OCCUPATIONAL HEALTH AND SAFETY CONCEPTS

Chemical and Processing Hazards

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M.D., M.F.C.M., D.I.H.

Professor of Safety and Hygiene,
Department of Safety and Hygiene,
University of Aston in Birmingham, UK

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Preface

This book is aimed specifically at readers with little background in biology who nevertheless wish to know something of the biological aspects and a little of the social aspects of occupational health and safety. The subject matter is selective, reflecting that of the course taught in the Department of Safety and Hygiene at the University of Aston in Birmingham, where the subject of Occupational Health and Safety is divided into four headings: (a) human safety, (b) safety engineering, (c) law, and (d) individual and organizational behaviour. This division is convenient though far from rigid, all four subject divisions having a social as well as a technical framework.

This book is principally concerned with human safety and not with the other divisions, though there is some intentional overlap. Its specific aim is to provide a basis (in the sense of substratum) for knowledge of human safety. My purposes are to convey and explore the concepts supporting three ideas:

(1) that the biological nature of the harm occasioned by danger from work can be perceived in terms of a flow-chart or, to give it a more pretentious title, an input–output model;

(2) that the selection and implementation of action against danger is ultimately determined by social and economic pressures as well as scientific knowledge; and

(3) that strategies intended to preclude or minimize danger can be classified on a simple hierarchy.

Contents

Section 1: ORIENTATION

This section shows in broad terms how the book fits into the field of occupational health and safety and presents the input–output model as a framework for the remainder of the book.

Chapter 1

Introduction to Human Safety

OBJECTIVES OF THE CHAPTER

This chapter:

(1) outlines the scope of human safety, and shows that it involves knowledge of human biology applied in a social setting,

(2) specifies broad objectives for the study of occupational health and safety of which human safety forms part,

(3) indicates the professional context of human safety, and

(4) introduces the three principal themes of the book.

INTRODUCTION

Danger arising from work is an unwanted and unintended by-product of the processes of work. All interested parties—the public, government, the agencies of government, employers, managers, employees, representative organizations, technologists, scientists, and occupational health care personnel—are concerned with the minimization or elimination of danger associated with work. This concern is growing, and justifiably so, because the decline in mortality and morbidity from infectious diseases caused by micropredators is bringing man-made diseases into greater prominence. Moreover, 'environmental' factors are increasingly recognized as causative agents in serious disease such as cancer. Of environmental factors, a substantial proportion, though by no means all, has a human instrumentality. Included in the category of human instrumentality are occupation-linked diseases, injuries, and deaths. No longer is there unquestioned acceptance of the belief that death, life-shortening and disablement are an 'acceptable risk' that must necessarily be run by working people.

Against this background it is hardly surprising that occupational health and safety is being carefully studied, whether from motives of humanitarianism or academic interest, or because there are excellent career opportunities for those with a degree of mastery of the subject. All practitioners and students soon recognize, however, the breadth of knowledge needed to achieve awareness let alone mastery of the subject. Comprehensive knowledge is needed of a variety of scientific subjects; biological subjects as diverse as the intimacies of genetics of the cell, carcinogenesis, and epidemiology, as well as a wide diversity of topics in the physical sciences. Herein lies the problem encountered by students of occupational health and safety. Almost no one enters the field of study of occupational health and safety with the necessary prerequisite knowledge of all the subject's constituent topics.

Differing views exist about policy towards health and safety problems. It is generally agreed that social policy should attend to occupational health and safety, but the specific aims of that policy and the means by which these should be met are topics on which agreement is difficult. Very often those concerned in the discussion have inadequate knowledge of the interplay of social policy and the scientific basis of occupational health and safety.

Taken together, the topics relevant to occupational health and safety constitute a massive subject for study. The task is Herculean but not impossible, because a start is being made, world-wide, in delineating areas of knowledge which are central to occupational health and safety, and in specifying the depth to which that knowledge is required. The broad objective, in academic terms, is to specify the scope and depth of knowledge required by students in order that they should:

have broad comprehension of the subject's principles,
be able to read across the subject from one topic to another, and
be able to develop a perspective for their studies.

Academic institutions throughout the world are currently working towards this objective. Although approaches and emphases inevitably vary, there is general agreement that the subject is not purely a specialism within medicine and that its study should not be restricted to graduates in medicine.

It seems likely that in Britain there are now about equal numbers of medical and non-medical graduates with specialist qualifications relative to occupational health and safety. If persons with professional qualifications in the health and safety field are included, the 'medicals' are heavily outnumbered. The trend, moreover, is towards a larger proportion of non-medical personnel. Of these (if the University of Aston's experience is at all representative) many have a limited background in the biological and/or social areas, because these are topics not normally embraced by the physical sciences, graduates of which constitute a substantial proportion of new recruits.

THE INPUT–OUTPUT MODEL: PRELIMINARY

'Input' is used to describe all harmful or undesirable factors relevant to occupational health and safety. 'Input' suffices for this purpose provided we recognize that it includes factors which may be harmful by being deficient or absent (oxygen, for example). This conceptual difficulty can be rationalized by our supposing that such inputs, in arithmetic terms, are negative quantities. 'Modes of input' is used to describe the various routes and means whereby inputs gain access to the body.

A category of output, termed 'bio-dumping', involves substances and energies being removed from the body in the course of regulatory biological activities. Another category of output, 'harm' in its broadest sense, can be used to include a continuum of effects of chemical, physical, microbiological, or psychological inputs of which effects the most serious are injury, disease, disablement, and death.

Inputs are likely to provoke reactive changes in biological processes. In this book, for descriptive purposes, three broad groupings are implied—defensive processes, corrective processes, and normal biological processes. It should be recognized, however, that these are not mutually exclusive and that particular processes may be classifiable under different headings according to circumstances.

The manifestations of disease are the changes in the biological processes. However, not all such changes result in disease being manifested; defensive and corrective processes may successfully resist the input and bring about restoration of the biological state of affairs prior to the input's presence. 'Disorder' is used here to label those changes in biological processes which result in disease being manifested. It serves present purposes well enough, although I recognize that some authorities might demur on the grounds that some of the changes so labelled are over-reactions (*hyper*-reactions) or under-reactions (*hypo*-reactions) rather than disorders. Nevertheless, these types of change can be labelled 'disorder' provided that the term is clearly used in its broadest sense.

'Mode of action' is used as a general heading for descriptions of the way in which inputs provoke changes in biological processes.

SELECTION AND IMPLEMENTATION OF ACTION IN OCCUPATIONAL HEALTH AND SAFETY

Sooner or later, the recognition of danger in a particular context is followed by talk of action against the danger. In selecting and implementing action, legislators, administrators, and enforcing authorities usually have a number of strategies to choose from. The case histories and examples, given in Section 5, show that choice of strategy is influenced by social and economic considerations as well as scientific considerations.

HIERARCHICAL CLASSIFICATION OF STRATEGIES

From almost any comparative study of actions against dangers it soon becomes apparent that there is a common pattern for the actions considered and selected, almost irrespective of the danger. Time and time again, certain strategies seem especially favoured. Close scrutiny reveals that the strategies most commonly adopted can be classified in a way that exhibits their relative effectiveness, and which also indicates why their selection and implementation are influenced by socio–economic as well as scientific factors.

Chapter 2

An Input–Output Model for Human Safety

OBJECTIVES OF THE CHAPTER

This chapter:

(1) Describes an input–output model which provides a suitable framework on which to build an understanding of human safety, and

(2) defines certain terms and concepts central to human safety.

THE MODEL

The input–output model shown in Fig. 2.1 is a convenient framework for important sectors of human safety and should provide readers with a usable model for understanding the subject's essential concepts and terms. The model is used as the basis for the subject matter in this book. The principal function of the model is instructional, and readers should not hesitate to adapt it for their own purposes. Because the field of human safety is rapidly advancing, the input–output model should be seen as being flexible and capable of extension to encompass new knowledge.

Human safety represents a branch of knowledge instrumental in the prevention of death, injury, and disease associated with work. In the context of this study, death, injury, and disease are undesired outputs resultant upon a variety of inputs which have activated one or more processes within the living body. Intervention with a view to prevention can be made at various points in the input–output sequence. Measurements, too, can be made at various points in this sequence; these can be used to indicate the extent to which the input is, or is likely to be, the cause of an undesired output; or measurements can be made in order to evaluate the effectiveness of intervention.

The link between a defined input and an observed output may be clear and unambiguous. On the other hand, the link may be no more than a matter of scientific speculation. This uncertainty can be reduced only by the application of rigorous scientific methods. In order to establish beyond reasonable scientific doubt that a particular output is related to a particular input, that is to say a causal relation exists, information of two basic kinds is required (Harré, 1967):

(a) *Supporting statistics* A causal relation can be assumed to

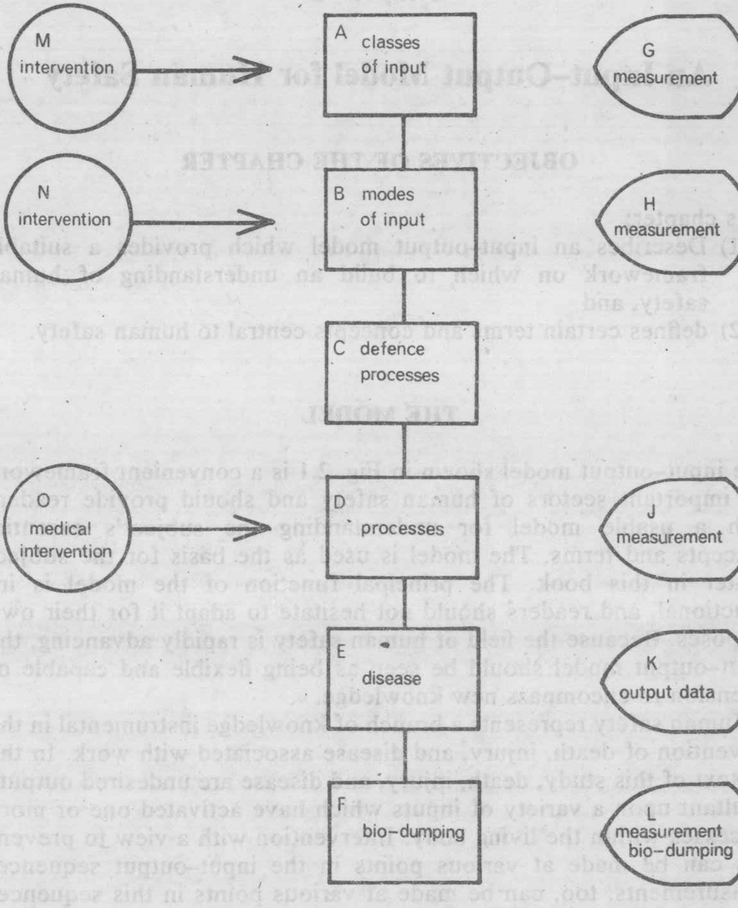

FIG. 2.1. The input–output model.

exist if the output is observed when the input is present and not observed when the input is absent. A similar assumption can be made if the output increases in incidence or magnitude as the input increases and/or the output decreases with a decrease in input. If the statistics show a complete relation which satisfies all these criteria, and certain others, it may be possible to conclude unequivocally that a link—but not necessarily a causal one—exists between the output and the input. In practice, however, all the necessary criteria are seldom satisfied, though in some instances a causal relation can still exist. For example, cancer may be triggered by a carcinogen, the removal of which does not remove or stop the cancer. In other instances the output is non-specific and can be causally related to more than one type of input. But, despite all the difficulties, the search for causal relations is a matter of practical as well as theoretical importance.

(b) *Generative mechanism* There must be a scientifically-plausible generative mechanism to explain the link between the output and the input. Sometimes the generative mechanism will be straightforward and scientifically secure, but in other instances the generative mechanism may lie at or beyond frontiers of existing knowledge. Normally, in order to scientifically establish that a link exists and that the output is not just coincidental with the input, it is necessary not only to demonstrate favourable supporting statistics but also put forward a plausible generative mechanism. Thus in the understanding of human safety, 'processes' and 'modes of action,' as understood for the purposes of this book, can be regarded as the generative mechanisms. The necessary statistics are provided by the epidemiological or other evidence relating exposure to death, disease, or injury. Thus knowledge of the processes and modes of action—the generative mechanisms—is necessary not only for the practical business of prevention but also for the scientific business of establishing that an observed output can reasonably be attributed to a particular input. There are numerous instances in occupational health and safety where statistics are uncertain and links are tenuous. Even though on humanitarian grounds action may be called for in the face of evidence which is scientifically incomplete—as, for example, in the case of carcinogens—this does not excuse us from observing the discipline of scientific methods.

ELEMENTS OF THE MODEL

The model, depicted in Fig. 2.1, comprises a number of elements which are described and subdivided in the following paragraphs. It should be noted that the flow-chart format considerably simplifies the processes involved; in particular the model does not convey any impression of the *interactions* which are possible and which, on occasion, play such an important part in the processes of occupational disease and injury.

In general it should be assumed that a member of one of the classes of input is likely to have more than one mode of input, to be involved in more than one biological process, to evoke more than one defence process and to result in more than one type of output (see Fig. 2.1).

There are a number of examples specified in later chapters where one member of a class of input may interact with another of the same class or with one or more members of other classes of input. Moreover, inputs acting in conjunction with each other behave differently to inputs acting singly. For some inputs the nature of the defence process depends on the level of the input, and this presents a further complication. 'Loopback' mechanisms are additional factors which must be considered. Any model which purports to display all possible relations between input and output is, thus, likely to be inpenetrably complex.

The model shown in Fig. 2.1 is not intended to display the interrelations. It is merely intended to provide a serviceable framework for the remainder of the book.

(A)* Classes of Inputs

Inputs, for the purposes of the model, can conveniently be described under four separate headings: (1) chemical substances, (2) energies, (3) climates, and (4) micropredators.

(1) *Chemical Substances*

These include the whole range of substances and compounds embraced by organic and inorganic chemistry. The range can be subdivided into: (a) nutrients, and (b) non-nutrients.

(a) Nutrients are substances or compounds which are used by the body for the production of energy or the synthesis of tissue. Nutrients, generally, range from complex proteins to common metals.

(b) Non-nutrients are substances which do not normally take part in either energy production or biosynthesis; they are thus not required by the body for normal healthy growth and function. However, it is possible for non-nutrients to be present in the body without necessarily causing harm.

Examples of non-nutrients which are harmful and which are discussed in later chapters include the aromatic amines, asbestos, and certain inorganic substances. Also mentioned are certain metals which are essential in trace amounts but definitely harmful when excessive amounts are present in the body. Manifestly, the word 'toxic' cannot properly be used, without qualification, to describe essential micronutrients. Here we see a point which will be made again in later chapters, namely that the property of being toxic should not be considered a fixed attribute of a chemical substance. Whether a substance is or is not harmful depends on (i) the substance, (ii) the

*The capital letters correspond with those shown on the input–output model.