

# The Value of Occupational Health Research

History, Evolution and Way Forward

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**CONFLICTS OF INTEREST:**

None

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## RECOMMENDATIONS

**Recommendation 1:**

There is a requirement for a co-ordinating body in the UK to provide leadership on OH research, to disseminate research to key stakeholders simply and meaningfully and to facilitate the translation of research into practice. Further functions should be to grow and support the OH academic base through training and development, to attract research funding to the specialty and to promote the value of OH research (see recommendations below).

**Recommendation 2:**

A national co-ordinated OH research strategy is required to progress the research agenda and inform policy development. Current research priorities have recently been identified from two UK studies<sup>1,2</sup> and these can be used as a platform. To date, what has been lacking is collaboration with research funding organisations. This would be essential to the success of any strategy, as would their continued engagement with the evolving OH research agenda.

**Recommendation 3:**

Urgent attention needs to be given to retaining and developing the OH academic base; to attract, train and support new OH researchers with appropriate resourcing for this. Unlike other clinical disciplines, there are no established pathways for academic training and careers in OH research and neither is there a co-ordinated approach across the UK or in its constituent countries. This is a fundamental barrier that needs to be addressed.

**Recommendation 4:**

Improved dissemination and better 'marketing' of key and relevant OH research findings is required to promote their 'value' among key stakeholders including OH clinicians, employers, employees and Government.

**Recommendation 5:**

Current research priorities of employers, human resources and worker representatives should be identified. Addressing their priorities could be an important measure to 'add' value.

**Recommendation 6:**

There is a need for integration of technological advances into OH research and incorporation of more innovative methodologies, particularly in the fields of occupational database development, social media and artificial intelligence. This forward thinking and 'cutting-edge' approach is likely to increase the OH research profile and attract the attention of funding organisations and prospective OH researchers.

**Recommendation 7:**

High quality economic evaluation studies are required across the different OH research areas to establish their economic value, to help decision makers to make best use of resources and potentially strengthen the business case to employers and Government.

**Recommendation 8:**

The benefits of OH can accrue to a wide range of stakeholders hence broad societal perspective economic evaluations are required. New guidance on conducting and reporting economic evaluations are recommended for this purpose. Economic evaluations of OH interventions and services should include a long-term time horizon, allow for reporting multiple sector effects and report costs and outcomes from a broad societal perspective along with other perspectives including the NHS and the employer. Frameworks such as cost-benefit analyses, return on investment and cost-consequences analyses are likely to capture the effects beyond the traditional, narrower, cost-effectiveness methods.

**Recommendation 9:**

The feasibility and implementation of many of the recommendations above will only be possible with funding investment in OH research. Government, employers and industry, as co-beneficiaries of workplace health, should lead this investment. Potential gains could include: healthy working lives with improved workforce productivity and retention, improved public health and a thriving national economy.

*Additional recommendations for the provision of multidisciplinary OH clinical services as a whole (linking to the OH research agenda):*

**Recommendation 1:**

The gaps in OH provision should be addressed. There is incomplete OH coverage of the working population due to a system of self-funded and optional provision of OH services by employers. Small and Medium Enterprises (SMEs) in particular have poor coverage and there is no systematic coverage of the unemployed working age population. Alternative models of OH provision for the UK working age population should be investigated and potential new models assessed with rigorous evaluation and research.

**Recommendation 2:**

The numbers of clinical and other staff providing OH need to increase, through more training posts and recruitment. OH remains a poorly publicised and understood specialty. Much work is still needed to increase its profile and to 'market' careers in OH.

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## EXECUTIVE SUMMARY

As a follow-on to the two previous UK and Global reports on the value of occupational health (OH)<sup>3,4</sup>, the aim of this report was to assess the value of OH research.

The reader might wonder why three reports are thought to be necessary on the value of this specialty area of medicine and health care and it can be argued that it is precisely because OH provision in most countries sits outside mainstream medical services. Employers have to purchase it; it is therefore an overhead cost; and because a large proportion of OH conditions are chronic, with long latency, the perceived value appears to be low.

This has been reflected in the serious decline of academic OH resources in the UK over the past 30 years, at a time when recognition of the interaction between work and health has never been higher. Worldwide the costs of work-related health issues are an estimated 4% of global GDP and equivalent to the entire GDP of the UK<sup>5</sup>. This figure<sup>5</sup> refers to work injuries and illnesses only, with the burden likely to be considerably higher when accounting for the impact of health on work, and going forward, the ageing working population with multiple morbidity and longer exposures to work environments.

Historically, OH research has meant different things to different people and a single definition is yet to be established. A potential reason for this could be its growth, development and evolution over time.

In its broadest sense, OH research is the scientific study of the interaction between work and health. It is multidisciplinary and covers a range of study areas including: occupational disease epidemiology, exposure assessment, toxicology and hygiene, sickness absence management, workplace and worker wellbeing/health promotion, evaluation of OH interventions and health economics. These different approaches provide complementary insights to the evidence-base, and its application to practice and policy.

This report has approached the 'value' of OH research from a general OH perspective i.e. improving health, wellbeing and functional capability of the working age population, a societal and public health perspective and an economic perspective.

These elements have been addressed by: a brief scoping review of workplace interventions with economic evaluations, qualitative interviews of key stakeholders in the field of OH research, and supplemented by an overview of related reports and publications, including those on occupational epidemiology and other OH research areas.

Systematic reviews to evaluate the cost-effectiveness of OH interventions<sup>6-9</sup> have identified poor methodological quality as a key barrier to drawing meaningful conclusions. It has been five years since the most recent review<sup>7</sup> so we undertook a brief scope of the literature and its methodological quality to explore whether there had been any improvement since then in the quality of economic evaluations. We found a relatively low number of intervention studies in OH research that incorporated economic evaluations. Few were cost-effective or cost-beneficial. For the majority, the economic evaluations were typically of low methodological quality and often from an 'employer' perspective only. Only a small number included a broader societal perspective. The majority of studies did not consider a long-term time horizon nor use any extrapolation or modelling approaches.

Nevertheless, although there is a persisting lack of evidence to support the economic value, based on our evaluation of the literature and the qualitative interviews we conducted, in our view there is a strong case to support the OH (i.e. improving health, wellbeing and functional capacity of the working age population), societal and public health value of OH research.

Occupational epidemiological research has made an enormously valuable contribution in these areas. Many diseases and risk factors for diseases were first discovered in occupational studies<sup>10,11</sup>, with increased recognition of the work setting and occupational cohorts as remarkably good study populations to assess exposures<sup>10-12</sup>. Early epidemiological studies of large scale occupational diseases and resulting workplace exposure limits and descriptions of best practice have led to their reduction (and in some cases elimination) and have substantially improved population health, possibly more than most other population or clinical interventions. The morbidity and mortality in relation to work historically was very high and this has improved to a substantial degree through industry and policy makers paying increasing attention to research on health and the systematic study and developments that followed.

These falling trends have been corroborated by early 21st century databases on prevalence of and trends in work-related disease in different occupations internationally and nationally in a number of countries<sup>13,14</sup>. The OH, public health and societal value here has been the substantial reduction in mortality and morbidity of the working age population.

Indeed, the impact of this historical OH research has been much wider in that it has also contributed to the broader understanding of disease mechanisms, particularly in the fields of toxicology and carcinogenesis, and recognition of the significance of environmental exposures.

Historically, much of what was known about the causes of cancer was derived from studies undertaken in the workplace. Up until the early 1980's, almost half of the recognised human carcinogens were occupational in nature<sup>11,15</sup>. Although this may no longer be the case with the growing number of non-occupational carcinogens, they still represent a substantial proportion. In 2017, there were 47 established occupational carcinogens compared with 28 in 2004<sup>11</sup>. Although recognition of occupational carcinogens are important for occupational cancer prevention, given that many occupational exposures find their way into the general environment, the potential benefit of these discoveries extends beyond the workplace.

Waddell and Burton's pioneering evidence review<sup>16</sup> leading to the development of the Faculty of Occupational Medicine Guidelines for the Management of Low Back Pain at Work in 2000, as mentioned in our stakeholder interviews, conveys the powerful impact robust research can have on revolutionising not just risk but clinical and OH management. It marked the introduction of the first national OH guidelines in the UK, and brought to the forefront the biopsychosocial model of health<sup>17,18</sup>.

Without doubt, one of the most valuable contributions of OH research in current times has been demonstration of the health benefits of 'good work' and the adverse health impact of being away from work. This is effectively the underpinning supportive evidence-base for OH as a specialty, and has empowered all those in workplace health to confidently promote the benefits of being in work. This triggered a paradigm shift that has not only influenced Government to act (particularly with the challenges they face with growing benefit dependency) and employers in their management of absence (in recognition that "Good Health is Good Business"<sup>19,20</sup>) but also public perceptions, with broader societal ramifications in reducing health and social inequalities, as highlighted in our interviews. The evidence-base on the health benefits of work has gone a step further in consolidating the concept of work as a health outcome, in rightful recognition within mainstream healthcare, of the important impact of work on health. This could become even more important with ageing demographics and the mental health epidemic<sup>19</sup> where work may prove to be a positive health intervention.

Given the decline in heavy manufacturing industry in the UK and other developed countries in recent decades, there is an overarching perception that occupational diseases

are a thing of the past. However, this shift in industry, technological advances and the global economic drive have brought with them new occupational hazards. With rapidly evolving work situations, new hazards will inevitably emerge and, as has been the case historically, it is imperative that there is robust epidemiological evidence derived from within the UK, to inform national OH and safety policy development and safer work practices.

UK and US surveys of the perceived value of health research by the public<sup>21,22</sup> have found that they hold a very positive view of research, believing that developments in science play a very important role in our health and the economy and are essential for improving the quality of human lives and society<sup>21,22</sup>. A UK health and safety study identified that members of the public are more supportive of health and safety efforts to promote safer workplaces than interventions out of work and half the respondents thought more could be done to protect workers from health and safety risks<sup>23</sup>.

Although we did not identify any employer data on their perceived value of research, in one UK study of employer and employee priorities of the required competencies for occupational physicians (OPs), 75% of respondents considered research to be an important OP competency<sup>24</sup>.

It is not difficult to see why we need to continue to encourage and drive high quality OH research, with the report providing striking examples of the benefits it has provided to OH, public health and society as a whole. Modern day OH research has scope to be even broader in its role, not just targeting 'occupational diseases' but also accessing a wide range of the population to 'prevent' and 'manage' broader population health issues.

Commitment and action is required to continue to innovate and drive the OH research agenda and to actively convey and 'better market' this value to key stakeholders (e.g. OH clinicians, employers, the HR community, employees, employee representative organisations and Government). Equally, the future maintenance of this potentially 'valuable' contribution can only be secured through retention and development of the OH academic base and attracting research grant funding.

In summary therefore, while there is a persisting lack of good quality evidence to demonstrate the economic value of OH interventions, based on our evaluation of the research and qualitative study, in our view there is a strong case supporting the OH, societal and public health value of OH research.

We conclude that OH research should be at the core of shaping a healthy workforce and productive economy and should be developed accordingly.

## 1. DEFINING OCCUPATIONAL HEALTH RESEARCH

Since its inception, occupational health (OH) research has meant different things to different people and a clear definition has yet to be established. A potential reason for this could be its growth, development and evolution over time. It was initially focussed around occupational hazards and work related ill health and, while this has remained important, OH research has evolved to also encompass the impact of health on work. In recent years, its scope has developed even more broadly, to investigate the health of the working age population and worklessness.

In its broadest sense, OH research is the scientific study of the interaction between work and health.

OH research covers a range of study areas. These include: occupational disease epidemiology, exposure assessment, toxicology and hygiene, sickness absence management, workplace and worker wellbeing/health promotion, evaluation of OH interventions and health economics. These study areas can provide important information about occupational disease trends and risk factors, outcomes of work interventions, facilitating early rehabilitation and return to work (RTW), improving functional capability, patterns of service delivery and economic evaluation, although this list is not exhaustive. These different approaches to OH research provide complementary insights to the evidence base, and its application to practice and policy.

In recent years the key focus areas have included: the psychosocial work environment, musculoskeletal disorders (MSD), hazardous substances and occupational safety and health (OSH) services and management.

OH research is multidisciplinary and researchers might include: physicians, nurses, epidemiologists, hygienists, statisticians, toxicologists, ergonomists, health economists, sociologists, geneticists, data managers, clinical scientists, social scientists and market researchers.

## 2. THE HISTORICAL BACKGROUND OF OCCUPATIONAL HEALTH RESEARCH

Scientific investigation and research on work and health date back to the 16th and 17th centuries with increasing recognition of occupational hazards to health and disease<sup>25</sup>. Agricola and Paracelsus described the hazards and disease associated with metal mining. The harmful health effects of lead, carbon monoxide and arsenic were also observed during this early period. A key development occurred in 1775 when Percival Pott described scrotal cancer in chimney sweeps, the first occupational cancer recorded in history. Other examples between the late 18th century and early 19th century include: Thomas Percival's study of textile mill workers, Charles Thackrah's work on occupational disease epidemiology and mortality and Greenhow's work on dusts/fumes and respiratory disease<sup>25</sup>.

These scientific reports influenced workplace and government policy and a continual series of legislation related to working conditions in the 19th century both in Europe and the UK. The Factory Acts in the UK regulated working hours and working age. It also introduced physician examinations of workers with specific exposures, factory inspectors, safety processes and notification of industrial disease. In 1898 Thomas Legge was appointed the first Medical Inspector of Factories in the UK<sup>25</sup>.

The growing body of evidence ultimately led to the introduction of trade unions, worker's compensation and increased bargaining power to continually improve working conditions and prevent injuries and disease.

The ensuing decades saw research focussed on high incidences of byssinosis, lead poisoning, coal workers pneumoconiosis, asbestos-related diseases, silicosis, and many other diseases<sup>25</sup>. Even with its use banned in the UK for several decades in response to the scientific research, because of the prolonged latency of disease onset, asbestos remains the single biggest cause of work-related deaths in the UK<sup>26</sup>.

## 3. THE EVOLUTION OF WORK

Work and concomitantly, OH services have evolved in recent decades with manifest changes in customer and workforce needs, working population demographics and work practices and patterns. The latter have been largely driven by a marked shift from heavy manufacturing industry to service based industries, the emergence of small and medium sized enterprises (doing some of the work previously undertaken by larger industrial corporations) but also regulatory and legislative requirements and technological advances. OH problems vary with these dynamics and change and develop accordingly.

#### 4. RECENT AND CURRENT DEVELOPMENTS IN OCCUPATIONAL HEALTH RESEARCH

Through the pioneering advances in workplace health science described earlier and the developments that followed, notably establishment of occupational hygiene, workplace exposure limits and description of best practice, substantial improvements in workplace occupational health and safety in developed countries have occurred.

Government agencies such as the UK Health and Safety Executive (HSE) and professional associations such as International Labour Organisation (ILO) and International Commission on Occupational Health (ICOH) were developed in the early 20th century to record and monitor trends in occupational disease. The mid-20th century brought further material developments in UK Occupational Health and Safety legislation and EU directives.

The late 20th century saw national OHS organisations in the US, UK, Italy, EU and Japan develop their research agendas. Early 21st century databases looking at prevalence and trends of work-related disease in different occupations have been established on international and national levels as a driver for both further clinical research and legislative changes. Examples include: ILO– Recording & notification of occupational accidents and diseases and ILO list of occupational diseases<sup>27</sup>, the HSE and THOR<sup>28</sup> in the UK, NIOSH<sup>29</sup> in the US and MODERNET<sup>30</sup> in Europe. A Cochrane Work<sup>31</sup> Review Group has also been established with over 100 systematic reviews or protocols of reviews on topics relevant to OH and safety.

Recent decades have seen the growth of new (or perhaps, only newly recognised) conditions, such as work-related upper limb (and other musculoskeletal) disorders, occupational deafness, hand arm vibration syndrome (HAVS), occupational asthma and work-related stress/mental ill health. New occupational carcinogens have also been identified.

At the same time, a shift of emphasis has occurred from historical disease prevention to overall worker health and wellbeing and the impact of health on work.

Waddell and Burton's pioneering evidence review<sup>16</sup> leading to the development of the Faculty of Occupational Medicine Guidelines for the Management of Low Back Pain at Work in 2000, revolutionised the clinical management of low back pain. It marked the introduction of the first national occupational health guidelines in the UK, and brought to the forefront the biopsychosocial model of health<sup>17,18</sup>.

The study of biopsychosocial factors in OH has continued to grow in importance, an example being the CUPID study which across 18 countries showed large differences in the prevalence of musculoskeletal pain and related sickness absence among workers doing similar occupational tasks<sup>32</sup>.

In recent decades, there has been a strong emergent focus on disability management and workplace adjustments to enable workers with chronic diseases to remain at work. The introduction of disability discrimination legislation in the UK<sup>33,34</sup> has undoubtedly been a key driver in this trend, as has the recent Government target to see one million more disabled people in employment by 2027<sup>35</sup>.

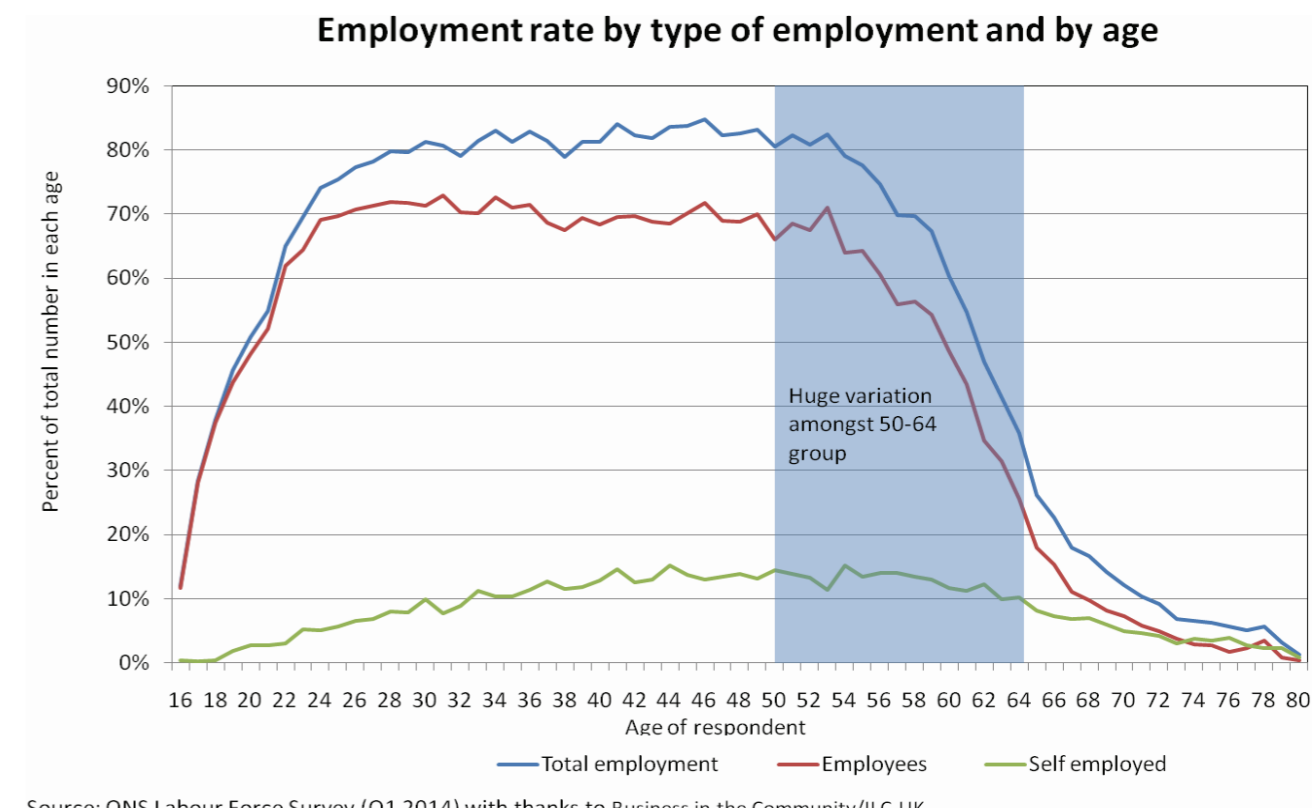
In tandem, the developing evidence base on the adverse health effects of prolonged absence from work (such as poor prognostic outcomes and increased risk of work loss) has been established, along with a drive toward pro-active absence management and rehabilitation and a focus on early interventions in sickness absence.

There is also an increasing interest in studying sickness presenteeism<sup>36</sup> (i.e. a person's decision to go to work despite feeling ill) and the related factors including work, personal circumstances and attitudes towards sickness absence<sup>36</sup> but there is still much heterogeneity in how it is assessed.

The changing demographics of an increasing ageing population and pension eligibility changes have made it necessary to keep people in work for longer<sup>37</sup>.

While policy imperative is toward extending working lives, a 2014 ONS report (see **Figure 1**) demonstrated a substantial proportion of those aged between 50-60 falling out of work<sup>38</sup>.

Figure 1. Employment rate by age



Source: ONS Labour Force Survey (Q1 2014) with thanks to Business in the Community/ILC-UK

Ageing is associated with multiple morbidity, which in turn is a cause of job loss<sup>39</sup>. A recent study of 13,000 benefit claimants in the welfare to work programme confirmed a strong inverse relationship between the number of medical conditions and the likelihood of return to work (RTW)<sup>39</sup>. Much of the current OH research undertaken in the UK is still focused on occupational groups and specific clinical areas such as respiratory, musculoskeletal and mental health conditions. However, more research on multi-morbidity and maintaining function in an ageing population is needed.

OH services in the UK are funded by the employer; those who have lost their job through ill health generally have no access to OH advice or services, which are currently focussed on the survivor population. Some attention is now given to the previously overlooked 'workless' population and importantly, modifiable factors that may prevent these individuals falling out of work in the first place. There is a need for much more research in this field. The concept of 'good' work and the related health benefit is now established. There is also emerging recognition of the workplace as a forum for influencing health behaviours, of worklessness as a public health issue, and of work as a health outcome<sup>19,35</sup>.

## 5. THE BURDEN OF HEALTH ON WORK AND WORK-RELATED ILL HEALTH

Ill health among the working population has a significant societal and economic impact. In 2017, the Labour Force Survey estimated that 131 million days were lost due to sickness absence, with an average of 4.1 lost days per worker<sup>40</sup>. Minor illnesses were the commonest absence reason accounting for 34.3 million days, followed by musculoskeletal problems and mental health problems (stress, depression, anxiety)<sup>40</sup> with 28.2 million and 14.3 million lost days, respectively.

Similarly, work-related illnesses present a heavy socio-economic burden. According to HSE figures in 2017/2018, an estimated 30.7 million working days were lost due to work-related illness or workplace injuries with an estimated total annual cost in 2016/17 of £15 billion for work-related injury and new cases of ill health (excluding long latency illness such as cancer), £5.2 billion for injuries and £9.7 billion for new cases of illness<sup>41</sup>. These figures refer to work injuries and illnesses only, with the burden likely to be considerably higher when accounting for the impact of health on work.

In quantifying the burden of work-related illnesses, it is important to distinguish between the overall incidence of illnesses that can be caused by work, and the excess incidence of such illnesses that are attributable to work. The latter is much harder to measure, and sources such as self-report of illness that is caused or made worse by work and counts of medically attributed cases are not considered a particularly reliable indicator.

When the NHS was formed in 1948, OH was not included, and at that time OH funding and development were primarily driven by health and safety legislation. The socio-economic burden of health on work has been highlighted as a 'powerful incentive' for the government to fund broader OH service provision, with a proposal to integrate OH into NHS care systems<sup>19,42</sup>.

The developing concept of work as a health outcome has stimulated growing awareness of the importance of wider provision of OH to all people of working age<sup>35</sup>. Similarly, the Public Health Responsibility Deal in England aiming to improve public health by addressing workplace health through public-private partnership 'health at work' pledges has initiated the culture changes and 'big picture' perspective that is necessary<sup>43</sup>.

## 6. ESTABLISHING RESEARCH PRIORITIES

Evolving OH practice has presented new and changing priorities in OH research. Evaluation and establishment of current research priorities is essential to ensure research is relevant and impactful at key levels (academic, policy and practice) and to target funding. Numerous countries have established national OH research priorities<sup>44</sup> including the USA<sup>45,46</sup>, the Netherlands<sup>47</sup>, Italy<sup>48,49</sup>, Japan<sup>50</sup>, Malaysia<sup>51</sup>, UAE<sup>52</sup>, Australia<sup>53</sup> and the UK<sup>54,55</sup>. A global study<sup>56</sup> and European studies<sup>57,58</sup> have also been undertaken. Research priorities identified from these have included cost-benefit studies<sup>47,57</sup>, workplace injuries<sup>49,53</sup>, occupational carcinogenesis<sup>49</sup>, psychosocial hazards<sup>53</sup> and changing work patterns/workforce<sup>50,58</sup>. Musculoskeletal disorders were the highest priority among OH clinicians in an earlier UK study undertaken over 20 years ago<sup>54</sup>, with musculoskeletal disorders and stress top in a study of personnel managers<sup>55</sup>.

These study findings highlight<sup>44-59</sup> varying national priorities between countries<sup>44-59</sup> due to differences in work/workforce demographics, economic development, socio-cultural backgrounds, and health and safety legislation. Nevertheless, the importance of their findings is evident from the impact they have had within their countries in attracting research funding<sup>59</sup>.

In a more recent UK study of both occupational physicians (OPs) and occupational health researchers (OHRs) undertaken in 2017<sup>1</sup>, economic evaluation/cost-effectiveness studies and disability management were identified jointly as the top research priority, followed by occupational disease/injury/illness. The study results also showed a priority emphasis on mental health and psychosocial hazards, supporting the changing landscape of disease epidemiology, and mental ill health (including work-related mental ill health) as a key player<sup>1</sup>. A need for an increase in evidence-based guidance for clinical OH practice was also identified<sup>1</sup>.

Although the highest priority in the previous UK study 20 years ago<sup>54</sup>, musculoskeletal issues were absent among top priorities<sup>1</sup>. These differences across two decades were probably a reflection of evolving OH practice and related legislation.

## 7. RESOURCING IN OCCUPATIONAL HEALTH RESEARCH

Challenges in OH resourcing are two-fold. Firstly, only a limited number of organisations specifically fund OH and work-related research in the UK. It is more commonly funded as part of larger, broader multi-specialty research projects. Therefore, total research funding allocation to OH and work-related research is difficult to quantify, particularly in key priority areas. There has also been recognition of an important potential influence of research funding scheme criteria and specific study types awarded grants.

Concomitantly, a declining OH academic base and reduction in the number of OH research centres/groups<sup>61-63</sup> present significant challenges in progressing the research agenda. For example, in 2011<sup>37</sup> approximately seven specialist occupational physicians held substantive UK academic appointments, with others undertaking part-time teaching/research (totalling around 24 FTEs). Current estimations are of no full-time posts and less than three full-time equivalents (UK Academic Forum for Health and Work, Society of Occupational Medicine and Faculty of Occupational Medicine). Lack of funding and opportunity for able young academics<sup>63</sup> and the separation of OH from mainstream healthcare<sup>61</sup> are reported barriers in OP research participation.

In recent years, the decline in the number of OP academics has been balanced to some degree by a growth in academics from other disciplines who have an interest in the broader aspects of health and work.

Of note, the 2017 study<sup>1</sup> also highlighted disparities between areas in which research is currently being undertaken (occupational disease/injury/illness, occupational hazards to health and risk assessment and sickness absence management) and areas where current priorities were identified (economic evaluation/cost-effectiveness studies and disability management). Potential reasons for this divergence included: increased emphasis on 'higher profile' intervention and aetiological studies within the established OH research agenda<sup>60</sup> and specific criteria of schemes for funding research.

Another recent UK study of health and safety professionals, younger workers and OPs has identified three sets of health conditions as priority for future research: occupational stress, musculoskeletal disorders (including HAVS) and occupational lung disorders<sup>2</sup>.

## 8. TRANSLATING RESEARCH INTO PRACTICE AND POLICY CHANGES

As with research in general<sup>64</sup>, within OH and safety<sup>65</sup>, concerns around research–practice gaps<sup>66</sup> and the so-called practitioner–researcher divide<sup>67</sup> have been expressed in recent years. These pertain to the degree to which researchers address questions they perceive of primary importance to them, rather than practitioner-focussed research<sup>68</sup>.

There has also been debate around the extent to which research findings translate into practice or policy changes<sup>66</sup>. It has been reported that, despite multiple decades of advances in medical knowledge based on high-quality empirical evidence, widespread implementation of these findings into practice has not been achieved<sup>69</sup>. Additionally, in OH, there is increasing recognition of the importance of even broader dissemination of research findings (beyond academics and practitioners) to employers, human resources, the business community and Government. Wider public engagement is also necessary to inform and educate about advancing developments and thereby improve both general and occupational health and wellbeing. The value clinicians and practitioners place on research has also been debated with re-iteration that ‘relevant and useful research’ is more likely to draw the attention of practitioners and influence their practice<sup>68</sup>.

## 9. DEFINITION OF VALUE

This report completes a trilogy of reports related to the value of maintaining and improving the health and wellbeing of the working age population. The first, **Occupational health: the value proposition**<sup>3</sup>, was aimed at UK policy makers and commissioners of services and provided a narrative synthesis of the evidence from the scientific and wider literature to help illustrate and publicise the benefits that OH services provide to employees, employers and to the economy.

The second, **Occupational Health: the Global Evidence and Value**<sup>4</sup> provided an extensive global perspective of the considerable financial and societal benefits.

Both applied a broad meaning to the word ‘value’ as including the financial, legal and moral aspects.

Value can be defined as ‘the regard that something is held to deserve; the importance, worth or usefulness of something’ (Oxford Dictionary). In a modern consumer context, it is often associated with economic worth and cost-benefit, although it can also apply at a personal level or ‘for the greater good’.

In an OH context, an applied ‘value’ definition could be improving health, wellbeing and functional capability of the working population with resultant economic, industry, societal, occupational and public health benefits<sup>70</sup>.

The reader might wonder why three reports are thought to be necessary on the value of this specialty area of medicine and health care and it can be argued that it is precisely because OH provision in most countries sits outside mainstream medical services. Employers have to purchase it; it is therefore an overhead cost; and because a large proportion of OH conditions are chronic, with long latency, the perceived value appears to be low.

This has been reflected in the serious decline of academic OH resources in the UK over the past 30 years as highlighted above, at a time when recognition of the interaction between work and health has never been higher, and globally the costs of work-related health issues are an estimated 4% of global GDP and equivalent to the entire GDP of the UK<sup>5</sup>. Once again, this figure<sup>5</sup> refers to work injuries and illnesses only, with the burden likely to be considerably higher when accounting for the impact of health on work, and going forward, the ageing population and multiple morbidity.

## 10. SCOPING REVIEW OF ECONOMIC EVALUATION WORKPLACE INTERVENTIONS

We elected to focus our scope of the literature on workplace intervention studies over other aspects of OH research. This is on the basis that intervention studies evaluate effects of treatment/programmes in real-world settings. Furthermore, they are often the natural follow-on from occupational epidemiology studies.

In recent years, several interventions at the workplace have been developed, implemented and assessed with the aim to modify or improve working conditions, worker health and workplace practices. The “effectiveness” of the intervention focuses on the extent to which an intervention improves health outcomes for individuals. The “cost-effectiveness” refers to cost of the intervention or its economic effect. This includes an analysis of the direct and, less frequently, the indirect costs of implementing the intervention, and considers the effect or consequences of an intervention upon economic variables. In other words, it seeks to determine the best “value for money” or the “financial return” from the intervention in order to maximise individuals’ health, wellbeing and function, given the available resources.

The two previous reports<sup>3,4</sup> on the value of occupational health have identified high quality economic evaluations to be an important gap in the OH evidence base. Furthermore, in a recent study<sup>1</sup> on the OH research priorities of UK OH physicians and researchers, economic evaluation/cost-effectiveness studies were ranked the highest priority jointly, along with disability management.

A number of systematic reviews have been conducted to evaluate the cost-effectiveness of OH interventions<sup>7-9</sup>, all of which have identified poor methodological quality as a key barrier to drawing meaningful conclusions and making a value case. As it has been five years since the last systematic review<sup>7</sup>, we undertook a brief scoping review of the literature and its methodological quality to explore whether there had been any improvement since then in the quality of economic evaluations. This review focussed on workplace interventions where an economic evaluation had been performed or where economic outcomes had been assessed. For the purpose of the review, workplace interventions were defined as all interventions carried out in the workplace, implemented directly or indirectly by the employer, including the involvement and participation of a variety of professionals from internal (company/sector occupational health departments) or external occupational health services.

While acknowledging the varying and broad definitions and perspectives held, the scope of this report has approached the ‘value’ of OH research from a general OH perspective i.e. improving health, wellbeing and functional capability of the working age population, a societal and public health perspective and an economic perspective.

These elements have been addressed by: a brief scoping review of workplace interventions with economic evaluations, assessment of their methodological quality, qualitative interviews of key stakeholders in the field of OH research, and supplemented by an overview of related reports and publications, including those on occupational epidemiology and other OH research areas.



## METHODOLOGY OF THE REVIEW

### Search strategy

An electronic search was carried out using MEDLINE (Pubmed) database. Our search strategy combined four blocks of keywords or MESH terms intended to cover all different aspects of our review: i) workplace setting ii) occupational exposures and outcomes iii) intervention, randomised controlled trials, clinical trials and systematic review studies and iv) economic evaluation and financial outcomes. The detailed search strategy is available from the authors upon request.

### Study selection and eligibility criteria

Randomised controlled trials, controlled trials, cluster-randomised trials, before and after studies and systematic reviews published in English or Spanish until April 2019 were included if they involved economic evaluation of workplace interventions or financial outcomes were included, such as productivity or indirect cost derived from absenteeism.

A total of 1,333 citations were obtained from the electronic search. One reviewer screened titles and, when necessary, abstracts for eligibility. The reference lists from selected papers were searched by hand and additional studies derived from relevant systematic reviews selected in our search were also identified. 123 potentially suitable publications were identified from the electronic search and a full text was obtained for all of them. Those 123 studies were reviewed by two independent reviewers. Disagreements were resolved by discussion and, where necessary, by a third reviewer who made the final decision. 33 papers met our inclusion criteria and were considered for this brief scoping review.

### Data extraction and synthesis

The 33 interventions were classified into four broad categories: a) health promotion interventions b) ergonomic interventions c) interventions related to employability/work adjustments/work rehabilitation/return to work d) psychosocial interventions. Selected information was obtained from each of the 33 studies, including author, publication year, country of origin, intervention setting and study participants. Likewise, characteristics of intervention and control groups, follow-up period and primary and secondary outcome measurements were also documented from each paper. This information is summarised in Tables 1-4.

## TYPES OF INTERVENTIONS

### a) Health promotion interventions

Six health promotion interventions were identified from our search. Two identified papers related to the same intervention<sup>71,72</sup> (Strijk 2013, van Dongen 2013). Four studies were performed in the United States<sup>73-76</sup> (Palumbo 2012, Kuehl 2013, Serxner 2012, Serxner 2001), one in The Netherlands<sup>71,72</sup> (Strijk 2013, van Dongen 2013) and one in Taiwan<sup>77</sup> (Lin 2018). The workplace settings were very variable, including an aerospace industry<sup>77</sup> (Lin 2018), a telecommunications company<sup>76</sup> (Serxner 2001), a fire department<sup>73</sup> (Kuehl 2013), a large financial services corporation<sup>75</sup> (Serxner 2012) and two academic hospitals/medical centres<sup>71,72, 74</sup> (Palumbo 2012, Strijk 2013, van Dongen 2013). Table 1 provides a summary of all the health promotion interventions included in the scoping review. In general, most of the selected interventions sought to decrease sedentary activities and to promote physical activities at the workplace, including exercise programmes such as yoga, workout, aerobic exercise and Tai Chi classes. One study included a free fruit programme<sup>71,72</sup> (Strijk 2013, van Dongen 2013) and only one intervention was oriented to workers on sick leave<sup>76</sup> (Serxner 2001). From all six health promotion interventions included, only four seemed to be cost-effective or cost-saving<sup>73-76</sup> (Palumbo 2012, Kuehl 2013, Serxner 2012, Serxner 2001).

### b) Ergonomic interventions

Table 2 describes the ergonomic interventions selected in our review. Nine interventions fulfilled our eligibility criteria. The majority of the interventions included were performed in North America, and from those, seven were performed in the United States<sup>78-82</sup> (Rempel 2006, Lahiri 2005, Collins 2004, Evannoff 1999, Banco 1997) and one in Canada<sup>83</sup> (Chhokar 2004). Only one intervention was implemented in Europe<sup>84-86</sup> (Driessen 2011, Driessen 2012). In general, the selected interventions included ergonomic training, workstation modifications, mechanical aides or lifts, participatory ergonomics programmes and a safety programme to reduce cutting injuries at the workplace. Six<sup>79-81, 83</sup> (Lahiri 2005, Collins 2004, Chhokar 2004, Evannoff 1999) out of nine interventions were before-and-after assessments and no control group was selected. All the ergonomic interventions seemed to be cost-effective or cost-saving, with the exception of one<sup>84-86</sup> (Driessen 2011, Driessen 2012).

### c) Interventions in relation to employability, work adjustments, work rehabilitation and return to work

13 interventions were identified in relation to employability, work adjustments, work rehabilitation and return to work. The characteristics and main outcomes of the selected interventions are presented in Table 3. The Netherlands with five studies is the predominant country publishing on these types of intervention<sup>87-91</sup> (van Holland 2018, Koolhaas 2015, Meijer 2006, Steenstra 2006, Hlobil 2007), two studies were performed in Sweden<sup>92-93</sup> (Karrholm 2006, Jensen 2005), two studies in Canada<sup>94-95</sup> (Badii 2006, Loisel 2002) and one study in Germany<sup>96</sup> (Enriquez-Diaz 2012), Denmark<sup>97</sup> (Bultmann 2009), United States<sup>98</sup> (Maniscalco 1999) and Brazil<sup>99</sup> (Comper 2017) respectively. Programmes to identify workers at risk for reduced employability, job rotation programmes, problem-solving strategies for ageing workers, combined occupational and clinical interventions, workplace programmes to reduce injuries due to musculoskeletal disorders, manufacturing methods, health assessment programmes and cognitive behavioural and work rehabilitation programmes were the type of interventions included. Absenteeism, days lost or time loss as a proxy of productivity loss were included in eight<sup>87, 90-95, 97</sup> (van Holland 2018, Badii 2006, Karrholm 2006, Bultmann 2009, Jensen 2005, Loisel 2002, Steenstra 2006, Hlobil 2007) of the 13 studies. Four workplace interventions<sup>87, 93, 95, 98</sup> (Maniscalco 1999, Karrholm 2006, Loisel 2002, Hlobil 2007) seemed to be cost-effective and from those, only one study did not include a control group<sup>98</sup> (Maniscalco 1999).

### d) Psychosocial interventions

Only four psychosocial interventions were identified with our eligibility criteria. Two studies came from the United States<sup>100, 101</sup> (Lavelle 2018, Childs 2014) and two from Nordic countries<sup>102, 103</sup> (Gupta 2018, Anderzen 2005). The study settings were military installations<sup>100, 101</sup> (Lavelle 2018, Childs 2014), manufacturing factories<sup>103</sup> (Gupta 2018) and internal revenue service<sup>102</sup> (Anderzen 2005). All interventions were educational programmes to map and enhance psychosocial aspects at the workplace. Outcomes assessed in the selected interventions included mental health<sup>101</sup> (Lavelle 2018) and musculoskeletal disorders<sup>100</sup> (Childs 2014). From the four included interventions, only one<sup>101</sup> (Lavelle 2018) seemed to be cost-effective.

## METHODOLOGY ASSESSMENT OF ECONOMIC EVALUATIONS

The majority of the economic studies were conducted in the United States. The overall rating of these economic evaluations was low/moderate quality. The main perspective of the studies was the 'employer' perspective. In a few of the identified studies were broader perspective economic evaluations such as cost-benefit analysis performed. The majority of the outcomes evaluated within these economic evaluations were productivity and reduced absenteeism. Only one study used a formal threshold to assess value for money. This study was also the only one to include a recommended preference-based quality of life outcome measure. The highest quality economic evidence comes from those studies evaluating employability/work adjustments/ rehabilitation/return to work interventions (n=13). 5/13 of these studies were from the Netherlands, two from Canada and two from Sweden. These latter studies tended to adopt a greater use of cost-benefit analyses and other approaches including return on investment.

## SUMMARY OF SCOPING REVIEW AND ECONOMIC EVALUATION METHODOLOGY FINDINGS

Most of the interventions were implemented in the United States, the Netherlands or in Nordic countries. None of the interventions identified within our search criteria came from the United Kingdom and a number were before-and-after studies without a control group.

Overall the economic evaluations focussed on measuring and valuing absenteeism and productivity, using a narrow ‘employer’ perspective. They focussed on cost savings and typically did not include preference-based quality of life outcomes nor utilise thresholds for making assessments of value.

Of those minority of studies that were higher quality, there were however insights to the possible value workplace interventions could have in society. Economists/health economists have not paid this OH area sufficient attention in regard to the adoption of relevant methodology with a greater use of broad evaluative frameworks, including cost-benefit analysis and/or cost-consequences analysis. There has been an insufficient use of longer-term time horizons and little adoption of modelling methods to assist with this.

In the UK, with bodies such as the National Institute for Clinical Excellence (NICE) paying a renewed attention to the economic evaluation of ‘preventive’ population health interventions and an associated rise in the methodological guidance for conducting these complex evaluations, economists should capitalise on this opportunity to explore the economics of OH.

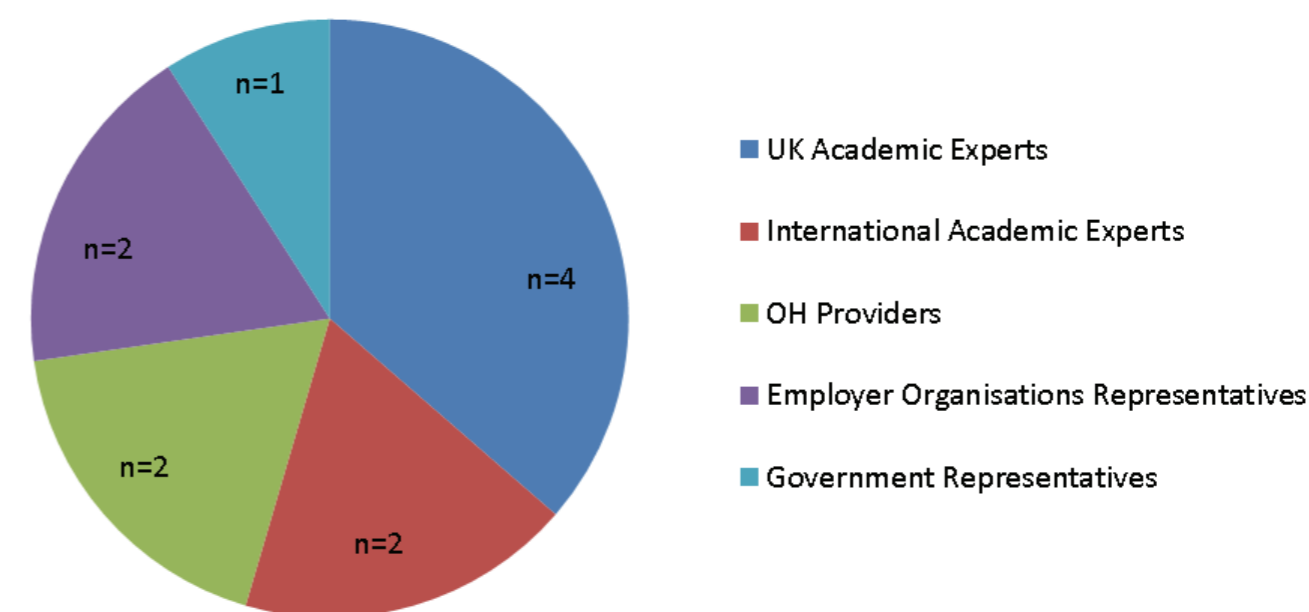
## 11. STAKEHOLDER PERSPECTIVES

Understanding how key stakeholders perceive the value of OH research and what they think about its current and future status is just as critically important as understanding the scope and quality of published research in the field.

We supplemented our literature review with insights from qualitative interview data collected from a range of stakeholders, including UK and international academic experts, employer organisations representatives, OH providers, and a Government representative (Figure 2). The study was approved by the University of Glasgow ethics committee. Participants – identified through the professional networks of the research team – were selected based on three factors: (a) their substantial experience and expertise in the field of OH (b) their professional

category/role, and (c) their accessibility (mainly in terms of time availability). Between March and April 2019, a total of 11 semi-structured, telephone interviews were conducted, lasting on average half an hour. With participant permission, all interviews were audio-recorded, fully transcribed, and thematically analysed. This section provides an overview of the qualitative findings, organised under two main headings: a) ‘What has OH research ever done for us?’ and (b) ‘Key challenges in moving forward’. Direct quotes from participants are used throughout to illustrate main points. To ensure anonymity and confidentiality, participant names have been replaced with participant numbers; gender and professional category are nonetheless indicated.

Figure 2. Number of participants by professional category



**a) What has OH research ever done for us?**

Participating stakeholders talked extensively about the 'value' of OH research, conceptualised primarily as the development of a solid evidence base for identifying and controlling occupational health hazards and creating safer working environments: "Take for instance all the research that was done about risk factors and management of back pain at work. That's had a huge impact on health at work and on managing risks at work. I mean, 20 years ago, you used to see nurses who did their first shift on the ward and they'd do something stupid... not stupid, but they'd do some major manual handling activity and they'd end up with back pain, and some of them never got back to work – or, well, certainly never got back to work in nursing. That almost never happens now." (Participant 6 – Female, Employer Organisations Representative).

Such real-world examples of impact or 'success stories' were common in participants' narratives, with several highlighting the crucial role that OH research has had in reducing traditional occupational diseases, such as occupational asthma and silicosis: "There have been several success stories over the last decades. You're usually going to find them by looking at surveillance data. Some diseases are – I don't know if I can use the word 'disappearing' – markedly going down. An anecdotal example and I hope this is still true... I remember going to a scientific conference a few years ago and talking, among other things, about silicosis. And somebody – one of the presenters – said, 'you know, in Sweden we have stopped measuring rates of silicosis, because our numbers are so low that we just simply count the cases.' And I thought that was a beautiful example of success, right? Because one is too many." (Participant 9 – Male, International Academic Expert).

Participants also discussed how the field of OH has evolved over the last decades and how the focus of research has gradually shifted from hazard identification and control to a broader consideration of the health benefits of work and the importance of 'good work': "The most important thing we've proven beyond reasonable doubt is that being at work is better for you – if you're in good work – than being away from work and absent from work. And this has massively changed Government policy and is beginning to move Government policy to the long-term sickness and absence, and people on benefits. And it is one of the most important things that we can do in terms of reducing health and social inequalities. I don't think we are very good at blowing that trumpet, I have to say, but I think we've got to basically choose to use it to demonstrate the important impact on societal health inequalities." (Participant 1 – Male, OH Provider).

**b) Key challenges in moving forward**

Notwithstanding the overall positive outlook, informants identified a number of key challenges that need to be addressed so that the field of OH research continues to evolve and expand. Among the most commonly reported ones were the lack of a consistent funding stream to support OH research activities, as well as the steady decline in the number of OH research centres (and, more broadly, in the number of people choosing an academic pathway). A Government representative commented: "I think, at the moment, it all feels to me a little bit 'hit-and-miss' in terms of both resourcing the research and what's currently being done and where. It doesn't feel like it's coherent at all and I think there's definitely a role for central Government in providing a bit of coherence into what needs to be done... I mean, sitting in Scottish Government, we don't have resources that we can put into this at the moment or, at least, the case is not being made well to ministers that they should be thinking about putting resources into this and I think, possibly, it's the same with the UK Government. I think the other problem is the status of occupational health within the NHS. It's not part of core NHS services, so provision is patchy. It's not coherent, it's not consistent and, therefore, it's not providing career paths or opportunities for people to develop a career and then, therefore, there isn't the teaching and research base that is needed to support that. So, it probably needs to be given a more significant status in terms of what the NHS does." (Participant 8 – Male, Government Representative).

*"I think it has to do with the lack of a sort of reference structure that supports it, that supports occupational medicine as a clinical discipline that should have research in the same way as other specialities. And that's linked to the lack of national support for it, because it's seen, at the moment, very much in Government terms, as getting people back to work, which is a good agenda - it's absolutely right - but the agenda should be wider than that."*

Participant 6 – Female,  
Employer Organisations Representative

The need to attract high quality people in OH research was a recurring theme across the interviews, with some stakeholders admitting that "occupational medicine has never been very good at marketing itself within academic institutions" and others talking about a lack of a culture of research in occupational medicine: "So, I think there's a few things to that... I think there's a lack of an academic pathway, so that's one thing. There's a lack of people who want to do occupational medicine research, so posts have been advertised and nobody's applied for them. That's probably something to do with people that want to do occupational medicine as a specialty; they're not as interested in research as perhaps they might be in other specialties, such as cardiology or respiratory. And the third thing: there's just not a culture of research in occupational medicine, so that's our fault, really, that we have not made it a culture." (Participant 4 – Female, UK Academic Expert).

Doing 'better' research and research that is socially relevant and can influence policy and practice was also voiced as a key priority for moving forward. 'Better', in this context, was seen as going beyond the traditional occupational health approaches and finding ways to effectively address the complexity of emerging challenges. According to the participants, this could be accomplished through various means, including strengthening interdisciplinary collaboration and adopting a more systems-based approach to analysing and intervening on occupational health problems: "But since 2011, there's also a new paradigm shift that is occurring in what is the next challenge in occupational health. And this is the... you've probably heard of the concept of 'total worker health'. 'Total worker health' implies an important paradigmatic shift. It has been sometimes portrayed over-simplistically as simply bringing traditional occupational safety and health together with health promotion in the workplace. It's not – it's more than that. It's a lot more than that, but the shift is, conceptually, from our objective, going from wanting to keep – and this is a little bit euphemistic – the worker as healthy when he or she leaves at the end of the work day, as when he or she came in that day. Shifting to, again euphemistically, hoping even that their health is even a little bit better when they leave the workplace. And to do that, you have to go beyond traditional occupational health and safety approaches, such as identifying workplace risks and how to control them. And use a much more systems-based approach to looking at exposure as a much broader thing that includes individual behaviours, that includes community exposures, it includes risk factors inside and outside of the workplace, and how they all interact to affect the health of the worker in both a positive and a negative sense, because it doesn't always have to be negative." (Participant 9 – Male, International Academic Expert).

Last but not least, equally important was seen to be the integration of technological advances into OH research. As one of the participants described: "Occupational data is not included in any of the routine data collection in primary or secondary care in the UK, and that is a big limitation. So, trying to kind of improve data and evidence through electronic systems – they might not necessarily be designed solely for research purposes but they may have other purposes. So, what I'm saying is that they do not need to be part of a research project, but we need to kind of develop systems that can collect intelligent evidence of lagging and leading indicators, mainly leading indicators in occupational health." (Participant 3 – Male, UK Academic Expert).

Similarly, another academic commented: "We are not alone in the world anymore. There's a big digitalisation occurring at the moment. And I think that's an opportunity and a challenge at the same time. I think our traditional context, in which we are seeing patients within a medical setting, and in which the physician does the examination and gives advice, I think that model is not valid anymore. I think we need to work much more on shared decision-making kind of consultations and fully make use of the opportunities that the digital world is offering us, the data that can be collected, and also artificial intelligence, so that we can improve our knowledge and prove the return, actually." (Participant 5 – Male, International Academic Expert).

## 12. DISCUSSION

As a follow-on to the two previous UK and Global reports on the value of OH<sup>3,4</sup>, the aim of this report was to assess the value of OH research. As highlighted previously, this report has approached 'value' from a general OH perspective i.e. improving the health, wellbeing and functional capability of the working age population, a societal and public health perspective and an economic perspective.

### a) The economic value

The two previous reports<sup>3,4</sup> on the value of OH highlighted a paucity of high quality economic evaluations as an important gap in the OH evidence base.

Given that intervention studies evaluate effects of treatment/programmes in real-world settings and are often the natural follow-on from occupational epidemiology studies, we elected to undertake a scope of the literature on workplace intervention economic evaluations over other aspects of OH research.

Systematic reviews on the cost-effectiveness of OH interventions<sup>6-9</sup> have identified poor methodological quality as key barriers to drawing meaningful conclusions. As it has been five years since the last systematic review<sup>7</sup> so we undertook a brief scoping review of economic evaluation workplace intervention studies and their methodological quality, to explore if there had been any improvement in the quality of the economic evaluation evidence-base over that time.

Our findings identified a relatively low number of economic evaluation intervention studies in OH research and rarely were economists involved in these evaluations. Few were cost-effective or cost-beneficial. A number were before-and-after studies with no control group. For the majority, the economic evaluations were typically of low methodological quality and often with an 'employer' perspective only. Only a small number included a broader societal perspective. The majority of studies did not consider a long-term time horizon nor use any extrapolation or modelling approaches. In summary therefore, our updated findings confirm a persisting lack of high-quality economic evaluation evidence.

One reason why there are not more economic evaluations of OH interventions may be that such research is expensive and often the information generated is not expected to represent value for money.

On the other hand, other types of OH research, for example using observational data for decision analysis<sup>104, 105</sup>, service needs assessments and quality<sup>105-108</sup> may provide much better return on investment, and high quality economic

evaluations in these other areas should also be encouraged.

In current times when recognition of the economic burden of work related ill health has never been higher<sup>5</sup>, there is a need for an increase in economic evaluation studies (at individual, employer, NHS, Government and economy levels) and importantly, for these to be of good methodological quality. These can help decision makers to make the best use of resources<sup>106, 107, 109</sup> and to consolidate the business case for OH. A 2017 survey<sup>110</sup> of 500 UK employers reported that 54% of businesses were not clear on how much absence was costing them and only 46% believed that the absence reduction measures they had in place have clear benefits.

Addressing this persisting gap in the evidence could be a powerful tool to increasing the perceived value of OH research among employers, businesses and funders.

### b) The occupational health, public health and societal value

While to date, there is a persisting lack of good quality evidence on the economic value of OH intervention research, based on our evaluation of the literature and the qualitative interviews we conducted, in our view there is a strong case to support the OH (i.e. improving health, wellbeing and functional capacity of the working age population), societal and public health value of OH research.

#### *The significant contribution of historical occupational disease research*

Occupational epidemiology research (the primary methodology used in OH to investigate and identify work-related health hazards) has made an enormously valuable contribution in these areas. Many diseases and risk factors for diseases were first discovered in occupational studies<sup>10, 11</sup>, with increased recognition of the work setting and occupational cohorts as remarkably good study populations to assess exposures<sup>10-12</sup>.

Early epidemiological studies of large scale occupational diseases and resulting workplace exposure limits and descriptions of best practice have led to their reduction (and in some cases elimination) and have substantially improved population health, possibly more than most other population or clinical interventions. The morbidity and mortality in relation to work historically was very high and this has improved to a substantial degree through industry and policy makers paying increasing attention to research on health and the systematic study and developments that followed.

These falling trends have been corroborated by early 21st century databases on prevalence of and trends in work-related disease in different occupations internationally (ILO – Recording and notification of occupational accidents and diseases and ILO list of occupational diseases) and nationally in a number of countries<sup>13, 14</sup>. The OH, public health and societal value here has been the substantial reduction in mortality and morbidity of the working age population. Furthermore, although not formally quantified, the consequent improvement in workforce and public health is bound to have inferred cost savings from a healthcare, employer and government perspective with ultimate benefits to the economy.

Several 'real-world' success story examples in reducing traditional occupational disease prevalence were described by key stakeholders participating in our qualitative study, notably in relation to silicosis. It also highlights anecdotally that in some countries, for example silicosis rates in Sweden, levels have been so low that the need to actively monitor trends is no longer deemed necessary.

#### *The wider significant contribution of historical OH research*

The impact of this historical OH research has been much wider in that it has also contributed to the broader understanding of disease mechanisms particularly in the fields of toxicology and carcinogenesis and recognition of the significance of environmental exposures. Historically, much of what was known about the causes of cancer was derived from studies undertaken in the workplace. Up until the early 1980's, almost half of the recognised human carcinogens were occupational in nature<sup>11, 15</sup>. Although this may no longer be the case with the growing number of non-occupational carcinogens, they still represent a substantial proportion.

Although recognition of occupational carcinogens are important for occupational cancer prevention, given that many occupational exposures find their way into the general environment, the potential benefit of these discoveries extends beyond the workplace. The number of established occupational carcinogens has increased over time with 47 agents in 2017 compared with 28 in 2004<sup>11</sup>. These are a likely underestimate with a number of 'yet undiscovered' carcinogenic agents present in workplaces<sup>12</sup>.

#### *A key example of research translating into and revolutionising clinical OH practice*

Waddell and Burton's back pain management guidelines<sup>16</sup> example, as mentioned in our stakeholder interviews, conveys the powerful impact robust research can have on revolutionising not just risk but clinical and OH management. Their pioneering work also initiated an important shift toward self-management and the biopsychosocial model of health<sup>17, 18</sup>.

Interestingly, this product of OH research i.e. making workplaces safer and provision of a solid evidence-base for OH practice and risk management was perceived as being of greatest value to the stakeholders interviewed. Remarkably economic benefit, which arguably could be a high priority for employers and industry, was not a key 'value' concept theme to emerge from the stakeholder interviews.

#### *Establishment of the health benefits and importance of 'good work' and the adverse health effects of prolonged work absence*

Without doubt, one of the most valuable contributions of OH research in current times has been demonstration of the health benefits of work and the importance of 'good work'. The concept in its simplest term is described by one stakeholder: "that being at work is better for you – if you're in good work– than being away from work and absent from work." This is effectively the underpinning supportive evidence-base for OH as a specialty, and has empowered all those in workplace health to confidently promote the benefits of being in work.

Demonstration of the adverse health effects of prolonged absence from work (including poor prognostic outcomes and increased risk of falling out of work) has in turn driven a large body of research on pro-active rehabilitation, sickness absence management and a focus on early interventions in sickness absence to facilitate return to work (RTW).

Establishment of the health benefits of 'good work' and the adverse health impact of being away from work, triggered a paradigm shift that has not only influenced Government to act (particularly with the challenges they face with growing benefit dependency) and employers in their management of absence (in recognition that "Good Health is Good Business"<sup>19, 20</sup>) but also public perceptions, with broader societal ramifications in reducing health and social inequalities, as highlighted in our interviews.

#### *Evaluation of the effectiveness of workplace interventions*

The body of evidence on effective workplace interventions identified from research over the decades is too broad to describe within the scope of this report. Common outcome measures include: prevention and reduction of disease prevalence, sickness absence reduction and early RTW.

Two systematic reviews<sup>111, 112</sup> have concluded that there is strong evidence that workplace interventions reduce the duration of sickness absence, with early contact between the employee and their workplace and offers of work accommodation as important contributing factors<sup>111</sup>.

While a body of evidence on improved outcomes from interventions to prevent and manage musculoskeletal disorders is established<sup>113</sup>, for mental ill health the evidence to date is limited with reviews reporting mixed results<sup>114</sup>. There is evidence for disability case management interventions<sup>8</sup>, notably those that include early contact with employees on sickness absence and specific agreements around work modifications, resulting in earlier RTW and demonstrated cost-benefit<sup>111</sup>.

The effectiveness of case management interventions has been demonstrated. One such example in the UK was the EASY study<sup>115</sup> which established a day 1 biopsychosocial intervention for individuals going off sick. It demonstrated a 21% reduction in sickness absence (compared to other traditional interventions), cost-effectiveness and high levels of worker satisfaction. This effect was sustained over a four year follow up. Another UK study<sup>116</sup> which entailed intensive case management and a biopsychosocial approach for staff with over four week sickness absence was associated with a 10.7% reduction two years later compared to a control site. The intervention was also cost-effective<sup>116</sup>.

#### **Work as a health outcome**

The shift of emphasis from historical occupational disease prevention (i.e. the impact of work on health) to the impact of health on work and overall worker health and wellbeing, was also raised in our stakeholder interviews. Participants described the concept of 'total worker health' and the aspiration of ultimately achieving worker health that is 'even a little bit better when they leave the workplace' than when they arrived at work that day. This was developed further by another stakeholder proposal of a broader approach to exposure assessment, including individual behaviours, community exposures, i.e. risk factors inside and outside of the workplace, and how they all interact to affect the health of the worker, both positively and negatively. These innovative and more 'holistic' approaches are areas where future potential value may be demonstrated, not just in OH but public health and society as a whole.

The evidence-base on the health benefits of work has gone a step further in consolidating the concept of work as a health outcome, in rightful recognition within mainstream healthcare of the important impact of work on health. This could become even more important with ageing demographics and the mental health epidemic<sup>19</sup> where work may prove to be a positive health intervention.

#### **Establishment of new and emerging occupational hazards and diseases**

Given the decline in heavy and manufacturing industry in the UK and other developed countries in recent decades, there is an overarching perception that occupational diseases/work-related ill health are a thing of the past. However this shift in industry, technological advances and the global economic drive have brought with them new occupational hazards which merit in-depth study. Organisational changes in the labour market and psychosocial hazards at the workplace include: work exposure intensification, double burden, high emotional load, violence and harassment at work, flexibility of the labour market, ageing workers and presenteeism. Emerging risks at work related to dangerous agents, substances or technologies include: engineered nanomaterials and nanotechnologies, emerging chemicals and composite substances and new biological hazards. With rapidly evolving OH practice, newly recognised hazards will inevitably emerge and, as has been the case historically, it is imperative that there is robust epidemiological evidence derived from within the UK to inform national OH and safety policy development and safer work practices. Future research needs to be ambitious, interdisciplinary and inclusive.

#### **Positive public perceptions of the value of health research**

American surveys have been conducted to assess the perceived value of health research by the public<sup>21,22</sup>. A high majority of respondents had a positive view of medical research, believing that developments in science have made society better and that it is essential for improving the quality of human lives<sup>21,22</sup>. In two surveys, nearly 80% of respondents were interested in health research findings, with a similar proportion reporting that science plays a very important role in our health<sup>22</sup>. A very high proportion felt that health research was important to the economy, and supported the education and training of healthcare researchers<sup>21</sup>.

Similar results were found in a UK study<sup>117</sup> with very positive views on healthcare research and over 90% believing that medical research will lead to an improvement in the quality of life for people in the UK in the next 20 years. Concerns were expressed that not enough money is being spent (40%) and that research is not progressing fast enough (17%). A majority of adults and young people said that they were fairly or very interested in medical research<sup>117</sup>.

To our knowledge no formal study of the value placed by the public on OH research has been undertaken. However, of relevance, a 2015 OSHA report on the changing legitimacy of health and safety at work<sup>118</sup> identified that negative perceptions of health and safety were more associated with 'public' than 'workplace' issues and that members of the public are more supportive of efforts to promote safer workplaces than interventions out of work. The study also found that almost 50% of respondents thought more could be done to protect workers from health and safety risks<sup>23</sup>.

We have not been able to identify any studies on the value placed by employers on OH or health research. However, in a study of employer and employee priorities of the required competencies for OPs, 75% of respondents considered research to be an important OP competency<sup>24</sup>.

#### **Identified factors and challenges on how the value of OH research is perceived and demonstrated and potential solutions**

In the context of OH research, a number of factors and challenges have been identified in relation to how value is perceived and demonstrated. The first is a lack of coherence in resourcing and undertaking research. As a Government representative observed in our qualitative study, "it all feels to me a little bit 'hit-and-miss' in terms of both resourcing the research and what's currently being done and where". Concerns around a lack of leadership and dissemination among the OH community has previously been highlighted in Dame Carol Black's 2008 report<sup>19</sup>.

Poor resourcing of OH research through lack of funding and a reduction in the OH academic base and expertise have also been highlighted in the interviews. Additionally, current research governance frameworks and related challenges gaining ethics and governance approvals, have been barriers described among the OH academic community. As previously recognised, a key hindrance to OH research funding has been attributed to the practice of OH out with the NHS (and predominantly in private industry). Consequently, OH is excluded from NHS targeted funding opportunities from 'patient-centred' funding organisations and charities and is also overlooked by Government. Importantly though, it has been observed (by a Government representative in our interviews) that a strong enough case is not being made to Government ministers that they should be thinking about putting resources into workplace health research and initiatives. This could be a result of a lack of leadership<sup>19</sup>, the absence of a national co-ordinated OH research strategy and a lack of coherence in consolidating, disseminating and presenting OH research findings<sup>19</sup>.

There is a need to 'market' and make OH research attractive and to train new generations of researchers. Access to training and support is a key factor to achieving this.

Beneficiaries of OH research (OH providers, employers, human resources, employee representatives and Government) should all take responsibility for supporting, resourcing and driving OH research.

While academics are up to date with current research findings, dissemination to beyond the academic community is inconsistent. There is a fundamental need to quickly and simply translate research findings and new knowledge into practical guidance for key users, including OH clinicians, employers and employees. Advances in social media can drive this agenda. Employers need to understand the benefits to their business and society as a whole, beyond the legal and statutory requirements. The stronger the evidence and value case presented, the more likely both employers and Government are to engage.

Issues around the research-practitioner gap have already been described but as highlighted earlier, the current research priorities of employers, human resources and worker representatives, should be formally studied. This is an essential step to understand what is important to these key research users and an important opportunity to 'add' value. Worker health of small and medium sized enterprises (SMEs) and the self-employed has been poorly studied and merits particular attention.

The need for integration of technological advances into OH research has also been highlighted. While big data and artificial intelligence are current key players in information technology, the substantial 'lag' of OH has been highlighted by the fact that occupational data is not included in any routine data collection in primary or secondary care in the UK. The lack of routine collection of occupational data in the NHS not only inhibits important research, but also prevents investigation of potentially important occupational risks.

These current shortfalls in the development of OH research highlight a fundamental requirement for a co-ordinating body in the UK to provide leadership on OH research and publishing, to disseminate and promote research to key stakeholders (while establishing engaging networks with them), to build research capacity and to attract research funding to the specialty.

### 13. CONCLUSION

The establishment of a Centre for Work and Health was first proposed by Dame Carol Black in 2008<sup>19</sup> and is a policy of the UK Academic Forum for Health and Work, with the goal of achieving some of the aims described above.

The proposal is for a multi-disciplinary institute that will provide leadership, co-ordination of UK OH research together with training for early career researchers, OH clinicians, employers and employees. A further objective is to network and collaborate with academic institutes, research funders, businesses and public and third sector organisations to ‘market’ OH research and generate impact, to drive the research agenda and facilitate translation of research into practice.

In recognition of similar challenges within Europe i.e. of very limited coordination and promotion of European health research on occupation and employment, a COST (European Cooperation in Science and Technology) funded project has recently been established, with some common objectives and functions to that proposed for the UK Centre for Work and Health. The Network on the Coordination and Harmonization of European Occupational Cohorts (OMEGA-NET)<sup>19</sup> – in addition to creating a network to optimise the use of occupational, industrial, and population cohorts at European level – also aims to connect scientific communities on occupational health in Europe and beyond and to provide networking, leadership, and training opportunities for early career researchers in occupational epidemiology and exposure assessment.

A UK Centre for Work and Health could gain valuable insights from this European model in its set up and development. Other nationally established example models include: The Finnish Institute of Occupational Health (FIOH) and the Institute for Work & Health (IWH) in Canada.

In summary, although there is a lack of good quality evidence to demonstrate the economic value of OH interventions research (and further high quality research is needed in this and other areas of OH research), in our view there is a strong case supporting the OH (i.e. improving health, wellbeing and functional capability of the working population) societal and public health value of OH research.

Modern day OH research has scope to be even broader in its role, not just targeting ‘occupational’ diseases’ but also accessing a wide range of the population to ‘prevent’ and ‘manage’ broader population health issues.

Commitment and action is required to continue to innovate and drive the OH research agenda and to actively convey and ‘better market’ this value to key stakeholders (e.g. OH clinicians, employers, the HR community, employees, employee representative organisations and Government).

Equally, the future maintenance of this ‘valuable’ contribution can only be secured through retention and development of the OH academic base and attracting research grant funding.

We conclude that OH research should be at the core of shaping a healthy workforce and productive economy and should be developed accordingly.

### 14. TABLES

Table 1. Health Promotion Interventions (n=7)

Author	Year	Country	Setting	Population	Intervention	Control	Follow-up	Main Outcomes
Lin et al. <sup>72</sup>	2018	Taiwan	Aerospace industrial	101 office workers	Increase participants’ self-efficacy and self-regulation in promoting physical activity and reducing prolonged sitting	Educational newsletters about benefits of physical activities	1 year	Significant improvements in self-regulation for sitting less and moving more, walking, weight, waist circumference, and insulin in the intervention group compared with the controls. Productivity loss was not different between groups
Palumbo et al. <sup>74</sup>	2012	USA	Academic medical centre	14 female nurses 49-54 years old	On-site Tai Chi classes once a week and practice on their own for 10 minutes each day	No intervention	15 weeks	Tai chi group showed a significant reduction in absenteeism and improvement in work productivity. The intervention seems cost saving
Strijk et al. <sup>71</sup>	2013	Netherlands	Academic hospitals	730 workers > 45 years old	Vitality Exercise Program (yoga, workout, aerobic exercise), Personal Vitality Coach visits, and free fruit	Written information about a healthy lifestyle	1 year	No significant differences in work engagement, sick leave, general vitality, work-related vitality and productivity between groups
van Dongen et al. <sup>72</sup>	2013	Netherlands	Academic hospitals	730 workers > 45 years old	Vitality Exercise Program, Personal Vitality Coach visits, and free fruit	Written information about a healthy lifestyle	1 year	The programme was neither cost-effective nor cost-saving. Per euro invested, €2.21 was lost
Kuehl et al. <sup>73</sup>	2013	USA	Fire departments	1,369 fire-fighters	Comprehensive medical testing, individualised counselling, and a team-based health promotion programme (PHLAME)	No intervention	2 years	Significant reduction in claims rates in the intervention group compared with controls. Total cost savings of the PHLAME programme was \$2,765
Serxner et al. <sup>75</sup>	2012	USA	A large financial services corporation	49,793 employees enrolled in medical plans	Employees enrolled on a health and productivity management (HPM) programme which addressed health risks, acute and chronic conditions, and psychosocial disorders	Employees not participating in any programme during the programme years	3 years	All participation categories yielded a lower cost increase compared to nonparticipation and a positive return on investment for years 2 and 3, resulting in a 2.45:1 return of investment for the combined programme years
Serxner et al. <sup>75</sup>	2001	USA	Large telecoms company	1,628 workers on short-term disability	A comprehensive health promotion programme was developed to reduce health care costs, improve employee satisfaction, and enhance the employer’s image	Employees who did not complete a health risk assessment	2 years	Non-participant average net days lost increased from 33.2 to 38.1, whereas the participant group average net days lost decreased from 29.2 to 27.8

Table 2. Ergonomic Interventions (n=9)

Author	Year	Country	Setting	Population	Intervention	Control	Follow-up	Main Outcomes
Rempel et al. <sup>81</sup>	2006	USA	Customer service centre of large healthcare company	182 customer service / call centre computer operators	(1) Ergonomics training only, (2) training plus a trackball, (3) training plus a fore-arm support, or (4) training plus a track-ball and forearm support.	Ergonomics training only	1 year	Intervention to support the forearms reduced neck/shoulder and right upper extremity pain and prevented incident neck/shoulder disorders in comparison to ergonomics training alone. A return-on-investment model predicted a full return of arm board and installation costs within 10.6 months.
Lahiri et al. <sup>81</sup>	2005	USA	Wood processing plant	123 workers: forklift, crane, and machine operators, technicians, and utility/general production workers	Engineering controls and workstation modifications (adjustable chairs, conveyors, lift tables, anti-fatigue matting, grabbers, and catwalks).	No control group	3 years	After the intervention, no cases of LBP were reported (effectiveness of 100%). There was a total net savings of \$76,872 for the company as a whole and it resulted in a savings of \$625 per worker.
Lahiri et al. <sup>81</sup>	2005	USA	Automotive supplier	637 workers: secretaries, engineers, engineering technicians, managers, & salespersons	Office ergonomic programme: lumbar pads, and backrests were made available to employees. Back school workshops were also conducted.	No control group	12 years	The prevalence of low back pain was lower after the intervention and no sick leave was reported due to the discomfort. Net cost for medical care was reduced by \$96 after intervention. Net savings per year were \$70,441 with savings per worker of \$111
Lahiri et al. <sup>81</sup>	2005	USA	Worker automobile and truck body plant	1,500 workers from assembly lines	Engineering controls implemented. Ergonomic dollies redesigned, lift and tilt tables installed and mechanical lift assists, and various platforms and risers introduced.	No control group	4 years	Low back pain was greatly reduced. An annual average of 3.3 acute cases occurred, with an annual average of one sick day. Net savings per year were \$2,334,409, with savings per worker of \$1,556.
Driessen et al. <sup>84-86</sup>	2011-2012	Netherlands	Four Dutch companies: railway company, an airline company, a university including its medical hospital, and a steel company.	3047 workers (37 depts)	Stay@Work Participatory Ergonomics programme (PE); prioritised ergonomic measures aimed to prevent low back pain and neck pain plus three short educative movies about the prevention of low back pain (LBP) and neck pain (NP).	Three short educative movies about the prevention of LBP and NP	1 year	PE was not more effective than the control group in reducing the prevalence, pain intensity and duration of LBP and NP. PE was not effective in the prevention of LBP and NP or the recovery from NP. PE was more effective in the recovery from LBP. Decision latitude and decision authority were increased in PE workers. However, PE was not effective in reducing the exposure to psychosocial and physical risk factors. Cost-effectiveness analyses (CEA) and cost-benefit analyses (CBA) were performed. Health care costs and costs of productivity losses were higher in the intervention group than in the control group (the mean total cost difference was €127). The PE programme was neither cost-effective nor cost-beneficial on any of the effect measures.

Author	Year	Country	Setting	Pop'n	Intervention	Control	Follow-up	Main Outcomes
Collins et al. <sup>79</sup>	2004	USA	Six nursing homes	1728 nursing staff	"Best practices" musculoskeletal injury prevention program consisting of mechanical lifts and repositioning aids, a zero lift policy, and employee training on lift usage.	No control group	6 years	Reduction in handling injury incidence, workers' compensation costs, and lost workdays due to injuries after the intervention. The initial investment of \$158,556 for lifting equipment and worker training was recovered in less than three years based on post-intervention savings of \$55,000 annually in workers' compensation costs.
Chhokar et al. <sup>83</sup>	2004	Canada	Extended care facility	Health care staff	Introduction of mechanical ceiling lifts and training.	No control group	6 years	Analysis of injury trends spanning 3 years pre-intervention and 3 years post-intervention found a significant and sustained decrease in days lost, workers' compensation claims, and direct costs associated with patient handling injuries. The payback period was estimated in the year (0.82 years) immediately preceding intervention.
Evanoff et al. <sup>80</sup>	1999	USA	A 1,200-bed urban hospital	On average, 100-110 orderlies	Introduction of a participatory ergonomics team.	No control group	2 years	The 2-year post-intervention period was marked by decreased risks of work injury, lost time injury, and injury with three or more days of time lost. Total workers' compensation expenses for orderlies was \$24,443 pre-intervention (\$237 per FTE) and \$34,207 post-intervention (\$139 per FTE), representing a 41% decrease in expenses per worker, or total savings of \$22,758. These savings can be compared to the \$5,000 costs incurred over 2 years. Substantial improvements in health and safety were seen following implementation of a participatory ergonomics programme.
Banco et al. <sup>78</sup>	1997	USA	Nine stores belonging to a single chain of supermarkets	Adolescent grocery store workers	A safety programme using a less hazardous case cutter combined with worker education. Group A stores, employees received new safety case cutters with education; in Group B stores, employees received education using old cutters.	Group C stores were the control	4 years	Cutting injury rates decreased 3.5/100,000 man-hours in Group A stores, compared to 1.5 in Group B stores and 1.6/100,000 man hours in control stores. Estimated savings for Group A stores were \$245 per year per store and \$29,413 per year for the chain. Benefits for Group B stores were less dramatic with total net savings of \$12,773 for the chain.

Table 3. Interventions related to Employability / Work Adjustments / Work rehabilitation / Return to Work Interventions (n=13)

Author	Year	Country	Setting	Population	Intervention	Control	Follow-up	Main Outcomes
van Holland et al. <sup>91</sup>	2018	Netherlands	Meat processing plants	986 meat processor workers	Comprehensive workers' health surveillance designed to identify workers at risk for reduced employability	Regular occupational healthcare	3 years	Sickness absence, work ability and productivity values were better in the control group
Comper et al. <sup>92</sup>	2017	Brazil	Textile factory	491 workers from four production sectors: finishing socks, finishing underwear, sewing socks and sewing underwear	Job rotation programme plus ergonomic training	Ergonomic training	1 year	Both groups showed an increase in working hours and days lost due to musculoskeletal disorders. No differences in productivity between both groups.
Koolhaas et al. <sup>88</sup>	2015	Netherlands	University and Medical Centre	125 nurse and administrative personnel (workers and supervisors)	Problem-solving strategy for increasing the awareness of ageing workers of their role and responsibility in living sustainable, healthy working lives	Usual business activity	1 year	The problem-solving intervention showed no positive effects on productivity, vitality and workability compared to business as usual
Badii et al. <sup>94</sup>	2006	Canada	Hospitals	348 employees with work-related or non-work-related musculoskeletal disorders in whom the ability to perform job demands is affected	Integrated workplace-based programme to reduce musculoskeletal injuries, including ergonomic assessments, early workplace modifications, physical therapy, work accommodations, and access to an onsite physician	Usual occupational health and safety management	1 year	Time-loss (TL) due to musculoskeletal disorders increased in the intervention site. However, the programme returned injured employees back to work in a shorter time and, compared with average historical data, reduced compensation costs and healthcare costs associated with time loss due to musculoskeletal disorders.
Enriquez-Diaz et al. <sup>96</sup>	2012	Germany	Automotive industry	Three samples (A: Handbrake lever; B: Exhaust Pipe; C: Gearbox) of blue-collar workers and team leaders	Chaku-Chaku (Japanese: Manufacturing Method based on assembly cells)	Line-based assembly lines	Not available	Chaku-Chaku assembly lines might represent a successful production strategy. However, workers spent more time on activities than before
Maniscalco et al. <sup>88</sup>	1999	USA	Offshore petroleum unit	147 Offshore Petroleum Employees	Health assessment, fitness programmes, education programmes (back care, nutrition, smoking cessation), and incentives	No control group	1 Year	The number of all types of injuries, including back injuries, decreased between 1991 and 1995. Calculations suggest a cost savings of over \$800,000 and a return on investment of \$2.51, as well as avoidance of pain and injury.

Author	Year	Country	Setting	Pop'n	Intervention	Control	Follow-up	Main Outcomes
Karrholm et al. <sup>93</sup>	2006	Sweden	Public employer Stockholm Co-operation Project	64 rehabilitees employed by a public employer in Stockholm	Systematic multi-professional coordinated rehabilitation (the Stockholm Co-operation Project)	Conventional rehabilitation	3 years	The study group had substantially less sick leave days per month than the comparison group. The economic benefit of the intervention was estimated to €1,278 per month and person based on the whole group, and to €2,405 per month and person based on those with more sick leave
Bultmann et al. <sup>97</sup>	2009	Denmark	Four participating municipalities: Vejle, Kolding, Egved, and Give	200 workers on sick leave for 4-12 weeks due to musculoskeletal disorders	Coordinated and tailored work rehabilitation program (CTWR): work disability screening by an interdisciplinary team followed by the collaborative development of a RTW plan	Conventional case management	1 year	The number of sickness absence hours was significantly lower in the CTWR group as compared to the control group. In terms of productivity loss, the intervention seems to be cost saving for the society. The total costs saved in CTWR participants compared to controls were estimated at \$1,366 per person at 6 months follow-up and \$10,666 per person at 12 months follow-up
Jensen et al. <sup>92</sup>	2005	Sweden	A nationwide health insurance scheme	214 persons 18-60 years old, blue-collar and service/care workers, on sick leave > 1 month and < 6 months	G1: behaviour-oriented physiotherapy (PT); G2: cognitive behavioural therapy (CBT); G3: behavioural medicine rehabilitation consisting of PT + CBT (BM)	Usual treatment	3 years	Sick leave was reduced in 201 days in the intervention (BM) compared to controls. Full-time behavioural medicine programme is effective in increasing health and decreasing costs for women suffering from spinal pain. The results reveal that compared to the control group the full-time programme (BM) is the most cost-effective programme, since it decreased the costs by about 137,509€ per subject in the female group during the first 3-years after rehabilitation.
Loisel et al. <sup>95</sup>	2002	Canada	31 workplaces more than 175 workers located in a radius of 30 km from the study back pain clinic	104 workers absent more than four weeks	G1: occupational arm: study occupational medicine physician and a participatory ergonomics intervention G2: clinical arm: clinical examination by a back pain medical specialist, participation in a back school, and G3: Sherbrooke model (combined occupational and clinical interventions)	Standard care	Mean follow up period was 6.4 years	The largest number of days saved from benefits was in the Sherbrooke model arm. Moreover, it was the most cost-beneficial with a mean saving of \$18,585 per worker. However, in spite of the large amounts saved, there was no statistically significant difference between the four arms. All experimental study arms showed a trend towards cost benefit and cost effectiveness.



Table 3 continued: Interventions related to Employability / Work Adjustments / Work rehabilitation / Return to Work Interventions (n=13)

Author	Year	Country	Setting	Population	Intervention	Control	Follow-up	Main Outcomes
<b>Meijer et al.</b> <sup>95</sup>	2006	Netherlands	Bank employees and workers at one of the two universities in Amsterdam	38 sick-listed workers with non-specific upper extremity musculoskeletal complaints	Psychological and physical sessions provided by a medical specialist, a psychologist, a physiotherapist and an occupational therapist G3: Sherbrooke model (Combined occupational and clinical interventions)	Usual care provided by occupational health service	1 year	Physical disabilities, kinesiophobia and physical functioning improved significantly in the intervention group as compared to usual care. It was also more effective in reducing the severity of complaints and equally effective in return to work than usual care. Multidisciplinary treatment affects individuals positively but shows no significant difference in (cost-) effectiveness on the societal level as compared to usual care
<b>Steenstra et al.</b> <sup>90</sup>	2006	Netherlands	Industry, health care and office work	196 workers sick-listed for a period of 2 to 6 weeks due to LBP	G1: Only occupational intervention (WI); Workplace assessment, work modifications and case Management G2: Occupational intervention and clinical intervention (WI + CI); physiotherapy based on operant behavioural principles	G3: Usual care and clinical intervention (UC + CI); G4: only usual care provided by an occupational physician (UC)	1 year	WI returned to work 30.0 days earlier than UC at slightly higher direct costs (ratio of 1 day: €19). WI*CI group returned to work 50.9 days later than WI*UC group. UC*CI returned to work 21.3 days later than UC*UC. The mean number of total days on sick leave is lower in the WI group. A workplace intervention was more effective than usual care in RTW at slightly higher costs and was equally effective as usual care at equal costs on other outcomes. A clinical intervention was less effective than usual care and associated with higher costs.
<b>Hiobil et al.</b> <sup>97</sup>	2007	Netherlands	Royal Dutch Airlines	134 blue-collar workers, sick-listed due to LBP	Graded activity (GA) intervention: twice a week a 60-min physical exercise session with a cognitive behavioural approach under the supervision of specifically trained physiotherapists	Usual care (UC)	3 years	At the end of the first follow-up year an average investment for the GA intervention of €475 per worker, only €83 more than health care utilisation costs in UC group, yielded an average savings of at least €999 due to a reduction in productivity/loss. The potential cumulative savings were an average of €1,661 per worker over a 3-year follow-up period.

Table 4. Psychosocial Interventions (n=4)

Author	Year	Country	Setting	Population	Intervention	Control	Follow-up	Main Outcomes
<b>Lavelle et al.</b> <sup>101</sup>	2018	USA	Army primary care clinics at military installations	629 active-duty service members with Post Traumatic Stress Disorder (PTSD) or depression	Centrally assisted collaborative tele-care including psychosocial treatment and routine mental health team monitoring plus standard integrated medical health	Standard integrated mental health approach: access to mental health specialists and follow-up by nurse care manager	1 year	Small to moderate improvements in the severity of PTSD and depression symptoms and fewer lost days (productivity gain of \$1255). However, costly intervention a 58% probability of being cost-effective at a \$100,000/QALY threshold.
<b>Gupta et al.</b> <sup>103</sup>	2018	Denmark	Three large Danish industrial workplaces (manufacturing work)	415 industrial workers	Three workshops to map positive and negative aspects of physical and psychosocial work environment and developed and implemented action plans addressing the highlighted issues	No intervention	1 year	No significant improvements for recovery and work ability, mental health, well-being, physical work demands and productivity were found between groups.
<b>Childs et al.</b> <sup>100</sup>	2014	USA	US Army	4295 soldiers who attended training to become a combat medic	Psychosocial education programme aimed to reduce fear and threat of LBP plus exercise programme	Exercise programme	2 years	The median total LBP-related health care costs for soldiers who received the intervention and incurred LBP-related costs were \$26 per soldier lower than the control group.
<b>Anderzen et al.</b> <sup>102</sup>	2005	Sweden	Swedish Internal Revenue Service	383 white-collar employees in 22 work units	Individualised intervention programme targeted to each worker's assessment of the prevailing psychosocial work conditions	No control group	1 year	Improvements in performance feedback, participatory management, employeeeeship, skills development, efficiency, leadership, employee well-being, and work-related exhaustion were identified. Absenteeism decreased and productivity improved.

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