Models of Causation: Health Determinants

Core Body of Knowledge for the Generalist OHS Professional

Safety Institute of Australia Ltd

Australian OHS Education Accreditation Board

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The OHS Body of Knowledge for Generalist OHS Professionals has been developed under the auspices of the **Health and Safety Professionals Alliance**

The Technical Panel established by the Health and Safety Professionals Alliance (HaSPA) was responsible for developing the conceptual framework of the OHS Body of Knowledge and for selecting contributing authors and peer-reviewers. The Technical Panel comprised representatives from:

The Safety Institute of Australia supported the development of the OHS Body of Knowledge and will be providing ongoing support for the dissemination of the OHS Body of Knowledge and for the maintenance and further development of the Body of Knowledge through the Australian OHS Education Accreditation Board which is auspiced by the Safety Institute of Australia.

Synopsis of the OHS Body Of Knowledge

Background

A defined body of knowledge is required as a basis for professional certification and for accreditation of education programs giving entry to a profession. The lack of such a body of knowledge for OHS professionals was identified in reviews of OHS legislation and OHS education in Australia. After a 2009 scoping study, WorkSafe Victoria provided funding to support a national project to develop and implement a core body of knowledge for generalist OHS professionals in Australia.

Development

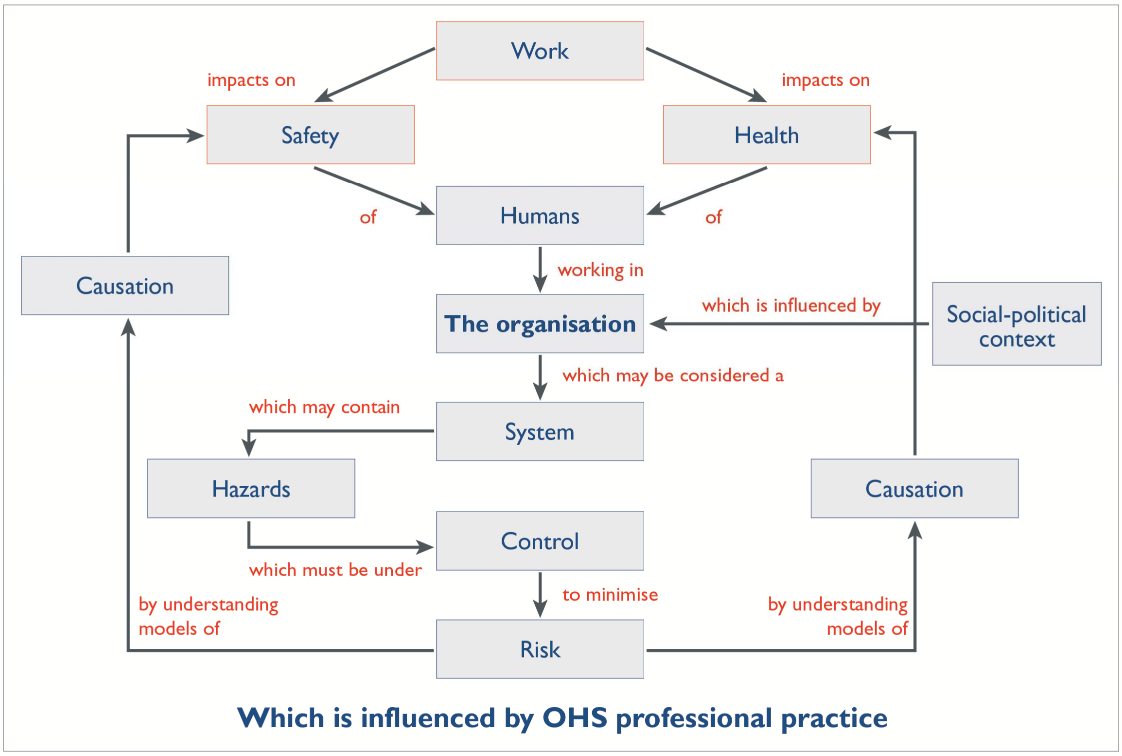
The process of developing and structuring the main content of this document was managed by a Technical Panel with representation from Victorian universities that teach OHS and from the Safety Institute of Australia, which is the main professional body for generalist OHS professionals in Australia. The Panel developed an initial conceptual framework which was then amended in accord with feedback received from OHS tertiary-level educators throughout Australia and the wider OHS profession. Specialist authors were invited to contribute chapters, which were then subjected to peer review and editing. It is anticipated that the resultant OHS Body of Knowledge will in future be regularly amended and updated as people use it and as the evidence base expands.

Conceptual structure

The OHS Body of Knowledge takes a ‘conceptual’ approach. As concepts are abstract, the OHS professional needs to organise the concepts into a framework in order to solve a problem. The overall framework used to structure the OHS Body of Knowledge is that:

> **Work** impacts on the **safety** and **health** of humans who work in **organisations**. Organisations are influenced by the **socio-political context**. Organisations may be considered a **system** which may contain **hazards** which must be under control to minimise **risk**. This can be achieved by understanding **models causation** for safety and for health which will result in improvement in the safety and health of people at work. The OHS professional applies **professional practice** to influence the organisation to being about this improvement.

This can be represented as:



Audience

The OHS Body of Knowledge provides a basis for accreditation of OHS professional education programs and certification of individual OHS professionals. It provides guidance for OHS educators in course development, and for OHS professionals and professional bodies in developing continuing professional development activities. Also, OHS regulators, employers and recruiters may find it useful for benchmarking OHS professional practice.

Application

Importantly, the OHS Body of Knowledge is neither a textbook nor a curriculum; rather it describes the key concepts, core theories and related evidence that should be shared by Australian generalist OHS professionals. This knowledge will be gained through a combination of education and experience.

Accessing and using the OHS Body of Knowledge for generalist OHS professionals

The OHS Body of Knowledge is published electronically. Each chapter can be downloaded separately. However users are advised to read the Introduction, which provides background to the information in individual chapters. They should also note the copyright requirements and the disclaimer before using or acting on the information.

Models of Causation: Health Determinants

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Abstract

Health is a state with both negative and positive dimensions; it extends beyond the absence of diseases and disorders to encompass personal wellbeing more generally. Its determinants are diverse and not confined to workplace hazard exposures, so identifying and managing the main *work-related* influences on health can be difficult. Models of occupational health causation range from macro-level conceptions, which include determinants external to the workplace but are insufficiently detailed to guide workplace risk management, through to evidence-based models depicting the work-related causes of a particular disease or disorder. An understanding of the latter type of causal model is particularly important to enable effective risk management of diseases and health disorders that have multiple and potentially interacting hazards (e.g. musculoskeletal disorders, mental disorders, cardiovascular diseases).

Keywords

health, illness, disease, causation, work

Contents

1 Introduction

The *safety* aspects of Occupational Health and Safety (OHS), concerned with prevention of accident-related injuries, are often seen as central to the role of the generalist OHS professional. However, contemporary OHS professional practice requires at least an equal focus on workersô *health*. This chapter ï one of two about models of causation[1] ï describes the kinds of health-related causal models required for effective OHS risk management. Section 2 outlines the historical contributions of various professional groups to our understanding of occupational health determinants. Section 3 discusses the basis for identifying observed health outcomes as ówork-relatedö, considers various models of causation, and outlines the importance of positive dimensions of occupational health and their determinants. Finally, section 4 summarises implications for OHS professional practice.

2 Historical overview

The history of occupational health practice dates back several thousand years (see Abrams, 2001; Gochfeld, 2005). This section briefly considers the contributions of various professional groups to our current understanding of occupational health determinants.

Medical practitioners played a key role during the earliest years, leading during the 20th century to development of the profession of occupational medicine (Lane & Lee, 1991). Occupational diseases were initially attributed only to physical hazards, particularly chemical, physical and biological exposures; the fields of industrial toxicology and occupational hygiene emerged from this approach. Occupational epidemiology and related sociological research also developed during the 20th century from origins traceable to the early 18th century work of Ramazzini (2001 translation), who documented the hazards and related health problems for more than 50 occupations in *De Morbis Artificum Diatriba* (*Diseases of Workers*).[2] More recently, epidemiologists and public health professionals have elucidated the social determinants of health, both within and external to workplaces; for example, the now famous WhiteHall Studies were instigated by Marmot during the 1960s and are ongoing (see Marmot, Siegrist & Theorell, 2006).

Development of sociotechnical systems theory during the 1940s and 50s by psychologists at the Tavistock Institute in London provided one of the first examples of a systems approach to optimise both work performance and employee wellbeing (Trist, 1981). Concurrently, the related field of ergonomics brought a human-centred approach to the workplace, focusing variously on system safety and performance, and on occupational health issues (Wilson, 2000). The field of occupational health psychology emerged during the 1980s from a

[1] See *OHS BoK* Models of Causation: Safety.
[2] For detail on the historical context for occupational health see *OHS BoK* The Human: As a Biological System.

confluence of industrial/organisational psychology and health psychology, with recent inputs also from psychoneurobiology as it relates to the physiological processes underpinning psychological wellbeing (for example see Pressman and Cohen, 2005). Professionals in this field have highlighted the widespread impacts on occupational health of work-related stressors, and have specialist expertise in managing workplace risks stemming from psychosocial hazards, particularly as they relate to mental disorders and wellbeing.[3]

In summary, it can be seen that the field of occupational health now spans highly diverse areas of expertise. Some implications for OHS professional practice are discussed in section 4.

3 Understanding the determinants of occupational health outcomes

This section first discusses the nature of ócausationô within an OHS context and the basis for concluding that observed health outcomes are work-related. It then discusses the nature and role of macro-level models of occupational health determinants. The third part identifies the kinds of diseases/disorders which typically have just one main work-related cause, and the fourth discusses causal models for diseases/disorders with multiple, possibly interacting determinants. The final part of this section considers positive dimensions of health and their determinants, since the importance of these is being increasingly recognised, consistent with the World Health Organization definition of health as ña state of complete physical, mental and social well-being and not merely the absence of disease or infirmityò (WHO, 1948).

3.1 ‘Causation’ and work-relatedness

The development and implementation of effective OHS intervention strategies requires an understanding of the factors ócausingô occupational health outcomes. In this context, causes include work-related hazards and other risk factors that increase the probability and/or severity of harm to health, as well as factors that promote *positive* states of health and wellbeing.

Determining the causes of *injuries* is usually a more straightforward process than diagnosing the causes of *health* outcomes. The most obvious reason for this difference is that with injuries there is usually no separation in time between the injury and the harmful event that is its immediate cause. For example, in the case of a personõs contact with the cutting edge of a machine blade, the harmful event provides a clear starting point for investigations to determine causation and the work-relatedness of the injury is not disputed. In contrast, *health*

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[3] See *OHS BoK* Psychosocial Hazards and Occupational Stress

outcomes often result from exposures to hazards[4] over extended periods of time, and there may be latency periods of many decades between the hazard exposure(s) and the manifestation of health effects. This longer timeframe makes it less likely that the harm to health will be identified as work-related, and increases the difficulty of identifying relevant hazards and other risk factors in any individual case.

Work-related injuries can often be attributed to several work-related causal factors, but the high salience of the injurious event can result in risk management focusing too narrowly on that event. For example, efforts to control risk of injury from a machine blade often focus on installation of a well-designed guard, but it might also be important to control factors such as production pressures that motivate workers to save time by disabling the machine guard, inadequate supervision, and poor safety culture more generally.[5]

Work-related *health* outcomes are different from *injury* outcomes in that many diseases by their nature are indicative of their cause, whereas this is not true of injuries. The nature of injuries suffered in an accident does not usually indicate the *cause* of the accident; for example, the causes of road accidents cannot usually be deduced from the nature of injuries suffered. In contrast, diseases such as mesiothelioma, or disorders such as noise-induced hearing loss, by their nature indicate the main work-related cause of that health outcome ï exposure to asbestos in the first case and to excessive noise in the second. Causal mechanisms differ widely between different health outcomes, and because of this diversity, a variety of quite different causal models are required to support occupational health management.

Another important difference between causation of injuries and of health outcomes is that the latter are usually more affected by non-work factors, and the work-relatedness of many health problems therefore tends to be poorly documented and inadequately acknowledged. Nevertheless, some diseases have been widely accepted as work-related (i.e. as óoccupationalô diseases) due to their hazard-specific nature and the low probability of non-work exposures to that particular hazard. Examples include diseases arising from exposure to dust, poisonings from exposures to some hazardous substances, and infections transmitted from farm animals to farmers, veterinarians or abattoir workers. Although noise-induced hearing loss is widely accepted as an occupational disorder, the increasing incidence of non-work exposures due to personal music devices may render this increasingly open to dispute. In the case of cancers, work-relatedness is often disputed, particularly those that are both very common and very severe in their effects so there is a lot at stake. Attempts have been made to determine the overall proportion of cancers that are work-related, but:

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[4] Exposure may be defined in terms of both its nature and its extent. For the present purpose, *nature of exposure* refers to the type of hazard to which people are exposed; this encompasses the various types of hazard listed in the *OHS BoK*. *Extent of exposure* refers to the severity and duration of the exposure.

[5] For conceptual models supporting analysis of the causation of harmful events see *OHS BoK* Models of Causation: Safety.

> Reliably establishing the causes of any one cancer type is very difficult because cancer proceeds from a combination of events, these events occur over a period of years or decades, and causal factors seldom fingerprint the cancer histology (Benke & Goddard, 2006, p. 485).

For any such health outcomes, a causal relationship, rather than just a statistical association, is more likely when:

- Exposure precedes the health outcome (essential for causality, but not always easy to establish, e.g. because cancer might start years before it manifests clinically)
- The observed association is strong
- More intense or prolonged exposures are associated with more frequent or severe outcomes (i.e. there is a dose-response relationship)
- The association between exposure and outcome is compatible with existing knowledge of biological mechanisms
- A particular kind of exposure tends to be associated with a particular health outcome
- Evidence is similar across different groups at different times (Hill, 1965; NRC&IM, 2001).

For further discussion of causation in an OHS context, see Hill (1965), or a report by the National Research Council and Institute of Medicine, USA (2001, pp. 65ï 82).

3.2 Macro-level models of occupational health determinants

Macro-level models of occupational health determinants provide comprehensive coverage of factors including, but not confined to, work-related hazards. A good example of such a model is the World Health Organizationôs Healthy Workplace Model (Burton, 2010) (Figure 1). This depicts the OHS risk-management action cycle (an eight-step continual improvement process ï Mobilize, Assemble, Assess, Prioritize, Plan, Do, Evaluate, Improve) in the context of four overlapping sets of occupational health determinants: the psychosocial work environment, the physical work environment, personal health resources, and linkages between the enterprise and its wider community. Of central importance are the enterpriseôs core ethics and values, supported and promoted by leadership engagement and worker involvement.

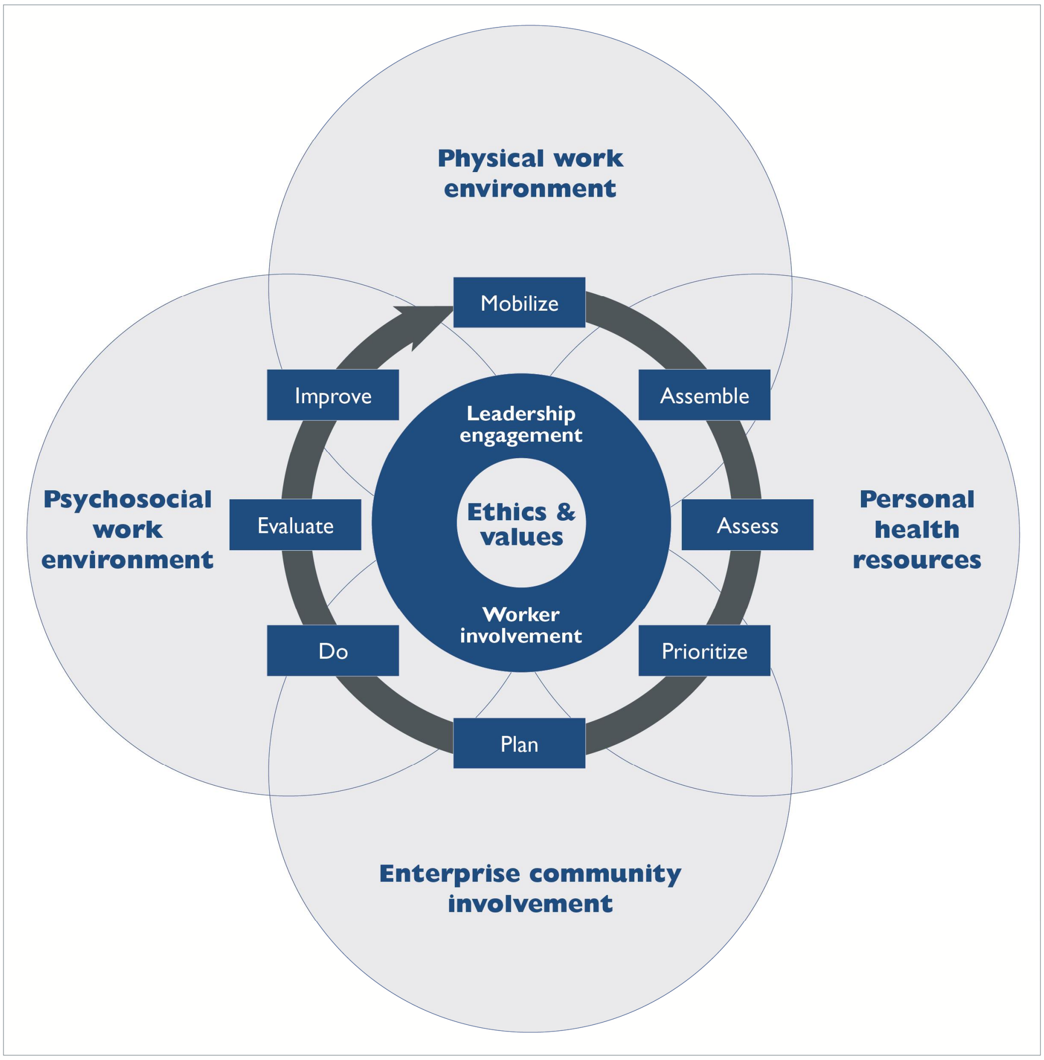

Figure 1: WHO Healthy Workplace Model: Avenues of Influence, Process and Core Principles (Based on Burton, 2010, p. 3)

Sorensen et al. (as cited in Ellis)[6] conceived an even "bigger picture" macro model that includes four sets of external influences on occupational health that are not depicted in the WHO model: legal, economic, political and social factors. However, the WHO model includes more detail at the *individual enterprise* level.

In common with most macro models of occupational health determinants, Figure 1 includes an element – "personal health resources" – representing relevant characteristics of workers. In the Sorensen et al. model used by Ellis this is termed "individual health-related behaviors"; in the systems models used by ergonomists such an element typically refers to the capacities and limitations that affect people's ability to cope with work demands (e.g. see "coping resources"

[6] *OHS BoK* Global Concept: Health (section 3)

in Figure 4). Thus, although these models differ in the particular individual variables identified, there is consensus that some individual-level factors should be included in the overall conceptual framework. Examples of individual variables that may be important in the occupational health context include:

- Personal vulnerabilities and causal factors stemming from:
    - *Permanent or stable factors:* age, gender, physical size and strength (anthropometrics), personality characteristics (e.g. positive/negative effect, locus of control), health-related genetic vulnerabilities and predispositions, chronic health problems, etc.
    - *Factors amenable to change within a medium timeframe*: work-related knowledge and skills, health-related behaviours (e.g. nutrition, exercise, smoking), some health problems and injuries, job satisfaction and morale, physical fitness, etc.
    - *More transitory states*: fatigue, stress, mood, etc.
- Lifestyle factors (e.g. having to cope with demands from personal commitments to family and friends; availability of personal support from non-work sources) might also be relevant in some contexts.

Personal and lifestyle factors such as the above are often seen as exerting a major influence on health. For example, even when someone suffers a ‘heart attack’ *at work*, the causes are more likely to be seen as personal and lifestyle rather than work-related factors (despite the evidence on work-related causes of cardiovascular disease discussed in section 3.3 below). In contrast, when someone suffers injury due to an accident at work, it is usual to look for work-related causes, even when personal factors are also identified as contributors.

Macro-level models illustrate the wide range of both work and non-work factors that influence occupational health. They span public health as well as occupational health domains, providing the basis for a broad range of health protection and promotion strategies both within and beyond the workplace. However, more narrowly focused causal models are required to guide the detailed development of risk-management strategies at the workplace level.

3.3 Hazard-specific diseases and disorders

Some occupational diseases and disorders are associated with one *primary* work-related hazard as opposed to a diverse range of hazards of varying importance.[7] Examples of hazard-specific health conditions are shown in Table 1, with the hazard of primary importance shown in the right-hand column. Effects of exposures to the primary work-related hazard

[7] Because of their strong association with a particular hazard, further information about the causation of such diseases or disorders is located in the relevant *OHS BoK* Hazard chapters.

(plus exposures external to the workplace) interact with individual susceptibilities to increase risk of the particular disease or disorder.

Table 1: Causal factors for a sample of diseases/disorders where there is one main work-related hazard

Example of hazard-specific disease/disorder	Individual susceptibility		Work-related hazards – causal agent(s)
	Inherent	Acquired	
Sensorineural hearing loss	• Male sex	• Some substance exposures (prescribed, occupational)	• Excessive noise levels
Mesothelioma	• Mechanism unknown, but a genetic influence is likely	• Unknown	• Asbestos dust
Q-fever		• Contact with infected animal fluids	• *Coxiella burnetii* (bacterium)
Allergic contact dermatitis	• Inherited or early acquired immune tendencies	• Continuing exposure to sensitising agent • Co-existing irritant dermatitis	• e.g. nickel, chromium, epoxy resins, latex particles, certain plants
Asthma	• Inherited or early acquired immune tendencies	• Prior exposure to sensitising agent • Hyper-reactivity of the individualôs airways	• e.g. volatile isocyanates, protein dusts, Western Red Cedar, aluminium smelting

3.4 Diseases and disorders with multiple determinants

Ellis noted that ñThe traditional OHS model is straining as the burden of health in workplaces shifts to illness arising from chronic disease.ö[8] This situation is primarily due to diseases/disorders that typically have *multiple* causes. These include cardiovascular diseases, musculoskeletal disorders and mental disorders, which are three of the eight diseases/disorders identified as warranting particular focus within Australiaôs *National OHS Strategy 2002–2012* (Safe Work Australia, 2010a).

In 2010, the Australian Institute of Health and Welfare reported:

> More than 6.1 million Australians aged 16ï 85 years suffer from a musculoskeletal condition at a point in time (38% of that population) and 3.2 million (20%) experience a mental disorder in a 12ï month period (AIHW, 2010, p. 1).

Such evidence illustrates that both musculoskeletal and mental disorders have major impacts on population health, beyond their more easily quantifiable costs in terms of compensation claims. Australian workersô compensation statistics for the period 2007ï 08 showed that

[8] *OHS BoK* Global Concept: Health (Abstract)

musculoskeletal injuries and disorders were responsible for the largest proportion of serious claims,[9] followed by mental disorders.

> The most common injury leading to serious claims was *Sprains & strains of joints & adjacent muscles*, which accounted for 43% of all serious claims. The most common diseases resulting in serious claims were *Disorders of muscle, tendons & other soft tissues* (6% of all serious claims), *Dorsopathies – disorders of spinal vertebrae* (6% of all serious claims) and *Mental disorders* (5% of all serious claims). (Safe Work Australia, 2010b, p. vii)

These compensation statistics create the impression that sudden-onset musculoskeletal *injuries* (sprains and strains) are much more common than cumulative disorders, in which case consideration of their determinants would be outside the scope of this chapter focussed on *health* determinants. However, many musculoskeletal problems cannot be clearly diagnosed as *either* an ‘injury’ *or* a ‘disease/disorder’ (ASCC, 2006), since it is now evident that thresholds for *acute* injury are reduced by *cumulative* exposures, both within a work shift and over longer time periods (e.g. Visser & van Dieen, 2006; van Dieen, 2007). The dichotomy between acute and cumulative injury is even more questionable when information about causation is derived from compensation claims data. Several factors combine to make it likely that compensation claims focus largely on events immediately preceding the report, resulting in substantial bias towards reporting an injury rather than a disease (see Macdonald & Evans, 2006, pp. 12–15). In any case, body stressing is the reported mechanism for *all* such claims categorised as diseases and *most* of those categorised as injuries; overall, body stressing is the reported mechanism in 41% of all serious claims (including both injuries and disorders). Consequently, causal models for cumulative onset musculoskeletal *disorders* encompass most of the important work-related hazards for musculoskeletal *injuries* also (ASCC, 2006). Risk factors specific to sprain/strain injuries where the mechanism is falls/slips/trips are considered elsewhere.[10]

As noted above, mental disorders constitute the second largest category of serious claims, following musculoskeletal disorders (Safe Work Australia, 2010c). Importantly, there is a statistical association between these two categories of disorder:

> Published studies suggest that causal pathways are more likely to be from musculoskeletal conditions to mental disorders than the reverse, although the latter can also occur… The clear association between musculoskeletal conditions and mental disorders found in this study emphasises the need for health-care providers to be aware of and provide for a multidisciplinary approach to the management of this comorbidity. (AIHW, 2010, p. 2)

Since psychosocial hazards are the primary work-related cause of mental disorders, the nature and causation of mental disorders is the chapter on that type of hazard, by Way[11].

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[9] “Serious claims are those lodged in the reference year and accepted by the date at which the data are extracted and involve either a death, a permanent incapacity, or a temporary incapacity requiring an absence from work of one working week or more” (Safe Work Australia, 2010b, p. 1).

[10] See *OHS BoK* Gravitational Hazards

[11] See *OHS BoK* Psychosocial Hazards and Occupational Stress

The third category of disease/disorder considered here is cardiovascular. Cardiovascular diseases are not responsible for a large proportion of compensation claims in Australia (where they are termed ódiseases of the circulatory systemô) ï probably because they have multiple causal factors unrelated to work and it is difficult to determine the contribution of work-related hazards in individual cases since they are often asymptomatic until well advanced. However, there is substantial research evidence that a wide range of work-related factors ï both physical and psychosocial ï can contribute to risk of these diseases (Driscoll, 2006; Kim & Kang, 2010; LaMontagna et al., 2006; Landsbergis et al., 2001). According to a 2006 review for the Australian Safety and Compensation Council:

> The evidence is strongest with exposure to four particular chemicals, namely carbon disulphide and, in terms of acute exposure, carbon monoxide, methylene chloride and nitroglycerin. There is also good evidence for the role of environmental tobacco smoke and psychosocial factors, particularly low job control, and considerable evidence for noise and shiftwork. Other exposures, for which the evidence is less strong, include chronic low-level exposure to carbon monoxide, methylene chloride and nitroglycerin, other chemicals, long working hours, electromagnetic fields, temperature extremes, diesel exhaust and other particulates, organic combustion products, manual work or strenuous occupations, sedentary work, and certain specific occupations. (Driscoll, 2006, pp. viï vii)

Other reviews have placed greater emphasis on the causal role of work-related psychosocial hazards (e.g. see LaMontagna et al., 2006, 2007). The importance of such factors was emphasised in a report from Koreaôs Occupational Safety and Health Research Institute (Kim & Kang, 2010), which found that the ñtriggering factorsò in cases of cerebrovascular diseases (n = 211) were job stress (20.9%), overload (32.7%), shift and night work (3.3%), professional driving (2.4%), environmental change (1.4%), others (7.1%) and unknown (32.2%). In cases of coronary heart disease (n = 117), the triggering factors were job stress (22.2%), overload (44.4%), shift and night work (3.5%), professional driving (0.9%), environmental change (0.9%), others (8.5%) and unknown (19.7%).

Where a large array of factors coalesces to produce an outcome, as for the above types of diseases/disorders, the processes involved can be depicted in a model of causation.[12] For diseases and disorders where risk typically arises from a multiplicity of hazards, there are models depicting the aetiology of each particular disease/disorder in terms of how exposures to various hazards combine with other risk factors in determining risk level. To illustrate this, the following section considers models of causation for musculoskeletal disorders.

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[12] See also *OHS BoK* Models of Causation: Safety

3.4.1 An example: Models of causation for musculoskeletal disorders[13]

For health or safety outcomes arising primarily from just one type of hazard, risk can be estimated in terms of the severity of the hazard and the extent of exposure to it. However, for multi-hazard conditions such as musculoskeletal disorders (MSDs), risk depends on the particular combination of hazards present. It has been shown that *interactions* between a number of hazards and related factors can substantially affect MSD risk (Bernard, 1997; Marras, 2008; NRC&IM, 2001), which means that the extent of a particular exposure, if considered independently of other exposures, is not necessarily a good indicator of MSD risk. Importantly, this means that MSD risk cannot be adequately assessed by separately evaluating each potential hazard or risk factor, as is typical for hazard-focused risk assessment. This point is discussed further below, with reference to hazards depicted in Figure 4.

Figures 2 to 4 show evidence-based models of MSD causation, illustrating the diverse array of hazards that can affect MSD risk.

[13] ñMusculoskeletal disorders include a wide range of inflammatory and degenerative conditions affecting the muscles, tendons, ligaments, joints, peripheral nerves, and supporting blood vessels....[They include] over 100 diseases and syndromes, which are usually progressive and are associated with pain...such as órepetitive strain injuriesô, óoccupational overuse syndromeô, óback injuryô, óosteoarthritisô, óbackacheô, ósciaticaô, óslipped discô, ócarpal tunnel syndromeô and others. [They] exert a substantial economic burden in health care and compensation costs, lost salaries and productivity borne not only by the employers and employees, but also by the community. As the conditions become more serious and impinge on the personôs functional capacity, their work performance and productivity are also likely to decrease.ò (ASCC, 2006, pp. 9ï 10)

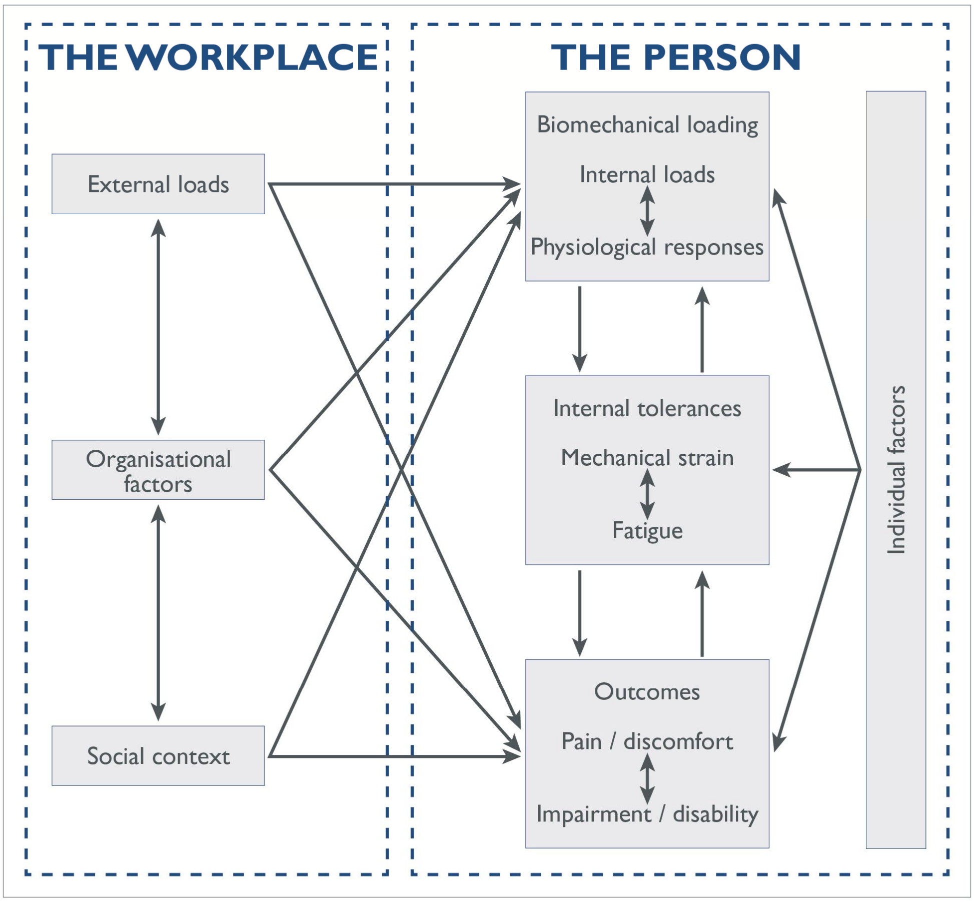

Figure 2: Model of hazards and other risk factors for work-related musculoskeletal disorders (based on NRC&IM, 2001, p. 3)

The model in Figure 2 resulted from a review of research evidence by a multidisciplinary committee of experts on behalf of the USA National Research Council and Institute of Medicine (2001). On the left side of the model within *The Workplace* there are three groups of hazards and risk factors: ‘external loads’ (biomechanical hazards),[14] ‘organisational factors’, and ‘social context’; those in the latter two groups are commonly known as psychosocial hazards.[15] Hazards within all three categories interact (shown by linking arrows) and can affect processes internal to *The Person* (*internal* biomechanical loading,[16] physiological responses) and personal outcomes (discomfort, pain, impairment, disability). Also, fatigue is recognised as a relevant factor.[17] As shown on the right of the diagram, individual factors influence all personal processes and outcomes.

Although stress is not highlighted in Figure 2, it is implicit there within ‘physiological

[14] See *OHS BoK* Biomechanical Hazards
[15] See *OHS BoK* Psychosocial Hazards and Occupational Stress
[16] Different from the *external* biomechanical loading discussed in *OHS BoK* Biomechanical Hazards
[17] See *OHS BoK* Psychosocial Hazards: Fatigue

responsesâ. The well-documented role of stress in MSD causation is much more apparent in Figure 3, which highlights the interacting effects of physical (mainly biomechanical) and psychosocial hazards on MSD risk. A personôs internal óstress response,ô as shown here, occurs when situations are experienced as stressful; it is multidimensional, with physiological and behavioural, as well as cognitive and affective dimensions (Cox, 1978). The cognitive and behavioural aspects of this response can directly affect safety, while the physiological and affective aspects can have profound effects on health including, but not confined to, MSD risk[18] (e.g. Aptel & Cnockaert, 2002; Chandola et al., 2008; Macdonald & Evans, 2006; Warren, 2001).

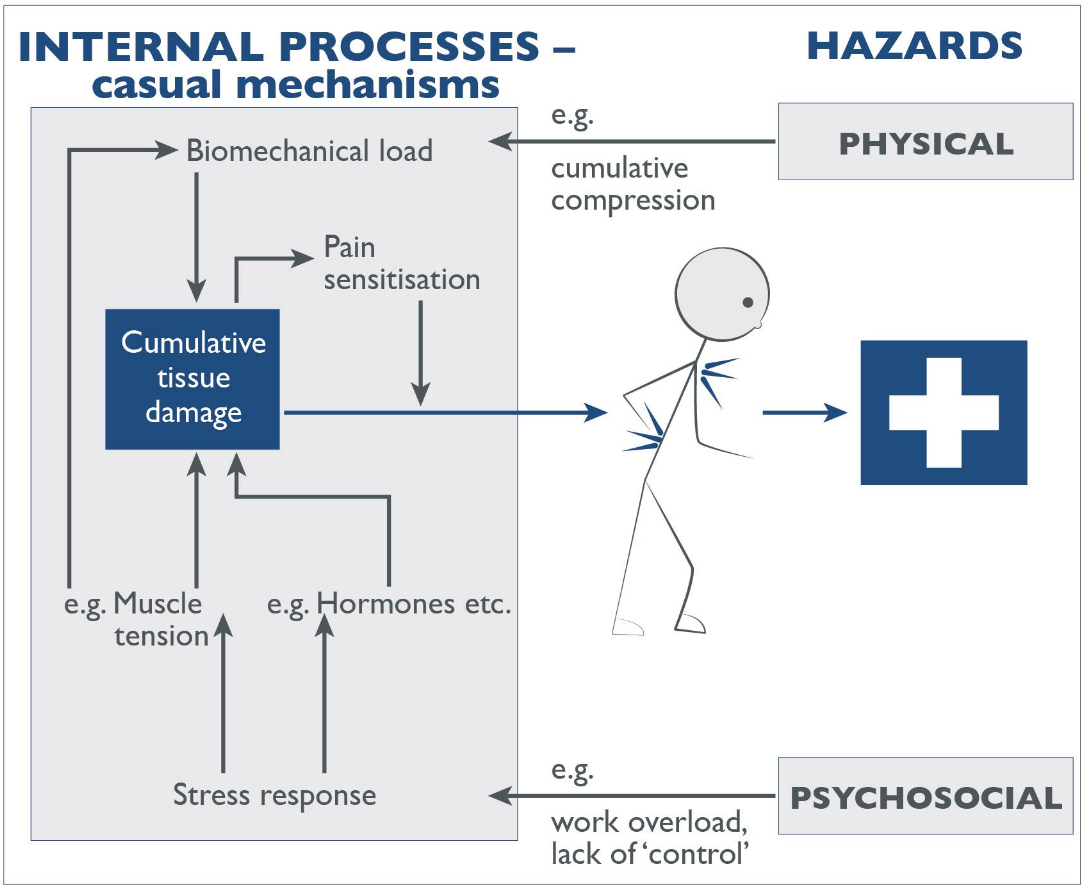

Figure 3: A model highlighting evidence that internal processes producing cumulative tissue damage include the multidimensional 'stress response' as well as internal biomechanical loads and pain sensitisation (Macdonald & Evans, 2006, p. 10)

[18] See *OHS BoK* The Human: Basic Principles of Psychology

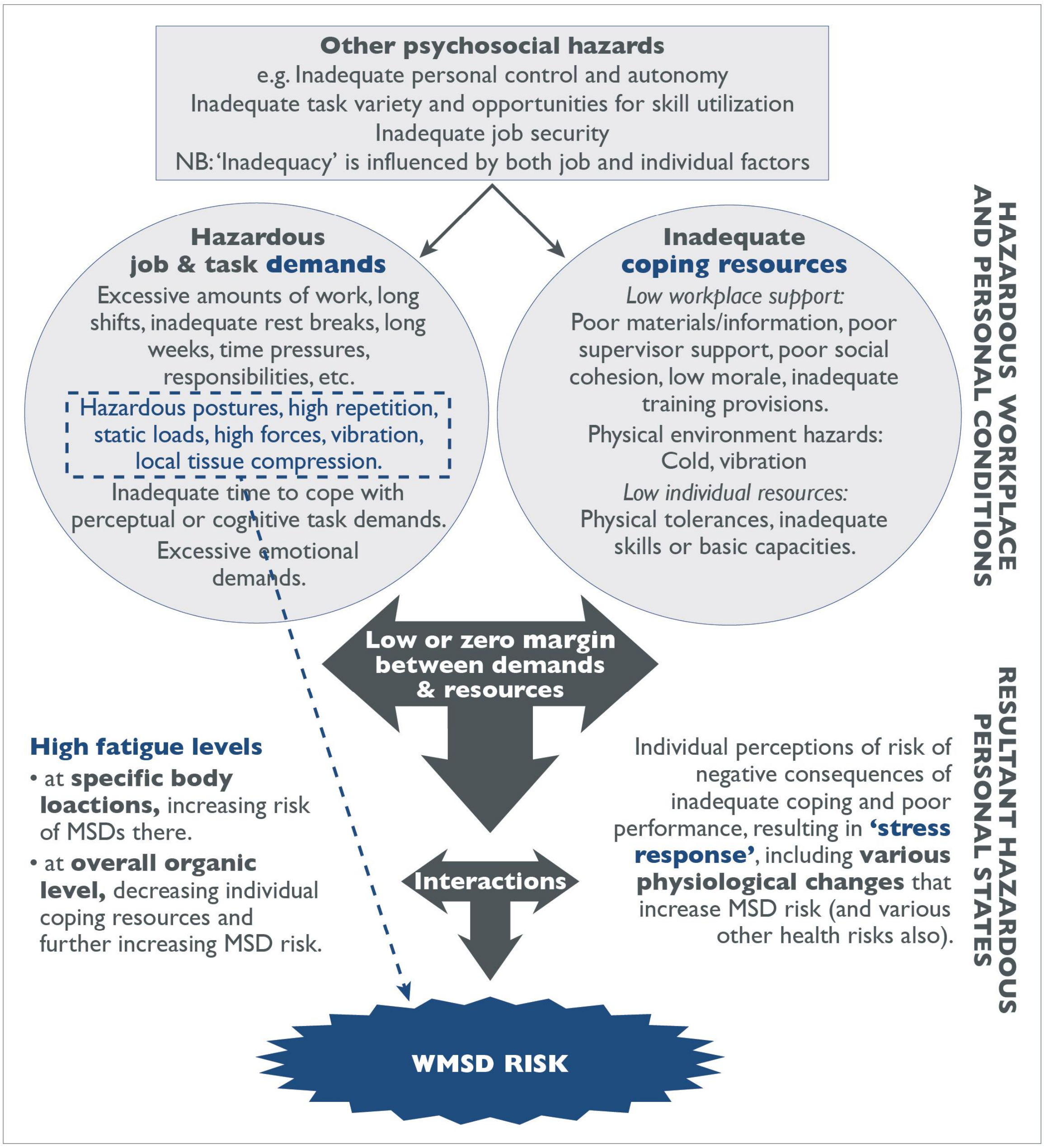

Figure 4: A composite ergonomics model of work-related hazards for musculoskeletal disorders (based on Macdonald & Evans, 2006, p. 24)

The primary purpose of the models in Figures 2 and 3 is to promote better understanding of MSD aetiology, based on current research evidence. The model in Figure 4 is in accord with these, but is more directly applicable to workplace risk management because it provides more detail concerning the wide range of work-related hazards that can combine to affect risk. This model shows that MSD risk is increased if ǿjob and task demandsô are hazardous or excessive in relation to available ócoping resources,ô and that risk is also affected by óother psychosocial hazards.ô *Job and task demands* include the widely recognised hazards of manual task performance, along with two other subsets ï those arising from the cognitive and emotional demands of task performance, and those arising from demands of the overall job. *Coping resources* are determined by workplace factors (support systems and resources; psychosocial and physical environment influences) and by the individualøs own capabilities. Importantly, it is the *combination* of these diverse variables that determines risk, which is why MSD risk cannot be adequately assessed by a process that considers each hazard separately. For example, a particular posture might be rated as low risk if considered alone, but for workers who are chronically fatigued and/or stressed due to long working hours, tight production schedules with few rest breaks, and supervisors perceived as unsupportive, the risk might be considerably higher.

Figure 4 shows various pathways leading from ôHazardous workplace and personal conditionsö to the occurrence of musculoskeletal injuries and disorders. In the case of sudden onset sprains and strains (which are classified as injuries rather than diseases/disorders), there is a direct link from excessive force and/or adverse posture to injury. However, our focus here is on the aetiology of cumulative disorders, and for these, the pathway to injury is via ongoing ôhazardous personal statesö where risk is increased by the kind of internal physiological and biomechanical processes indicated in Figure 2 and detailed in Figure 3.

The above models (Figures 2ï 4) clearly show that managing ômanual handlingö hazards is *not* synonymous with managing MSD risk. In light of this, it is unfortunate that MSDs are often referred to in Australia as ômanual handling injuriesö, since that terminology supports the erroneous assumption that biomechanical hazards are the *only* important cause of musculoskeletal problems. Clearly, a much wider range of hazards and risk factors including some related to work organisation, job design and the workplace environment (psychosocial as well as physical) must be managed. In particular, it is important to include management of fatigue and stress, since internal physiological and biomechanical dimensions of these are linked to MSD risk.

As outlined above, MSD risk management requires a holistic multidimensional approach that is founded on evidence-based models of causation and takes account of the particular *combination* of hazards present in a given situation. Further, there is evidence that:

> é a combination of several kinds of interventions (multidisciplinary approach) including organisational, technical and personal/individual measures is better than single measures...[and that] a participative approach which includes the workers in the process of change has a positive effect on the success of an intervention (EASHW, 2008, pp. 7ï 8).

3.5 Workplace benefits and determinants of positive wellbeing

The focus of conventional OHS practice has been to prevent harm to workers as reflected in the disease/disorder causal models reviewed in section 3.4. However, there is increasing recognition of the importance of achieving *good* health and wellbeing rather than just avoiding disease. This section considers the workplace benefits of good health and wellbeing, including their potential role in decreasing occupational disease risk. It finishes with an outline of key workplace determinants.

Various notions of wellbeing (e.g. happiness and wellness, and more work-specific concepts such as morale and job satisfaction) have been developed by researchers and applied in workplace settings. Concepts vary according to whether they concern fairly stable individual personality dimensions or ‘traits,’ or more transient ‘states.’ In an OHS context, personal states are of primary interest as these are most affected by workplace and job conditions.

Such concepts also vary according to their emphasis on affective versus cognitive dimensions. For example, ‘job satisfaction’ is cognitively oriented because it implies some personal *evaluation* of the job, although it is also influenced by people’s *enjoyment* of their job so it has an affective dimension also. ‘Morale’ signifies a positive affective state oriented towards engagement with and commitment to job performance; it is linked to concepts such as ‘vitality’ and ‘vigour’ (Ryan & Frederick, 1997). Hart and Cooper (2001) identified three dimensions of occupational wellbeing: morale (positive affect), psychological distress (negative affect), and job satisfaction (conceived as predominantly cognitive). Warr (2007a,b) also distinguished three dimensions within wellbeing, which he now refers to as ‘happiness’:

> A principal axis runs from feeling bad to feeling good, and two others (distinguished in terms of degree of activation as well as pleasure) extend from negative feelings of anxiety to experiences of happiness as tranquil contentment, and from states of depression to happiness as energised pleasure (Warr, 2007b, p. 726).

Good health and wellbeing clearly have intrinsic value, particularly to the individuals concerned. From an employer perspective, high vitality and morale also are beneficial because of their links to good work performance. Importantly in this OHS context, high levels of job satisfaction have been linked to lower duration of sickness absence (Marmot et al., 1995). Wegge, Schmidt, Parkes and van Dick (2007) concluded that the frequency of people ‘taking a sickie’ and the time lost due to these absences are affected by an interaction between job satisfaction and job involvement,[19] such that high job satisfaction greatly decreases the negative impact on sickness absence of low job involvement. In other words, low levels of psychological wellbeing are manifest in various ‘illness behaviours’,[20] including more frequent and longer sickness absence. Such absences could therefore serve as one

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[19] ‘Job involvement’ refers to the extent to which an individual identifies with the job.

[20] According to Mechanic (1986, p. 1): “Illness behaviour...involves the manner in which individuals monitor their bodies, define and interpret their symptoms, take remedial action, and utilize sources of help...It also is concerned with how people monitor and respond to symptoms and symptom change over the course of an illness and how this affects behaviour, remedial actions taken, and response to treatment. The different perceptions, evaluations and responses to illness have, at times, a dramatic impact on the extent to which symptoms interfere with usual life routines, chronicity, attainment of appropriate care and cooperation of the patient in treatment. Variables affecting illness behaviour usually come into play well before any medical scrutiny and treatment.”

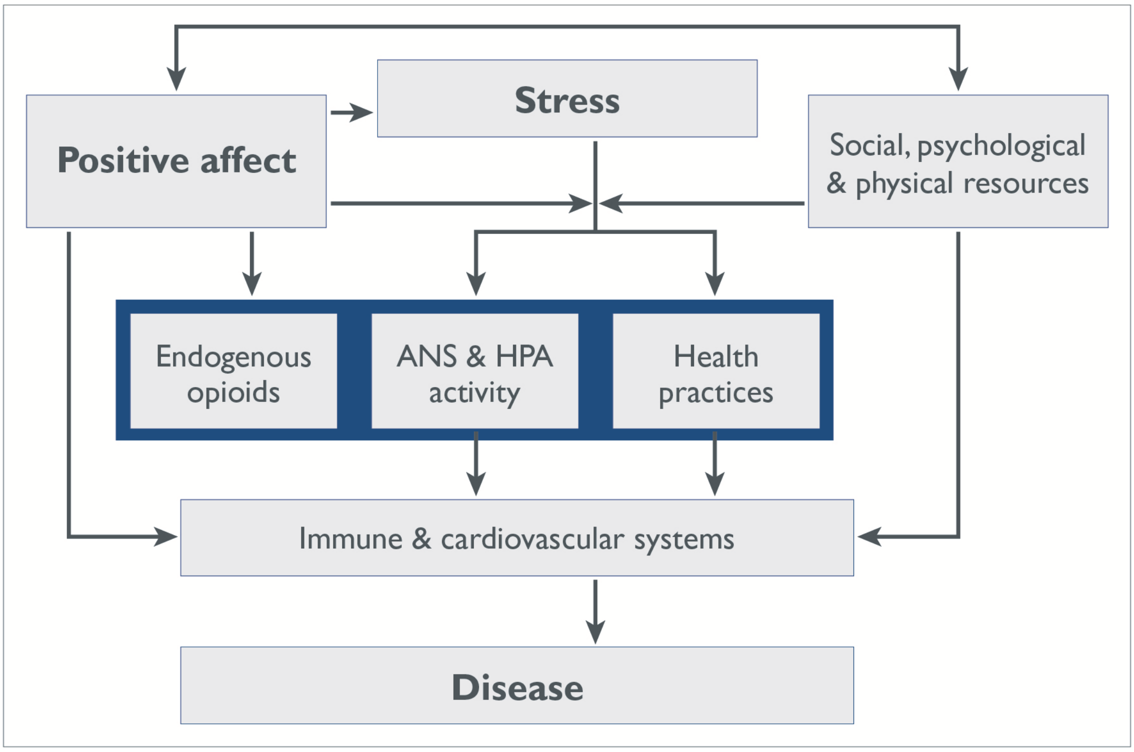
indicator of the success or otherwise of OHS risk management.

Looking beyond absenteeism to sickness itself, it is well established that *negative* states such as stress are linked to poor health.[21] Is there also evidence that *positive* states are beneficial to health? Based on a large meta-analysis of research reporting associations between job satisfaction and various measures of health, Faragher, Cass and Cooper (2005) found that high job satisfaction was strongly associated with good mental health (correlations with burnout, self-esteem, depression, and anxiety ranged from 0.478 to 0.420). Correlations between job satisfaction and *physical* health were smaller, but still highly significant statistically. The authors concluded that:

> The wellbeing of employeesð and in particular their mental healthð may be compromised if their work is causing them to experience high levels of dissatisfaction. Thus, the extent to which individuals feel satisfied with their work becomes an important (mental) health issue. (Faragher, Cass & Cooper, 2005, p. 111)

Pressman and Cohen (2005) analysed evidence concerning the role of positive affect in the aetiology of physical diseases and disorders. Their review included research on the functioning of the cardiovascular, endocrine and immune systems ï systems that appear to mediate the effects of positive affect on health as reported above. They concluded that positive affect can reduce disease risk via multiple pathways, shown in Figure 5.

[21] See *OHS BoK* Psychosocial Hazards and Occupational Stress



ANS = autonomic nervous system HPA = hypothalamicï pituitaryï adrenal axis

Figure 5: A 'stress buffering' model of behavioural and biological mechanisms by which positive emotions can reduce disease risk (Pressman & Cohen, 2005, p. 959)

Figure 6 presents a simple model of health, its determinants and its OHS impacts. Various types of work and non-work environmental factors are depicted as influencing health, along with individual factors, which reflects the more detailed causal models presented above. Health itself is enclosed within the blue rectangle; it can be seen that this encompasses both positive and negative personal states, consistent with the widely accepted WHO definition of health (WHO, 1948). However, these personal states are *also* among the determinants of diseases and disorders, which are also part of ôhealthö; that is, some aspects of ôhealthö (these personal states) are shown to be determinants of some other aspects of health (diseases/disorders).

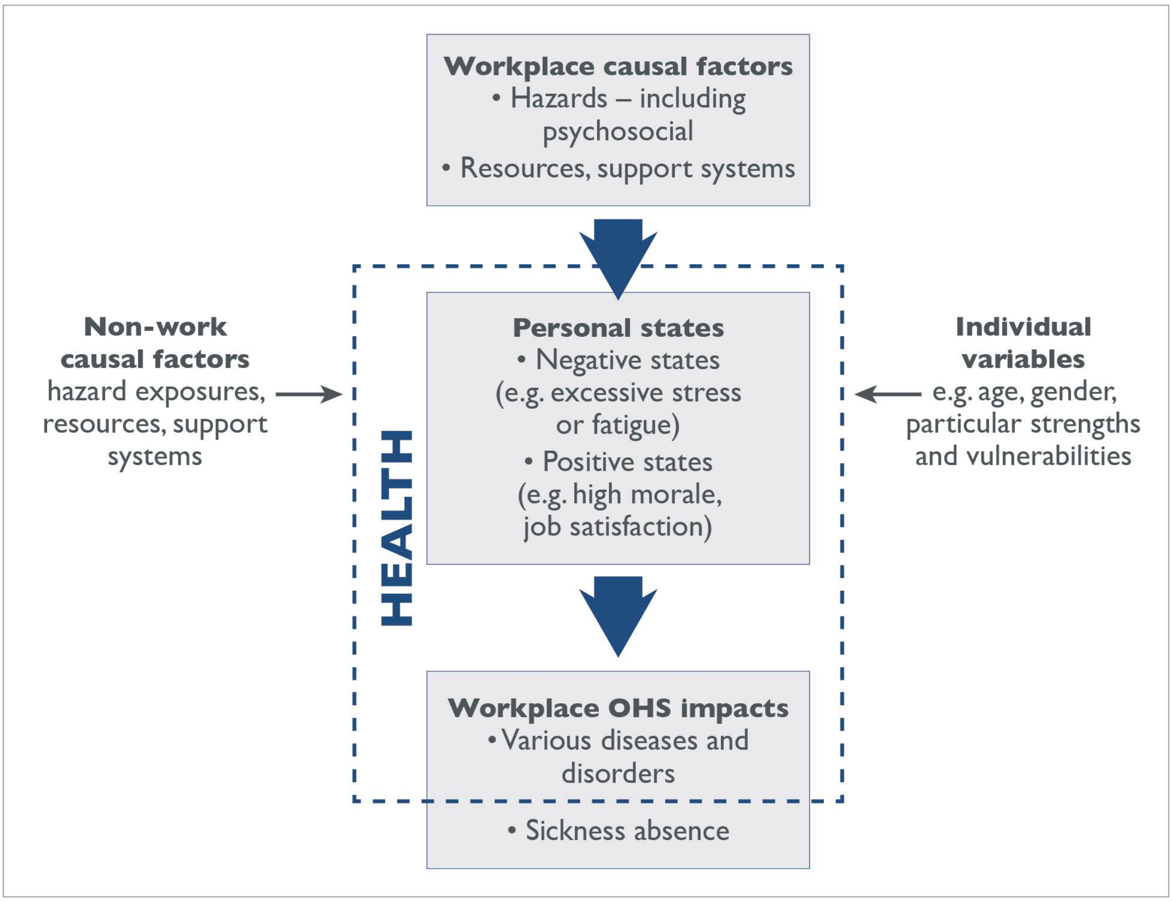


Figure 6: A model of health, its various work-related and other determinants, and OHS impacts.

Figure 6 also identifies some determinants of sickness absence. Such absences may be due to particular diseases and disorders, some of which are work-related, and/or they may be a manifestation of illness behaviours linked to states such as low morale and high stress, as discussed above.[22] Distinguishing absence from work due to a specific disease/disorder from absence representing illness behaviour is particularly difficult in the case of both musculoskeletal and mental disorders (Australiaôs two largest ôoccupational diseaseô compensation claims categories). In both these types of disorder, the influence of personal states as depicted in Figure 6 can be centrally important; consequently, an understanding of how best to manage these personal states is important for OHS professionals.

What then are the main work-related determinants of these personal states, which can influence health both positively and negatively? Causes of stress and fatigue are considered elsewhere.[23] What about the determinants of positive states such as morale and job

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[22] Ellis has highlighted the potential importance of illness behaviours, pointing out: ñAn underlying disease can be detected in only about half of presentations to general practitionersò (*OHS BoK* Global Concept: Health, section 2.3).

[23] *OHS BoK* Psychosocial Hazards and Occupational Stress; *OHS BoK* Psychosocial Hazards: Fatigue.

satisfaction? Warr (2007b) concluded that the main workplace determinants of wellbeing, or happiness, are:

- Opportunity for personal control ï discretion, decision latitude, participation, etc.
- Opportunity for skill use and acquisition ï a settingõs potential for applying and developing expertise and knowledge
- Externally generated goals ï ranging across job demands, underload and overload, task identity, role conflict, required emotional labour and work-home conflict
- Variety ï in job content and location
- Environmental clarity ï including role clarity, task feedback and low future ambiguity
- Contact with others ï both quantity and quality
- Availability of money ï the opportunity to receive income at a certain level
- Physical security ï including working conditions, degree of hazard, etc.
- Valued social position ï in terms of the significance of a task or role
- Supportive supervision ï the extent to which oneõs concerns are taken into consideration
- Career outlook ï encompassing job security and the opportunity to gain promotion or shift to other roles
- Equity ï both within the organisation and in that organisation's relations with society (Warr, 2007b, p. 727).

Comparison of the above factors with those identified as psychosocial hazards or stressors[24] shows a high degree of overlap, but the *importance* of each factor as a determinant of wellbeing is likely to vary depending on the particular context and the state or aspect of wellbeing that is of interest.

4 Implications for OHS practice

4.1 Management of risk for diseases/disorders with multiple, diverse causes

The conventional approach to OHS risk management has been to focus on hazard management ï identifying hazards, assessing risk from each identified hazard, and taking any necessary steps to control risk from each hazard separately. For health-related risks, this approach works well for hazard-specific diseases and disorders of the kind discussed in section 3.3.

However, a more holistic approach to risk management is required to achieve effective control of risk for diseases and disorders for which risk is determined by multiple, diverse hazards, such as musculoskeletal disorders and mental disorders. To manage such health risks effectively, the management process needs to be guided by an appropriate model of

[24] See *OHS BoK* Psychosocial Hazards and Occupational Stress.

causation. Such models identify the multiple causal pathways between the relevant set of hazards and the particular type of health outcome, so that risk management can be based on assessment of risk from the *combined* effects of the hazards identified as most relevant in the particular situation, taking account of the hazardsô additive and possibly interacting effects. Worker participation in this holistic approach to risk management is likely to be beneficial, if not essential.

4.2 Management of risk from psychosocial hazards

Occupational health is of course influenced by the presence or absence of diseases and disorders. Health is also directly influenced by psychological states such as stress, óvitalityô and morale (shown in Figure 6), which in turn are influenced by a wide range of work-related psychosocial hazards. It is therefore essential that OHS risk management deals effectively with risk from this kind of hazard. The importance of this is particularly clear in countries such as Australia, where the most expensive compensation claims are for diseases/disorders where risk is strongly influenced by psychosocial hazards. A participative, holistic approach is required to manage risk from psychosocial hazards and to promote positive aspects of health and wellbeing.[25]

4.3 Workplace health promotion

Ellis (2001) proposed a model of OHS risk management that encompasses health promotion as well as harm prevention. Based on current knowledge of the occupational health benefits of *positive* psychological states and the increasing importance of a sustainably healthy workforce in the context of population ageing, there are strong argument for incorporating health promotion strategies within OHS risk management programs. This viewpoint is evident in the WHO Healthy Workplace Model (Figure 1).

The concept of health promotion originated in the public health domain, and workplace health promotion strategies are sometimes simply public health promotion strategies implemented within a workplace setting (e.g. WHO, 2011). However, boundaries between occupational and public health are becoming increasingly blurred due to changes in the way we work,[26] and there is:

> ...a growing appreciation that there are multiple determinants of workersô health...[and] workforce health promotion initiatives have moved toward a more comprehensive approach, which acknowledges the combined influence of personal, environmental, organizational, community and societal factors on employee well-being (WHO, 2011).

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[25] *OHS BoK* Psychosocial Hazards and Occupational Stress.

[26] See *OHS BoK* Global Concept: Work

4.4 Professional roles

The body of scientific evidence concerning the nature and determinants of occupational health spans a wide variety of disciplines, as outlined in section 2. This diversity is reflected in the fragmented nature of current OHS professional practice, where specialist groups include occupational hygienists, occupational ergonomists, occupational physicians, occupational health nurses, occupational health psychologists, occupational rehabilitation professionals, and so on. Consequently, the task of defining a core body of occupational health knowledge and associated professional competencies for *generalist* OHS professionals presents a considerable challenge.

In light of the major differences in causation between different types of diseases/disorders, no OHS professional can be expected to have a high level of expertise in managing *all* types of risk to occupational health. Indeed, it seems likely that most generalist OHS professionals will have some degree of specialist expertise also, probably reflecting existing areas of specialist OHS professional practice. In this situation there are likely to be ongoing ethical dilemmas and debate concerning what constitutes an adequate level of competence or expertise for a particular work role.

Arguably the most important element of professional competency might be a good understanding of the *limitations* of oneȇs own knowledge and competencies. This will only be achievable if generalist OHS professionals are familiar with a comprehensive range of causal models of occupational health determinants relevant to their field of practice. On this basis they will be able to analyse and understand a particular problem or situation sufficiently to recognise if/when they need to enlist specialist support, consistent with the model of professional practice.[27]

5 Summary

This chapter has described models of occupational health determinants and their roles in supporting effective OHS risk management. An understanding of such models was shown to be particularly important for the effective management of diseases/disorders where risk is affected by multiple hazards, some of which can interact. Such health conditions include musculoskeletal disorders, mental disorders, and cardiovascular disease. The importance of positive wellbeing for occupational health was also described.

Key authors and thinkers

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[27] See *OHS BoK* Model of OHS Practice

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References

Abrams, H. K. (2001). A short history of occupational health. *Journal of Public Health Policy*, *22*(1), 34ï 80.

AIHW (Australian Institute of Health and Welfare). (2010). When musculoskeletal conditions and mental disorders occur together. *AIHW Bulletin*, *80* (Cat. no. AUS 129). Canberra, ACT: AIHW. Retrieved May 2011 from http://www.aihw.gov.au/publication-detail/?id=6442468392

Aptel, M., & Cnockaert, J. C. (2002). Stress and work-related musculoskeletal disorders of the upper extremities. *Trade Union Technical Bureau (TUTB) Newsletter*, *19–20*, 50ï 56. Retrieved May 2011 from http://hesa.etui-rehs.org/uk/newsletter/files/Newsletter-20.pdf

ASCC (Australian Safety and Compensation Council). (2006). *Work-related Musculoskeletal Disease in Australia.* Canberra, ACT: Commonwealth of Australia. Retrieved May 2011 from http://www.safeworkaustralia.gov.au/AboutSafeWorkAustralia/WhatWeDo/Publications/Documents/119/WorkRelatedMusculoskeltalDisorders_2006Australia_2006_ArchivePDF.pdf

Benke, G., & Goddard, D. (2006). Estimation of occupational cancer in Australia still needs local exposure data. *Australian & New Zealand Journal of Public Health*, *30*(5), 485ï 486.

Bernard, B. P. (Ed.). (1997). *Musculoskeletal disorders (MSDs) and workplace factors*. Cincinnati, OH: National Institute for Occupational Safety and Health.

Burton, J. (2010). *WHO Healthy Workplace Framework and Model: Background and Supporting Literature and Practice*. Geneva: WHO. Retrieved May 2011 from http://www.who.int/occupational_health/healthy_workplace_framework.pdf

Chandola, T., Britton, A., Brunner, E., Hemingway, H., Malik, M., Kumari, M., Badrick, E., Kivimaki, M., & Marmot, M. (2008). Work stress and coronary heart disease: What are the mechanisms? *European Heart Journal*, *29*(5), 640ï 648.

Cox, T. (1978). *Stress*. London: Macmillan.

Driscoll, T. (2006). *Work-related Cardio-vascular Disease in Australia* Canberra, ACT: Australian Safety and Compensation Council. Retrieved May 2011 from http://www.safeworkaustralia.gov.au/AboutSafeWorkAustralia/WhatWeDo/Publications/Documents/116/WorkRelatedCardiovascularDisease_2006Australia_2006_ArchivePDF.pdf

EASHW (European Agency for Safety and Health at Work). (2008). *Work-related*

Musculoskeletal Disorders: Prevention Report. Luxembourg: Office for Official Publications of the European Communities, EASHW. Retrieved May 2011 from http://osha.europa.eu/en/publications/reports/en_TE8107132ENC.pdf

Ellis, N. (2001). *Work and health: Management in Australia and New Zealand*. Melbourne, VIC: Oxford University Press.

Faragher, E. B., Cass, M., & Cooper, C. L. (2005). The relationship between job satisfaction and health: A meta-analysis. *Occupational & Environmental Medicine, 62*(2), 105ï 112.

Gochfeld, M. (2005). Chronologic history of occupational medicine. *Journal of Occupational & Environmental Medicine, 47*(2), 96ï 114.

Hart, P. M., & Cooper, C. L. (2001). Occupational stress: Toward a more integrated framework. In N. Anderson, D. S. Ones, H. K. Sinangil & C. Viswesvaran (Eds.), *Handbook of industrial, work and organizational psychology, Volume 2, organizational psychology* (2nd ed.) (pp. 93ï 114). London, UK: Sage.

Hill, A. B. (1965). The environment and disease: Association or causation? *Proceedings of the Royal Society of Medicine*, *58*, 295ï 300.

Kim, D-S., & Kang, S-K. (2010). Work-related cerebro-cardiovascular diseases in Korea. *Journal of Korean Medical Science*, *25*(Suppl.), S105ï S111.

LaMontagne, A. D., Keegel, T., Louie, A. M., Ostry, A., & Landsbergis, P. A. (2007). A systematic review of the job-stress intervention evaluation literature, 1990ï 2005. *International Journal of Occupational & Environmental Health, 13*(3), 268ï 280.

LaMontagne, A. D., Louie, A., Keegel, T., Ostry, A., & Shaw, A. (2006). *Workplace Stress in Victoria: Developing a Systems Approach* (Report to the Victorian Health Promotion Foundation). Carlton South, VIC: Victorian Health Promotion Foundation. Retrieved May 2011 from http://www.vichealth.vic.gov.au/workplacestress

Landsbergis, P. A., Schnall, P. L., Belkic, K. L., Baker, D., Schwartz, J., & Pickering, T. G. (2001). Work stressors and cardiovascular disease. *Work*, *17*(3), 191ï 208.

Lane, R. E., & Lee, W. R. (1991). The development of training in occupational medicine in the United Kingdom. *Environmental & Occupational Health, 19*(2), 247ï 255.

Macdonald, W., & Evans, O. (2006). *Research on the Prevention of Work-related Musculoskeletal Disorders. Stage 1 – Literature Review.* Canberra, ACT: Australian Safety & Compensation Council,. Retrieved May 2011 from http://www.safeworkaustralia.gov.au/ABOUTSAFEWORKAUSTRALIA/WHATWEDO/PUBLICATIONS/Pages/RR200606ResearchOnPreventionOfWRMusculoskeletalDisorders.aspx

Marmot, M., Feeney, A., Shipley, M., North, F., & Syme, S. L. (1995). Sickness absence as a measure of health status and functioning: From the UK Whitehall II study. *Journal of Epidemiology & Community Health*, *49*(2), 124ï 130.

Marmot, M., Siegrist J., & Theorell, T. (2006). Health and the psychosocial environment at work. In M. Marmot & R. G. Wilkinson (Eds.), *Social determinants of health* (2nd ed.). Oxford: Oxford University Press.

Marras, W. S. (2008). *The working back: A systems view.* Hoboken, NJ: John Wiley & Sons.

Mechanic, D. (1986). The concept of illness behaviour: Culture, situation, and personal predisposition. *Psychological Medicine*, *16*(1), 1ï 7.

NRC&IM (National Research Council and Institute of Medicine). (2001). *Musculoskeletal disorders and the workplace: Low back and upper extremities* (Methodological issues and approaches, pp. 65ï 81). Washington, DC: National Academy Press. Retrieved May 2011 from http://www.nap.edu/openbook.php?record_id=10032&page=R2

Pressman, S. D., & Cohen, S. (2005). Does positive affect influence health? *Psychological Bulletin, 131*(6), 925ï 971.

Ramazzini, B. (2001). De morbis artificum diatriba [Diseases of workers]. *American Journal of Public Health, 91*(9), 1380ï 1382.

Ryan, R. M., & Frederick, C. M. (1997). On energy, personality, and health: Subjective vitality as a dynamic reflection of well-being. *Journal of Personality, 65*(3), 529ï 565.

Safe Work Australia. (2010a). *National OHS Strategy 2001ï 2012*. Canberra, ACT: Commonwealth of Australia. Retrieved May 2011 from http://www.safeworkaustralia.gov.au/AboutSafeWorkAustralia/WhatWeDo/Publications/Documents/230/NationalOHSStrategy_2002-2012.pdf

Safe Work Australia. (2010b). *Compendium of Workers' Compensation Statistics Australia 2007–08.* Barton, ACT: Safe Work Australia.

Safe Work Australia. (2010c). *Occupational Disease Indicators 2010*. Barton, ACT: Commonwealth of Australia. Retrieved May 2011 from http://www.safeworkaustralia.gov.au/ABOUTSAFEWORKAUSTRALIA/WHATWEDO/PUBLICATIONS/Pages/RP201005OccupationalDiseaseIndicators2010.aspx

Trist, E. (1981). Occasional Paper 2: The evolution of socio-technical systems: A conceptual framework and an action research project Ontario Ontario Ministry of Labour

van Dieen, J. H. (2007). Injury models in observational and experimental research. (Keynote presentation) In *Proceedings of the Sixth International Scientific Conference on Prevention of Work-Related Musculoskeletal Disorders: PREMUS 2007*. Boston, USA.

Visser, B., & van Dieen, J. H. (2006). Pathophysiology of upper extremity muscle disorders. *Journal of Electromyography & Kinesiology*, *16*(1), 1ï 16.

Warr, P. (2007a). *Work, happiness, and unhappiness*. Mahwah, NJ: Erlbaum.

Warr, P. (2007b). Searching for happiness at work. *Psychologist*, *20*(12), 726ï 729.

Warren, N. (2001). Work stress and musculoskeletal disorder etiology: The relative roles of psychosocial and physical risk factors. *Work*, *17*(3), 221ï 234.

Wegge, J., Schmidt, K-H., Parkes, C., & van Dick, R. (2007). óTaking a sickieô: Job satisfaction and job involvement as interactive predictors of absenteeism in a public organization. *Journal of Occupational & Organizational Psychology, 80*(1), 77ï89.

Wilson, J.R. (2000). Fundamentals of ergonomics in theory and practice. *Applied Ergonomics,* 31, 557-567.

WHO (World Health Organization). (1948). *Constitution of the World Health Organization*. Retrieved March 10, 2011, from http://www.who.int/governance/eb/constitution/en/index.html

WHO (World Health Organization). (2011). Workplace health promotion. Retrieved May 2011 from http://www.who.int/occupational_health/topics/workplace/en/