal-published literature may be regarded as an element in quality-assuring the content.

The appraisal questions are:

1. Does the article describe a procedure for assessing or performing the design of a workplace-related solution? Yes, assessment (1p)/ Yes, performance (1p) / Yes, both performance and assessment (2p) / Unclear / No

2. Does the article contain an empirical application of the procedure? Yes (1p)/ Unclear / No

3. If Yes to 2), does the article make a critical analysis of the results and state limitations of the application that could impact the suitability of applying the procedure to other situations? Yes (1p) / Unclear / No

4. In which way does the procedure have the primary purpose of assessing or improving the workplace? Reducing injury risk (1p) / Increasing well-being (1p)/ Increasing participation (1p)/ Increasing performance (1p) / Supporting the design process (1p) / Multiple purposes (2p) / Other (specify) (1p)/ Unclear

5. At which level is the approach focused on workplace health? Individual level / Group level (between 2 and 20 co-working employees) / Macro level (entire organization or similar) / Unclear Was the study published in 2015 or later? Yes (1p) / No

Affirmative answers to Questions 1, 2, 3, 4 and 6 yield 1–2 points, so an article can score a maximum of 7 points (see scoring report in the tables that follow). Note that Question 5 does not confer any points, but serves a purely categorizing purpose. Question 6 is intended to emphasize more modern literature contributions, since modern technical advances are progressing rapidly.

	Source	Content (Approach / Process / Tool)	Area of applicability	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Points
D1	Bligård, L. O., & Berlin, C. (2019). ACD3 as a framework for design of ergonomic workplaces. Work, 62(1), 5–12.	**A,P,T** Design framework for workplace design - conceptual description	General	Yes, performance-	No	-	More results	Group	Yes	4
D2	Cao, C. G. L., & Rogers, G. S. (2004). Robotassisted minimally invasive surgery: the importance of human factors analysis and design. Surgical Technology International, 12, 73–82.	**A,P,T** Framework for modelling interactions between a surgeon and robotic equipment for minimally invasive surgery, in order to guide the design process and set requirements for interface design	Healthcare	Yes, performance	Yes	Unclear	Support design process	Ind	No	3
D3	Clements-Croome, D., Turner, B., & Pallaris, K. (2019). Flourishing workplaces: a multisensory approach to design and POE. Intelligent Buildings International, 1–14.	**A,P,T** Framework for workplace design and assessment with focus on multisensory experience	Knowledge work	Yes, performance and assessment	No	-	More results	Ind	Yes	5
D4	Harari, Y., Bechar, A., Raschke, U., & Riemer, R. (2017). Automated Simulation-Based Workplace Design that Considers Ergonomics and Productivity. International Journal of Simulation Modelling, 16(1), 5–18.	**A,P,T** Framework for modelling manual handling of 23 kg-weights with focus on time estimates and physical ergonomics, in order to guide the design process	Industrial work	Yes, performance	Yes	No	More results	Ind	Yes	5
D5	Malagon-Maldonado, G. (2016). Retrospective Preevaluation–Postevaluation in Health Design. HERD: Health Environments Research & Design Journal, 10(1), 13–22.	**A,P,T** Framework for supporting workplace design before and after an intervention	Healthcare	Yes, performance	No	-	Support design process	Ind	Yes	3
D6	Colombo, G., & Cugini, U. (2005). Virtual humans and prototypes to evaluate ergonomics and safety. Journal of Engineering Design, 16(2), 195–203.	**A,P,T** Framework for evaluating and developing workplaces with a focus on comfort	Industrial work	Yes, performance and assessment	Yes	-	Reduce injury risk	Ind	No	4
D7	Smith, M., Carayon, P., & Cohen, W. (2009). Design of Computer Workstations. In A. Sears & J. Jacko (Eds.), Human–Computer Interaction: Fundamentals (pp. 289–302). Boca Raton: CRC Press.	**A,T** Design recommendations for computer workstations	Knowledge work	Yes, performance	No	-	More results	Ind	No	3
D8	Álvarez-Casado, E., Zhang, B., Sandoval, S. T., & Pedro, M. (2016). Using ergonomic digital human modeling in evaluation of workplace design and prevention of work-related musculoskeletal disorders aboard small fishing vessels. Human Factors and Ergonomics in Manufacturing & Service Industries, 26(4), 463–472.	**P,T** Simulation, assessment and adjustment of workplace design	Miscellaneous occupations, vehicles (boat)	Yes, performance and assessment	Yes	Unclear	Reduce injury risk	Ind	Yes	5

	Source	Content (Approach / Process / Tool)	Area of applicability	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Points
D9	Andersen, S. N., & Broberg, O. (2015). Participatory ergonomics simulation of hospital work systems: The influence of simulation media on simulation outcome. Applied Ergonomics, 51, 331–342.	**P,T** Comparison of two different types of simulation in participatory design processes	Healthcare	Yes, performance and assessment	Yes	Yes	More results	Macro	Yes	7
D10	Aromaa, S., & Väänänen, K. (2016). Suitability of virtual prototypes to support human factors/ ergonomics evaluation during the design. Applied Ergonomics, 56, 11–18.	**P,T** Study of suitability of virtual and augmented prototypes for ergonomic evaluation	Industrial work	Yes, performance and assessment	Yes	Unclear	Support design process	Macro	Yes	5
D11	Ayuso Sanchez, J., Ikaga, T., & Vega Sanchez, S. (2018). Quantitative improvement in workplace performance through biophilic design: A pilot experiment case study. Energy and Buildings, 177, 316–328.	**P,T** Development of a tool to measure effects of greenery in workplaces	Not specified	Yes, assessment	Yes	No	More results	Ind	Yes	5
D12	Bayramzadeh, S., Joseph, A., Allison, D., Shultz, J., & Abernathy, J. (2018). Using an integrative mock-up simulation approach for evidence-based evaluation of operating room design prototypes. Applied Ergonomics, 70, 288–299.	**P,T** An approach for simulation and assessment of prototypes during the concept phase	Healthcare	Yes, performance	Yes	Yes	Support design process	Macro	Yes	5
D13	Bligård, L.-O., Berlin, C., & Österman, C. (2018). The power of the dollhouse: Comparing the use of full-scale, 1:16-scale and virtual 3D-models for user evaluation of workstation design. International Journal of Industrial Ergonomics, 68, 344–354.	**P,T** Comparison of two different types of prototypes in participatory design processes	Miscellaneous occupations, vehicles (boat)	Yes, performance	No	-	Support design process	Unclear	Yes	3
D14	Broberg, O., & Hermund, I. (2007). The OHS consultant as a facilitator of learning in workplace design processes: Four explorative case studies of current practice. International Journal of Industrial Ergonomics, 37(9–10), 810–816.	**P,T** Roles for work environment consultants in workplace design processes	Industrial work	Yes, performance	Yes	Unclear	Support design process	Unclear	No	
D15	Broberg, O., Andersen, V., & Seim, R. (2011). Participatory ergonomics in design processes: The role of boundary objects. Applied Ergonomics, 42(3), 464–472.	**P,T** Comparison of five different types of prototypes/tools in participatory design processes	Not specified	Yes, performance	Yes	Unclear	Support design process	Unclear	No	3
D16	Broberg, O., Seim, R., & Andersen, V. (2010). Collaborative Design of Workplaces: The Role of Boundary Objects. In G. Salvendy & W. Karwowski (Eds.), Advances in Occupational, Social, and Organizational Ergonomics (pp. 49–58). Boca Raton: Taylor & Francis.	**P,T** Comparison of two different types of prototypes/tools in participatory design processes	Multi-occupation	Yes, performance	Yes	Unclear	Support design process	Unclear	No	3

	Source	Content (Approach / Process / Tool)	Area of applicability	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Points
D17	Califano, R., Naddeo, A., Gatto, A., Leo, S., Milosa, P., Nazzaro, M., & Straccia, L. (2019). Virtual prototyping for workplace analysis: the effect of expectation on perceived comfort while using office devices. International Journal on Interactive Design and Manufacturing (IJIDeM), 13(1), 235–242.	**P,T** Application of simulations to assess users' physical interactions with various types of digital tools (desktop computer, laptop, tablet and smartphone) and resulting perceived comfort	Knowledge work	Yes, assessment	Yes	Unclear	Reduce injury risk	Ind	Yes	4
D18	Caputo, F., Greco, A., Fera, M., & Macchiaroli, R. (2019). Workplace design ergonomic validation based on multiple human factors assessment methods and simulation. Production & Manufacturing Research, 7(1), 195–222.	**P,T** Development of a predictive tool for assessing workplace design during the concept phase, focusing on physical ergonomics	Industrial work	Yes, performance and assessment	Yes	Unclear	Reduce injury risk	Ind	Yes	5
D19	Carey, E. J., & Gallwey, T. J. (2002). Evaluation of human postures with computer aids and virtual workplace designs. International Journal of Production Research, 40(4), 825–843.	**P,T** Application of simulation and digital tools for ergonomic evaluation	Industrial work	Yes, performance and assessment	Yes	Unclear	Support design process	Ind	No	4
D20	Conceição, C., Silva, G., Broberg, O., & Duarte, F. (2012). Intermediary objects in the workspace design process: Means of experience transfer in the offshore sector. Work, 41(SUPPL.1), 127–135.	**P,T** Application of various representations for knowledge transfer in a participatory design process	Industrial work	Yes, performance	Yes	Unclear	Support design process	Macro	No	3
D21	Diego-Mas, J. A., Poveda-Bautista, R., & GarzonLeal, D. (2017). Using RGB-D sensors and evolutionary algorithms for the optimization of workstation layouts. Applied Ergonomics, 65, 530–540.	**P,T** Use of sensors and algorithms for optimization of workstation design	Industrial work	Yes, performance	Yes	Unclear	Support design process	Macro	Yes	4
D22	Favi, C., Moroni, F., Manieri, S., Germani, M., & Marconi, M. (2018). Virtual Reality-Enhanced Configuration Design of Customized Workplaces: a Case Study of Ship Bridge System. ComputerAided Design and Applications, 16(2), 345–357.	**T** Use of virtual simulation in participatory workplace design	Miscellaneous occupations, vehicles (boat)	Yes, performance	Yes	No	Support design process	Macro	Yes	4
D23	Golabchi, A., Han, S., & AbouRizk, S. (2018). A simulation and visualization-based framework of labor efficiency and safety analysis for prevention through design and planning. Automation in Construction, 96, 310–323.	**A,P,T** Framework for guiding the use of various methods during the design process, for the purpose of reducing injury risks	Industrial work	Yes, performance	Yes	Unclear	More results	Ind	Yes	5
D24	Grant, M. P., Okechukwu, C. A., Hopcia, K., Sorensen, G., & Dennerlein, J. T. (2018). An Inspection Tool and Process to Identify Modifiable Aspects of Acute Care Hospital Patient Care Units to Prevent Work-Related Musculoskeletal Disorders. Workplace Health & Safety, 66(3), 144–158.	**P,T** Assessment tool for identifying workplace adjustments to reduce injury risks	Healthcare	Yes, performance and assessment	No	-	More results	Macro	Yes	5

	Source	Content (Approach / Process / Tool)	Area of applicability	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Points
D25	Hanson, L., Sperling, L., Gard, G., Ipsen, S., & Olivares Vergara, C. (2009). Swedish anthropometrics for product and workplace design. Applied Ergonomics, 40(4), 797–806.	**T** Anthropometric data from Sweden for the design of products and workplaces	Multi-occupation	Yes, performance	No	-	Support design process	Ind	No	2
D26	Kogi, K. (2006). Action-oriented use of ergonomic checkpoints for healthy work design in different settings. Proceedings – Ergo Future 2006, International Symposium on Past, Present and Future Ergonomics, Occupational Safety and Health, 36(2), 321–325.	**A,P,T** An approach for using checklists for workplace improvements	Not specified	Yes, performance and assessment	Yes	Unclear	More results	Macro	No	5
D27	Lind, C. M., Forsman, M., & Rose, L. M. (2019). Development and evaluation of RAMP I – a practitioner's tool for screening of musculoskeletal disorder risk factors in manual handling. International Journal of Occupational Safety and Ergonomics, 25(2), 165–180.	**P,T** An assessment tool for identifying injury risks	Industrial work	Yes, assessment	No	-	Reduce injury risk	Ind	Yes	3
D28	Mallam, S. C., Lundh, M., & MacKinnon, S. N. (2017). Integrating Participatory Practices in Ship Design and Construction. Ergonomics in Design: The Quarterly of Human Factors Applications, 25(2), 4–11.	**A,P** Application of participatory processes and prototypes for designing workplaces	Miscellaneous occupations, vehicles (boat)	Yes, performance	Yes	Unclear	Support design process	Macro	Yes	4
D29	Margaritis, S., & Marmaras, N. (2007). Supporting the design of office layout meeting ergonomics requirements. Applied Ergonomics, 38(6), 781–790.	**A,P,T** Approach for designing office workplaces	Knowledge work	Yes, performance	Unclear	-	More results	Macro	No	4
D30	Mateus, J. C., Claeys, D., Limère, V., Cottyn, J., & Aghezzaf, E.-H. (2019). A structured methodology for the design of a humanrobot collaborative assembly workplace. The International Journal of Advanced Manufacturing Technology, 102(5–8), 2663–2681.	**A,P,T** Approach for design of work sequence for collaboration work between humans and robots	Industrial work	Yes, performance and assessment	Unclear	-	More results	Macro	Yes	5
D31	Mazzola, M., Forzoni, L., D'Onofrio, S., & Andreoni, G. (2017). Use of Digital Human Model for ultrasound system design: A case study to minimize the risks of musculoskeletal disorders. International Journal of Industrial Ergonomics, 60, 35–46.	**P,T** Application of simulations in ultrasound tool and system design	Healthcare	Yes, performance and assessment	Yes	Unclear	Reduce injury risk	Ind	Yes	5
D32	Miranda-Sánchez, J. A., & Contreras-Valenzuela, M. R. (2015). Development of the "QOC Matrix – The Worker's Voice" (Part 2). Procedia Manufacturing, 3, 4748–4755.	**T** Tool for supporting decision-making during a design process with a participatory approach	Multi-occupation	Yes, performance	Yes	Unclear	Reduce injury risk	Ind	Yes	4

	Source	Content (Approach / Process / Tool)	Area of applicability	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Points
D33	Noedlá, M., & Pikalová, I. (2015). Ergonomics in Catia 3D CAD system and its utilization in clothing industry. Vlakna a Textil, 2015(2), 3–10.	**T** Simulation of activities and body postures, plus ergonomic assessment	Industrial work	Yes, assessment	Unclear		Reduce injury risk	Ind	Yes	3
D34	Ondriga, L., Michalconok, G., Lubos, O., & German, M. (2014). Automation of Force Assessment Generated by Upper Limb for Ergonomic System EAWS. Applied Mechanics and Materials, 693, 98–103.	**P,T** Use of sensors in ergonomic assessment	Industrial work	Yes, assessment	Unclear		Reduce injury risk	Ind	No	2
D35	Otto, A., Boysen, N., Scholl, A., & Walter, R. (2017). Ergonomic workplace design in the fast pick area. OR Spectrum, 39(4), 945–975.	**P,T** Calculation of injury risks during manual handling by ageing workforce, and a quantitative approach for identifying optimization and improvement potential	Industrial work	Yes, performance and assessment	Unclear		Reduce injury risk	Ind	Yes	4
D36	Palvalin, M., & Vuolle, M. (2016). Methods for identifying and measuring the performance impacts of work environment changes. Journal of Corporate Real Estate, 18(3), 164–179.	**P,T** Assessment of methods for analysing activity-based working methods	Knowledge work	Yes, assessment	Yes	Unclear	More results	Macro	Yes	5
D37	Ramsauer, F. (2001). Prevention concept in industry: Improvement in occupational safety and health protection – An empirical study. Journal of Occupational Rehabilitation, 11(4), 321–330.	**A,P,T** Framework for participatory assessment of working conditions and improvement of workplaces	Industrial work	Yes, performance and assessment	Yes	Unclear	Reduce injury risk	Ind	No	4
D38	Reiman, A., Sormunen, E., & Morris, D. (2016). Ergonomics in the arctic – a study and checklist for heavy machinery in open pit mining. Work, 55(3), 643–653.	**P,T** Checklist for assessment of workplace in mining environments	Miscellaneous occupations, vehicles in mining environment	Yes, assessment	Yes	Yes	Reduce injury risk	Macro	Yes	5
D39	Silva E Santos, M. (2012). The PhOCoe Model – Ergonomic pattern mapping in participatory design processes. Work, 41(SUPPL.1), 2643– 2650.	**P,T** Approach for a participatory design process	Multi-occupation	Yes, performance and assessment	Unclear		Support design process	Unclear	No	3
D40	Skoglind-Öhman, I., & Shahnavaz, H. (2004). Assessment of Future Workshop's Usefulness as an Ergonomics Tool. International Journal of Occupational Safety and Ergonomics, 10(2), 119–128.	**P,T** Testing of the "Future Workshop" as a tool for supporting participatory design processes	Multi-occupation	Yes, performance and assessment	No	Support design process	Unclear	No	4	4

	Source	Content (Approach / Process / Tool)	Area of applicability	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Points
D41	Spasojević Brkić, V. K., Veljković, Z. A., Golubović, T., Brkić, A. D., & Kosić Šotić, I. (2016). Workspace design for crane cabins applying a combined traditional approach and the Taguchi method for design of experiments. International Journal of Occupational Safety and Ergonomics, 22(2), 228–240.	**P,T** Application of a quantitative tool for designing cranes, based on anthropometrics	Miscellaneous occupations, vehicles (crane)	Yes, performance	No	-	Reduce injury risk	Ind	Yes	3
D42	Sundin, A., & Medbo, L. (2003). Computer visualization and participatory ergonomics as methods in workplace design. Human Factors and Ergonomics in Manufacturing, 13(1), 1–17.	**P,T** Application of simulation to support participatory design processes	Industrial work	Yes, performance	Yes	Unclear	Support design process	Macro	No	3
D43	Tsarouchi, P., Michalos, G., Makris, S., Athanasatos, T., Dimoulas, K., & Chryssolouris, G. (2017). On a human–robot workplace design and task allocation system. International Journal of Computer Integrated Manufacturing, 30(12), 1272–1279.	**P,T** Approach for designing human–robot division of labour	Industrial work	Yes, performance	Yes	No	Support design process	Macro	Yes	4
D44	Vilar, E. V., Filgueiras, E., & Rebelo, F. (2007).	**P,T** Tool for ergonomic assessment of workplaces, focusing on accessibility	Multi-occupation	Yes, assessment	Unclear		More results	Ind	No	3
D45	Yang, J. (James), & Abdel-Malek, K. (2009). Human reach envelope and zone differentiation for ergonomic design. Human Factors and Ergonomics in Manufacturing, 19(1), 15–34.	**T** Simulation tool for modelling reach for gripping	Industrial work	Yes, performance	Unclear		Reduce injury risk	Ind	No	2
D46	Caple, D. C. (2012). A toolkit for MSDs prevention – WHO and IEA context. Work, 41(SUPPL.1), 3930–3932.	**A,P** A framework for supporting participatory ergonomic processes	Multi-occupation	Yes, assessment	No	-	Reduce injury risks	Ind	No	2
D47	Azadeh, A., Fam, I.., & Garakani, M. M.. (2007). A Total Ergonomic Design Approach to Enhance the Productivity in a Complicated Control System. Information Technology Journal, 6(7), 1036– 1042.	**A** Approach for designing workplaces with a focus on performance	Industrial work	Yes, performance	Yes	No	More results	Macro	No	4
D48	Caroly, S., Coutarel, F., Landry, A., & MaryCheray, I. (2010). Sustainable MSD prevention: Management for continuous improvement between prevention and production. Ergonomic intervention in two assembly line companies. Applied Ergonomics, 41(4), 591–599.	**A** Approach for iterative and continuous improvement of workplaces	Industrial work	Yes, performance and assessment	Yes	Unclear	More results	Ind	No	5
D49	Chim, J. M. Y. (2014). The FITS model office ergonomics program: a model for best practice. Work (Reading, Mass.), 48(4), 495–501.	**A** Approach for office design	Knowledge work	Yes, performance	No	-	More results	Ind	No	2

	Source	Content (Approach / Process / Tool)	Area of applicability	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Points
D50	Clements-Croome, D. (2005). Designing the Indoor Environment for People. Architectural Engineering and Design Management, 1(1), 45–55.	**A** Framework for workplace design, focusing on multi-sensory experience	Multi-occupation	Yes, performance	No	-	More results	Macro	No	3
D51	Cutting, S. (2008). Safety in design: Current standards for sugar mills. 2008 ASSCT Conference – 30th Annual Conference Australian Society of Sugar Cane Technologists, 111(1322), 484–494.	**T** Overview of standards for injury prevention	Industrial work	Yes, performance	Yes	Unclear	Reduce injury risk	Ind	No	3
D52	DeForge, D. H. (2002). Physical Ergonomics in Veterinary Dentistry. Journal of Veterinary Dentistry, 19(4), 196–200.	**T** Design recommendations for veterinary workplaces	Miscellaneous occupations, veterinarians	Yes, performance	Yes	No	Reduce injury risk	Ind	No	3
D53	Ulrich, R. S., Berry, L. L., Quan, X., & Parish, J. T. (2011). A conceptual framework for the domain of evidence-based design. Health Environments Research and Design Journal, 4(1), 95–114.	**A** Framework for workplace design	Healthcare	Yes, performance	No	-	More results	Macro	No	3
D54	Wells, R., Laing, A., & Cole, D. (2009). Characterizing the intensity of changes made to reduce mechanical exposure. Work, 34(2), 179–193.	**A,T** Analysis tool for assessment and categorization of workplace interventions to reduce injury risks	Industrial work	Yes, assessment	Yes	Yes	Reduce injury risk	Ind	No	4
D55	Whedon, G. A. (2000). Frames of reference that address the impact of physical environments on occupational performance. Work, 14(2), 165–174.	**A** Equal perspectives for assessment of workplace design	Knowledge work	Yes, assessment	Yes	Unclear	Unclear	Ind	No	2
D56	Yerian, L. M., Seestadt, J. A., Gomez, E. R., & Marchant, K. K. (2012). A Collaborative Approach to Lean Laboratory Workstation Design Reduces Wasted Technologist Travel. American Journal of Clinical Pathology, 138(2), 273–280.	**A** Application of Lean as a framework, in a case study of workstation design to increase productivity	Miscellaneous occupations, laboratory work	Yes, performance	Yes	Unclear	Increase performance	Ind	No	3
D57	Aptel, M., Claudon, L., & Marsot, J. (2002). Integration of Ergonomics Into Hand Tool Design: Principle and Presentation of an Example. International Journal of Occupational Safety and Ergonomics, 8(1), 107–115.	**P** Design process for hand tools	Multi-occupation	Yes, performance	Yes	No	Reduce injury risk	Ind	No	3
D58	Bäckstrand, G., Hogberg, D., Vin, L. J. De, Case, K., & Piamonte, P. (2007). Ergonomics analysis in a virtual environment. International Journal of Manufacturing Research, 2(2), 198.	**T** Simulation and assessment of design concepts	Industrial work	Yes, performance and assessment	Yes	Unclear	Reduce injury risk	Ind	No	4

	Source	Content (Approach / Process / Tool)	Area of applicability	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Points
D59	Bellemare, M., Trudel, L., Ledoux, É., Montreuil, S., Marier, M., Laberge, M., & Vincent, P. (2006). Allowing for MSD Prevention During Facilities Planning for a Public Service: An a Posteriori Analysis of 10 Library Design Projects. International Journal of Occupational Safety and Ergonomics, 12(4), 387–397.	**P** Mapping of design aspects and process recommendations for implementation of design modifications in a library environment	Miscellaneous occupations, librarians	Yes, performance	Unclear		Reduce injury risk	Ind	No	2
D60	Bittencourt, J. M., Duarte, F., & Béguin, P. (2017). From the past to the future: Integrating work experience into the design process. Work, 57(3), 379–387.	**P** Approach for a participatory design process using design representations, with a focus on supporting job tasks	Knowledge work	Yes, performance	Yes	Unclear	Increase performance	Macro	Yes	4
D61	Brandt, M., Madeleine, P., Samani, A., Ajslev, J. Z. N., Jakobsen, M. D., Sundstrup, E., & Andersen, L. L. (2018). Effects of a Participatory Ergonomics Intervention With Wearable Technical Measurements of Physical Workload in the Construction Industry: Cluster Randomized Controlled Trial. Journal of Medical Internet Research, 20(12), e10272.	**P,T** Use of wearable technology to assess a participatory training programme focusing on injury risk reduction	Industrial work	Yes, performance	Yes	Yes	Reduce injury risk	Ind	Yes	5
D62	Caputo, F., Greco, A., Fera, M., & Macchiaroli, R. (2019). Digital twins to enhance the integration of ergonomics in the workplace design. International Journal of Industrial Ergonomics, 71, 20–31.	**P,T** Process recommendation for use of digital twins to simulate new workplaces	Industrial work	Yes, performance and assessment	Yes	Unclear	More results	Ind	Yes	6
D63	Case, K., Hussain, A., Marshall, R., Summerskill, S., & Gyi, D. (2015). Digital Human Modelling and the Ageing Workforce. Procedia Manufacturing, 3, 3694–3701.	**T** Simulation of physical capacities, i.e. joint mobility in older workers, for workplace assessments	Industrial work	Yes, performance	Yes	Unclear	More results	Ind	Yes	5
D64	Castro, I. S., De Paula Antunes Lima, F., & De Castro Moura Duarte, F. J. (2012). The start up as a phase of architectural design process. Work, 41(SUPPL.1), 140–144.	**P** Process recommendations for post-occupancy adjustments after move to new workplace	Healthcare	Yes, performance and assessment	Yes	Unclear	Unclear	Unclear	No	3
D65	Castro, I. S., Lima, F. de P. A., & Duarte, F. J. de C. M. (2015). Users contributions to an architectural project at the start up. Production, 25(2), 310–322.	**P** Process recommendations for post-occupancy adjustments after move to new workplace	Healthcare	Yes, performance and assessment	Yes	Unclear	Unclear	Unclear	Yes	4
D66	Chang, S.-W., & Wang, M.-J. J. (2007). Digital human modeling and workplace evaluation: Using an automobile assembly task as an example. Human Factors and Ergonomics in Manufacturing, 17(5), 445–455.	**T** Application of simulation in workplace assessments	Industrial work	Yes, assessment	Yes	No	Reduce injury risk	Ind	No	3

	Source	Content (Approach / Process / Tool)	Area of applicability	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Points
D67	de Jong, A. M., & Vink, P. (2002). Participatory ergonomics applied in installation work. Applied Ergonomics, 33(5), 439–448.	**P** Process description of a participatory approach to reduce injury risks	Industrial work	Yes, performance and assessment	Yes	Yes	Reduce injury risk	Ind	No	5
D68	de Looze, M. P., Urlings, I. J. M., Vink, P., van Rhijn, J. W., Miedema, M. C., Bronkhorst, R. E., & van der Grinten, M. P. (2001). Towards successful physical stress reducing products: an evaluation of seven cases. Applied Ergonomics, 32(5), 525–534.	**P** Mapping of success factors in tool design	Multi-occupation	Yes, performance and assessment	Yes	Yes	More results	Ind	No	6
D69	Eklöf, M., Ingelgård, A., & Hagberg, M. (2004). Is participative ergonomics associated with better working environment and health? A study among Swedish white-collar VDU users. International Journal of Industrial Ergonomics, 34(5), 355–366.	**P** Assessment of participatory design processes	Knowledge work	Yes, assessment	Yes	Yes	More results	Ind	No	5
D70	Fritzsche, L. (2010). Ergonomics risk assessment with digital human models in car assembly: Simulation versus real life. Human Factors and Ergonomics in Manufacturing & Service Industries, 20(4), 287–299.	**T** Comparison of risk assessment in simulation versus real-life environments	Industrial work	Yes, assessment	Yes	Unclear	Reduce injury risk	Ind	No	3
D71	Golabchi, A., Han, S. S., Seo, J., Han, S. S., Lee, S., & Al-Hussein, M. (2015). An Automated Biomechanical Simulation Approach to Ergonomic Job Analysis for Workplace Design. Journal of Construction Engineering and Management, 141(8), 04015020.	**T** Simulation of work to assess injury risks	Industrial work	Yes, performance and assessment	Yes	Unclear	Reduce injury risk	Ind	Yes	5
D72	Lee, J., Kim, S., Jung, H., Koo, J., Woo, K., & Kim, M. T. (2009). Participatory Action Oriented Training for Hospital Nurses (PAOTHN) Program to Prevent Musculoskeletal Disorders. Journal of Occupational Health, 51(4), 370–376.	**P** Description of a participatory process for identifying and implementing workplace modifications	Healthcare	Yes, performance	Yes	Unclear	Reduce injury risk	Unclear	No	3
D73	Li, X., Han, S., Gül, M., & Al-Hussein, M. (2019). Automated post-3D visualization ergonomic analysis system for rapid workplace design in modular construction. Automation in Construction, 98, 160–174.	**T** Simulation tool for ergonomic assessments	Industrial work	Yes, assessment	Unclear		Reduce injury risk	Ind	Yes	3
D74	Mallam, S. C., & Lundh, M. (2016). The physical work environment and end-user requirements: Investigating marine engineering officers' operational demands and ship design. Work, 54(4), 989–1000.	**P** Needs identification and requirement specification in workplace design	Miscellaneous occupations, vehicles (boat)	Yes, performance	Unclear	-	More results	Macro	Yes	4
D75	Munck-Ulfsfält, U., Falck, A., Forsberg, A., Dahlin, C., & Eriksson, A. (2003). Corporate ergonomics programme at Volvo Car Corporation. Applied Ergonomics, 34(1), 17–22.	**P** Description of processes for injury prevention at Volvo Cars	Industrial work	Yes, performance and assessment	Yes	No	Reduce injury risk	Ind	No	4

	Source	Content (Approach / Process / Tool)	Area of applicability	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Points
D76	Nathanael, D., & Marmaras, N. (2018). From the seat to the system: Re-designing a tram drivers' workstation combining technical and contextual aspects. Applied Ergonomics, 73, 214–226.	**P** Description of an activity-centered design process	Miscellaneous occupations, vehicles (tram driving)	Yes, performance and assessment	Yes	Unclear	More results	Macro	Yes	6
D77	Noati, A., Shepley, M., Rodiek, S., Lee, C., & Varni, J. (2016). Restorative Design Features for Hospital Staff Break Areas. HERD: Health Environments Research & Design Journal, 9(2), 16–35.	**T** Performance of qualitative and quantitative user studies to assess restorative break areas in healthcare environments	Healthcare	Yes, assessment	Yes	Unclear	Increase well-being	Ind	Yes	4
D78	Rasmussen, C. D. N., Lindberg, N. K., Ravn, M. H., Jørgensen, M. B., Søgaard, K., & Holtermann, A. (2017). Processes, barriers and facilitators to implementation of a participatory ergonomics program among eldercare workers. Applied Ergonomics, 58, 491–499.	**P** Mapping of success factors and barriers in participatory processes to reduce injury risks among elder-care workers	Multi-occupation	Yes, performance and assessment	Yes	Yes	Reduce injury risk	Ind	Yes	6
D79	Ratib, O., Valentino, D. J., McCoy, M. J., Balbona, J. A., Amato, C. L., & Boots, K. (2000). Computeraided Design and Modeling of Workstations and Radiology Reading Rooms for the New Millennium. RadioGraphics, 20(6), 1807–1816.	**P,T** Use of simulation in a participatory design process for ultrasound workstation design	Healthcare	Yes, performance	Yes	Unclear	Support design process	Macro	No	3
D80	Rolfö, L. V. (2018). Relocation to an activitybased flexible office – Design processes and outcomes. Applied Ergonomics, 73, 141–150.	**P** Assessment of a change process involving a move to new types of offices	Knowledge work	Yes, performance	Yes	Unclear	More results	Macro	Yes	5
D81	Rosecrance, J. C., & Cook, T. M. (2000). The Use of Participatory Action Research and Ergonomics in the Prevention of WorkRelated Musculoskeletal Disorders in the Newspaper Industry. Applied Occupational and Environmental Hygiene, 15(3), 255–262.	**P** Description of a participatory process for reducing injury risks	Multi-occupation	Yes, performance and assessment	Yes	Unclear	Reduce injury risk	Ind	No	4
D82	Rousek, J. B., & Hallbeck, M. S. (2011). Improving Medication Management Through the Redesign of the Hospital Code Cart Medication Drawer. Human Factors: The Journal of the Human Factors and Ergonomics Society, 53(6), 626–636.	**P** Needs identification and requirement specification through employee involvement	Healthcare	Yes, performance	Yes	Yes	Increase performance	Macro	No	4
D83	Savin, J. (2011). Digital human manikins for work-task ergonomic assessment. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 225(8), 1401–1409.	**T** Simulation of work for assessment of design proposals and description of pitfalls in the use of simulations	Industrial work	Yes, performance and assessment	Unclear	-	Reduce injury risk	Ind	No	3

	Source	Content (Approach / Process / Tool)	Area of applicability	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Points
D84	Seim, R., & Broberg, O. (2010). Participatory workspace design: A new approach for ergonomists? International Journal of Industrial Ergonomics, 40(1), 25–33.	**P** Description of a participatory process for workplace design facilitated by corporate healthcare experts	Industrial work	Yes, performance	Yes	Unclear	Support design process	Macro	No	3
D85	van der Molen, H. F., Sluiter, J. K., Hulshof, C. T. J., Vink, P., van Duivenbooden, C., Holman, R., & HW Frings-Dresen, M. H. (2005). Implementation of participatory ergonomics intervention in construction companies. Scandinavian Journal of Work, Environment & Health, 31(3), 191–204.	**P** Assessment of a participatory approach to reduce injury risks	Industrial work	Yes, performance and assessment	Yes	Yes	Reduce injury risk	Ind	No	5
D86	van Eerd, D., Cole, D., Irvin, E., Mahood, Q., Keown, K., Theberge, N., … Cullen, K. (2010). Process and implementation of participatory ergonomic interventions: a systematic review. Ergonomics, 53(10), 1153–1166.	**P** Mapping of success factors and barriers in participatory processes; systematic literature review	Multi-occupation	Yes, performance	-	-	Reduce injury risk	Ind	No	2
D87	Vink, P., Koningsveld, E. A. P., & Molenbroek, J. F. (2006). Positive outcomes of participatory ergonomics in terms of greater comfort and higher productivity. Applied Ergonomics, 37(4), 537–546.	**P** Description of participatory processes for realising workplace well-being at the macro level	Multi-occupation	Yes, performance	Yes	Yes	More results	Macro	No	5
D88	Abdol Rahman, M. N., Abdul Rani, M. R., & Rohani, J. M. (2011). WERA: an observational tool develop to investigate the physical risk factor associated with WMSDs. Journal of Human Ergology, 40(1–2), 19–36.	**T** Ergonomics assessment method for physical risks	Industrial work	Yes, assessment	Yes	Unclear	Reduce injury risk	Ind	No	3
D89	Abdel-Malek, K., Yu, W., Yang, J., & Nebel, K. (2004). A mathematical method for ergonomicbased design: placement. International Journal of Industrial Ergonomics, 34(5), 375–394.	**T** Mathematical simulation to assess reach and offer recommendations for adjustment of workplaces	Industrial work	Yes, performance and assessment	No	-	More results	Macro	No	4
D90	Bowie, P., & Atkinson, S. (2015). Participatory design of a preliminary safety checklist for the general practice work system. Contemporary Ergonomics and Human Factors 2015, 65(634), 197–200.	**T** A checklist for assessing patient safety	Healthcare	Yes, assessment	Unclear	-	More results	Macro	Yes	4
D91	Broberg, O. (2010). Workspace design: a case study applying participatory design principles of healthy workplaces in an Industrial setting. International Journal of Technology Management, 51(1), 39.	**T** Application of a participatory approach to workspace design	Industrial work	Yes, performance	Yes	Unclear	More results	Macro	No	4
D92	Chaffin, D. (2005). Improving digital human modelling for proactive ergonomics in design. Ergonomics, 48(5), 478–491.	**T** Development of a simulation tool for modelling movements	Industrial work	Yes, assessment	No	-	Reduce injury risk	Ind	No	2

	Source	Content (Approach / Process / Tool)	Area of applicability	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Points
D93	Cimino, A., Longo, F., & Mirabelli, G. (2009). A multimeasure-based methodology for the ergonomic effective design of manufacturing system workstations. International Journal of Industrial Ergonomics, 39(2), 447–455.	**T** Application of a method for integrating simulation tools into workplace design.	Industrial work	Yes, performance	No	-	More results	Ind	No	3
D94	Colombo, G., Regazzoni, D., & Rizzi, C. (2013). Ergonomic Design through Virtual Humans. Computer-Aided Design and Applications, 10(5), 745–755.	**T** Ergonomics assessment method based on simulation and virtual prototypes	Industrial work	Yes, performance and assessment	Yes	Unclear	Reduce injury risk	Ind	No	4
D95	Dolan, P., Foy, C., & Smith, S. (2016). The SALIENT checklist: Gathering up the ways in which built environments affect what we do and how we feel. Buildings, 6(1).	**T** Development of a checklist for workplace design and assessment	Multi-occupation	Yes, performance and assessment	Unclear	-	Increase well-being	Ind	Yes	3
D96	Dul, J., de Vries, H., Verschoof, S., Eveleens, W., & Feilzer, A. (2004). Combining economic and social goals in the design of production systems by using ergonomics standards. Computers & Industrial Engineering, 47(2–3), 207–222.	**T** Compilation of 174 international ergonomics standards	Industrial work	Yes, performance	-	-	More results	Macro	No	4
D97	Eswaramoorthi, M., John, M., Rajagopal, C. A., Prasad, P. S. S., & Mohanram, P. V. (2010). Redesigning assembly stations using ergonomic methods as a lean tool. Work, 35(2), 231–240.	**T** Application of an ergonomic assessment method and simulation for workplace assessment and design	Industrial work	Yes, performance and assessment	Yes	Unclear	More results	Ind	No	5
D98	Fischer, S. L., & Dickerson, C. R. (2014). Applying psychophysics to prevent overexposure: On the relationships between acceptable manual force, joint loading, and perception. International Journal of Industrial Ergonomics, 44(2), 266– 274. https://doi.org/10.1016/j.ergon.2012.09.006	**T** Recommendations for use of psychophysical methods in assessing injury risks	Industrial work	Yes, assessment	Yes	-	Reduce injury risk	Ind	No	3
D99	Gordon, C. C., & Bradtmiller, B. (2012). Anthropometric change: Implications for office ergonomics. Work, 41(SUPPL.1), 4606–4611. https://doi.org/10.3233/WOR-2012-0076-4606	**T** Mapping of anthropometric changes to guide workplace design – data from the USA	Knowledge work	Yes, performance	-	-	Support design process	Ind	No	2
D100	Hsiao, H., Simeonov, P., Dotson, B., Ammons, D., Kau, T.-Y., & Chiou, S. (2005). Human responses to augmented virtual scaffolding models. Ergonomics, 48(10), 1223–1242.	**T** Comparison of real and virtual worksite assessment	Industrial work	Yes, assessment	Yes	-	More results	Ind	No	4
D101	Jia, B., Kim, S., & Nussbaum, M. A. (2011). An EMG-based model to estimate lumbar muscle forces and spinal loads during complex, higheffort tasks: Development and application to residential construction using prefabricated walls. International Journal of Industrial Ergonomics, 41(5), 437–446.	**T** Development of an ergonomics assessment model	Industrial work	Yes, assessment	Unclear	-	Reduce injury risk	Ind	No	2

	Source	Content (Approach / Process / Tool)	Area of applicability	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Points
D102	Joshi, A., Guttenberg, R., Leu, M., & Murray, S. (2008). Modeling of the hand–arm system for impact loading in shear fastener installation. International Journal of Industrial Ergonomics, 38(9–10), 715–725.	**T** Modelling of hand movements in manual handling of electric hand tools	Industrial work	Yes, assessment	No	-	Reduce injury risk	Ind	No	2
D103	Jung, H. S., & Jung, H.-S. (2001). Establishment of overall workload assessment technique for various tasks and workplaces. International Journal of Industrial Ergonomics, 28(6), 341–353.	**T** Development of an ergonomics assessment method	Industrial work	Yes, assessment	Unclear	-	Reduce injury risk	Ind	No	2
D104	Kirin, S., Dragčević, Z., & Rogale, S. F. (2014). Workplace redesign in the computer-aided technological sewing process. Tekstil, 63(1–2), 14–26.	**T** Design recommendations based on ergonomics assessment and simulation	Industrial work	Yes, performance	No	-	Reduce injury risk	Ind	No	2
D105	Laring, J., Forsman, M., Kadefors, R., & Örtengren, R. (2002). MTM-based ergonomic workload analysis. International Journal of Industrial Ergonomics, 30(3), 135–148.	**T** Development of an assessment tool for physical workload-related risks	Industrial work	Yes, assessment	Yes	Unclear	Reduce injury risk	Ind	No	3
D106	Lin, J. H., Radwin, R. G., & Nembhard, D. A. (2005). Ergonomics applications of a mechanical model of the human operator in power hand tool operation. Journal of Occupational and Environmental Hygiene, 2(2), 111–119.	**T** Guidelines for workplace design and selection of electric hand tools	Industrial work	Yes, performance	Unclear	-	Reduce injury risk	Ind	No	3
D107	Löffler, D., Wallmann-Sperlich, B., Wan, J., Knött, J., Vogel, A., & Hurtienne, J. (2015). Office Ergonomics Driven by Contextual Design. Ergonomics in Design: The Quarterly of Human Factors Applications, 23(3), 31–35.	**T** Design recommendations to reduce sedentary behaviour	Knowledge work	Yes, performance	No	-	Increase well-being	Ind	No	2
D108	Ma, L., Zhang, W., Fu, H., Guo, Y., Chablat, D., Bennis, F., … Fugiwara, N. (2010). A framework for interactive work design based on motion tracking, simulation, and analysis. Human Factors and Ergonomics in Manufacturing & Service Industries, 20(4), 339–352.	**T** A framework for workplace design based on motion tracking and simulation	Industrial work	Yes, performance	Unclear	-	Reduce injury risk	Ind	No	2
D109	Marciano, F., Rossi, D., Cabassa, P., & Cocca, P. (2018). Analytic Hierarchy Process to support ergonomic evaluation of ultrasound devices. IFAC-PapersOnLine, 51(11), 328–333.	**T** Development of a method for supporting selection of ultrasound devices	Healthcare	Yes, performance	Yes	No	Reduce injury risk	Ind	Yes	3
D110	McDonald, A. C., Brenneman, E. C., Cudlip, A. C., & Dickerson, C. R. (2014). The Spatial Dependency of Shoulder Muscle Demands for Seated Lateral Hand Force Exertions. Journal of Applied Biomechanics, 30(1), 1–11.	**T** Development of a 3D body map to map physically demanding postures and workload-related musculoskeletal disorders	Not specified	Yes, assessment	Yes	Unclear	Reduce injury risk	Ind	No	3

	Source	Content (Approach / Process / Tool)	Area of applicability	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Points
D111	Müglich, D., Sinn-Behrendt, A., Schaub, K., & Bruder, R. (2015). Development of a database for capability-appropriate workplace design in the manufacturing industry. Occupational Ergonomics, 12(3), 109–118.	**T** Development of a database to adapt workplace design based on the elderly and their work capacity	Industrial work	Yes, performance	Unclear	-	Reduce injury risk	Ind	Yes	3
D112	Nanthavanij, S., Udomratana, C., Hansawad, S., Thepkanjana, J., & Tantasuwan, W. (2013). Worksheets for Computing Recommended Notebook Computer and Workstation Adjustments. International Journal of Occupational Safety and Ergonomics, 19(2), 259–274.	**T** Development of a tool that recommends adjustments in the design of computer workstations	Knowledge work	Yes, performance	Unclear	-	Reduce injury risk	Ind	No	1
D113	Peres, S. C., Mehta, R. K., & Ritchey, P. (2017). Assessing ergonomic risks of software: Development of the SEAT. Applied Ergonomics, 59, 377–386.	**T** Development of a method for assessing injury risks based on computer interaction and software design	Knowledge work	Yes, assessment	Yes	Unclear	Reduce injury risk	Ind	Yes	4
D114	Rasmussen, J., Tørholm, S., & de Zee, M. (2009). Computational analysis of the influence of seat pan inclination and friction on muscle activity and spinal joint forces. International Journal of Industrial Ergonomics, 39(1), 52–57.	**T** Development of a template for chair design	Multi occupation	Yes, performance	No	-	Reduce injury risk	Ind	No	2
D115	Sanchez-Lite, A., Garcia, M., Domingo, R., & Angel Sebastian, M. (2013). Novel Ergonomic Postural Assessment Method (NERPA) Using Product-Process Computer Aided Engineering for Ergonomic Workplace Design. PLoS ONE, 8(8), e72703.	**T** Testing of a simulation tool for ergonomic assessments	Industrial work	Yes, assessment	Yes	Unclear	Reduce injury risk	Ind	No	3
D116	Speklé, E. M., Hoozemans, M. J. M., van der Beek, A. J., Blatter, B. M., & van Dieën, J. H. (2012). The predictive validity of the RSI QuickScan Questionnaire with respect to arm, shoulder and neck symptoms in computer workers. Ergonomics, 55(12), 1559–1570.	**T** Validation of RSI QuickScan Questionnaire for predictive assessment of workload-related musculoskeletal disorders	Knowledge work	Yes, assessment	Yes	Yes	Reduce injury risk	Ind	No	4
D117	Tang, J., Zhang, X., & Li, Z.-M. (2008). Operational and maximal workspace of the thumb. Ergonomics, 51(7), 1109–1118.	**T** Measurement of thumb reach and design guidelines for digital hand tools	Not specified	Yes, performance	No	-	Reduce injury risk	Ind	No	1
D118	Van Kasteren, Y., Maeder, A., & Perimal-Lewis, L. (2018). Understanding Episodes of Physical Activity at Work Using Fitbit® Data. Studies in Health Technology and Informatics, 252, 151–157.	**T** Testing of wearable sensors to understand physical activity	Knowledge work	Yes, assessment	Yes	No	Increase well-being	Ind	Yes	4

	Source	Content (Approach / Process / Tool)	Area of applicability	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Points
D119	Xu, X., Robertson, M., Chen, K. B., Lin, J., & McGorry, R. W. (2017). Using the Microsoft KinectTM to assess 3-D shoulder kinematics during computer use. Applied Ergonomics, 65, 418–423.	**T** Testing of sensors for physical strain assessment	Knowledge work	Yes, assessment	Yes	Unclear	Reduce injury risk	Ind	Yes	4
D120	Zha, X. F. (2001). A neuro-fuzzy hybrid scheme for design and simulation of human machine systems. Applied Artificial Intelligence, 15(9), 797–823.	**T** Simulation; mathematical model, proof-of-concept for design and simulation of human machine systems	Industrial work	Yes, performance and assessment	Yes	No	Unclear	Ind	No	3
D121	Zunjic, A., Milanovic, D. D., Milanovic, D. L. , Misita, M., & Lukic, P. (2012). Development of a tool for assessment of VDT workplaces – A case study. International Journal of Industrial Ergonomics, 42(6), 581–591.	**T** Development of a checklist as an assessment tool for computer screen work, which incorporates the EU Directive 90/270/EEC (1990). The checklist was tested at 582 workplaces in various sectors at 49 organizations in Serbia.	Not specified	Yes, assessment	Yes	Yes	Unclear	Ind	No	3

Excluded articles, with reported reasons

Explanation of reasons for exclusion:

Wrong article type: The publication takes a purely theoretical approach or is a discussion or opinion article.

Wrong focus: The publication focuses primarily on work environmental, psychosocial and/or organizational aspects, and consequently has limited relevance to the physical design of workplaces.

Wrong population: The publication focuses on the wrong interest group, e.g. patients in healthcare environments rather than caregivers, as well as studies that pertain to the rehabilitation of injured individuals.

Wrong language: The primary content of the publication is in a language other than English.

	Excluded articles	Reason
E1	Abbasi, N., Fisher, K., & Gerrity, R. (2018). Designing better Workspaces for Academic Library Staff Case Study of University of Queensland Library. New Arch – International Journal of Contemporary Architecture, 5(1), 9–16.	Wrong focus
E2	Adeyemi, H. O., Ismaila, S. O., Adefemi, A. A., Akinyemi, O. O., & Olorunfemi, B. J. (2016). Modeling Sand-Shoveling Related Pain Risks with Fuzzy Logic. Mindanao Journal of Science and Technology, 14, 36–56.	Wrong focus
E3	Ahearn, D. J., Sanders, M. J., & Turcotte, C. (2010). Ergonomic design for dental offices. Work, 35(4), 495–503.	Wrong article type
E4	Ahern, C., McKinnon, M. C., Bieling, P. J., McNeely, H., & Langstaff, K. (2016). Overcoming the Challenges Inherent in Conducting Design Research in Mental Health Settings. HERD: Health Environments Research & Design Journal, 9(2), 119–129.	Wrong focus
E5	Alling, A., Nelson, M., Silverstone, S., & Van Thillo, M. (2002). Human factor observations of the Biosphere 2, 1991–1993, closed life support human experiment and its application to a long-term manned mission to Mars. Life Support & Biosphere Science: International Journal of Earth Space, 8(2), 71–82.	Wrong focus
E6	Alnefaie, M., Alamri, A., Hariri, A., Alsaad, M., Alsulami, A., Abbas, A., … Abbadi, H. (2019). Musculoskeletal Symptoms Among Surgeons at a Tertiary Care Center: a Survey Based Study. Medical Archives, 73(1), 49.	Wrong focus
E7	Anderson, J., Gosbee, L. L., Bessesen, M., & Williams, L. (2010). Using human factors engineering to improve the effectiveness of infection prevention and control. Critical Care Medicine, 38(8 SUPPL.), S269–S281.	Wrong article type
E8	Anema, J. R., Steenstra, I. A., Urlings, I. J. M., Bongers, P. M., de Vroome, E. M. M., & van Mechelen, W. (2003). Participatory ergonomics as a return-to-work intervention: A future challenge? American Journal of Industrial Medicine, 44(3), 273–281. https://doi.org/10.1002/ajim.10259	Wrong population
E9	Anton, D., Rosecrance, J. C., Gerr, F., Merlino, L. A., & Cook, T. M. (2005). Effect of concrete block weight and wall height on electromyographic activity and heart rate of masons. Ergonomics, 48(10), 1314–1330.	Wrong focus
E10	Applebaum, D., Fowler, S., Fiedler, N., Osinubi, O., & Robson, M. (2010). The Impact of Environmental Factors on Nursing Stress, Job Satisfaction, and Turnover Intention. JONA: The Journal of Nursing Administration, 40(7/8), 323–328.	Wrong focus
E11	Apud, E. (2012). Ergonomics in mining: The Chilean experience. Human Factors, 54(6), 901–907.	Wrong article type
E12	Arlinghaus, A., Caban-Martinez, A. J., Marino, M., & Reme, S. E. (2013). The role of ergonomic and psychosocial workplace factors in the reporting of back injuries among U.S. home health aides. American Journal of Industrial Medicine, 56(10), 1239–1244.	Wrong focus
E13	Ashelin, C. (2012). Controlling facility noise with curtain walls. Occupational Health & Safety (Waco, Tex.), 81(10).	Wrong article type; Wrong focus
E14	Attaianese, E., & Duca, G. (2012). Human factors and ergonomic principles in building design for life and work activities: an applied methodology. Theoretical Issues in Ergonomics Science, 13(2), 187–202.	Wrong article type
E15	Augusto, V. G., Sampaio, R. F., Ferreira, F. R., Kirkwood, R. N., & César, C. C. (2015). Factors associated with inadequate work ability among women in the clothing industry. Work, 50(2), 275–283.	Wrong focus

	Excluded articles	Reason
E16	Axtell, C., Pepper, K., Clegg, C., Wall, T., & Gardner, P. (2001). Designing and evaluating new ways of working: The application of some sociotechnical tools. Human Factors and Ergonomics in Manufacturing, 11(1), 1–18.	Wrong focus
E17	Baker, N. A., Moehling, K. K., & Park, S. Y. (2015). The effect of an alternative keyboard on musculoskeletal discomfort: A randomized cross-over trial. Work, 50(4), 677–686. https://doi.org/10.3233/WOR-131797	Wrong population
E18	Bao, S., Silverstein, B., & Stewart, K. (2013). Evaluation of an ergonomics intervention among Nicaraguan coffee harvesting workers. Ergonomics, 56(2), 166–181.	Wrong population
E19	Bartnicka, J., & Winkler, T. (2010). Innovation-Based Enhancing Work Conditions in Healthcare Organizations. In Khalid, H., Hedge, A., & Ahram, T. (Eds.) Advances in Ergonomics Modeling and Usability Evaluation (pp. 578–587), Boca Raton: CRC Press.	Wrong article type
E20	Bazley, C., Vink, P., Montgomery, J., & Hedge, A. (2016). Interior effects on comfort in healthcare waiting areas. Work, 54(4), 791–806. https://doi.org/10.3233/WOR-162347	Wrong population
E21	Bellmann, V. K., Brede, S., & Nyhuis, P. (2017). Ergonomic evaluation 4.0 – Real-time and camera-assisted evaluation of ergonomics and measures in assembly. ZWF Zeitschrift Für Wirtschaftlichen Fabrikbetrieb, 112(9), 588–592.	Wrong language
E22	Ben-Gal, I., & Bukchin, J. (2002). The ergonomic design of workstations using virtual manufacturing and response surface methodology. IIE Transactions, 34(4), 375–391.	Wrong focus
E23	Benjamin, J. L., & Meisinger, Q. C. (2018). Ergonomics in the Development and Prevention of Musculoskeletal Injury in Interventional Radiologists. Techniques in Vascular and Interventional Radiology, 21(1), 16–20.	Wrong article type
E24	Bhattacharyya, N., & Chakrabarti, D. (2012). Design development scopes towards occupational wellness of women workers: Specific reference to local agro based food processing Industries in NE India. Work, 43(4), 403–409.	Wrong population
E25	Bitencourt, R. S., & De MacEdo Guimarães, L. B. (2012). Macroergonomic analysis of two different work organizations in a same sector of a luminary manufacturer. Work, 41(SUPPL.1), 2686–2694. https://doi.org/10.3233/WOR-2012-0512-2686	Wrong article type
E26	Bittencourt, M. C., Pereira, V. L. D. do V., & Júnior, W. P. (2015). The Usability of Architectural Spaces: Objective and Subjective Qualities of Built Environment as Multidisciplinary Construction. Procedia Manufacturing, 3, 6429–6436.	Wrong focus
E27	Björkstén, M. G., Boquist, B., Talbäck, M., & Edling, C. (2001). Reported neck and shoulder problems in female Industrial workers: the importance of factors at work and at home. International Journal of Industrial Ergonomics, 27(3), 159–170. https://doi.org/10.1016/S0169-8141(00)00047-0	Wrong population
E28	Bohle, P., Pitts, C., & Quinlan, M. (2010). Time to call it quits? The safety and health of older workers. International Journal of Health Services, 40(1), 23–41.	Wrong article type
E29	Boubekri, M., Cheung, I. N., Reid, K. J., Wang, C.-H., & Zee, P. C. (2014). Impact of Windows and Daylight Exposure on Overall Health and Sleep Quality of Office Workers: A Case-Control Pilot Study. Journal of Clinical Sleep Medicine, 10(6), 603–611. https://doi.org/10.5664/jcsm.3780	Wrong focus
E30	Brand, D. M., & Rensink, H. J. T. (2002). Reduce engineering rework, plant life cycle costs. Hydrocarbon Processing, 81(12), 41–42, 44.	Wrong article type
E31	Brandt, M., Madeleine, P., Ajslev, J. Z. N., Jakobsen, M. D., Samani, A., Sundstrup, E., … Andersen, L. L. (2015). Participatory intervention with objectively measured physical risk factors for musculoskeletal disorders in the construction industry: study protocol for a cluster randomized controlled trial. BMC Musculoskeletal Disorders, 16(1), 302.	Wrong article type

	Excluded articles	Reason
E32	Brick, N. (2014). Candrane review brief: Ergonomic design and training for preventing work-related musculoskeletal disorders of the upper limb and neck in adults. Online Journal of Issues in Nursing, 19(3).	Wrong article type
E33	Bump, S., Whitten, D., Caballero, M., Banaszynski, J., Keelean, K., & Miller, J. (2002). Health physics technician injury reduction. Health Physics, 82(5 SUPPL.), S92–S96.	Wrong article type
E34	Burmeister, C. P., Moskaliuk, J., & Cress, U. (2018). Ubiquitous Working: Do Work Versus Non-work Environments Affect Decision-Making and Concentration? Frontiers in Psychology, 9(MAR).	Wrong focus
E35	Callaghan, J. P., De Carvalho, D., Gallagher, K., Karakolis, T., & Nelson-Wong, E. (2015). Is Standing the Solution to Sedentary Office Work? Ergonomics in Design: The Quarterly of Human Factors Applications, 23(3), 20–24.	Wrong article type
E36	Calvet, B., Riel, J., Couture, V., & Messing, K. (2012). Work organization and gender among hospital cleaners in Quebec after the merger of 'light' and 'heavy' work classifications. Ergonomics, 55(2), 160–172.	Wrong focus
E37	Campos-Andrade, C., Hernández-Fernaud, E., & Lima, M.-L. (2013). A better physical environment in the workplace means higher well-being? A study with healthcare professionals. PsyEcology, 4(1), 89–110.	Wrong focus
E38	Cantor Cutiva, L. C., Puglisi, G. E., Astolfi, A., & Carullo, A. (2017). Four-day Follow-up Study on the Self-reported Voice Condition and Noise Condition of Teachers: Relationship Between Vocal Parameters and Classroom Acoustics. Journal of Voice, 31(1), 120.e1-120.e8.	Wrong focus
E39	Carlson, N. G., Schwartz, A., Greenwell, J., & Casura, G. (2019). The office changes leading to sit-to-stand ergonomics. Work, 61(4), 501–507.	Wrong article type
E40	Carr, S. J. (2016). Insights in Public Health: Building Well-Being: Linking the Built Environment to Health. Hawai'i Journal of Medicine & Public Health: A Journal of Asia Pacific Medicine & Public Health, 75(1), 22–24.	Wrong article type
E41	Chanchai, W., Songkham, W., Ketsomporn, P., Sappakitchanchai, P., Siriwong, W., & Robson, M. (2016). The Impact of an Ergonomics Intervention on Psychosocial Factors and Musculoskeletal Symptoms among Thai Hospital Orderlies. International Journal of Environmental Research and Public Health, 13(5), 464.	Wrong focus
E42	Cheesman, A. (2008). Workplace Ergonomics for the Health Care Professional. Journal of Medical Imaging and Radiation Sciences, 39(4), 198–205.	Wrong article type
E43	Childre, F., & Koehl, B. (2009). An effective office ergonomic assessment and intervention program. AAOHN Journal: Official Journal of the American Association of Occupational Health Nurses, 57(12), 488–490.	Wrong article type
E44	Choi, J.-H., & Moon, J. (2017). Impacts of human and spatial factors on user satisfaction in office environments. Building and Environment, 114, 23–35.	Wrong focus
E45	Cifuentes, M., & Fulmer, S. (2015). Research Needs for and Barriers to Use of Treadmill Workstations. Ergonomics in Design: The Quarterly of Human Factors Applications, 23(3), 25–30.	Wrong article type
E46	Clements-Croome, D. (2015). Creative and productive workplaces: a review. Intelligent Buildings International, 7(4), 164–183.	Wrong article type
E47	Clements, N., Zhang, R., Jamrozik, A., Campanella, C., & Bauer, B. (2019). The Spatial and Temporal Variability of the Indoor Environmental Quality during Three Simulated Office Studies at a Living Lab. Buildings, 9(3), 62.	Wrong focus
E48	Colombini, D., & Occhipinti, E. (2006). Preventing upper limb work-related musculoskeletal disorders (UL-WMSDS): New approaches in job (re)design and current trends in standardization. Applied Ergonomics, 37(4), 441–450.	Wrong article type

	Excluded articles	Reason
E49	Culig, K. M., Dickinson, A. M., Lindstrom-Hazel, D., & Austin, J. (2008). Combining Workstation Design and Performance Management to Increase Ergonomically Correct Computer Typing Postures. Journal of Organizational Behavior Management, 28(3), 146–175.	Wrong focus
E50	Dahlberg, R., Karlqvist, L., Bildt, C., & Nykvist, K. (2004). Do work technique and musculoskeletal symptoms differ between men and women performing the same type of work tasks? Applied Ergonomics, 35(6), 521–529.	Wrong focus
E51	Dainoff, M. J., Aarås, A., Horgen, G., Konarska, M., Larsen, S., Thoresen, M., & Cohen, B. G. F. (2005). The effect of an ergonomic intervention on musculoskeletal, psychosocial and visual strain of vdt entry work: Organization and methodology of the international study. International Journal of Occupational Safety and Ergonomics, 11(1), 9–23.	Wrong article type
E52	Dangelmaier, M., Bauer, W., Vocke, C., & Melcher, V. (2015). Work and Workout - How to Introduce Healthy Workload at Workplaces. Procedia Manufacturing, 3, 4971–4977.	Wrong focus
E53	Davis, K. G., & Kotowski, S. E. (2015). Stand Up and Move; Your Musculoskeletal Health Depends on It. Ergonomics in Design: The Quarterly of Human Factors Applications, 23(3), 9–13.	Wrong article type
E54	Davis, M. C., Leach, D. J., & Clegg, C. W. (2011). The Physical Environment of the Office: Contemporary and Emerging Issues. In International Review of Industrial and Organizational Psychology, 26, 193–237. Chichester, UK: John Wiley & Sons, Ltd.	Wrong article type
E55	De Magistris, G., Micaelli, A., Evrard, P., Andriot, C., Savin, J., Gaudez, C., & Marsot, J. (2013). Dynamic control of DHM for ergonomic assessments. International Journal of Industrial Ergonomics, 43(2), 170–180.	Wrong focus
E56	Estryn-Behar, M., Milanini-Magny, G., Raphael, M., Avrillon, E., Bressler, S., Echard, A., … Martin, S. (2013). Participatory ergonomics in emergency medicine – Implementation of changes after two statistical studies: Part 2. Proposals. Annales Francaises de Medecine d'Urgence, 3(4), 230–239.	Wrong language
E57	Estryn-Behar, M., Raphael, M., Milanini-Magny, G., Hennequin, M., Bressler, S., Avrillon, E., … Martin, S. (2013). Participatory ergonomics in emergency medicine - Implementation of changes: Part 1. Real-task analysis. Annales Françaises de Médecine d'urgence, 3(4), 217–229.	Wrong language
E58	Ferguson, S. A., Marras, W. S., & Burr, D. (2005). Workplace design guidelines for asymptomatic vs. low-back-injured workers. Applied Ergonomics, 36(1), 85–95. https://doi.org/10.1016/j.apergo.2004.07.002	Wrong focus
E59	Flyte, M. G. (2000). Vehicle as an IT office environment: ergonomics design requirements for mobile computing. International Journal of Vehicle Design, 23(3), 329–341.	Wrong article type
E60	Gambatese, J. A. (2008). Research Issues in Prevention through Design. Journal of Safety Research, 39(2), 153–156. https://doi.org/10.1016/j.jsr.2008.02.012	Wrong focus
E61	Górny, A. (2015). Man as Internal Customer for Working Environment Improvements. Procedia Manufacturing, 3, 4700–4707.	Wrong article type
E62	Graham, R. B., Sadler, E. M., & Stevenson, J. M. (2011). Automotive assembly and low back pain: A review of the problem and various ergonomic solutions. Automotive Industry: Technical Challenges, Design Issues and Global Economic Crisis, 205–225.	Wrong article type
E63	Harisinghani, M. G., Blake, M. A., Saksena, M., Hahn, P. F., Gervais, D., Zalis, M., … Mueller, P. R. (2004). Importance and Effects of Altered Workplace Ergonomics in Modern Radiology Suites. RadioGraphics, 24(2), 615–627.	Wrong article type
E64	Helland, M., & Horgen, G. (2012). Visual challenges using Visual Display Units (VDU) in office landscapes. Work, 41(SUPPL.1), 3575–3576.	Wrong article type

	Excluded articles	Reason
E65	Higgins, N. A., Talone, A. B., Fraulini, N. W., & Smither, J. A. (2017). Human factors and ergonomics assessment of food pantry work: A case study. Work, 56(3), 455–462.	Wrong population
E66	Jacobs, J. V., Hettinger, L. J., Huang, Y.-H., Jeffries, S., Lesch, M. F., Simmons, L. A., … Willetts, J. L. (2019). Employee acceptance of wearable technology in the workplace. Applied Ergonomics, 78, 148–156.	Wrong focus
E67	Jankovský, M., Merganič, J., Allman, M., Ferenčík, M., & Messingerová, V. (2018). The cumulative effects of work-related factors increase the heart rate of cabin field machine operators. International Journal of Industrial Ergonomics, 65, 173–178. https://doi.org/10.1016/j.ergon.2017.08.003	Wrong focus
E68	Karakhan, A. A., & Gambatese, J. A. (2017). Safety Innovation and Integration in High-Performance Designs: Benefits, Motivations, and Obstacles. Practice Periodical on Structural Design and Construction, 22(4), 04017018.	Wrong article type
E69	Kausto, J., Miranda, H., Pehkonen, I., Heliövaara, M., Viikari-Juntura, E., & Solovieva, S. (2011). The distribution and co-occurrence of physical and psychosocial risk factors for musculoskeletal disorders in a general working population. International Archives of Occupational and Environmental Health, 84(7), 773–788.	Wrong focus
E70	Kirk, E., & Strong, J. (2010). Management of eWork health issues: A new perspective on an old problem. Work, 35(2), 173–181.	Wrong focus
E71	Kogi, K. (2006). Participatory methods effective for ergonomic workplace improvement. Applied Ergonomics, 37(4), 547–554.	Wrong focus
E72	Kotradyova, V. (2015). Material Surface Features in Body Conscious Spatial Design. New Arch – International Journal of Contemporary Architecture, 2(2), 38–44.	Wrong article type
E73	Kristjuhan, Ü. (2010). Decreasing the aging velocity in industry workers. Annals of the New York Academy of Sciences, 1197(1), 49–53.	Wrong article type
E74	Kumar, P., Chakrabarti, D., Patel, T., & Chowdhuri, A. (2016). Work-related pains among the workers associated with pineapple peeling in small fruit processing units of North East India. International Journal of Industrial Ergonomics, 53, 124–129.	Wrong population
E75	Lamy, S., Descatha, A., Sobaszek, A., Caroly, S., De Gaudemaris, R., & Lang, T. (2014). Role of the work-unit environment in the development of new shoulder pain among hospital workers: a longitudinal analysis. Scandinavian Journal of Work, Environment & Health, 40(4), 400–410.	Wrong focus
E76	Larson, B. A., & Ellexson, M. T. (2000). Blueprint for ergonomics. Work, 15(2), 107–112.	Wrong article type
E77	Larson, N., & Wick, H. (2012). 30 years of ergonomics at 3M: A case study. Work, 41(SUPPL.1), 5091–5098.	Wrong article type
E78	Leber, M., Bastic, M., Moody, L., & Schmidt Krajnc, M. (2018). A study of the impact of ergonomically designed workplaces on employee productivity. Advances in Production Engineering & Management, 13(1), 107–117.	Wrong focus
E79	Lee, E. W. C., Fok, J. P. C., Lam, A. T., Law, R. K. Y., Szeto, G. P. Y., & Li, P. P. K. (2014). The application of participatory ergonomics in a healthcare setting in Hong Kong. Work, 48(4), 511–519.	Wrong focus
E80	Lewis, R. J., Fogleman, M., Deeb, J., Crandall, E., & Agopsowicz, D. (2001). Effectiveness of a VDT ergonomics training program. International Journal of Industrial Ergonomics, 27(2), 119–131.	Wrong focus
E81	Lowe, B. D., Swanson, N. G., Hudock, S. D., & Lotz, W. G. (2015). Unstable Sitting in the Workplace—Are There Physical Activity Benefits? American Journal of Health Promotion, 29(4), 207–209.	Wrong article type

	Excluded articles	Reason
E82	Makhbul, Z. M. (2012). Workplace Environment Towards Health and Performance. International Business Management, 6(6), 640–647.	Wrong focus
E83	Mangone, G., Capaldi, C. A., van Allen, Z. M., & Luscuere, P. G. (2017). Bringing nature to work: Preferences and perceptions of constructed indoor and natural outdoor workspaces. Urban Forestry & Urban Greening, 23, 1–12.	Wrong focus
E84	Matt, S. B., Fleming, S. E., & Maheady, D. C. (2015). Creating Disability Inclusive Work Environments for Our Aging Nursing Workforce. JONA: The Journal of Nursing Administration, 45(6), 325–330.	Wrong article type
E85	Moussaoui, A., Pruski, A., & Maaoui, C. (2012). Virtual reality for accessibility assessment of a built environment for a wheelchair user. Technology and Disability, 24(2), 129–137. https://doi.org/10.3233/TAD-2012-0341	Wrong population
E86	Mukhopadhyay, P., & Ghosal, S. (2008). Ergonomic Design Intervention In Manual Incense Sticks Manufacturing. The Design Journal, 11(1), 65–80.	Wrong focus
E87	Mula, A. (2018). Ergonomics and the standing desk. Work, 60(2), 171–174.	Wrong focus
E88	Mulville, M., Callaghan, N., & Isaac, D. (2016). The impact of the ambient environment and building configuration on occupant productivity in open-plan commercial offices. Journal of Corporate Real Estate, 18(3), 180–193. https://doi.org/10.1108/JCRE-11-2015-0038	Wrong article type
E89	Myerson, J., & Ramster, G. (2017). Architecture: Workplace health and wellbeing: can greater design participation provide a cure? In R. Cooper & E. Tsekleves (Eds.), Design for Health: Design for Social Responsibility. UK: Routledge.	Wrong focus
E90	Olendorf, M. R., & Drury, C. G. (2001). Postural discomfort and perceived exertion in standardized box-holding postures. Ergonomics, 44(15), 1341–1367. https://doi.org/10.1080/00140130110085358	Wrong focus
E91	Parry, S., Straker, L., Gilson, N. D., & Smith, A. J. (2013). Participatory Workplace Interventions Can Reduce Sedentary Time for Office Workers—A Randomised Controlled Trial. PLoS ONE, 8(11), e78957.	Wrong focus
E92	Peters, R. H., Fotta, B., & Mallett, L. G. (2001). The Influence of Seam Height on Lost-Time Injury and Fatality Rates at Small Underground Bituminous Coal Mines. Applied Occupational and Environmental Hygiene, 16(11), 1028–1034.	Wrong focus
E93	Pilgård, G., Söderfeldt, B., Hjalmers, K., & Rosenquist, J. (2008). Work environment factors affecting quality work in Swedish oral and maxillofacial surgery. Swedish Dental Journal, 32(3), 149–155.	Wrong article type
E94	Pollack-Simon, R. (2000). All the right moves: integrating technology & ergonomics into your patient care environment. Dentistry Today, 19(10), 112–117.	Wrong article type
E95	Potters, D. (2010). An ergonomic, safe and healthy working environment for crane operators. Iron and Steel Technology, 7(2), 26–28.	Wrong focus
E96	Prairie, J., Plamondon, A., Larouche, D., Hegg-Deloye, S., & Corbeil, P. (2017). Paramedics' working strategies while loading a stretcher into an ambulance. Applied Ergonomics, 65, 112–122.	Wrong article type
E97	Australian Printer Magazine (2008) Producing success with advanced ergonomics. April, 90–91.	Wrong population
E98	Richter, J. M., Mathiassen, S. E., Slijper, H. P., Over, E. A. B., & Frens, M. A. (2009). Differences in muscle load between computer and non-computer work among office workers. Ergonomics, 52(12), 1540–1555. https://doi.org/10.1080/00140130903199905	Wrong focus

	Excluded articles	Reason
E99	Robertson, M. M., Ciriello, V. M., & Garabet, A. M. (2013). Office ergonomics training and a sit-stand workstation: Effects on musculoskeletal and visual symptoms and performance of office workers. Applied Ergonomics, 44(1), 73–85.	Wrong focus
E100	Rolo, G., Hernández-Fernaud, E., Díaz-Cabrera, D., Hernández-Fernau, E., Díaz-Cabrera, D., Hernández-Fernaud, E., … Díaz-Cabrera, D. (2010). Impact of perceived physical and environmental conditions on mental workload: An exploratory study in office workers. PsyEcology, 1(3), 393–401.	Wrong article type
E101	Roquelaure, Y. (2016). Promoting a Shared Representation of Workers' Activities to Improve Integrated Prevention of Work-Related Musculoskeletal Disorders. Safety and Health at Work, 7(2), 171–174.	Wrong article type
E102	Ruohomäki, V., Lahtinen, M., & Reijula, K. (2015). Salutogenic and user-centred approach for workplace design. Intelligent Buildings International, 7(4), 184–197.	Wrong article type
E103	Ryan, C. O., Browning, W. D., Clancy, J. O., Andrews, S. L., & Kallianpurkar, N. B. (2014). Biophilic design patterns: Emerging nature-based parameters for health and well-being in the built environment. Archnet-IJAR, 8(2), 62–76.	Wrong focus
E104	Schall, M. C., Sesek, R. F., & Cavuoto, L. A. (2018). Barriers to the Adoption of Wearable Sensors in the Workplace: A Survey of Occupational Safety and Health Professionals. Human Factors: The Journal of the Human Factors and Ergonomics Society, 60(3), 351–362.	Wrong article type
E105	Schatz, S. L., & Bowers, C. A. (2005). 10 Questions on Room Color: Answers for Workplace Designers. Ergonomics in Design: The Quarterly of Human Factors Applications, 13(4), 21–27.	Wrong article type
E106	Schneider, F. (2001). Four steps to an effective office ergonomics program. Occupational Health & Safety, 70(9), 140–144.	Wrong focus
E107	Singh, A., Syal, M., Grady, S. C., & Korkmaz, S. (2010). Effects of Green Buildings on Employee Health and Productivity. American Journal of Public Health, 100(9), 1665–1668.	Wrong focus
E108	Skepper, N., Straker, L., & Pollock, C. (2000). A case study of the use of ergonomics information in a heavy engineering design process. International Journal of Industrial Ergonomics, 26(3), 425–435.	Wrong focus
E109	Smith-Jackson, T. L., & Klein, K. W. (2009). Open-plan offices: Task performance and mental workload. Journal of Environmental Psychology, 29(2), 279–289.	Wrong article type
E110	Smith, K. D., & Walker, B. A. (2001). Optimum console design promotes control room efficiency. Hydrocarbon Processing, 80(9), 163–170.	Wrong article type; Wrong focus
E111	Sorensen, G., Peters, S., Nielsen, K., Nagler, E., Karapanos, M., Wallace, L., … Wagner, G. R. (2019). Improving Working Conditions to Promote Worker Safety, Health, and Wellbeing for Low-Wage Workers: The Workplace Organizational Health Study. International Journal of Environmental Research and Public Health, 16(8), 1449.	Wrong article type
E112	Stichler, J. F. (2007). Using Evidence-based Design to Improve Outcomes. JONA: The Journal of Nursing Administration, 37(1), 1–4.	Wrong focus
E113	Tint, P., Traumann, A., Pille, V., Tuulik-Leisi, V. R., & Tuulik, V. (2012). Computer users' health risks caused by the simultaneous influence of inadequate indoor climate and monotonous work. Agronomy Research, 10(SPEC. ISS. 1), 261–268.	Wrong article type
E114	Vanwonterghem, K. (2009). Ergonomics and Human Factors: Methodological Considerations About Evidence Based Design of Work Systems. In Schlick, C. M. (Ed.) Industrial Engi-neering and Ergonomics (pp. 413–425), Dordrecht: Springer.	Wrong article type

	Excluded articles	Reason
E115	Vogel, K., Karltun, J., Eklund, J., & Engkvist, I.-L. (2013). Improving meat cutters' work: Changes and effects following an intervention. Applied Ergonomics, 44(6), 996–1003. https://doi.org/10.1016/j.apergo.2013.03.016	Wrong population
E116	Wandzich, D. E., & Płaza, G. A. (2017). New and Emerging Risks Associated With "Green" Workplaces. Workplace Health & Safety, 65(10), 493–500.	Wrong article type
E117	Welch, L., Haile, E., Boden, L. I., & Hunting, K. L. (2009). Musculoskeletal disorders among construction roofers—physical function and disability. Scandinavian Journal of Work, Environment & Health, 35(1), 56–63. https://doi.org/10.5271/sjweh.1302	Wrong article type
E118	Wojcikiewicz, K. (2003). Seven key factors for ergonomic workstation design. Manufacturing Engineering, 131(1).	Wrong focus
E119	Wong, S. W., Smith, R., & Crowe, P. (2010). Optimizing the operating theatre environment. ANZ Journal of Surgery, 80(12), 917–924.	Wrong article type; Wrong focus
E120	Yan, X. W., & England, M. E. (2001). Design Evaluation of an Arctic Research Station: From a upper perspective. Environment and Behavior, 33(3), 449–470.	Wrong focus
E121	Zborowsky, T., & Hellmich, L. B. (2011). Impact of place on people and process: The integration of research on the built environment in the planning and design of critical care areas. Critical Care Nursing Quarterly, 34(4), 268–281.	Wrong population

Swedish Agency for Work
Environment Expertise

www.sawee.se

ISBN 978-91-986142-0-6