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1. Introduction

Since inception, pain research has conceptualised pain as an ‘intra-organismic’ phenomenon, where the mechanisms responsible for pain experience and impact all reside within the body. There is increased recognition that this conceptualization lacks both explanatory and predictive power. Increasingly, research points to important contextual factors that influence the experience and impact of pain. One such factor is ‘work’. The relations between work and pain are multiple and complex, where pain influences work, work influences pain, and features of working environments (e.g. satisfaction, workload, control) moderate the prevalence, severity and consequences of pain.

Work is often construed as a source of both pleasure and pain; it can be a punishing necessity but also symbolise personal value [34]. Historically, there may be more hardship than reward, but the modern concept of ‘work’ is constantly changing [12,86]. Here, we define work as occupation with economic value, broadly cast to include direct labour market engagement and activities with indirect reward such as caring. Safe and appropriate work is better for our health and wellbeing than worklessness, [80,84] but people who are not in employment because of ill-health or disability are more likely to have chronic pain than the employed [50]. It is important that people living with chronic pain are not left behind in the drive to enable sustainable employment. In the last seventy-five years, in the wealthy economies at least, it has become not only possible but desirable to talk about work as having benefits other than access to resources for survival, as a positive force for personal growth and social development. Just as the concept of work is changing, so the relationship between work and pain has also changed.

In this topical review we outline the emerging modern field of work and pain studies. First, we introduce a public health perspective with a population focus on ageing, chronic pain, and pain as a reason for exiting work. Second, we focus on the workplace as provider of occupational intervention. Third, we consider how pain-related psychological variables may affect work disability and how this impacts and could affect intervention design. Fourth, we consider policy initiatives aimed at altering systems to reflect the changing relationship of work and pain. Finally, we discuss how all these perspectives inter-relate, and introduce a lifespan development model of work and pain to guide development and intervention in different domains, from individual to societal.

2. A public health perspective

Pain is a common feature of life; working life is no exception. The percentage of the population with pain increases with age and by birth cohort; a higher pain burden than previously is reported by today’s populations [16] related in part to the context of work [8,40]. Socioeconomic factors have both time-critical and cumulative effects on pain onset and experience [10,57]. Those cumulatively exposed to adverse socioeconomic circumstances are more likely to have increased levels of stress, anxiety, and depression, and to engage in unhealthy behaviours such as smoking and physical inactivity leading to obesity which are associated with pain prevalence, and the likelihood of developing pain-related disability [57]. Socioeconomic factors also separately influence the work options of people and the resulting occupational exposures that are known to increase the risk of adverse pain outcomes [31,69]. Additionally, there is evidence that system-level socioeconomic circumstances can moderate the effect of individual-level socioeconomic circumstances on adults’ risk of developing disabling pain [29,40]. Explanations for this may include independent psychological and biological effects of environmental causes of disabling pain onset and prevalence in areas of higher or lower deprivation, including occupational distribution in the community, and access to social, educational, and medical services [40].

Globally, there is widespread population ageing [55]. As this challenges the ability of governments to fund income support for retirees, there is increased societal pressure for workers to stay at work and build retirement savings [4]. Conversely, for the first time in recent

history in many countries, retirement can be a choice as there is no legal compulsion to retire at a set age. Older workers are more likely to have multiple chronic health conditions, notably musculoskeletal conditions, which are strongly age-related [50]. There is a strong association between musculoskeletal conditions and pain: most musculoskeletal conditions are chronic and painful and their prevalence increases with age, so they feature prominently in considerations of disability prevention due to pain [37,38]. Schofield et al (2008) found that back problems (10.4%) and arthritis (8.6%) were the most common conditions for which Australian workers aged 45-64 took early retirement [66]. In a related microsimulation study, early retirement due to back problems significantly limited individuals' financial capacity by reducing immediate income as well as longer-term wealth accumulation, increasing the cumulative socioeconomic disadvantage associated with back problems [65].

From a public health perspective, it is important to understand the multiple functions of work, not only personally but societally. Extending working life is associated with a greater number of multiple health complaints; with trends towards working at older ages than in previous decades, there is the potential for the effects of pain on individuals and society to be more significant.

3. Occupational health perspective

Work does not inoculate one from pain. Pain is as likely to be experienced when working as at any other time, in any other activity. From an occupational health perspective, there are organisations and agents with responsibility to provide a working environment, including place, time and task, which is as safe as possible from undue exposure to the risk of hurt and harm. For example, the discipline of ergonomics evolved to maximise control of exposures such as heavy lifting, bending, awkward postures, and tasks considered physically demanding and whole body vibration, which we know increase the risk of low back pain [5,35]. Interestingly, although we have mechanised many industries and minimised many of the physical stressors in workplaces, these measures have repeatedly failed to eradicate pain in workforces. The reasons for this are complex. For example, provision of lifting equipment (with appropriate training) in hospitals failed to reduce the risk of low back pain in nurses [71] and at least one of the explanations is that the lifting aids are not always used or are not used as intended [44].

Numerous studies report that workplace factors explain just a small proportion of the risk of disabling pain (typically 10-20%) [18]. Whilst some of the remainder of the risk of pain remains unexplained, another important element of the risk is attributable to personal factors. For example, employee perception of work, its safety, value, and the extent to which it is flexible, and fair, has emerged as important [32]. Work environments perceived as positive are associated with less pain and sickness absence, whilst productivity is also improved [1,45,46]. Workplaces must be on board with interventions otherwise these may fail; Main and Shaw propose a sustained model of managing pain-related limitations at work in which the levels of worker, workforce, supervisor and organisation are all included in designs to improve working lives [48]. The model includes a managerial focus on including disability prevention as part of wider health and wellness policies, and supervisory training for improved supportive communication.

Many different interventions have been tried to improve work outcomes amongst people with painful musculoskeletal disorders [56]. Generally, cheaper and easier interventions are indicated: there is little evidence of improved cost-effectiveness with more expensive strategies [56]. Two models with a clear role are personalised case management and Individual Placement and Support (IPS). Case management by an occupational health practitioner reduces sickness absence and improves workability by enabling constructive dialogue between employee, healthcare practitioners, and employer [52,63,70]. IPS is a model of vocational rehabilitation which has a very strong evidence base for improving return to work rates for people with severe psychiatric conditions [11,19,26,27]. Based upon a "place then train" model, prioritising a supported work placement, unemployment rates amongst people

with psychiatric illness reduced 90% to 60% [11]. There is growing interest in using the same approach for people with other long-term conditions, notably chronic pain [36,47,58]. Large UK pilots have been recently funded by the Department for Work and Pensions and Public Health England and their evaluation is due for publication soon. Musculoskeletal pain is ubiquitous in the workplace. Whatever the cause, pain increases the psychological and physical burdens of work. Working with pain will be more challenging than working without pain.

4. Disability prevention and early workplace intervention

Once symptoms of pain and disability become chronic, available methods of managing pain have only modest impact on suffering and function [67]. Prominent clinical researchers have commented that current treatments for whiplash and traumatic musculoskeletal injury have not reduced the proportion of individuals who transition from acute to chronic pain [41, 42, 59, 60, 75]. As well, research shows that symptomatic treatment of pain does not necessarily yield reductions in work-disability [25]. There are indications that some symptomatic approaches to the treatment of pain, such as the prescription of opioids or cannabinoids, are more likely to extend rather than shorten the period of work-disability [64,85].

There is accumulating evidence that pain-related psychological variables such as recovery expectancies [13,15], self-efficacy [28,82], pain catastrophizing [15,79], perceived injustice, [14,77] and fear-avoidance beliefs [81] play a significant role as determinants of work-disability in individuals with musculoskeletal pain. Mental health problems such as depression [43,78] and PTSD [76] have also been shown to contribute to prolonged work disability in individuals with musculoskeletal pain. The robustness of these findings makes a strong case for recommending assessment of pain-related psychological variables, depression and PTSD when planning treatment for individuals with musculoskeletal pain. Indeed, the results of several investigations have revealed that treatment-related reductions in pain-related psychological variables are prospectively associated with reductions in pain severity, emotional distress, and work-disability [39,51,61,68,72,73,83]. The results of these and other studies have provided evidence that reductions in pain-related psychological factors are stronger predictors of successful return to work than reductions in pain severity. Additionally, the role of workplace system factors is important. There is strong evidence that duration away from work for musculoskeletal or pain-related conditions can be significantly reduced by multi-domain workplace-based return-to-work and disability management interventions that include at least two out of the three domains of healthcare provision, service co-ordination, and work accommodation [20].

There are still important knowledge gaps that need to be addressed. First, it is not clear that all pain-related psychological variables contribute 'unique' variance to the prediction of work-disability. Available research suggests significant variance overlap among these variables. Identification of the key psychological variables, and combinations of them, impacting on return-to-work outcomes would permit streamlining assessment protocols which focus on variables with the highest predictive values. Additionally, research examining the relative importance of different pain-related psychological variables might help identify key targets for psychosocial interventions.

5. Policy Perspectives

In many countries those responsible for policy initiatives, development and deployment are at a remove from the individual, the occupational health setting, or even from the public health perspective; their role is to influence macro-economic changes. Policy for workplace health sits often uncomfortably between traditional responsibilities: health, economic development, and social security (where available). In the UK, policy on workplace health, including pain, is made at the Government Department for Work and Pensions but in consultation with the Department for Health and Social Care [22,23,87]. Changing ill-health certification procedures involving primary care physicians affects more than the nation's health [24]. Similarly, when

wage replacement measures for non-work due to disability change, the effect reaches further than annual budgets [2,62].

With increasing prevalence of pain in the working-age population, and the number of workers – 16% of men and 13% of women – who leave the labour market prematurely because of pain and pain-related conditions [54], policy-makers should have a keen interest in trying to reduce its impact on the workforce. Employment policy might prioritise support for job retention, workplace adjustments, and vocational rehabilitation. Welfare policy might incentivise phased return to work alongside part-time sick leave. Health policy might prioritise work as a clinical outcome of care, referral and commissioning, recognising that being in good quality work can deliver therapeutic benefits. Such ‘joined-up’ thinking remains rare [6]. As the workforce ages and as the prevalence of chronic pain grows, this policy vacuum risks an avoidably increased burden on both individuals and the wider economy.

The policy challenge in the changing relationship between work and pain is to capture current trends, and predict major changes. The COVID-19 pandemic has questioned the value and relevance of common work practices. There is potential for an increase in chronic pain, as a consequence of contracting COVID-19, or exacerbated by pandemic conditions in the absence of infection, including stress caused by job insecurity [17]. The impact of COVID-19 on how we experience pain at work has not yet been well assessed although there is some evidence of an increase in musculoskeletal pain linked to home-working [3,7] and of changes to employment status making life more difficult for people living with pain [53]. There is also the emerging issue of Long COVID or post-COVID-19 syndrome, of which ongoing pain is a key symptom. A survey of people identifying as living with Long COVID reported almost half needed a reduced work schedule compared with pre-illness; almost a quarter were now unable to work [49]. Global health emergencies aside, it is clear that lives lived longer means lives working for longer, that caring responsibilities can extend long into later life [74] and that the idea of a three-stage working life – of education, work, and retirement, is likely to be replaced by portfolio working in which people enter and re-enter the labour market at different times, often changing roles [33]. Creating policy that can promote the prevention of pain where possible, and the engagement with work despite pain, should be a major target.

6. A lifespan development model

When not sleeping, we spend much of our lives working, labouring to produce value for ourselves, others, or wider society. In considering relationships between work and pain we should broaden the scope and lengthen the duration of what we include. If projections of life expectancy remain, such that those born in 2010 have realistic prospects of living until 100 [33] then the concept of later life is in flux. How to think about work is changing rapidly: how long we spend at work, where work happens, how to undertake work when in pain, how to construct work (its flexibility, control, communication) and what meaningful occupational engagement is, are all changing. Emerging is a new field of study in work and pain, one that builds on advances in occupational medicine and workplace rehabilitation [21,30], and in public health and policy science [6,9]. This new area of study has at its centre the person developing across their lifetime, from adolescent to later life production, attempting to work, make sense of work, and avoid or manage pain in the workplace. Figure 1 outlines the major stages of this lifespan development.

[Figure 1 about here]

As the field develops, questions arise regarding the major influences on pain and work in each domain above. Table 1 summarises core research questions in the domains, and intervention possibilities where relevant. We have also considered ‘the individual’ since they are at the centre of why we might wish to think about pain and work from a lifespan development perspective.

[Table 1 about here]

Table 1: Core research questions and possibilities of intervention

Domain	Research questions	Intervention possibilities
Individual	How do individuals experience the cognitive and affective effects of pain, in the modern workplace?	Interventions designed for individuals to isolate and reduce real time cognitive and affective interruptions at work. Interventions might comprise dynamic data collection methods and instant online feedback mechanisms using contextual cognitive behavioural therapy principles.
-Individual lifespan approach	How can we recover developmental impairments associated with pain, such as feeling socially delayed, to support our working lives?	Individualised support which recognises that, for example, the key to occupational success for one person might be treating anxiety about social elements of working practices and the workplace setting, whereas for another it may be most important to help colleagues and managers understand the pain issues and respond to the worker supportively.
-Individual lifespan approach	How can we respond to the psychological and physical challenges of pain regarding our identity as a producer, as we change and age?	Interventions using psychological, vocational, and physiotherapy support, to enable meaningful occupation across the lifespan.
Public Health	How do systematic socioeconomic factors interact with individual psychological factors to maintain negative effects of pain at work? What can we do to reduce negative interactions (e.g., stigma from poverty combining with poor recovery expectancies?)	Multi-level interventions (population and individual levels) which promote community and individual resilience, including public and individual education and social marketing to promote “the process of effectively adapting to or managing significant source of stress or trauma”, including stress and trauma from poverty. Additional population-level interventions include reduction of social

		inequalities and provision of health-promoting work environments that reduce risk factors for work-related pain conditions.
-Public health lifespan approach	How can we support early academic attainment achieved despite deprivation, such that there is a positive relationship between this and later work outcomes?	Multi-level interventions focus on sensitive period during the life course (e.g., childhood, early adolescence), preparing young adults for healthier later life and passing health to the next generation. These interventions need to focus on developing academic skills and assets such as self-efficacy for health-promoting behaviours while also addressing the social and environmental influences to enable educational attainment and behaviours change. Population-level interventions (school-based and area-focused interventions) include enhancing parental involvement in children's education and improving access to further and higher education.
Occupational health	How can we best provide occupational health for all?	Early individualised interventions by non-medical but vocationally trained advisors, alongside occupational health professionals, Individual Placement and Support and case management, all show promise.
-Occupational health lifespan approach	How can we embed the principle that good work, and more broadly occupation, is linked to positive health outcomes, throughout our productive lives? Who could be the agents of behaviour change to promote good work for health? How can we involve ourselves as individuals, our	Interventions in which pharmacists' medicine use reviews include a question about the effect of pain on work or other meaningful

	teachers, families, healthcare professionals (not only in primary care but in other settings including secondary care, allied health professionals and first contact practitioners), employers and organisations?	occupational activity that their patients are doing.
Disability prevention	We know pain and disability do not correlate well. Which pain-related psychological variables contribute unique variance to disability predictions? Which are the best combinations of variables/therapeutic targets given the well-known inter-relationships between them?	Interventions with assessment protocols increasingly streamlined to focus on variables with the highest predictive values
-Disability prevention lifespan approach	Do which pain-related psychological variables contribute unique variance to disability predictions change as we move along the working age continuum? For example, are there differences in this respect between those entering the labour market for the first time and those extending their working life as a response to Government pension policy changes?	Interventions with assessment protocols increasingly streamlined to focus on variables with the highest predictive values. These protocols may also be tailored to different life stages, if there are differences between which variables work best when.
Policy	How can we encourage joined-up policy that goes beyond one electoral term?	Interventions sponsored by cross-party committees, which may be delivered via collaboration between local agencies and governmental departments.
-Policy lifespan approach	How can policy support good work for health, from first transition into the labour market, until later life production, in an epoch where many people transition in and out of different working structures over longer working lives?	Interventions focused on transitions, such as from school to active labour market, from mainstream to later working life. Translation of policy interventions, nudges and legislation designed to promote good work in traditional working patterns,

		into newer working lives which include precarious, portfolio and self-employed work.
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7. Conclusion

Safe and appropriate work is good for our health and wellbeing, including that of people living with chronic pain. Modern work and pain research illuminates how we can support people with chronic pain to have sustainable working lives. We have discussed contributions from public health, occupational health, disability prevention, and policy, and shown how these perspectives may be interrelated, using a lifespan development approach to guide questions for development and intervention in different domains. This approach enables us to focus on understanding more about how early developmental pain-related disruption can be repaired as we age. It enables us to consider how work and occupation across the lifespan, is affected by and affects pain, and how such interaction may be shaped by different life stages. By considering how the different perspectives included here interrelate with each other and across the lifespan, we have opportunity to think differently about enabling occupation and work to reduce negative impacts of living with pain.

Conflicts of interest

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Figure 1: Barriers and enables to occupation using a lifespan approach to pain and work



