Foundation Science

Core Body of Knowledge for the Generalist OHS Professional

Safety Institute of Australia Ltd

Australian OHS Education Accreditation Board

Bibliography.
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Registrar, Australian OHS Education Accreditation Board
Safety Institute of Australia Ltd, PO Box 2078, Gladstone Park, Victoria, Australia, 3043
registrar@ohseducationaccreditation.org.au

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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

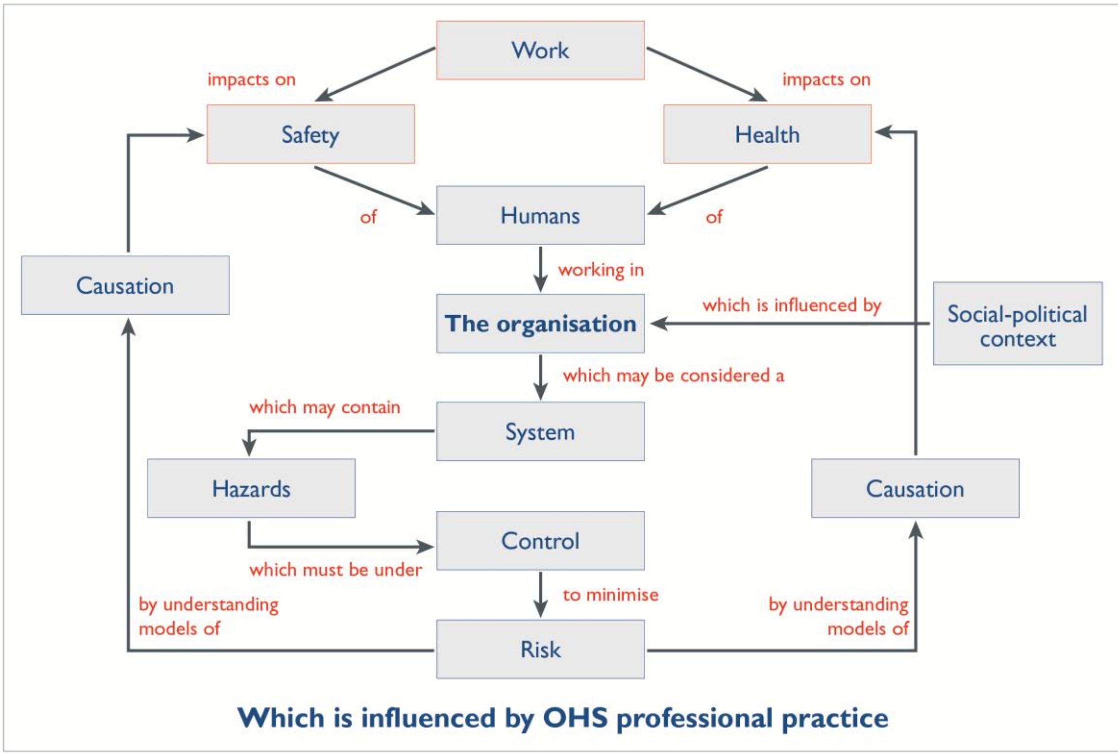
The process of developing and structuring the main content of this document was managed by a Technical Panel with representation from Victorian universities that teach OHS and from the Safety Institute of Australia, which is the main professional body for generalist OHS professionals in Australia. The 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.

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Pam Pryor **BSc, BEd, GDipOHM, FSIA**

Secretary, SIA OHS Education Chapter

Sessional Lecturer, Senior Research Fellow and PhD candidate, University of Ballarat

Email: pampryor@ballarat.edu.au

With qualifications in science and education, Pam was a secondary school science teacher before a career change saw her complete OHS qualifications and commence a more-than-20-year career as an OHS professional working in both internal and external OHS consultant roles. Pam was the SIA representative on the Technical Panel for the OHS Body of Knowledge project and chair of the Technical Panel.

Professor Mike Capra **BSc, MSc, PhD, FSIA**

School of Biomedical Sciences, University of Queensland

Vice President, SIA OHS Education Chapter

Email: m.capra@uq.edu.au

Mike has held teaching and research positions at eight universities in Australia, Fiji, New Zealand and the United Kingdom. He has taught in areas of biology, physiology, toxicology, research methods, and occupational and environmental health. Mike has been involved in projects in many countries, including Mozambique, Vietnam, Singapore and Malaysia.

Peer reviewers

Dr David Goddard BMedSc, MBBS, DipOH FAFOEM, MFOM

Senior Lecturer, Monash Centre for Occupational and Environmental Health, Monash University

Associate Professor Warwick Pearse BSc(Hons), MSc, PhD, DipEnvStud, DipEd, CPMSIA

School of Public Health, Queensland University of Technology

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Abstract

Scientific knowledge that could be used to prevent work-related fatality, injury, disease and ill health is often well known long before it is seriously applied. The time is past when prevention of work-related injury and ill health can be considered a matter of 'common sense.' There is a science base to understanding how hazards behave, how they cause harm and how the body reacts. This understanding is vital in designing effective control measures. Generalist Occupational Health and Safety (OHS) professionals must embrace this knowledge as part of their professional practice. The breadth and depth of the scientific knowledge required by individual OHS professionals will depend on the industry and hazards where they work and the nature of the advice they provide. How the OHS professional gains this knowledge may vary from school or vocational study to university education or specifically designed bridging programs. This chapter provides science-topic 'maps' to assist educators and OHS professionals in identifying the basic science required for professional practice, and also identifies fundamental numeracy requirements.

Keywords

OHS, occupational health and safety, health, science, physical, chemical, biological, health science

Contents

1 Introduction

Generalist Occupational Health and Safety (OHS) professionals develop strategies and actions to prevent, minimise and mitigate the effects that a broad range of hazards and workplace conditions have on humans. The defining characteristic of professional practice is that the generalist OHS professional understands how these hazards behave, how they cause injury and ill health, and how workplace conditions may interact with hazards and humans to potentially cause injury, disease, illness or even death. To achieve this understanding, the generalist OHS professional must have a broad multidisciplinary knowledge base; a grasp of basic physical/chemical and biological/health sciences together with the principles and key concepts of psychology[1]. While perhaps not considered 'science,' basic numeracy is also a key requirement for the effective OHS professional.

When the scientific basis of OHS is ignored or poorly understood, OHS practice defaults to a superficial 'common sense' or 'flavour of the month/year' approach. Such a tendency limits recognition of the need for specialist advice to identify and manage OHS, and weakens the effectiveness of hazard management strategies. Our society acknowledges the need to consult medical specialists for advice and treatment, but lacks similar recognition of the underpinning science in the identification and management of OHS problems (Viner, 1991, p. 1).

While some OHS professional education programs require high school or first year university-level science and some generalist OHS professionals consider such education a pre-requisite for professional practice there is no common agreement. This chapter takes a minimalist approach by reviewing the foundation physical, chemical, biological, and health science and basic numeracy skills required by the effective OHS professional together with how that knowledge might be obtained. Many practicing OHS professionals will have greater depth to their scientific knowledge than outlined in this chapter.

2 Historical perspective

The effects of work on human health have long been recognised. The Italian physician Bernardino Ramazzini, who published *Diseases of Workers* in 1700, observed: "Many an artisan has looked at his craft as a means to support life and raise a family, but all he has got from it is some deadly disease…" (Crowl, 2009). Historically, the application of science to workplace injury and ill health has tended to lag behind the acquisition of relevant scientific knowledge. For example, although the carcinogenic nature of asbestos was well known by the 1960s, it was 1984 before asbestos mining ceased in Australia and 2003 before a total ban on the use of asbestos products was implemented (Australian Council of Trade Unions, 2003). The toxicity of various chemicals, such as lead[2] and

[1] See *OHS BoK* The Human: Basic Principles of Psychology.
[2] Lead poisoning has been implicated in the downfall of the Roman empire (Grout, 2011).

polychlorinated biphenyl (PCB)[3], were known for decades before adequate control measures were implemented. Despite the identification of tuberculosis bacillus and its infective link in 1882, tuberculosis in Welsh slate miners was still considered a social disease in the 1920s (Viner, 1991, pp. 3,4).

While policy making is usually the domain of government, science-aware OHS professionals should be at the forefront in driving change to ensure that workplace OHS practice is both informed by science and responsive to scientific knowledge.

3 The approach taken in this chapter

As the Body of Knowledge is not a textbook and there are many good references on basic science available, the minimalist approach taken in this chapter is, firstly, to map the key concepts in physical science and biological and health science relevant to OHS practice and, secondly, to identify the fundamental numeracy skills required by generalist OHS professionals. The division between the sciences facilitates ease of presentation and follows common divisions in learning and available texts.

The concepts listed in the science-topic maps should be familiar to anyone who has studied senior-school science, and the linkages to OHS practice related to physical hazards and the human body's response to the hazards are clear. While some understanding of each concept is required by all OHS professionals, the breadth and depth of knowledge necessary for individual OHS professionals will depend on the hazards they deal with, the industry in which they work and the nature of advice they provide. Indeed, many practicing OHS professionals will have greater depth to their scientific knowledge than that outlined in this chapter. For example, an OHS professional with a degree in science (with some chemistry) will have an in-depth understanding of particles, atoms and molecules, atomic structure; chemical reactions; chemical energy; endothermic and exothermic reactions, etc., which may be essential knowledge for working in the chemical industry. Alternatively, all generalist OHS professionals, irrespective of background, should have a basic understanding of the science-map topics and their links. How the OHS professional arrives at this knowledge may vary from high school, vocational or university-level study to bridging programs or, in some cases, informal/self-directed study.

4. Science that underpins OHS practice

Although addressed separately below, there is a strong link between physical science concepts, particularly those relating to chemical energy, and biological/health science concepts. Knowledge of these enables understanding of the potential effect of hazards on the physiology of the human body and consequent adverse health outcomes. As there is a

[3] Refer ("Chemical Industry Archives: The inside story - Monsanto knew about PCB toxicity for decades ", 2009)

close link between physiological response to conditions and human psychology, an understanding of biological/health concepts will also affect understanding of the basic principles of psychology.

4.1 Physical science

The first topic map (Figure 1) presents the physical/chemical science concepts that underpin OHS practice. It presents links to aid understanding of physical hazards and how hazards affect the human body and its physiological response to harm. This topic map highlights various forms of energy and provides a basis for understanding physical hazards as sources of potentially damaging energy, which is the key principle of the energy-damage concept first formulated by Gibson and further developed by Haddon in the 1960s (Guarnieri, 1992)[4].

4.2 Biological science

The second topic map (Figure 2) presents the biological/health science concepts that underpin OHS practice. It illustrates the link between atoms and molecules that are the basic building blocks for the complex sub-cellular and cellular components that give rise to tissues, organs and systems that integrate to form a functioning human.

Figure 3 complements Figure 2 by identifying the relationship between the external environment, be it the work environment or the non-work environment, and the underlying biological functions at various organisational levels within the human body.

[4] Refer chapter: Hazard as a concept

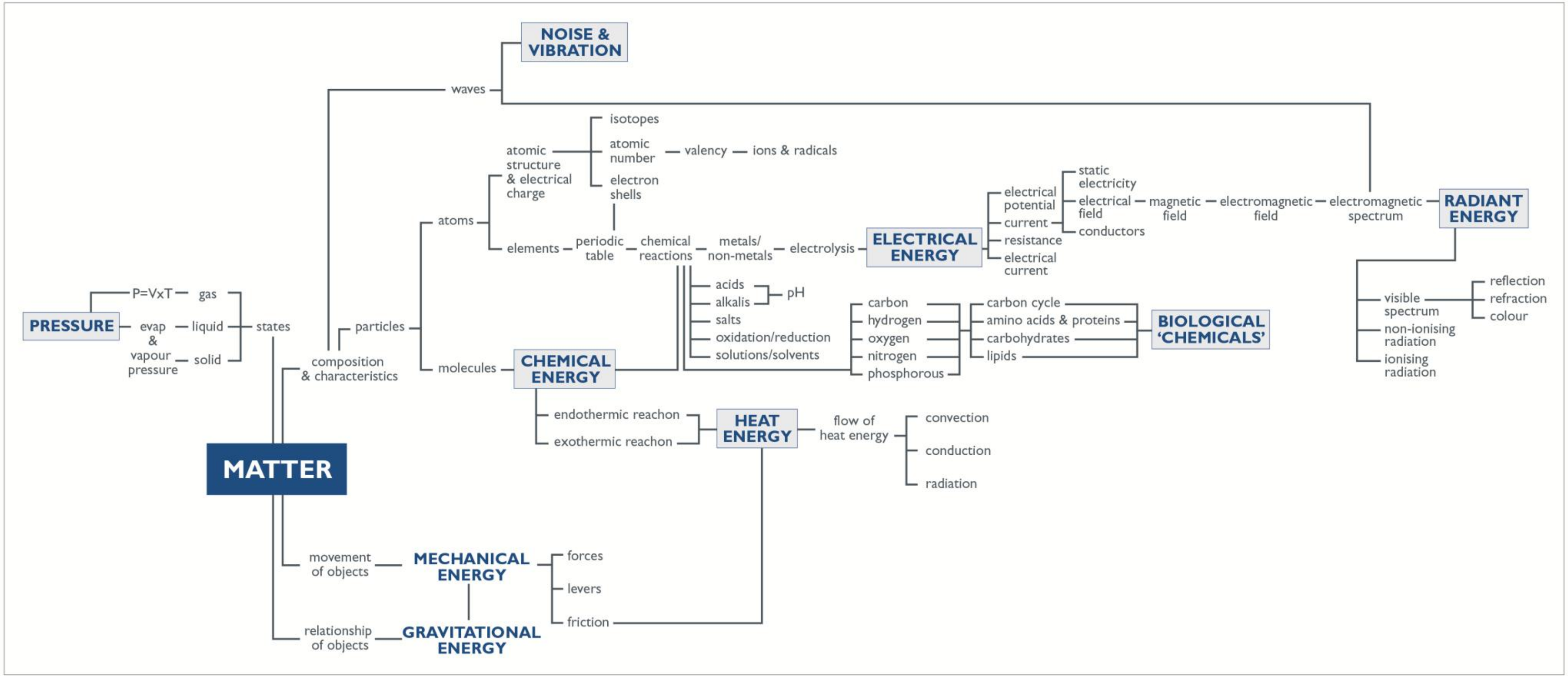

Figure 1: Topic map: Physical science concepts underpinning OHS practice

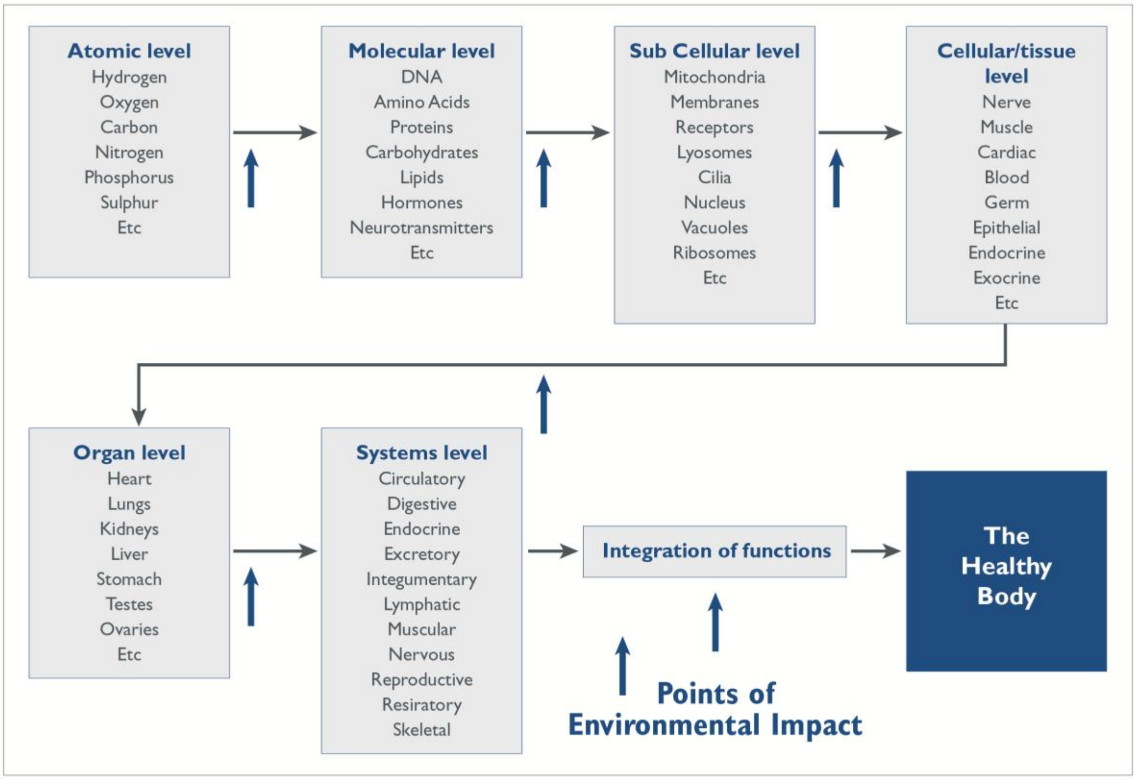

Figure 2: Biological/health science terms and concepts underpinning OHS practice

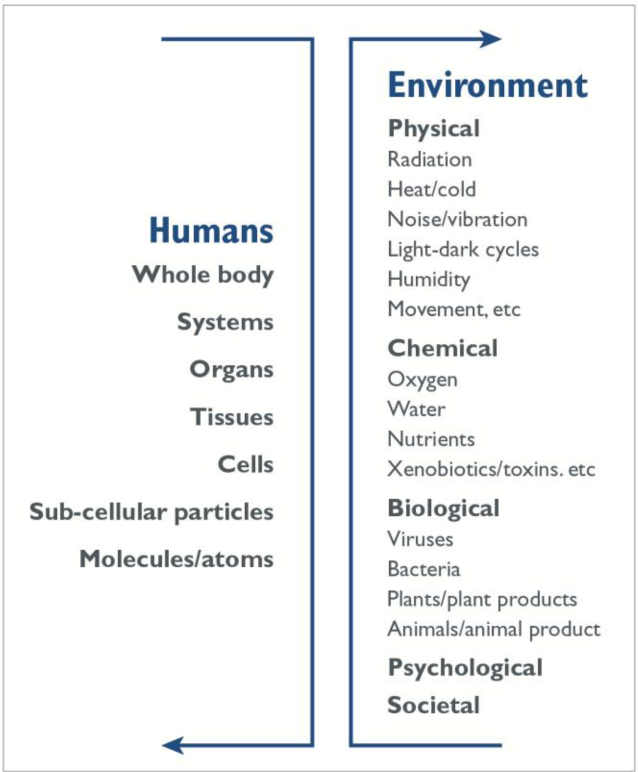

Figure3: Possible environmental impacts on biological systems

5 Numeracy skills for OHS practice

All OHS professionals should have basic numeracy skills as indicated in Figure 4.

1 Arithmetical skills

- Various ways of describing fractions: vulgar, decimal, percentage, ppm, ratios.
- Arithmetical processes: addition, subtraction, multiplication, division, BODMAS (order of operations), including manipulation of fractions, ratios.
- Squares, square roots, inverse square, powers, significance and rounding off.
- Basic algebraic manipulation (eg: $PV = nRT$)

2 Measurement

- Logarithms
- Prefixes, their meanings and abbreviations (e.g. kilo-, G, 10^3; centi-, c, 10^{-2})
- Units of measurement related to OHS: length, area, volume, mass, frequency, density, force; pressure; energy; electricity; sound; light, temperature; chemical concentration; pH; radiation

3 Basic statistical measures

Some statistical measures used in occupational health and safety are:

- frequency rate
- incidence
- average duration
- percentage and percentage change
- mean
- median
- mode.

Display of data including knowing which display to use for a particular type of data including:

- tabulation
- line graphs
- bar charts (histogram)
- pie chart.

4 Probability, sampling distribution and confidence intervals

Figure 4: Basic numeracy skills required for effective OHS practice

Correct procedure in multiplying, squaring or taking the logarithm of a number will provide a numerical answer. However, numeracy skill is not merely about getting an answer; how the answer is interpreted is crucially important. Numbers often speak loudly, but they must not become such an object of focus that one loses sight of the context.

The language of basic statistics is much used in OHS publications. Some knowledge of statistical terms may be useful for:

- Reading, interpreting and applying OHS research literature including epidemiological studies[5]
- Analysing and evaluating OHS performance and the effectiveness of a series or set of OHS interventions
- Communicating findings and outcomes and justifying recommendations.

The first use relates to the OHS professional as a critical consumer of research that involves statistical analysis. This requires some understanding of both descriptive and inferential statistics. The second use requires a higher level of statistical skills that, while useful to the OHS professional, may not be considered core knowledge. The third use could be considered a core requirement for OHS professionals providing strategic advice.

For those interested in further statistical skills for the OHS professional these may include descriptive and inferential statistics, quantitative and qualitative research methods, experimental design, and parametric and non-parametric statistics. Education programs and textbooks are available on these topics.

6 Use of the foundation science-topic maps and numeracy skills list

As previously indicated, the topic maps provide only the title of the concept with the breadth and depth of knowledge required by individual OHS professionals being dependent on their background, the industry they work in, the hazards they deal with and the nature of advice they provide. OHS professional education programs may address the foundation science and numeracy requirements through content within the program, required prerequisites, bridging programs or a combination of such strategies. The concepts may represent the basis of major studies or they may represent topics in an integrated underpinning science unit(s). Also, the topic maps could provide the basis for an OHS professional to design their own program of professional development.

It is recognised that there are some challenges in ensuring OHS professionals have the requisite foundation science. These challenges include:

- University resources and processes dictate that students in undergraduate OHS programs are required to complete a first-year science program that is common to all science students; much of the material may not be directly applicable to OHS or the links with OHS may not be obvious to the student.
- The majority of OHS professional education programs are postgraduate with insufficient course time to address these foundation concepts and skills.

[5] See *OHS BoK* Practice: Using research to inform practice

- Some currently practising OHS professionals may not have the breadth of foundation science identified in the topic maps.

There is an opportunity here for purpose-designed modules to be developed for a flexible delivery mode to address the content and assessment of the physical and biological science concepts identified and the basic numeracy skills.

7 Implications for practice

The generalist OHS professional requires a base of scientific knowledge and numeracy skills to:

- Understand the action of hazards and be capable of identifying their presence and method of causing harm
- Understand the mechanism of long-term health effects as a result of exposure to hazards
- Analyse and estimate risk
- Develop and implement controls taking account of human, physical, organisational and social factors
- Access and evaluate a wide range of information.

Not only is OHS an emerging profession, but work environments and the hazards with which the professional is required to engage are becoming more complex. For example, without some understanding of basic physical sciences it will be difficult for the OHS professional to comprehend the nature and effects of nanomaterials and nanotechnology.

The importance of an understanding of physical and biological science is well illustrated by considering carbon monoxide (CO) poisoning in humans. Work-related CO poisoning, often with fatal consequences, is not uncommon. An understanding of basic chemistry will arm an OHS professional with the knowledge that CO is a colourless and odourless gas that is the product of the incomplete combustion of fossil fuels or other sources of carbon. From the physiological perspective, it is known that CO has approximately 200 times the affinity for the oxygen binding sites on the haemoglobin molecule. The displacement of oxygen from sites on the haemoglobin molecule and the subsequent decrease in delivery of oxygen to vital tissues and organs can lead to tissue damage and even death. An understanding of the partial pressure of gases and the kinetics of oxygen-haemoglobin binding informs the OHS professional of the mechanisms underlying CO poisoning and its severity in different circumstances of exposure.

8 Summary

An OHS professional requires a foundation of basic knowledge of physical/chemical and biological/health sciences together with numeracy skills to be able to provide informed advice on managing workplace hazards and preventing fatality, injury, disease and ill health. The extent of scientific knowledge required will depend on the industry and hazards where the OHS professional works, and the nature and extent of the required advice. The source of such knowledge may vary from senior-school science, vocational study or bridging programs to more advanced levels acquired from science-specific university education.

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