OCCUPATIONAL HAZARDS *in the* HEALTH PROFESSIONS

Dag K. Brune
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Occupational Hazards in the Health Professions

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PREFACE

An increasing concern about occupational hazards in the health profession has prompted this book. Different topics covered include chemical, biological, and radiation hazards as well as ergonomics, eczema, psychosomatic risks, and indoor climate in the hospital environment.

The veterinary surgery safety aspects for health professionals are similar to those described within the field of human medicine and specific hazards in the veterinary profession have not been surveyed in this book.

Questions and concerns about HIV and AIDS are assigned a separate chapter.

Radiation hazards have been paid particular attention not solely in view of common problems inherent with X-ray therapy and diagnosis, but also in topics dealing with lasers, microwave equipment, as well as ultra- and infrasound equipments.

A dentist who is concerned about the safety aspects of dental surgeries will find that the book includes various topics pertinent to this matter, such as ergonomics specifically devoted to muscular strain, hazards during amalgam treatment, as well as safety recommendations related to curing lights and the handling of vibrating tools.

Due to a broad knowledge of the frequency of injuries inherent with various occupations as well as comprehensive governmental legislation in the appropriate fields in Sweden, such matters have been emphasized according to Swedish experience.

The aim has been to give the book a wide presentation of various safety aspects for different categories of health professionals, and it might be useful for physicians, nurses, dentists, veterinarians, etc. The book may be of particular interest to professionals within the occupational safety area in hospitals and dental clinics.

Several authors have contributed to this book. The editors take the opportunity to forward their sincere thanks to the contributors for fruitful discussions and cooperation in the editing of the book.

The Editors

EDITORS

Dag Brune, Ph.D., was appointed Docent(Associate Professor) in Nuclear Chemistry in 1967 at Chalmers University of Technology, Gothenburg, Sweden. From 1957 to 1975 Dr. Brune served as a research associate at the Swedish Atomic Energy Commission at Studsvik, working with basic research in nuclear physics and chemistry as well as implementing nuclear technique in various biomedical, metallurgical, and environmental fields. During this period much attention was devoted to studies of trace elements in the human body, and health related to various occupational conditions. During 1976 to 1982 Dr. Brune served as Head of the Physical/Chemical Division at the Scandinavian Institute of Dental Materials in Oslo, and was mainly active in biomaterial research and in studies of pollution of internal working environments. Special attention was paid to man's internal exposure to various heavy metals from biomaterials. Further, Dr. Brune has been assigned during various periods by the United Nations, working as an expert for the International Atomic Energy Agency in Colombia, Peru, Ecuador, and Turkey, implementing nuclear technology in medical and industrial fields. He has been a visiting scientist at Centre d'Etudes Nucleaires, Grenoble, France, and at the Mayer-Leibnitz Institute in Garching, Munich.

Dr. Brune is author/coauthor of about 120 publications and author/editor of 3 books. He is also chairman of the A & J Brune Memorial Foundation, and has been involved in social and humanitarian activities in Latin America. His current research interest is in the area of trace element research and human ecology.

Christer Edling, M.D., Ph.D., is a Professor of Occupational Medicine and Head of the Department of Occupational Medicine, University Hospital, Uppsala, Sweden.

Dr. Edling obtained a B.A. degree in psychology from Stockholm University in 1962 and his M.D. degree from Karolinska Institute in 1969. He received his Ph.D. degree in occupational medicine from Linköping University in 1983.

He has been the organizer, chairman, and speaker of several national and international symposia held in Europe, Africa, Australia, and North America. Since 1985 he has been Chairman of the "Section for Occupational Medicine and Environmental Health" at the Swedish Medical Society and since 1984 Chairman of the "Board on Postgraduate Medical Training in Occupational Medicine" at the National Board of Health and Welfare. Furthermore, he is a member of the "Criteria Group" at the National Institute of Occupational Health. He serves on the editorial board of the *Scandinavian Journal of Work Environment & Health* and is a member of several national and international professional societies. He has authored or coauthored more than 100 papers dealing with research areas such as occupational epidemiology, radon and lung cancer, solvents and neurotoxic effects, as well as irritants and nasal disturbances.

His current research interests are in the areas of occupational cancer and toxic effects of gases and vapors.

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Chapter 1

GENERAL CONCEPTS

Per Lundberg

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I. INTRODUCTION

In this chapter, a few examples are given of substances which might involve a risk for the health professionals. The hazards of these chemicals will be dealth with in more detail elsewhere in this book, as will the hazards of, for example, inorganic mercury in dental offices and formaldehyde in pathological departments. The examples given are merely to illustrate different ways of providing occupational standards and to point out that there exist some national differences in regulating the work enviroment.

The basis for providing occupational safety for health professionals is the same as for occupational safety for the working environment as such. The regulatory authorities provide occupational standards which may be recommendations or which may have a legal status. Usually, in the area of occupational health, one thinks of standards in terms of exposure limit values for workplace contaminants, but standards may, for example, involve requirements of the best available technology.

II. EXPOSURE LIMIT VALUES AND RISK MANAGEMENT

Laws, recommendations, stipulations, and engineering standards, etc. for acceptable and permitted levels of chemicals in workroom air have been published during the last 50 years. Such lists exist in more than 70 countries. However, few countries generate or update their lists independently. The expression "exposure limit value" is used here as a general term and will therefore cover the various expressions employed in the national lists, such as "maximum allowable concentration", "threshold limit value", "permissible level", "limit value", "average limit value", "permissible limit", "time-weighted average", "industrial hygiene standard", etc. The definition of these various expressions is given in the separate national lists, but it should be noted that the same terms are used with different meanings. As an example, the expression "maximum permissible concentration" in certain countries indicates ceiling values, whereas in others it defines average concentrations.[1]

The risk management underlying the occupational exposure limit values can be divided into four steps:

1. Risk identification
2. Risk estimation
3. Risk evaluation
4. Risk control

At least the first two steps are scientific issues and the last two are political and administrative in nature. It is important to realize that risk management is a focus for the driving forces of society. This fact also makes a simple comparison of exposure limit values from different countries partly misleading. Within the context of different health policies and differences in technical development and economic capacities, national exposure limit values will differ. However, all countries can strive to achieve a common scientific approach in a standard setting.

In the first phase in setting exposure limit values, experts evaluate the current knowledge on a toxic compound. Knowledge of the adverse effects of many toxic substances is, however, limited. Furthermore, the conclusions drawn are often based on the effects of short-term experiments only. Consequently, long-term effects such as carcinogenicity and neurobehavioral effects may not have been considered. In the second phase of the establishment of an exposure limit value, technological and economical consequences are considered. The final value is thus usually a compromise between the medical/toxicological, technical, and economical points of view which means it is the result of political decision making. Exposure

limit values should therefore be considered primarily as administrative norms. They may have a legal status or be recommendations. They should never be used as fine lines between safe and dangerous concentrations. They rather reflect exposures accepted by the society.

The scientific parts of the risk management should deal with published scientific literature only. The assessment should aim to describe dose-effect relationships, dose-response relationships, and the critical effect. These concepts can be defined as follows. *Dose-effect* relationship means a factor-specified relationship between dose or exposure and the degree of effect on the individual level. *Dose-response* relationship describes a factor-specific relation between dose or exposure and the frequency of affected individuals. A dose-response relationship can be obtained for different types of effects, such as irritation, peripheral neuropathy, or cancer. A *critical effect*, finally, may be defined as that particular effect which appears earliest or at the lowest exposure level. The critical effect could be any adverse and unwanted effect and is not merely the most dramatic effect. With this use of the concept, the best prevention to any acute or chronic change will be obtained.

The documentations of the medical/toxicological considerations are published in some countries. For example, the American Conference of Governmental Industrial Hygienists (ACGIH),[2] the Federal Republic of Germany,[3] and Sweden[4] yearly publish a documentation for new or revised exposure limit values. The techological and economical considerations are usually not publicly documented. The ACGIH is an association of scientists and hygienists within the occupational health sciences. They publish annually an unofficial list of exposure limit values, called threshold limit values (TLVs). The ACGIH values are only intended as recommendations and do not represent the official U.S. occupational exposure limits, although some of their values have been adopted by the Occupational Safety and Health Administratio (OSHA) as official values for the U.S.

Except for the documents specifically written in connection with national exposure limit values, evaluated information on health hazards is produced by some international bodies. The International Program on Chemical Safety (IPCS) is a joint venture of the United Nations Environmental Program, the International Labor Organization (ILO), the the World Health Organization (WHO). WHO, under this joint sponsorship, publishes environmental health criteria, where ad hoc expert groups evaluate the health effects of chemicals. The WHO also publishes technical reports where some of them also give recommendations for health-based occupational exposure limits. The International Agency for Research on Cancer (IARC), within the WHO, evaluates the carcinogenic risk of chemicals to humans, presented in a series of monographs. Here, too, the evaluation is made by ad hoc expert working groups. (Some addresses to distributors of the different documents mentioned here are given in the Appendix to this chapter.)

A large body of scientific articles and reviews has, during the last decades, been published concerning interpretation and management of exposure limit values; some examples are given in the reference list.[5-25] Whatever numerical value an exposure limit is given, it should never be regarded as a borderline between safe and dangerous concentrations. The best practice is to maintain concentrations as low as possible. The differences between different countries can be exemplified by a couple of substances occurring in the work environment of health professionals.

III. HALOTHANE, EXPOSURE LIMIT VALUES

Halothane (2-bromo-2-chloro-1,1,1-trifluoroethane) is used as an anesthetic gas, usually together with other halogenated anesthetic gases or nitrous oxide. The introduction of the 1986-1987 ACGIH TLV Booklet[26] states: "Threshold limit values refer to airborn concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect. Because of wide

variation in individual susceptibility, however, a small percentage of workers may experience discomfort from some substances at concentrations at or below the threshold limit''. The time-weighted average exposure limit in the ACGIH 1986-1987 TLV booklet[26] for halothane is given the value of 50 ppm (400 mg/m^3). Halothane is placed in the list under ''Notice of Intended Changes'', where it has been since the 1984-1985 list. It means that it is not yet adopted, but is considered as a trial limit. The documentation behind this trial limit has not been published. It should be noticed in this context that the lists given by the ACGIH are used in many countries as the basis for their own national exposure limit levels.

In Sweden the National Board of Occupational Safety and Health (NBOSH) gives a list of exposure limit values.[27] The list has a legal status through the Occupational and Safety Act. The scientific considerations are handled by the Criteria Group for Occupational Standards. This group consists of, besides occupational health scientists from the Institute of Occupational Health (former Research Department of NBOSH) and from the universities, experts from the employers' and employees' central organizations. For each substance discussed, the Criteria Group publishes a consensus report.[4] Another group, within the Supervision Department of NBOSH, takes care of the technical and economical issues and proposes exposure limit values which are finally promulgated by the Laymen Board of NBOSH.

Halothane is, in the Swedish list of exposure limits, given a value of 5 ppm (40 mg/m^3). Furthermore, it is said that ''the same value expressed in parts per million is also applied to similar halogenated anesthetizing gases which do not have their own set of limit values.''[27] In their consensus report on halothane,[28] the Criteria Group concluded that the critical effect of exposure to halothane seems to be its effect on the central nervous system (CNS). The Criteria Group also concludes that ''in estimating the risks of halothane exposure the possible effects on pregnancy outcome should be taken into account.''[28]

In the Federal Republic of Germany (FRG), a special Commission for the Investigation of Health Hazards of Compounds in the Work Area has been established in order to deal with exposure limit values. The commission annually produces a list of exposure limit values, which has official status, and also, since 1972, prepares scientific documentation with an argumentation to justify the magnitude of the exposure limit value. The commission consists of scientists from universities and industry.

Halothane, in the list from the FRG,[29] is given an exposure limit value of 5 ppm (40 mg/m^3). In the scientific documentation[3] on halothane (written in 1979), the commission notes that an indirect risk estimation must be used, as the epidemiological and experimental data are inadequate. Halothane gives trifluoroacetic acid as a metabolite, which is easily accumulated in the body. This metabolite interferes possibly with tricholoroacetic acid in binding to plasma proteins. The commission therefore proposes that the blood level of trifluoroacetic acid should not exceed 2.5 μg/ml and that an exposure limit value of 5 ppm would satisfy that. They also stress the uncertainty in this risk estimation.

Although the exposure limit value for halothane is the same in Sweden and the FRG, the scientific basis differs. One reason, of course, is that the FRG documentation was prepared in 1979 and the Swedish documentation was prepared in 1985. One other difference between the two countries is that the exposure limit values in the FRG are officially purely health-based while the Swedish exposure limit values are administrative norms based on technological and economical as well as scientific considerations.

The exposure limit values for halothane given above are all time-weighted average concentrations for a normal 8-h workday and a 40-h workweek. However, there also exist *short-term* exposure limits, which usually are 15-min time-weighted average concentrations. The short-term limits are not separate, independent exposure limits, but should be regarded as supplemental where acute health effects are recognized.

Again taking halothane as an example, the ACGIH[26] in their list of ''Notice of Intended

Changes'' has not given any short-term value. In Sweden, halothane is given a short-term value of 10 ppm (80 mg/ml[3]). However, as said in the Swedish list,[27] the short-term values should only be regarded as approximate guidelines and they do not have the same legal status as the 8-h time-weighted values. In the list from the FRG,[29] the short-term value for halothane is expressed as twice the 8-h average exposure limit value as a 30-min time-weighted average exposure.

IV. NITROUS OXIDE, EXPOSURE LIMIT VALUES

Nitrous oxide (N_2O) is another substance commonly used for anesthetic purposes. Of the three examples given for halothane above, ACGIH, Sweden, and the FRG, only Sweden has adopted an exposure limit value for nitrous oxide, 100 ppm (180 mg/m^3).[27] The Swedish Criteria Group, in a consensus report,[30] concludes that the critical effect of irreversible nature seems to be the teratogenic effect and the critical effect of reversible nature is the disturbance of mental function. In the case of mental disturbances, it is further said that as there is a large variation in the quality of the studies published and contradictory results, the question of the lowest exposure level which can interfere with mental function remains unanswered. The teratogenic effects are seen in animal studies where rats were exposed to 1000 ppm of N_2O for 19 d.[31]

The U.S. National Institute for Occupational Safety and Health (NIOSH) in 1977 recommended[32] that ''occupational exposure to nitrous oxide shall be controlled so that no worker is exposed at a TWA (time-weighted average) concentration greater than 25 ppm during anesthetic administration.'' The choice of this value was based mainly on observations that N_2O might have a potential to impair functional capacities of exposed workers. In a study,[33] measurable decrements in audiovisual tasks of volunteers exposed during testing at concentrations as low as 50 ppm of N_2O were shown.

V. OCCUPATIONAL STANDARDS OTHER THAN EXPOSURE LIMIT VALUES

A. Anesthetic Gases

In most cases in the practical situation, exposure levels less than the exposure limit values for anesthetic gases are attainable. This does not mean that the risk is negligible for adverse effects among health professionals working with anesthetic gases in hospitals, dental offices, or elsewhere. To further minimize the risk, the regulatory authorities may provide standards other than exposure limit values. These standards may be recommendations or may have a legal status.

In the case of anesthetic gases, NIOSH can be taken as an example of proposing a recommended standard.[32] This standard recommends control procedures and work practices which include handling of anesthetic gas machines, use of a face mask, pressure tests, and anesthetic equipment maintenance. There are also recommendations of medical surveillance for all employees subject to exposure to anesthetic gases and of information to the employees of hazards from anesthetic gases.

In Sweden the occupational standard for anesthetic gases has a legal status. It is issued by NBOSH,[34] and contains regulations about anesthetic equipment maintenance, ventilation, and control of the workroom air. According to the Swedish Occupational and Safety Act, it is the responsibility of employers to inform employees about the hazards. In contrast to the NIOSH recommendations, nothing special is said about medical surveillance. More than anything else, this reflects a difference of principles. The NIOSH criteria documents invariably define exposure levels at which certain actions are initiated as fractions of the proposed exposure value (e.g., 40%). In Sweden, as well as in other Nordic countries, medical or other preventive measures should be instituted on the basis of assessment of the actual health risk.

B. Cytotoxic Drugs

Cytotoxic drugs are preparations which are used mainly in the treatment of malignant growing cells. They may damage growth and reproduction of normal cells as well. The potential for harmful effects developing over the longer term is, however, well known. In several countries, the authorities have provided occupational standards for handling cytotoxic drugs. These standards, whether guidelines or mandatory, all aim to minimize the risk of exposure for health professionals. In the U.S., OSHA has given guidelines for cytotoxic drugs which recommend controls and work practice techniques to reduce the risk of a hazard.[35] The guidelines describe practices in preparation, usage, and disposal of cytotoxic drugs, including personal protective equipment, preparation equipment, administration equipment, medical surveillance, etc. About preparation equipment, they say that "work with cytotoxics must be carried out in a BSC" (Biological Safety Cabinet) "but where one is not currently available, a respirator with a high efficiency filter provides the best protection."[35]

In the Swedish ordinance,[36] with legal status, it is said that the preparation of cytotoxic drugs shall be carried out in a BSC or by using other techniques which give at least the same degree of protection. One example of a suitable BSC is given, with special requirements for the air filtration capacity. One step further is taken by the Standards Association of Australia in its standard on cytotoxic drug safety cabinets.[37] It has determined the construction and function of the cabinet in more detail, including the exhaust filter that should be used.

The medical surveillance recommended in the OSHA guidelines[35] includes full information to all employees, a preplacement physical examination, and a registry of all staff who routinely prepare and administer cytotoxic drugs. The medical staff may recommend group screening for urine mutagenesis or for the presence of certain cytostatic drugs in the urine. They note that, at present, no techniques exist for screening individual employers. It is also recommended that staff members who are pregnant or breast-feeding should be transferred to comparable duties that do not involve handling of cytotoxic drugs, if they so request.

In the context of medical surveillance, the Swedish ordinance[36] concludes that, at present, screening methods indicating exposure to mutagenic or carcinogenic environmental factors are under development. They cannot yet be used for individual screening. Nothing special is said about pregnant or breast-feeding employees in the ordinance, but if any uncertainty is at hand, the occupational medicine clinics should be consulted.

As an example of an adverse effect, it could be mentioned that an increased frequency of sister-chromatid exchanges (SCE) has been found in lymphocytes of nurses handling cytotoxic drugs compared to office workers.[38] Patients under therapy, however, had a five to six times higher frequency of SCEs than the oncology nurses. On the other hand, the SCE frequency of the oncology nurses and the nurses from other hospital departments did not differ statistically significantly. No health effect is known to be associated with SCEs as such, but SCEs should be considered to be an adverse sign of exposure to mutagenic and potentially carcinogenic environmental agents, for the population studied.[39]

These are only a few examples and details of occupational standards for work with cytotoxic drugs. Standards of similar content exist in several countries and, furthermore, some hospitals and other institutions have special guidelines of their own. The standards for handling cytotoxic drugs are also an example of where use of the best available technology seems to be the way of minimizing the health hazard risk and of protecting employees of adverse effects.

VI. MONITORING EXPOSURE LEVELS

In order to ensure that the air levels of contaminants in the occupational environment are well below the exposure limit values given, analytical methods should be used. Most common

is air sampling during the work day and analysis of the samples. In many countries,[40,41] the authorities provide descriptions of methods for sampling and analysis. With stationary sampling, the analytical result will tell if the level of the contaminant in the workroom is acceptable or not. With personal sampling, a measurement of the concentration inhaled by an individual is recorded. Another way of evaluating the individual exposure is by biological monitoring, which includes measurements of a substance or its metabolic product(s) in tissues, fluids, or exhaled air of exposed workers. There are, however, generally some problems that hinder wider use of biological measurements:

1. The relatively wide range in individual response and the wide range of "normal"
2. The lack of simple specific analytical methods of sufficient sensitivity
3. The different breathing rates during physical work
4. The complexity of metabolism

In a few cases, a biological exposure limit value has been established. One example is halothane in the FRG.[29] The value is given to 250 μg of tricholoroacetic acid per deciliter of blood, in samples taken at the end of the workweek. In the scientific documentation[42] given 1982, it is said that the value given corresponds to the exposure limit value for halothane of 5 ppm (see also Section III).

Air monitoring and/or biological monitoring can thus be used to control the exposure levels of hazardous substances in the occupational environment. Air monitoring is mainly utilized to ensure that an acceptable level is maintained. Biological monitoring can furthermore be used in a medical surveillance program and thereby detect individuals at risk.

VII. CONCLUDING REMARKS

It is not uncommon for health care professionals to regard themselves as immune from any harm arising from their work. During the course of treating their patients, they may inadvertently exposure themselves and their staffs to hazardous substances. As "employers" it is their duty to fully inform their staffs of the hazards and of the standards given for handling a harmful substance, whether the standards have a legal status or are recommendations. Thus, in the practical situation, reliable information is one way of minimizing the risk.

The exposure may be derived from direct contact with the hazardous substances, via contaminated material, or via handling biological fluids or excreta. Work practices of highest hygienic quality, whether stated in an occupational standard or not, are another way of minimizing the risk and thereby having a good occupational environment in hospitals, dental offices, or elsewhere.

APPENDIX: USEFUL ADDRESSES

INTERNATIONAL DOCUMENTATION FOR OCCUPATIONAL EXPOSURE LIMIT VALUES

World Health Organization
Distribution and Sales Service
CH-1211 Geneva, Switzerland

NATIONAL DOCUMENTATION FOR OCCUPATIONAL EXPOSURE LIMIT VALUES

Federal Republic of Germany
Verlag Chemie GmbH
D-6940 Weinheim, FRG

The Netherlands
Direktoraat-Generaal van de Arbeid
Postbus 69
NL-2270 MA Voorburg, The Netherlands

Sweden
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Anesthetic Gases

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