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Integrative interventions for MSDs: Nature, evidence, challenges & directions

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Abstract *Background*: When applied to workplace interventions, integrative may be seen in various ways, requiring elucidation. *Methods*: Identification of primary studies through systematic reviews, limited bibliographic literature searches, the Cochrane Occupational Health Field database on intervention studies, and authors' files. Focus was 2000 on. Categorization according to the Cochrane classes and lenses on integrative. Synthesis as narrative review. *Results*: Examples of each lens on integrative were uncovered: biomechanical *and* psychosocial, multiple component, primary *and* secondary prevention, organizational, and system. Each contributed different understanding to the potential impacts on different knowledge, exposure, behavior, health and administrative outcomes. *Conclusions*: Considerable opportunities exist to expand the range of integrative interventions, particularly at the organizational and system levels, and incorporate a combination of knowledge transfer and exchange with intervention evaluation.

Keywords Repetitive strain injury/cumulative trauma disorders · Prevention · Disability management · Health promotion · Program evaluation · Review

Introduction

The burden of neck and upper extremity musculoskeletal disorders (MSD as per [61]) among workers in office settings and using VDUs, has been an ongoing concern of workplace parties (labor and management), office equipment manufacturers, and policy makers for over two decades. MSD have been linked to a broad range of physical, psychological, and increasingly, work organizational risk factors [49]. Workplace interventions to reduce this burden have ranged from specific pieces of equipment or software, through extensive training programs, to

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organizational policies in keeping with the breadth of approaches suggested for dealing with MSD [49].

Among such interventions are those judged to be "integrative." The adjective derives from integrate which has the following meanings according to different dictionaries of English: Oxford (British) [16] "to complete by addition of parts; combine parts into a whole"; Webster (USA) [17] "to make entire; to form into one whole; to give the sum of or total of;" and Gage (Canadian) [30] "(1) to make more unified or harmonious; (2) to bring together parts into a whole; (5) to become unified, brought together or desegregated." Two related threads run through these definitions, combining parts into a whole and making more harmonious, unified or desegregated.

In keeping with combining parts into a whole, we see "integrative" workplace interventions including both biomechanical *and* psychosocial aspects, aiming at achieving both primary *and* secondary prevention, and/or consisting of multiple components versus only a single component. In keeping with more harmonious, unified, desegregated we see "integrative" workplace interventions involving either the entire organization, versus just one department or section, or the broader occupational health and safety system, through partners such as health and safety associations and insurers in ways which reach multiple workplaces/organizations. For each of the latter, the aim would be to have ongoing activities that become a new way of doing things for the organizations involved, leading to more sustainable change. We can think of each of these ways of seeing "integrative" as a particular lens on workplace interventions that highlights different characteristics with implications for impact upon indicators of exposure and burden. As we shall see below, they are not mutually exclusive. Hence the use of the word "lens," to emphasize the framing involved.

In this paper, we start with methods by which we sought relevant literature. We use the studies found to demonstrate the different lenses on integrative and highlight some evidence they provide on impacts of "integrative" workplace interventions on exposures and MSD burden. We lay out the kinds of challenges we face if we want to replicate such studies, improve their rigor or enlarge their scope, in particular for some integrative approaches. Finally, we suggest some directions for applied research and dissemination of our existing knowledge.

Methods

Study identification

We started with systematic reviews that were relevant to our interest in integrative workplace interventions for neck and upper extremity MSD, including those completed [20, 25, 53, 54] and those in preparation [10]. Although several focused on ergonomics, most took a broad view of ergonomics, particularly where participatory interventions were involved. The reviews were helpful for ideas on the different lenses and for guidance towards primary studies involving office workplaces. We also searched the recently compiled data base of occupational health intervention studies of the Cochrane Occupational Health Field (COHF) [62, 63] for those occurring in offices. We supplemented these two sources by non-systematic searches on organizational interventions or office interventions, combined with various terms for MSDs, and by those papers and books that we knew about from conferences and through our own work.

Selection

We focused our citation of evidence on the last five years. We included studies that researched relevant variables along the pathway to health outcomes, e.g. changes in exposure or behavior,

not just those with health outcome data e.g., signs & symptoms, injury or disability, in keeping with the range of classes of final outcomes (Classifier 1) considered in the COHF classification. Whenever possible, we focused on neck & upper extremity MSD, in keeping with the focus of this special edition on work-related upper extremity disorders (WRUEDS). However, we did not exclude studies in which general MSD disorders or sick leave were the health outcome, if no WRUEDS specific studies were available.

Classification

We classified the intervention reported in each study according to both our lenses and the COHF classification (see Table 1). Of note here was that COHF classifiers 5, the Target Group, and 6, the Place of Delivery, were automatically narrowed since our interest was in workplace interventions directed to workers, either as patients or employees. We use workers in the generic sense for members of workplaces who carry out waged work (by whatever form of remuneration) rather than the hierarchical sense of managers versus workers. We chose not to engage in quality assessment of the articles not already passed through a systematic review process, because of the heterogeneity of the "integrative" interventions, the limited number of studies available for some lenses, and the illustrative rather than summative purpose of our review.

Synthesis

Our aim was to *exemplify* within a coherent framework, rather than be exhaustive. Other contributions to this volume provide systematic reviews of interventions ([10] for the fuller breadth of ergonomic interventions; Bongers et al. [8], for the fuller breadth of psychosocial interventions), which include a number of integrative workplace interventions.

Evidence

We found some studies that exemplified each lens, with most exemplifying several (see Table 2). We shall summarize their nature and findings, starting with the most common lenses.

Biomechanical *and* psychosocial

From an intervention standpoint this integrated approach is appealing, targeting two main categories of risks to better prevent and manage MSD in the workplace. As we have argued elsewhere [58], measurement of both physical and work organizational risk factors and interventions directed at both are important for elucidating how interventions operate and what aspects of work are the most important potential targets for achieving improvements in worker health.

In a number of the workplace interventions, explicit attention was paid to each category of risks e.g., workstation adjustments and stress management classes in Feuerstein et al. [24]; feedback on work technique and psychosocial factors in Ecklof et al. [22]. The latter found that although feedback to individuals, workgroups or supervisors led to similar changes in work technique and work station design, feedback through supervisors was more effective at changing psychosocial risk factors. These studies provide the fullest examples of "integrative" through this lens.

In others, a participatory approach was taken, involving workers either in group training e.g. Bohr [7], or individual assessment and consultation Ketola et al. [41]. Here, participatory can be understood in a pedagogical sense, involving participants in the recognition of risks and options

Table 1 Lenses on *integrative* workplace interventions and corresponding Cochrane Occupational Health Field categories

Lens on Integrative	Cochrane OH field categories		
	Classifier	*Sub-classifier*	Classes
Biomechanical and psychosocial	2 Mode of action (Classes include those from both sub-classifiers)	*Exposure reduction Interventions*	1. Technical measures, hierarchy of controls 2. Behavioral measures 3. Organizational measures
		Behavioral change interventions	1. Educational: increase of knowledge, skills, attitude 2. Reward and punishment, taxation & subsidies 3. Legislation and banning—NA[a] as societal 4. According to theoretical background
Multi-component	4 Complexity	Class 2 only in lens	1. Simple interventions 2. Complex multi-component, multi-actor interventions
Primary and secondary prevention	2 Mode of action (Classes include one of above plus at least one class from either of these sub-classifiers)	*Occupational disease & injury treatment*	1. Drug treatment 2. Operation 3. Conservative treatment 4. Workplace interventions
		Disability management	1. Workplace interventions 2. Behavioral, worker-directed interventions 3. Rehabilitation, clinical interventions 4. Supervisor directed interventions 5. Health care directed interventions
	7 Moment of application	Both classes in lens	1. Preventive, before symptom occurrence 2. Curative, after symptom occurrence
Organizational	3 Level or point of action [Expanded # of classes]	Classes new 2 & 3 in lens	1. Individual level 2. Workgroup level 3. Workplace level
OHS[a] system wide		Classes new 4 & 5 in lens	4. Community level 5. System/society level

Note. Verbeek [63] and Verbeek et al. [63]—note that Classifiers 1 (final outcome—vary within each lens), 5 (Target Group—workers for all lenses here), 6 (Place of Delivery—workplace for all lenses here), & 8 (Mode of Delivery—multiple for most lenses) are not listed here.

[a]OHS: Occupational health & safety; NA: not applicable.

for their resolution, thus stimulating problem-solving strategies that can be applied to other risks. A more sophisticated look at the mechanisms and pedagogical implications of such participatory approaches among college students is laid out in Robertson et al. [55].

Multi-component

In examining best practices for control of WRUEDS, the US National research Council Panel on Musculoskeletal Disorders cited four office-based companies experience ([49], chapter 8, table 8.4). Each of the company programs included multiple components: engineering controls

Table 2 Studies exemplifying the different lenses on integrative workplace interventions for *WRUEDS* at *office* workplaces

First author (year)	Lens on "integrative"				
	Biomechanical & psychosocial	Multi-component	Primary & secondary prevention	Organizational	Occupational Health & Safety system
Amick [1]		√ New chairs & training			
Arnetz [3]		√ Pro-active role for insurance case managers, workplace ergonomic interventions			
Bernacki [6]		√ Employee and supervisory training, job accommodation, ergonomic assessments medical mgt. guidelines		√ Program through Joint Committee on Health, Safety & Envt	
Bohr [7]	√ Education including posture, workstation setup and stress				
Cole ([13] & submitted); Polanyi [5]	√ New equipment, training re risk factors, consideration of work load	√ Risk factor reduction, enhanced reporting, on-site physio		√ RSI committee & Ergonomic Policy	
Eklof [22]	√ Feedback re workplace design, work technique, & psychosocial factors				√ Consultants to multiple organizations
Feuerstein [24]	√ Workstation adjustments & stress management	√ Individual consultation & group classes			
Ketola [41]	√ Individual, participatory ergonomic consultations				
Martin [48]		√ Series of individualized sessions: education, workstation re-design & purchase, task modification			
Nieuwen-huijsen [50]	√ Workstation tips and posture advice, dealing with stress & relationships	√ Education via posters, e-mail tips, mini-workshops, and activities of a Wellness Ergonomic Team			

(3/4), administrative/production (4/4), employee involvement (2/4), management support (4/4), training (4/4), medical management (2/4). All reported positive impacts.

In a pilot study among office workers in a small college, Martin and colleagues [48] implemented a multi-faceted work injury prevention program. Although conducted primarily one on one among those with and without MSD, the program included consultation on multiple relevant components including education on MSD, ways of re-configuring one's workstation, purchase of additional pieces of equipment, and ways of modifying office work tasks. A more rigorous study evaluating the impact of guidance on and use of a highly adjustable chair along with office ergonomics training [1], found clear value in reducing the extent of increases in MSD symptoms over the work day.

In parallel work, a critical review of evaluation studies of the health-related effects of multi-component worksite health promotion programs [35] also found different components including health education to employees, opportunities to learn and practice new skills, modifications in organizational policy, changes to the physical work environment, and individual risk reduction counseling. In keeping with the notion of comprehensive programming, the authors argued that one component in isolation may not be as effective as an integrated, multi-component intervention, particularly given the multi-factorial causation of health conditions that are usually targeted by health promotion programs.

Among programs for office workers with a clear health promotion framing was that by Nieuwenhuijsen and colleagues [50]. They investigated the impact of a multi-component intervention aimed at preventing repetitive strain injuries among office/computer workers. The intervention consisted of posters, e-mail tips, mini-workshops, and activities of a Wellness Ergonomics team. Positive behavior change was reported for 62% of the participants following the intervention.

The use of multiple components is also apparent in the disability management literature (Franche et al. [25]). An example which included white collar workers (15%) was that by Arnetz and colleagues [3] who examined the impact of a combined proactive case management strategy by the insurer and workplace ergonomic interventions for cases of work disability (sickness absence). Compared to traditional case management techniques, faster assessments and earlier return to work were observed.

Primary, secondary $+/-$ tertiary prevention

Prevention of MSD burden can be conceptualized at three stages during the course of a WRUED. Primary prevention among those without a WRUED usually consists of measures to reduce exposures that could give rise to WRUEDs among the workforce. Secondary prevention often includes active surveillance for early detection of WRUEDs or enhanced reporting systems for those with early symptoms of WRUEDs, so that exposure reductions and workplace supports can both stop progression of the WRUED and reduce the risk of work disability, including stay at work programs. Tertiary prevention some regard as a misnomer, because it primarily involves treatment for an episode of work disabling WRUED, along with rehabilitation that promotes early return to work among those already off work. Nevertheless, some group all three prevention approaches into "work disability prevention" as each may have an impact on a workplace's WRUED burden [47].

Particularly relevant to the combined prevention lens on integrated are two themes described by Frank et al. [27]: (1) With multiple causes for workplace injury, illness and disability, preventing these problems requires multiple solutions, operating in synergy; (2) Efforts to reduce workplace injury, illness and disability must build on both primary and secondary prevention approaches, merging these to create a more effective strategy. Yassi et al. [68] have argued

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strongly for breaking down the solitudes between programs aimed primarily at injury prevention and those concerned with return to work.

In our work at a large newspaper, we explicitly set out primary and secondary prevention objectives [13] and a framework for monitoring indicators of changes within short to longer term time horizons [12]. The goal was: To demonstrate the effectiveness of a workplace program for primary, secondary and tertiary prevention of work-related musculoskeletal disorders (WMSD) of the neck and upper extremity, using a prospective, longitudinal design with mixed methods.

In the collaborative research process, the workplace parties built on earlier research to develop an innovative Ergonomic Policy. Special RSI/WMSD training sessions were held in all departments, with 58% of 2001 survey respondents remembering these sessions and another 11% indicating that they received training on RSI/WMSD as part of their orientation. Ninety percent of 2001 respondents felt that The Toronto Star RSI Program had completely to moderately "ensured that all employees are informed about RSI." Compared to our earlier 1996 survey, significantly greater endorsement of relevant responses as to potential causes of RSI/WMSD were observed e.g., workstation, tools, breaks, keyboarding, workload, exercise and posture, at the same time that "lack of training" was mentioned less frequently. Further, 85% of 2001 survey respondents completely to moderately agreed that the RSI Program "promoted continuous improvement in the technology and management practices to control exposure to workplace risk factors that can cause RSI" and 74% agreed or strongly agreed (vs. 64% in 1996) that Toronto Star management were supportive in dealing with RSI. Nevertheless, similar proportions indicated that their immediate supervisor was aware and concerned about RSI and the proportion of respondents who disagreed that "I can take breaks when I want to" was unchanged from 1997 to 2001 (28%). The interviews helped provide explanations where little change occurred. As one manager said, ". . .productivity is really important here. You have to be always available on your phone. And all their incentives . . .[are] based on how much you're producing." Similarly, changes were not as apparent in proactive technology choices and job design as RSI Committee members and we had hoped for, due to the limited mandate of the RSI Committee and a range of sectoral, company and departmental level constraints [51].

The RSI Program was associated with some positive changes in self-reported exposures to physical and psychological WMSD risk factors. The proportion reporting equipment in more optimal orientations increased between 1996 and 2001 from 56% to 72% for the keyboard as did levels of social support at work. The proportion of respondents sitting continuously for greater than two hours increased by 9%, to 33% of 2001 respondents. Among those with pain, 57% had consulted a health practitioner, including the on-site physiotherapist. Further, 72% of 2001 respondents with pain reported being engaged in a wide variety of other active efforts to respond to pain, including: doing exercises (65%), making posture changes (59%), reporting their pain to the workplace (40%), educating themselves (38%), and using relaxation techniques (31%).

In repeat cross-sectional analyses, the proportion reporting moderate pain or worse, at least once per month or for longer than one week, declined from 20 to 16% ($p = 0.01$). Among a cohort that participated in both 1996 and 2001, 26% got better, 54% stayed the same, and 21% had increased pain. In path analyses, pain intensity and work disability in 1996 were the strongest predictors of 2001 health status (both $p < 0.001$). after taking account demographic confounders (gender, seniority and age), stable or increased supervisor awareness and concern about RSI was associated with decreased pain in 2001 ($p < 0.01$). Participation in RSI training was associated with increases in decision latitude ($p < 0.05$), which themselves were associated with decreased work disability in 2001 ($p < 0.05$). Increased time mousing was associated with increases in work disability ($p < 0.05$) (See figure from Cole et al. [15]).

Substantial aggregate increases in physiotherapy services, promoted by the RSI Program, and musculoskeletal (MSK)-related drug utilization, particularly NSAIDs, occurred through the

intervention period. Pain severity of those presenting for in-house physiotherapy declined during the intervention period. At the same time, workers' compensation claim related absence declined to zero new lost-time claims in 2001.

Organizational

The interventions across the prevention spectrum implemented by workplace parties of this large newspaper also exemplify another lens on integrated—"organizational"—more commonly applied in workplace stress reduction case studies [42]. Labor and management, working together, generated a variety of creative strategies to "market" RSI/WMSD awareness among company staff and used industrial relations tools, such as periodic collective bargaining sessions and mandated health and safety representatives, to drive organizational wide implementation of their RSI/WMSD program. The joint RSI committee has continued updating training and ergonomic assessments, worked closely with therapists on site and advocated for strengthening management practices supportive of dealing with RSI, particularly at the supervisory level [13]. The term "integrative workplace health management" has been coined to emphasize workplace involvement in a broad spectrum of activities [11].

Some work disability management interventions also involve the organization as a whole, including both internal and external stakeholders [4]. A good example is Bernacki and colleagues [6] Facilitated Early Return to Work Program that was developed under the auspices of the Joint Committee on Health, Safety and Environment for a large teaching hospital and university i.e. including office workers. A combination of policy changes, training, guideline development, and case tracking were instituted over time. Substantial reductions in lost-time and associated costs were observed.

The implication of organizational factors in the development of MSD has encouraged the use of participatory ergonomic (PE) interventions. Working together to improve workplace conditions through multi-stakeholder participation, communication, and group problem solving, PE may have a positive impact on the organizational aspects of the work environment, even if the process focuses on technical factors (Laitinen et al., 1998). Early participatory ergonomic (PE) studies included those that involved different levels within an organization jointly involved in overseeing, designing or implementing changes (e.g. ref. [64, 65] as cited by Denis et al. [20]). Haims and Carayon [33] described an ongoing process of training, design team activities and multiple interventions over time which affected ongoing organizational ways of doing things. In parallel work in a PE intervention in a courier company, we have shown that greater participation was associated with improvements in perceptions of influence on job conditions, which in turn were associated with reductions in MSD pain [53].

A related issue for organizationally oriented interventions is how long interventions continue. In a recent systematic review of participatory ergonomic intervention effectiveness [54] interventions lasted up to seven years. Six of the 12 higher quality studies reported intervention durations of 24 months or greater, perhaps reflecting the time required to demonstrate change to important outcomes as a result of PE processes. Longer multi-component health promotion interventions have shown more impact than shorter ones, though just how long interaction needs to occur is difficult to identify [35, 38]. Considerable work has been done in health promotion on the nature of sustainability [31, 59, 52]. Goodman et al., particularly focus on the extent to which an intervention becomes institutionalized or an integral part of an organization in its organizational routines. Sehdiac-Rizkallah & Bone emphasize the need for capacity building within organizations and coalitions involved (links to Occupational health & safety system). Pluye and colleagues describe the conditions for sustainability, particularly in joint planning and implementation processes. During the organizational inter-

vention in a described above, we used qualitative methods to document the nature of capacity building, as suggested by Griffiths [32]. Commitment to change among members of the organization, skills within the RSI Committee change team, and resources applied to the intervention all played an important role in influencing intervention effectiveness, and sustainability [13, 51].

Occupational health & safety system

In a final lens on "integrative" we may look to cross-workplace interventions where the interveners are part of the occupational health and safety system. The rationale for working with system partners reaching multiple workplaces is that factors influencing work disability operate at multiple levels [14]. Eklof and colleagues' study [22] provides an example of working with multiple workplaces at different levels. Working through ergonomics' consultants, the research team involved 36 workgroups from 9 Swedish public or private organizations, all white collar workers using computers (63% women). The intervention consisted of feedback about computer ergonomics and psychosocial factors delivered to individual workers, supervisors only, or supervisors and work groups. A control group received no feedback. Work groups were randomly allocated to the intervention groups or control group. A team of eight ergonomists were trained to provide feedback orally, through printed reports or through presentations. Feedback was presented during a single one hour session within one month of the baseline data collection, a feasible intervention for potential coverage of large numbers of workers.

The study examined the quality and quantity of ergonomic modifications as well as the impact of the modifications on emotional stress, musculoskeletal symptoms and eye discomfort. There were modest positive effects noted and the authors cautiously suggest that simple feedback may have an effect on modifications to the workplace and work techniques. Part of the reason the effects of some interventions were not statistically significant may be that the intensity and duration of the intervention (as per the organizational lens above) was limited. On the other hand, the influences of sectoral markets, social norms, and societal organizations on workplace design, priority setting and resource allocation may be overarching in setting the limits of change in particular workplaces (as in the newspaper we worked with, Polanyi et al. [51]). Insurance policies and programs, legislation, regulations, and health and safety prevention programs are explicitly directed at influencing workplace control of work-related injury, MSK pain and disability. Unfortunately few broad evaluations of such societal instruments are available which clearly delineate impacts upon office workers. Nevertheless, greater opportunities may be associated with involving multiple stakeholders to achieve synergistic and multi-level interventions [26], that are supportive of changes in office workplaces.

Challenges

There remain significant challenges in reaching many workplaces either to share existing interventions or test new ones. In terms of the former, application of workplace interventions for those with work-related CTS in Massachussetts ([66]; Table V) including among occupations and industries covering office work was limited. Few single interventions occurred in follow-up (about 40%), with likely lower rates for multiple interventions to assist return to work. Further, inequalities were apparent, with managers and professionals having better access to accommodations, particularly changes to equipment or the work environment, than did non-professionals.

Recruiting workplaces

Workplace participation in intervention research appears to be similarly restricted. Among small & medium enterprises, contacted by a research team regarding occupational health services using four different strategies to obtain interviews, response rates varied from 4 to 43% [9]. In a North Carolina Business Needs Survey of businesses where individuals (previously surveyed) currently worked, only 53% of businesses responded [60]. Among US not-for-profit organizations with >$100,000 in annual revenues, response to a survey on abroad array of organizational issues was approximately 50% [36]. These data were just for surveys. Most workplace intervention studies do not report on how workplaces were either selected or came forward to participate in intervention research, leaving one to fear that selection may be primarily "opportunistic." As Bradshaw and colleagues noted [9], "The studied group eventually turned out to be a highly selected group by virtue of the fact that they wished to participate in the research."

Linnan and colleagues [46] have explored recruitment into workplace health promotion programs at both the organizational/workplace and individual levels. They noted multiple influences on participation: organizational characteristics, health behavior involved, worker and workplace incentives/expectations, feasibility of various approaches given provider and worker constraints, as well as concerns and considerations of management, labor and insurance carriers. In our experience, workplaces that volunteer for research usually have internal drivers, such as proactive union membership, exceptionally skilled and evidence-oriented health and safety staff, or enlightened executive management, unless productivity improvements associated with better ergonomics and/or work organization are the primary drivers. Hence, most volunteer workplaces have already achieved a relatively better work environment. This likely reduces potential effect sizes of risk reduction or health improvement for the same intervention intensity, a bias that may reduce the strength of the evidence available. We need to confront the barriers and increase the incentives for workplaces and their employees to participate in workplace intervention research and expand the evidence available (see Table 3).

Interpreting evidence

Currently there exist mixed messages on workplace intervention effectiveness due to: Different disciplinary cultures of evidence; interventions corresponding to different organizational levels from jobs to workplace policies; varying intensities of interventions, varying considerably by resources allocated by workplaces; and marked heterogeneity in documentation/indicators of both intervention processes and outcomes of interest by researchers and their workplace partners [14]. The use of logic models, multiple indicators, complementary quantitative and qualitative methods, and nested measurement approaches are important means by which to strengthen the validity of workplace intervention evaluations [12, 14].

Applying evidence

Our experience in a large newspaper indicated that less changed in physical and psychosocial risk factors during a much-heralded team re-organization that occurred, than was initially hoped for [13]. In keeping with renewed NIOSH emphasis on work organization and WMSD and in the interest of informing public policy and encouraging workplace change which promotes worker musculoskeletal health as well as improved business performance, organizational leaders need to move "upstream" to influence decisions on new technology, organization of work and design of jobs [51] i.e. engage in integrative organizational re-design.

Table 3 Barriers and incentives to participation in workplace intervention research

Stakeholder	Barriers	Incentives
Researchers	Different time lines than most workplaces e.g., ethics approval, results turnaround	More representative workplace & employee populations will improve research generalizability
	Limited understanding of what is important to workplaces	Including more workplaces with more severe problems provides greater rooms for improvement, hence larger effect sizes
	Unaware of how decisions are made in workplaces, impatient with approval processes but limited access to either "champions" or "resisters"	
Owners/managers	Not their decision: headquarters responsible for 43% of North Carolina industries	Reducing workers' compensation costs
	Research not part of workplace culture e.g. policy against filling out surveys for 16% of non-participating North Carolina industries	Realizing commitment to health and safety
	Concern re sharing of confidential financial or personal information: 26% of non-participating North Carolina industries	Quality & efficiency improvements via production improvements and right first time as part of evaluation process
	Lose competitive advantage e.g. of work disability management programme	Compare themselves with other companies—benchmarking
Supervisors	Not enough time: 25% of non-participating North Carolina industries. In negotiations with companies/workplaces, often asked how much time? for whom?	Training in ways to assess MSD risk factors and rewards for improvements (safety culture)
		Participation in improving working conditions & resolving work accommodation challenges for those they supervise
		Reducing competing demands for good safety records, better quality, and maintenance of productivity
Employees	Studies may be used to rationalize work process as per re-engineering pressure to reduce waste time	Assessments of working conditions may highlight areas for change
		Participatory ergonomic or work organization initiatives improve influence in work design [53, 54]
		Potential for reduced work demands, better accommodation for those with pain, less time off because of MSD
System partners[a]	Focus on prevention or disability management but not both	Synergies if combine 1ry, 2ndy & 3ry prevention approaches
	Entrenched mandates	Be perceived as pro-active

[a]Insurers, unions, employer organizations, health & safety associations, government ministries.

Dutch Monitor study, that included banking and finance sectors i.e. lots of offices, are also interesting [37]. Intervention measures that had been found to be effective, in the perceptions of employers, were associated with employers implementing more types of preventive policies or measures in the last year including hiring professional expertise, dealing with work stress and physical loads, and starting rehabilitation programs i.e. multi-component interventions. Conversely, a weak labour market was negatively associated with implementation of rehabilitation programs.

Directions

Alternative organizational approaches

Organizational approaches that have been used to make change for business purposes or for safety concerns [19] likely warrant greater attention on the part of WRUED researchers. Aspects of social relations at work, such as supervisory leadership style [5] or perceptions of organizational justice [23, 56], can impact on MSD. These are intimately related to a variety of workplace organizational factors that have been shown to affect both the initial occurrence of injuries or MSK pain and the extent of work disability that may ensue [57]. Roughly speaking, these can be thought to reflect the roles, skills, resources and decisions made by workplace parties. The latter include: hourly employees and supervisors most directly engaged in work tasks; operational personnel in human resource, production or health and safety middle management positions; and executive managers that set priorities and decide on major design changes. Implementing interventions very much depends upon access across levels, as in some preliminary work that we have done in the courier sector [21]. Policies made at higher levels, may or may not be implemented at lower levels, a central tenet of the safety climate literature which has documented differences between policies and practices relevant for acute injuries, primarily in manufacturing settings [69–71]. Application of such literature more fully in work with organizations on MSD among office workers may be another fruitful area for exploration.

Organizational change research suggests that some companies are likely to be more innovative e.g. with more "open systems," those that exchange information across boundaries, have constant access to and frequently consider external knowledge [29], and they have core values that include risk taking, being supportive of change, and being flexible [43]. An important factor is readiness for organizational change, as defined by Armenakis et al. [2]:

> Readiness is reflected in organizational members' beliefs, attitudes, and intentions regarding the extent to which changes are needed and the organization's capacity to successfully make those changes.

Readiness for organizational change has been associated with musculoskeletal symptoms longitudinally in health care settings [18]. For interventions that require organizational change, the development of a program logic model that incorporates readiness for organizational change concepts across different worksites may be particularly useful. Haslam and colleagues [34] have carried out preliminary work applying a stages of change approach to ergonomic interventions. Since complex interventions most often operate at multiple organizational levels, the theoretical framework should include readiness at multiple levels as well.

System and workplace multi-level studies

Above we noted the limited number of multiple workplace studies in collaboration with system partners, and the strong tendency for volunteer bias at the level of the workplace. Intervention studies could take advantage of groupings of workplaces such as industry associations or workers' compensation (WC) cost containment programs. An example of the latter, in which membership in the group provides financial incentives as long occupational health and safety performance requirements are met, is the Ontario Safety Groups and the Safe Communities Incentive Programs. Employers participating in these programs must complete a baseline occupational health and safety (OHS) audit, agree to accept health and safety mentoring from other members of the group, and provide performance monitoring data to the Ontario Workplace Safety and Insurance Board (WSIB). Each year, participants select five elements of their OHS program for which specific objectives for improvement are set. To remain in the program, objectives must be achieved for at least three of the elements. These could include WRUED control programs. Employers can earn financial rebates on their WC premium and the rebate amount is tied to the performance of entire group in terms of overall reduction in lost time injury frequency and duration [67]. As a new cohort of companies is recruited and agree to participate each year, opportunities exist for both greater coverage and more rigorous quasi-experimental design options that we are currently exploring. Proposed evaluation research would incorporate the examination of the effects of intervention factors at multiple levels—as the Safety Groups Program facilitates mentorship and support of member companies (within group) as well as encourages partnering with organizations within Ontario's health and safety system. Other work through provincial health and safety associations includes office staff or those that work with visual display units, to evaluate the impacts of transformational leadership interventions on MSD.

Integrated knowledge transfer & exchange and intervention evaluation

A growing literature indicates that for substantial change in practices to occur as the result of an intervention research process, intense interactions among the different parties involved are required [38, 39]. Taking the needed time to achieve strong linkages, having multiple informal contacts, and involving numerous people in order to achieve a critical mass are also emerging in the incipient workplace health and safety research transfer and knowledge exchange literature [44]. Our work with stakeholders in developing research programs, as per the above, is one way of promoting such interaction sufficiently early on to guide both the research and the knowledge transfer and exchange processes [45].

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