ABSTRACT

MANAGING OCCUPATIONAL
HAZARDS CONFRONTING HEALTHCARE WORKERS

by
Kiran Mody

The primary goal of this thesis is to identify, evaluate, and control occupational hazards that may exist in health care facilities.

Due to the complex nature of health care facilities, healthcare workers are always challenged by an imposing group of occupational hazards. The magnitude and diversity of these hazards, and the constantly changing nature of government regulations make it difficult to guarantee absolute protection and accuracy of the material contained herein. However, awareness of the risks, compliance with basic preventive measures, and adequate interventions are all essential components to consider in protecting healthcare workers.

Therefore, potential health effects of various hazards such as back injuries, heat, noise, infectious hazards, pharmaceutical hazards, chemicals, exposure to radiation, and prevalent psychosocial (stress) problems are reviewed, and rational approaches to managing and preventing these problems are offered.

This thesis also presents a broad overview of hospital safety programs, and job safety analyses; it offers assistance in understanding and complying with regulations and guidelines issued by the Centers for Disease Control and Prevention (CDC), the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), and the Joint Commission on Accreditation of Healthcare Organizations (JCAHO).

MANAGING OCCUPATIONAL HAZARDS CONFRONTING HEALTHCARE WORKERS

by
Kiran A Mody

A Thesis
Submitted to the Faculty of
New Jersey Institute of Technology
in Partial Fulfillment of the Requirement for the Degree of
Master of Science in Occupational Safety and Health
Engineering

Department of Mechanical and Industrial Engineering

May 1994

APPROVAL PAGE

MANAGING OCCUPATIONAL HAZARDS CONFRONTING HEALTHCARE WORKERS

Kiran A Mody

5/10/94

Dr. Howard Gage, Thesis Advisor — Date
Associate Professor of Industrial Engineering and
Director of the Occupational Safety and Health Program, NJIT

5/6/94

Dr. David Kristol, — Date
Professor of Chemistry, Director and Graduate Advisor of
Biomedical Engineering and Director of the Center for
Biomedical Engineering, NJIT

5/5/94

Ms. Gail Buckler, — Date
Clinical Assistant Professor, School of Nursing,
University of Medicine and Dentistry of New Jersey (UMDNJ)

BIOGRAPHICAL SKETCH

Author: Kiran A Mody

Degree: Master of Science in Occupational Safety and Health Engineering

Date: May, 1994

Date of Birth:

Place of Birth:

Undergraduate and Graduate Education

- Master of Science in Occupational Safety and Health Engineering, New Jersey Institute of Technology, Newark, New Jersey, 1994

- Bachelor of Science in Electrical Engineering, Rutgers University, The College of Engineering, New Brunswick, New Jersey, 1991

Major: Occupational Safety and Health Engineering

This thesis is dedicated to
all brave healthcare workers
who risk their lives to help those in need.

ACKNOWLEDGMENT

The author wishes to express his sincere gratitude to his advisor Dr. Howard Gage, for his never ending support, patient, tolerance, and guidance throughout this thesis.

Special thanks to Dr. David Kristol and Ms. Gail Buckler for serving as members of the committee.

A very special thanks to Dr. Min-Yong Park for his friendship, financial support and opportunity to work with him.

The author is grateful to the National Institute for Occupational Safety and Health (NIOSH) for financial support during this thesis.

The author would also like to acknowledge the Veteran's Administrative Medical Center (VAMC) Library and Mr. Kish Mody, Industrial Hygienist at VAMC, East Orange for providing necessary information and assistance.

And finally, a sincere thanks to the author's parents, for their moral and financial support thoughout the author's education.

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

BACKGROUND

1.1 Introduction

Health care facilities present workers with a myriad of potential health and safety hazards. Compared with the total civilian workforce, hospital workers have a greater percentage of workers' compensation claims for sprains and strains, infectious and parasitic diseases, dermatitis, HIV and hepatitis, mental disorders, eye diseases, influenza, and toxic hepatitis.

The challenges posed by occupational hazards are constantly evolving. The development of new medical therapies and technology can create additional risks. For example, the use of dynamic computerized tomography (CT) scanning, a new diagnostic imaging procedure, can potentially increase the exposure of certain health care workers (HCWs) to ionizing radiation. Ribavirin, a relatively new antiviral agent, may adversely effect the health of personnel who administer this agent if it is not handled properly. The evolution of infectious agents, ranging from the acquisition of antibiotic resistance by bacteria to the spread of relatively new agents such as the Human Immunodeficiency Virus (HIV), is another development that effects the nature of occupational health hazards.

It has been known that hospitals may be hazardous for patients, but hospitals may also be hazardous to employees who work in them. The hospital safety management committee is usually responsible for the health and safety of employees, yet many hospitals often lack and overlook the need for professionals trained to assess job related risk and institute appropriate preventive and corrective measures.

Unsafe practices, lack of awareness, and poor compliance with basic preventive measures by hospital staff at all levels contribute to occupational risk. Despite these problems, most occupational hazards can be effectively dealt with by identification, treatment, and training and education to reduce the risks of occupational health hazards. It is highly recommended that each hospital develop its own policies and procedures to insure the safety and health of patients, visitors, and employees in a safe working environment.

1.2 Overview of Hospital Hazards

Few workplaces are as complex as the hospital. Not only does the hospital provide the basic health care needs for a large number of people, but it is often a teaching and research center as well. As a result, the list of potential hazards includes back injuries, heat, noise, infectious hazards (tuberculosis, hepatitis B, HIV), pharmaceutical hazards (antineoplastic drugs, aerosol pentamidine), chemical hazards (ethylene oxide, formaldehyde, etc.), waste anesthetic agents, radiation and stress. The following are some typical hazards hospital personnel face.

Maintenance workers may be exposed to solvents, asbestos, and electrical hazards. Employees working in or around boiler rooms are regularly exposed to high levels of noise and heat.

Housekeepers are not only exposed to detergents and disinfectants that cause skin rashes, eye and throat irritation, but also face exposure to hepatitis and other infectious diseases from hypodermic needles that have not been discarded properly. Sprains and strains are also common problems for housekeepers.

Food service workers face problems such as cuts from sharp-edged equipment, burns from hot surfaces and steam lines, falls on slippery floors, and fatigue and stress from long periods of standing on hard surfaces. Nonionizing radiation from improperly maintained microwave ovens is another potential hazard.

Registered Nurses (RN's), Nurse Practitioners (NPs), Licensed Practical Nurses (LPN'S), and Nursing Assistants (NAs) confront potential exposures to infectious diseases, toxic substances, back injuries, and radiation.

Radiology Technicians may be exposed to radiation (X-rays and radioactive isotopes), chemicals, and biological hazards.

Operating-room workers may face the risk of reproductive problems (as from exposure to anesthetic gases), infection, radiation, and electrical hazards.

1.3 Overview of the Hospital's Safety Program

Safety problems in hospitals generally arise from unsafe conditions and/or practices. It should be emphasized that there is no cure for accidents, but they can be prevented.

The Hospital Safety Program must comply with the Occupational Safety and Health Administration (OSHA), Environmental Protection Agency (EPA), Joint Commission on Accreditation of Healthcare Organizations (JCAHO), and the guidelines set forth by other regulatory bodies. The safety program has four major elements (Prevention, Protection, Education and Motivation) with several sub-elements as listed in Table 1-1.

Prevention is an integral part of a safety program. Frequently some of the key aspects of prevention are allowed to slip by due to lack of time. Safety inspection is a form of prevention because it strines to correct unsafe conditions. Potentially unsafe conditions should always be monitored to prevent them from becoming unsafe and alluding detection. Standards must be referred to for unsafe areas, work practices, and controls. Qualified safety consultants should be used to determine appropriate corrective actions.

In hospitals, a very important element of the safety program is prevention through an employee health program.

Table 1-1 Elements of a Safety Program.
(Wear and Simmons, 1988)

Prevention	**Protection**
Safety Inspection	Protective equipment
Monitoring	Machine Guarding
Consultation	Overload devices
Implement standards	Fire Protection
Corrective Actions	Compartmentalization
Health programs	Smoke Detectors
Lockout systems	Fire Alarms
Safety rules	First Aid Care
Qualification Exams	Safety Belts
Job Safety Analyses	Rails, Barriers
Automation	Fume Hoods
Immunization	Eyewash Stations
Education	**Motivation**
Orientation	Recognition
Job Training	Commendations
Safety Meetings	Awards
Committees	Contests
Training Supervisors	Special Campaigns
Special Programs	Suggestions
Fire Drills	Promotional
Publications	Records
Signs	Objectives
Demonstrations	Competition
Safety Courses	Counseling
Material Data	Discipline

Employees are susceptible to infection from patients as well as from fellow employees. A Medical Surveillance Program must be initiated and fully implemented. Ideally, a specific Job Safety Analysis must be performed on every job. Safety rules, automation, and a lockout/tagout system are very effective methods to prevent accidents where an unsafe condition and/or work practice exists.

Protection refers to the hardware element of a safety program. First aid care, eyewash stations, showers, and personal protective equipment are a form of protection since they protect the employees from further harm. Compartmentalization, fire alarms, and smoke detectors should be used in areas where potential fire hazards exist. In areas like clinical laboratories, fume hoods should be installed.

Education is part of safety program often requiring a good deal of employee time. Rules and laws can be established, but for them to be effective, people need to be educated and motivated. Safety education must start as soon as an employee is hired. At the first orientation, the subject of general hospital safety must be introduced. As soon as the employee is on the job, he/she should be informed of safety and health hazards that apply to their job. He/She should be trained on how to perform this job properly and safely.

Safety education is a never ending process in the hospital. It consists of special programs, demonstrations, safety courses, and training of employees. Material Safety Data Sheets (MSDSs) and other labeling systems used on materials are safety reminders for employees. Signs can also remind personnel of safe habits as well as tell them that certain areas contain unsafe conditions such as radiation or infection hazards. Data on materials can inform employees of the hazards involved in handling certain materials.

Every department should have a safety committee where members of various groups meet with the safety manager, safety engineer, and other professionals to discuss specific safety and health problems.

Motivation is the most difficult part of any safety program. All the prevention, protection, and education are of little use unless employees are motivated to work safely. The greatest motivation is when an employee sees an accident or almost has one.

Competitions can be held to see which department can perform the longest without an accident. Special campaigns or contests can be run where individual awards are given for safety. Any incentives to get employees to be more safety conscious are worth trying. On a continuing individual basis, employees should be recognized for safe practices. Commendations can be issued by the hospital administrator for outstanding safety records. On the other hand, employees are to be counseled for unsafe practices and disciplinary action taken when necessary.

The National Institute for Occupational Safety and Health (NIOSH) has recommended the checklist summarized in Appendix A for developing a hospital safety and health program to identify and control occupational hazards within the hospital setting. However, personnel trained in occupational safety and health are needed to design, implement, and manage such a program.

1.4 Importance of Safety and Health Management Program

The basic reasons that make safety and health management programs a high priority for most well managed organizations such as hospital include:

1. It's humanitarian.
2. It promotes quality work.
3. It's economical.
4. It improves morale.
5. It avoids disasters and secondary ramifications.
6. It's mandatory.

First of all, such programs protect employees from physical injury and other health hazards. For instance, an effective safety and health program will prevent accidental injuries and deaths, reduce back injuries, avoid occupational health conditions such as needlestick injuries and dermatitis, and improve the overall health of employees.

When accidents occur, they reduce operational efficiency and effectiveness. Employees trained in safe work practices are more likely to avoid accidents and maintain a higher level of quality work. Fewer accidents mean lower workers' compensation costs.

Attention to safety helps to improve employee morale by making employees more confident that they are working in a safe environment. When the safety record is good, employees develop better attitudes about their work and the hospital where they are working.

Better attention to safety would also prevent secondary ramifications such as complaints, lawsuits, and negative publicity for the hospital. Good safety programs can also reduce lost work time, damaged product and equipment, and keep wasted management time and energy to a minimum.

Finally, in many cases, safety and health programs are important for government regulations. Hospitals need to comply with regulations as the government requires. The penalties for non-compliance may be significant.

A well-organized, comprehensive, and effective safety program is critical for any hospital. It's a big job, and a challenging one, but it can be achieved with careful hazard analysis, program planning, and execution.

1.5 Responsibilities

The success of any safety and health program is directly related to the concern of management, supervisors, and their employees. Supervisor responsibilities include: complying with standards and regulations, motivating workers to follow safety policies and procedures, as well as approving work practices and methods. Their responsibilities also include instructing and training employees in recognizing potential job related hazards, creating good safety attitudes, detecting unsafe conditions, assisting in job hazard analysis, abating job hazards, assisting in accident investigation, and taking necessary corrective actions with respect to unsafe or unhealthy situations.

CHAPTER 2

JOB SAFETY ANALYSIS

2.1 Definition

The grass roots of safety lie in the employee's job itself. If all aspects of a job are made as safe as possible, then the hospital should have a good safety record. To achieve maximum job safety, there should be a safety analysis of every job.

To define a job safety analysis, we must first determine what the job is. A job is a sequence of separate steps that are necessary to accomplish a work goal. These steps may be either broad or very detailed depending on the fineness of the job description. The job safety analysis is a method of studying a job to identify the hazards or potential accidents associated with each step of the job in order to develop solutions that will eliminate, nullify, or prevent such hazards or potential accidents.

The job safety analysis (JSA) is a detailed analysis of a job which can be used for several purposes. It can be used as instruction for new employees to teach them how to perform their job in a safe and proper manner. Continuing education offers one opportunity to apply the job safety analysis to remind employees about hazards and precautions involved in their jobs. Potential hazards that are found common to several jobs can be used in regular safety meetings to reinforce the solutions. Cost reductions can result from JSA as well as accident savings and improved ways to perform the job.

2.2 Basic Steps of JSA and Discussion

A job safety analysis has four basic steps:

1. The job to be analyzed is selected.
2. The job is broken down into steps.
3. The hazards or potential accidents for each step are identified.
4. Controls or solutions for each of these hazards or potential accidents are then developed.

The hospital safety engineer or specialist generally may look at job safety analyses and says that he/she understands their importance but does not have time to do them. Therefore, first-line supervisor is the key to any safety program and the individual who must perform job safety analysis as part of routine supervision.

A good job safety analysis takes time and even the first-line supervisor cannot review all jobs at once. Some priorities must be established for the selection of jobs to be analyzed. The priorities should be as follows:

1. Jobs with a high past accident frequency.
2. Jobs that have produced severe injuries.
3. Jobs that have severe injury potential.
4. Jobs that are newly established.

Once a job is selected for safety analysis, it must be described and broken down into its basic steps. The steps describe what is being done and in what order.

Table 2-1 is an example of an LPN's job broken down into seven basic steps. Table 2-2 is a breakdown of one of these basic steps on giving an injection into "finer" steps. This latter breakdown might be required for a basic step that has been determined to be a potential hazard. Once a job is broken down into its basic steps, each step is then reviewed for hazards and potential accidents. The job's environment, as well as the employee's actions must be examined for specific hazards.

If one looks at Table 2-1 and reviews what is involved in each of the steps, it is apparent that steps 3, 5, 6, and 7 may contain hazards for the employee. In step 3, the hazard is getting a needle puncture before or after the patient has been injected. A needle puncture before the injection is less hazardous since after injection there is the possibility of hepatitis, HIV or other infection from the patient. Step 5 involves possible contact with patient wastes and resulting infections depending on patient condition and the employee's personal hygiene. Steps 5 and 6 can involve lifting the patient with the resulting possibility of back injuries. Step 7 is hazardous if a mercury sphygmomanometer is used and broken resulting in a mercury spill.

Appendix B contains a few more examples of the breakdown of some of the jobs in a hospital setting which

Table 2-1 Breakdown of an LPN Job for Safety Analysis. (Wear and Simmons, 1988)

1. Maintains patients' charts
2. Takes patients' temperatures
3. Gives patients injections
4. Gives patients oral medications
5. Cleans patient up
6. Helps patients to bathroom
7. Takes blood pressures

Table 2-2 Steps for an LPN Giving an Injection. (Wear and Simmons, 1988)

1.	Select correct medication.
2.	Select proper size syringe and needle.
3.	Assure that she has correct patient.
4.	Take cover off disposable needle.
5.	Push syringe plunger all the way down.
6.	Put needle into rubber top of medication vial.
7.	Fill syringe to appropriate level.
8.	Swab patient in proper spot with alcohol.
9.	Force some medication out of needle.
10.	Insert needle into patient.
11.	Deliver medication.
12.	Remove the syringe.
13.	Put cotton ball on puncture to stop bleeding.
14.	Place cover back on needle.
15.	Take disposable syringe to needle cutter and cut of needle.
16.	Dispose of syringe.

are of importance in Job Safety Analysis. For each job, hazards and potential accidents must be recognized, reviewed, and discussed as shown in the example cited.

The development of solutions for potential accidents is the next step of a job safety analysis. A solution may take any one of the following forms:

1. Job procedural solution
2. Job environmental solution
3. A radical solution
4. A reduced frequency solution

2.3 Solutions

In a hospital job safety analysis, one main factor is the patient. The solutions recommended must not adversely affect patient care, inconvenience the patient, or increase the risk to the patient. Solutions to potential accidents or risks infer establishing some types of controls. These controls can be broken down in to engineering, administrative, work procedures, and personal protective controls.

The preferred solution is an engineering control, which means adding physical protection that employees cannot bypass. Second is an administrative solution which means changing how or where a job is done. This may involve training and/or educating employees on how to do the job differently which may be accepted as an improved way. The least acceptable solutions are the use of personal protective equipment and work procedure controls because many employees will not adhere to them.

2.3.1 Procedural Solution

A procedural solution shows what an employee must do or not do to protect himself against a potential accident. This may involve following hospital policies and procedures to do a job in a safe manner. The procedural solution also takes into account any compliance which needs to be fulfilled, following Standard Operating Procedures (SOPs), or using Personal Protective Equipment (PPE).

For an LPN giving injections, he/she must be careful at all times while handling an exposed needle to keep from self puncturing. He/She must always carry the syringe with a needle cover on. When finished, the entire syringe and needle must be disposed of in a sharps container for personal protection and to safeguard other housekeeping employees.

2.3.2 Environmental Solution

An environmental solution is required when the potential risk of an accident is due to the physical surroundings. This might include the location of equipment, line cords, space layout, lighting, or the presence of gases or infectious materials.

In the case of the LPN, the bed and line cords may be located in such a manner to make the job of cleaning patients awkward. This might require him/her to work in awkward positions that could cause strains. A solution would be to rearrange the room furnishings and/or install outlets so line cords are out of the way.

2.3.3 A Radical Solution

At times, both the environment as well as the way an entire job is done must be changed. A major change is a radical solution which generally improves how a job is performed from the standpoint of safety, time, effort, and/or cost. The question should always be asked: "Is there an entirely different and better way of doing this job?"

If the LPN must do a lot of lifting of certain patients in order to clean them, a patient lift might be installed. This could be especially true for paralyzed patients who cannot aid in their movements.

2.3.4 A Reduced Frequency Solution

Some jobs are performed more frequently than necessary so a possible reduction in the times needed for these tasks will be a reduced frequency solution. The actual times the job is done may not be reduced, but they may be clustered so the employee is performing the task less frequently but in a more concentrated fashion.

Giving injections may be primarily clustered at certain times or even restricted to a few LPNs. In this manner, they may be more conscious of the particular task and be less likely to make errors.

2.4 Methods for Doing JSA

There are three general methods for performing the job safety analysis and each requires understanding or acquiring knowledge of the job. These methods are observation, discussion, or recall and recheck.

2.4.1 The Observation Method

The observation method is where the person performing the analysis observes the job being performed. As he/she observes another employee perform the basic job steps in the proper environment, the employee can appreciate potential risks and/or accidents associated with each step. While observing the job he/she may get ideas for solutions or at least develop a framework that will allow appreciation if a proposed solution is workable.

This method stimulates ideas, promotes learning, and encourages interaction with the person doing the job. Several observations are necessary, therefore it is difficult to do on jobs which are performed infrequently.

2.4.2 The Discussion Method

The discussion method is a more elaborate technique that involves several people. A group of supervisors and employees who perform the job meet to discuss it. The basic job steps are agreed upon by recall and the potential accidents associated with each step are established. Solutions are proposed and agreed to by the group. This method involves several people with broad experience and promotes the acceptance of group solutions. It may even develop into a safety training session. It requires a scheduled meeting of several key people who may spend many hours developing solutions. Unfortunately some supervisors may classify these efforts as nonproductive manhours.

2.4.3 The Recall and Recheck Method

The simplest and probably the least effective method is the recall and check method. Here, one individual develops the basic job steps, potential hazards, and solutions by recalling how the job is performed.

For this method to be effective, the recall is considered a preliminary version of the job safety analysis. This recall version is then checked by discussions with employees directly or by observation of the critical steps of the job. It is a very flexible method, but requires the person doing the job safety analysis to have considerable experience with the job under study.

Figure 2-1 is a typical sample form that can be used to document a job safety analysis.

JOB: ______________________________ PERSONAL PROTECTIVE
JOB TITLE OF EQUIPMENT REQUIRED: __________
PERSON PERFORMING JOB: _______ ______________________________
______________________________ ______________________________

SERVICE: ______________________ ANALYSIS MADE BY: __________
SUPERVISOR: ___________________ DATE: ______________________

REMARKS: ______________________ ANALYSIS APPROVED BY: _______
______________________________ DATE: ______________________

SEQUENCE OF BASIC STEPS	POTENTIAL ACCIDENTS OR HAZARDS	SAFE WORK PRACTICES REQUIRED

Figure 2-1 A Typical Job Safety Analysis Form. (Wear and Simmons, 1988)

CHAPTER 3

HAZARD RECOGNITION

3.1 Overview

Good hazard recognition practice means being able to see the hazards that are not obvious and seeing the contributing factors behind the immediate cause of the accident. Many accidents in hospitals can be prevented if the potential hazards are recognized and corrective actions taken beforehand.

A hazard is any condition that threatens a person's safety and/or health. The recognition of hazards takes place at three levels. The worker on the job must be trained to recognize hazards in his/her job in order to eliminate, control or at least avoid them. Supervisors should recognize hazards in the area under their supervision, especially where procedures performed by one employee might produce a hazard to another employee. The professional in hazard recognition who is the facility expert must be committed and have the ability to recognize hazards that others may miss.

3.2 Checklist of Hazards

One way to make employees aware of hazards is to provide them with a list of potential hazards. But this can cause a sense of false security to arise because no checklist can ever be complete. In spite of possibly developing a sense of false security, hazard checklists can be useful.

A specific checklist for a job, location, or hospital department is useful for the employee, especially in an area with several potential hazards. Table 3-1 is a checklist of potential hazards for Nursing Service in a hospital. Nursing Service is the largest work force group in the hospital. It is responsible for providing immediate personal patient care, around the clock. Usually, all professional nurses are responsible for particular kinds of care. Therefore, careful attention is required for their exposure to various hazards that may exist at different locations and/or departments.

Table 3-2 is another example of a checklist for occupational hazards for Housekeeping Aid in the hospital. This is one of the jobs in the hospital which also requires a great deal of attention from a safety standpoint. A checklist of this kind needs to be made for each job, location, and/or department in the hospital.

Appendix C lists the occupational hazards by location and/or departments in the hospital which need to be addressed. Although this list is not exhaustive, it demonstrates the variety of hazards that can exist in a hospital environment. It could be used in safety training when new employees are hired and for refresher training as well. The safety coordinator and supervisors must look for additional hazards beyond the ones shown on this list.

Table 3-1 Hazard Checklist for Nursing Services.

Potential Hazards and Contributing Factors

1. "Materials" Handling (Strain/Sprain)
   - Usually associated with patient lifting and moving.

2. Needle Puncture Wounds (Infection/Systematic Disease)
   - Removing the clean needle.
   - Recapping the needle.
   - Improper disposal methods.

3. Communicable Disease and Infection
   - Close contact with patients before diagnosis is made.
   - Breaks in isolation techniques.

4. Ionizing Radiation Exposure
   - Portable X-rays, holding patients.
   - "implant" patients, isotope therapy.

5. Dermatitis/Systematic Diseases due to Chemical Exposure
   - Nitrous oxide in Operating Room and Obstetrics.
   - Ethylene oxide from nonaerated supplies.
   - Formaldehyde in dialysis.
   - Mercury from cantor tubes, thermometers, and blood pressure machines.
   - Medications, in general.
   - Soaps and disinfectants.

6. Antineoplastic Drugs or Cytotoxic Agents (CYTA) Exposure
   - Preparation of these drugs.
   - Administering drugs to patient.
   - Disposal of waste materials.

7. Stress
   - Psychological stress: high responsibility/inadequate staffing/low prestige; excessive workload; "life-death" decisions; lawsuits/malpractice; high expectations of society/inability to prevent suffering and death.

8. Security
   - Handling violent patients, particularly Emergency Room and Psychiatry.

Table 3-2 Hazard Checklist for Housekeeping Aid.

1.	Puncture from needles in waste containers.
2.	Cut on broken glass.
3.	Slipping on wet floors.
4.	Lifting too heavy container or equipment.
5.	Exposure to infection from contaminated waste.
6.	Exposure to infection from patients.
7.	Exposure to radiation in waste.
8.	Tripping over extension cords.
9.	Exposure to infection by smoking or eating without washing their hands.
10.	Pinching a hand in a mop wringer.
11.	Splashing cleaning agent in eyes.

An excellent tool is the accident report. Supervisors must investigate and analyze all reported accidents. The report should force them to find the underlying cause as well as all contributing factors to an accident. If these problems can be identified and corrected, than the accident should not reoccur. Therefore, the need to take the time to sharpen the hazard recognition skills of the safety coordinator, supervisors, and all employees is very important.

CHAPTER 4

PHYSICAL HAZARDS

4.1 Back Injuries

4.1.1 Introduction and Overview

Back pain and injury constitute the major cause of suffering in the western world; especially among health care workers. The most common lost time work injury in hospitals involves back injuries. Nearly 50% of all compensation claims for hospital workers involve back injuries. Among the workers most adversely affected by back problems are nursing assistant (NAs), orderlies, attendants, licensed practical nurses (LPNs), registered nurses (RNs), and radiologic technicians. Jensen, (1990) has documented that these nursing personnel, when compared to other occupational groups, have relatively high prevalence rates of back pain and high incidence rates of workers' compensation claims for back injuries. For example, NAs and LPNs ranked fifth and ninth, respectively, on a list of occupations with the largest annual incidence ratio (cases of workers' compensation claims for back sprains and strains per thousand employees). Harbor, (1985) reported various nursing activities as causes of back pain. He reported that lifting a patient in bed, helping a patient to get out of bed, moving beds, lifting a patient to a guerney and carrying equipment weighing 30 pounds or more were among the top activities found to cause back pain. He showed that occupational low-back pain is a major problem in hospital nurses.

Cox, (1993) investigated nursing personnel accidents and their causes from 1983-1990 related to musculoskeletal strains in a Veterans Administration hospital. He found that back strain was reported most frequently (68%), followed by shoulder strains (9%), and wrist and knee strains (4.4%). The predisposing factors primarily resulting in such injuries included lifting, transferring, and adjusting and turning patients in bed (Table 4-1).

4.1.2 Exposure Characterization

Exposure characterization has been a problem. There is no well-accepted exposure scale, e.g., parts per million, for quantifying the exposure of nurses to back-stressing tasks. This difficulty is troublesome when attempting to characterize exposure to the most pervasive back-stressing task: patient handling.

There are several different methods for quantifying single lifts; however, these methods have limitations when applied to patient handling.

First, they have been limited to lifts in the sagittal plane (and selected asymmetric positions that are not applicable to patient handling). The applicability of these exposure characterization methods is further complicated by

Table 4-1 Predisposing Factors of Musculoskeletal Strains. (Cox, 1993)

CAUSE	TOTAL CASES 1983-1990
Lifting to bed or cart	60
Transferring from bed to wheelchair	55
Adjusting in bed	35
Turning patient in bed	20
Preventing a patient fall	15
Assisting up in bed	12
Push/pull cart or stretcher	12
Slipped	6
Cardiopulmonary arrest (Code blue)	5
Agitated behavior (Code orange)	4
Bending	3
Unknown	68
Total	295

the fact that many patient-handling tasks consist of multiple elements. For example, moving a patient from a bed to a wheelchair includes pulling and pushing, followed by a motion similar to lifting, and another motion that involves both pulling and lowering.

Second, patient handling tasks tend to be very different from one patient to another and even with the same patient on different days.

Finally, these methods do not provide a clear way to assess exposure to the multiple patient handling tasks that occur throughout a workshift.

Industrial hygienists can appreciate the importance of measuring exposure to a hazardous chemical or physical agent for a full shift. Exposure criteria are commonly based on a time-weighted average exposure over eight hours for a forty hour work week. However, with respect to the exposure of nursing personnel to stressful patient handling tasks, there is no accepted methodology for calculating an exposure index similar to that of a time-weighted average.

Here are some points which make any work in the medical field complex and constantly challenging:

1. Moving a patient is a high risk work situation because the weight to be moved is variable. Body weight differs greatly, shifts, and attains many different positions and angles in a bed or a wheelchair. The object to be moved is not constant and the beginning position for motion varies greatly.

2. Patients who are medicated are not always cooperative. Mental clarity may be fuzzy, and a post-operative patient moves differently than he/she did before, creating apprehension, pain and stress for both patient and the employee designated to provide care.
3. The patient may reason, "Why do I have to walk? Is it necessary to sit up? I am sure I will fall, and if I do, then I will sue you."
4. The workers in the medical field move weight such as patients and pieces of equipment in many varying positions. Patients are moved from beds to chairs, commodes, wheelchairs, canes, other helpers, showers, tubs, and parallel bars. This combination of heights, angles, fabric covering variations, etc. can create a complex lifting situation.

When one considers these points, one can see why falls and lifting and back injuries associated with them must be given special attention in health care settings especially for the nursing field.

4.1.3 Frequent Causes of Back Pain

Lloyd, (1987) lists the most common causes of all work-related back pain as: (1) job performance by a worker who is unfit or unaccustomed to the task, (2) postural stress, and (3) work that approaches the limit of a worker's strength. Factors that contribute to these causes of back pain are understaffing, the lack of regular training programs in proper procedures for lifting and other work motions, and inadequate general safety precautions.

A comprehensive fact-finding accident investigation and a Job Safety Analysis of nursing activities would reveal that the major causes of back injuries result from:

1. Lack of formal training in proper body mechanics to be utilized during patient transfers.
2. The lack of teamwork between employees on the same unit who assist each other in moving their patients.
3. Lack of proper equipment to assist during patient transfers.
4. The number of times employees are required to physically move patients.
5. The high number of patients weighing 200 pounds or more that staff may have to move.
6. High Medicare patient load requiring more frequent assistance of older patients.

Specific causes of back problems for hospital workers are listed below by type of worker:

- Patient-care providers: Assisting patients and raising or lowering beds; pushing or pulling medication carts.
- Food service workers: Pushing or pulling carts, lifting heavy food trays, and moving dishes, racks, and containers
- Laundry workers: Pushing or pulling carts
- Maintenance workers: Lifting large boxes or equipment

- Housekeepers: Lifting and setting down objects, and using scrubbing machines, brooms, and mops
- Clerical workers: Using chairs that are not designed for desk work which do not provide the proper support

4.1.4 Prevention Techniques

Prevention of back injuries is the goal of any safety program that deals with lifting. The primary approach to preventing back injury involves reducing manual lifting and other load-handling tasks that are biomechanically stressful. A secondary approach relies on teaching workers how to (1) perform stressful tasks while minimizing the biomechanical forces on their backs, and (2) maintain flexibility while strengthening their back and abdominal muscles.

The most important elements in a program to prevent back injuries among hospital staff are:

- Mechanical devices for lifting patients and transferring cart tops, X-ray tables, and other heavy objects
- Wheels and other devices for transporting heavy, nonportable equipment
- Adequate staffing to prevent workers from lifting patients or equipment alone
- Close supervision for newly trained workers to assure that proper lifting practices have been learned

- In-service education for both new and experienced staff on the proper measures for avoiding back injuries
- A consensus on selecting the method and equipment to be used in the movement of patients. Though time consuming, such a consensus insures that the equipment purchased actually will be used and is safe for patient transfers.
- Preplacement evaluation of workers. Workers with pre-existing back disorders should not be assigned jobs that require lifting.

4.1.4.1 Training

The most common prevention program for any occupational hazard involves training and education; this is also true for the prevention of back injuries. The real problem with most training programs that require a person to learn a skill is that they are incomplete. Lifting patients is a skill similar to learning to ride a bicycle. You cannot teach someone to ride a bicycle with lectures and films even if they pass a written test. A proper lifting course must include demonstrations on how to move a patient in various situations. The participants must actually perform lifting and not just with very cooperative fellow participants. They need to perform some of the more difficult and unusual tasks which can be staged by instructors.

A training program for workers should emphasize:

1. Proper lifting techniques (Lloyd, 1987; NIOSH 1981b).
2. Preventing initial back injuries.

3. Requesting help.
4. Performing back exercises.
5. Transferring patients.
6. Reducing accident hazards such as wet floors, stairways obstructions, and faulty ladders.

A training program to prevent back injuries should include how to take care of the back in general terms. The human body can tolerate some abuse. The amount of stress that one can tolerate can be increased with the back being kept well and strong. Proper posture is an important element in maintaining a well back. How we sit, stand, walk, and sleep can cause back aches, as well as create strains. A worker with a strained back is a prime candidate for a back injury. Because a back that has already sustained an injury is much more likely to be reinjured, preventing the first back injury is a most important step. When in doubt about whether a task may strain the back, a worker should request help rather than take a chance. An exercise program can strengthen the back muscles so that they can withstand more abuse. A complete training program should include some simple exercise routines that only require a few minutes each day.

4.1.4.2 Transferring Patients

Patient transfers are particularly hazardous for hospital workers. The following special points should be emphasized to prevent back injuries during transfers:

- Communicate the plan of action to the patient and other workers to ensure that the transfer will be smooth and without sudden, unexpected moves
- Position equipment and furniture effectively (for example, move a wheelchair next to the bed) and remove obstacles
- Ensure good footing for the staff and patient (patients should wear slippers that provide good traction)
- Maintain eye contact and communication with patient; be alert for trouble signs
- If help is needed, request that a co-worker stand by before attempting the transfer
- Record any problems on the patient's chart so that other shifts will know how to cope with difficult transfer; note the need for any special equipment, such as a mechanical lift.

4.1.4.3 Additional Approaches for Prevention

The best means of prevention is to eliminate the hazard. Back injuries to nursing personnel could be prevented if the lifting of patients were eliminated. There are mechanical lifts that simplify patient lifting.

The logical first step is to identify those nursing jobs which involve the greatest frequency of stressful patient handling. These are the jobs that should receive the most attention. The nursing personnel who perform these jobs can identify the specific patient handling tasks that are most back stressing. These tasks can then be examined to identity possibilities for elimination, substitution, or control.

To illustrate the elimination principle, suppose the staff indicates that getting a patient from a wheelchair onto a toilet seat is an especially stressful task. A possible improvement would be to consider the use of commercially available chairs designed to serve the dual purpose of both transporting a patient and positioning the patient over a toilet. Use of such equipment would make it unnecessary to transfer the patient from the wheelchair onto the toilet. It would also eliminate the transfer back to the wheelchair.

The substitution approach is often a viable possibility. For example, moving a heavy patient from a wheelchair onto a bed can be accomplished with a portable or ceiling mounted patient hoist. Similarly, hoists can be affixed beside a bathtub to move a patient into and out of the tub. These are examples of substituting a mechanical device for the arm and back muscles of nursing personnel. Training in the proper procedures for using patient hoists is an important step to ensure that hoists are being used. A well organized, on-the-job training program is often found to be effective for insuring the regular use of mechanical hoists.

If neither elimination nor substitution provide practical alternatives, the third approach to consider is control of the exposure level. There are numerous types of devices that can reduce the intensity of biomechanical stresses associated with patient transfers. Among these are sliding boards, patient roller boards, gait belts, and ambulation belts. The boards can help reduce the pushing and pulling forces required to transfer a patient from one surface to another. The belts can help a nurse establish a position with better leverage as well as provide a place to grip in case the patient suddenly starts to fall.

Some suggestions are offered below to increase the use of patient handling equipment.

1. Provide training in the use of the equipment to all employees who might have an occasion to use it.
2. Have equipment situated close to the areas where its use is appropriate so that nursing personnel do not have to spend much time retrieving it.
3. Encourage the nursing department to determine and evaluate preferred patient handling procedures and appropriate equipment.
4. Make sure the facility has at least one portable patient hoist with maximum capacity for moving the occasional extremely heavy patient.

Wet floor hazards can be reduced by proper housekeeping procedures such as marking wet areas, cleaning up spills immediately, cleaning only one side of a passageway at a time, keeping halls and stairways clear, and providing good lighting for all halls and stairwells. Ladders are especially hazardous. Falls from even low stools and step ladders can cause painful and disabling injuries. Ladder hazards can be reduced before use by performing simple safety checks to ensure that (1) the ladder is in good condition, (2) the ladder has level and secure footing with nonslip feet and is supported by another worker if necessary, (3) the ladder is fully opened and is not too far from the wall, and (4) neither the rungs of the ladder nor the worker's feet are wet.

4.1.5 Summary

Falls and the lifting of patients are two of the most significant contributors to the problem of lower back injuries. Many Health care workers (HCWs), for example, nurses and radiologic technicians are required to lift heavy, even morbidly obese patients as part of their required duties.

Patients can be difficult to lift, particularly when they are uncooperative. The need to wash the floors of health care facilities frequently results in the presence of wet floors. HCWs must move swiftly to patient rooms to respond to emergency situations such as cardiopulmonary resuscitation. This requirement and the frequent presence of wet floors contribute to the incidence of falls by HCWs resulting in back injuries. Other causes of lumbosacral injury include moving equipment, pushing carts, and using chairs that are not ergonomically appropriate.

Programs to prevent back injuries must be multifaceted. The main features of a comprehensive program should include: adequate staffing, ready availability of mechanical devices for lifting and transferring patients, the training of workers regarding correct lifting procedures, and back exercise programs.

Back injury prevention efforts for nursing personnel ought to focus on those nursing jobs involving the greatest frequency of stressful patient handling. For these jobs, the most back stressing tasks should be identified. Such tasks can then be examined in detail to identity the possibilities for elimination, substitution, or control.

4.2 Heat

In a hospital, there are no large temperature extremes but there are areas where the temperature is above recommended levels. This can occur in laundries, kitchens, boiler rooms and shops, especially in older facilities that have inadequate ventilation and cooling systems. Cold rooms and walk-in freezers are low temperature environments but in hospitals, workers do not have to occupy in these facilities for extended periods of time so their exposure is minimized.

4.2.1 Potential Effects

Heat related health effects include heat stroke, heat exhaustion, heat cramps, fainting, and heat rash. Since the heart is pumping blood at a more rapid rate to try to keep the internal organs cool, this results in an increased heartbeat or a rapid pulse. If the body cannot be kept cool adequately, heat stroke, which may be fatal, may result. If the body loses an excessive amount of salt due to sweating, heat cramps or heat exhaustion may result. All of these factors may result in an illness to the employee. But in a place where an employee is doing a job that has some mechanical hazards, these could be contributing factors to other types of accident since the employee could become fatigued and might not be as attentive to his work.

4.2.2 Standards and Recommendations

If there is an area where there appears to be an excessive heat hazard, the area needs to be monitored by taking temperature readings or using a recording thermometer. A determination needs to be made as to how long the employees are allowed to remain in the stress area. A determination should also be made as to whether or not employees are able to become acclimated to the stress. NIOSH has recommended an occupational standard for workers exposed to hot environments which must be consulted to provide guidance in the control of heat related hazards.

4.2.3 Exposure Control Methods

Controlling high temperatures can be accomplished after the source of the heat stress has been determined. One method is by ventilating the area, moving the high temperature air out. This can be done through the use of fans. Another method is to use air conditioning to lower the temperature. At times, the cause of the heat stress may not be actually within the work area and so the work area can be isolated from the heat stress source by use of insulation. This is particularly true of rooms that may be next to boilers or large dryers which generate considerable heat.

Listed below are some specific steps for reducing heat stress in hospital workers exposed to hot work areas (NIOSH, 1986a; NIOSH, 1986b):

- Schedule heavy work for the coolest part of the day and allow frequent rest breaks in cool areas.
- Isolate, enclose, and/or insulate hot equipment.
- Install exhaust ventilation to draw heat or steam away from the work area.
- Install reflective shielding where appropriate.
- Provide fans to increase sweat evaporation.
- Make cool water available.
- Provide cool areas for rest breaks and lunches.
- Train workers to recognize symptoms of heat stress.
- Permit workers to become acclimatized to the hot environment.

4.3 Noise

Noise is any unwanted sound. It may not really be harmful but just undesired. However, at some level it does become harmful because of temporary or permanent hearing loss.

The hospital is actually a rather noisy environment, and there are some areas in the hospital where the noise is above a safe level for extended exposure. Some of the more common noisy places are: the boiler plant, where there are generators, and the engineering and maintenance department where there is heavy equipment. Shop areas like the plumbing and machine shop in larger hospitals may also be noisy areas although their noise level is generally intermittent. The grounds crew may be subject to high noise levels from mowing machines, chain saws and other powered equipment.

Laboratory areas which have ultrasonic scanners (devices that utilize echoes from ultrasonic waves for body tissue diagnosis) and sonicators (equipment that uses high frequency sound waves for physical therapy, cleaning, separating solid materials, etc.) have a very high noise level especially when someone is working with them.

The Intensive Care Unit is frequently a very noisy area because of all the people, and equipment that may be in use. Administrative areas or any areas where there are a large number of employees can at least be noisy enough to cause efficiency to drop. This is especially true where employees are required to maintain a high level of concentration. Exposure to noise tends to decrease the worker's concentration level.

4.3.1 Potential Effects

Noise can have psychological effects, physiological effects and can interfere with communication.

The psychological effect is when someone is startled by a sharp noise, annoyed by a continuing noise, or when concentration is disrupted by noise. This is an area where efficiency is normally lost. However, continuing noise can be so bad causing health problems similar to a mental disturbance. A noise that startles someone can be a contributing factor to an accident involving some other hazard. The Intensive Care Unit should be carefully analyzed for psychological effects of noise.

The physiological effects of noise are evident where there is an actual a loss of hearing either temporarily or permanently due to high noise level being too high. Noise may also trigger changes in cardiovascular, endocrine, neurologic, and other physiologic functions, all of which suggest a general stress reaction. A single instance of a very large noise such as an explosion in a laboratory may also cause hearing loss. Any noise level above 90 decibels (dB) for continuous periods can cause hearing loss.

Interference with communication is a hazard due to noise is probably not a health hazard unless it becomes a contributing factor to some other safety hazard. It does affect job performance if the person does not clearly understand instructions due to high noise levels. This can lead to a great loss of efficiency. Noise may also make it difficult for employees to warn others of impending danger (e.g., falling equipment or a slippery floor) or to concentrate on critical job functions. This type of noise hazard might occur in shops, office areas, or laboratories.

4.3.2 Standards and Recommendations

The OSHA occupational exposure limit for noise is 90 dB measured on the A-weighted scale (the frequency response of the human ear) as an 8 hour time-weighted average [TWA]). For more detailed information on determining and complying with the OSHA noise standard, refer to 29 CFR 1910.95.[96]

Because the noise exposure limit is time-weighted, the amount of time workers are permitted to spend in exposure areas varies according to the noise level, as follows:

Hours of exposure per workday	Permissible noise level (dBA)
8	90
6	92
4	95
3	97
2	100
1	105
0.5	110
0.25	115

4.3.3 Exposure Control Methods

A noise survey should be made by trained personnel. If a worker's noise exposure exceeds the standard, a noise abatement program is required. Such a program should include periodic noise measurement, engineering and administrative controls, providing hearing protection, and annual audiometric testing.

The goal of the hearing conservation program should be to reduce the noise level. This may mean moving the employees farther away from the equipment remembering that every time the distance doubles, the noise level is reduced by factor of four.

Engineering controls may be developed to reduce noise exposure. Examples include: shields or guards on machines enclosure of noisy equipment, and acoustical treatment of walls to reduce noise reflection. The noise level may also be decreased by reducing the time that employees are exposed to noise.

Of course, protective equipment such as ear muffs and ear plugs may be utilized if engineering or administrative controls are not feasible. However, some ear protectors are more effective than others depending on the noise level, frequency, and individual fit of the devices. Therefore, careful analysis of which protectors are effective and reasonably comfortable in a particular situation must be done.

CHAPTER 5

INFECTIOUS HAZARDS

5.1 Introduction

In recent years, hospital-acquired, or nosocomial, infections have increased at an alarming ratė among healthcare workers. The rise in occupational infections point to two factors in today's hospitals that are placing workers at high risk of exposure to pathogenic microorganisms. These factors are (1) the various kinds of occupational activities in the hospital and the way they are performed by hospital personnel and (2) the hospital environment itself.

Of course, hospitals have never been completely safe places in which to work. In spite of our detailed knowledge of the transmission and available methods of preventing and combating infections, the risk to healthcare workers of acquiring an infectious disease is high. For example, it is estimated that as many as 12,000 healthcare workers become infected with hepatitis B virus (HBV) every year, approximately 500 to 600 require hospitalization, and of these, 250 die (Hoffmann et al., 1991).

A hospital worker's risk of exposure and infection from a pathogen depends on a number of factors, such as:

- the pathogen's route of transmission,

- the pathogen's virulence (power or pathogenicity),
- the nature and location of a person's work assignments, and
- the failure of many healthcare workers to follow safety recommendations and to observe precautions, such as not recapping needles or wearing proper protective clothing that can reduce the occupational risk of pathogen exposure and infection.

5.1.1 Infections Transmission

The conditions of hospitals meet three basic requirements for the spread of infection: (1) a source of infecting organisms, (2) a susceptible host, and (3) a means of transmission for the organism. Pathogens that are of concern to healthcare workers are spread by three main routes of transmission: contact, vehicle, and airborne.

Pathogen transmission through contact is the most important and frequent means by which infections are spread in healthcare facilities. Transmission by this route can be by direct contact (between infected person and susceptible host), indirect contact (contaminated inanimate object), or droplet contact (airborne transfer of pathogens as a result of coughing, sneezing, or talking).

Vehicle transmission of diseases can be carried by food, water, drugs, or blood. Airborne transmission of pathogens occurs through the air. Organisms that are spread by this route are carried either on the residue of evaporated droplet nuclei or on dust particles and are dispersed widely in the environment before making contact with a susceptible host.

5.1.2 Common Pathogens Involved in Occupational Exposure

Healthcare workers are at risk of exposure to many kinds of pathogenic viruses besides the human immunodeficiency virus (HIV) and the hepatitis B virus (HBV). Some of the viruses and their associated diseases are listed on Table 5-1.

5.2 Infection Control Program

A hospital's main means of defense against the spread on disease within its facilities is a well-designed and efficiently run infection control program (ICP). ICP's typically consist of isolation precautions, hospital-wide infection control procedures, employee health programs, and medical surveillance.

5.2.1 Isolation Precautions

These infection control measures involve isolating patients with certain types of infectious diseases from uninfected patients by placing them in rooms by themselves or with other patients who have the same disease and by restricting traffic to their rooms.

Other measures include issuing instructions on what kind of precautions to take when attending to the infected patient (e.g., wearing protective clothing or gloves) and

Table 5-1 Pathogenic Viruses and Associated Diseases. (Anderson, 1991)

Virus	**Associated Disease**
Hepatitis A virus	Acute febrile illness with jaundice
Hepatitis C virus	Acute viral hepatitis
Measles virus	Measles
Rubella virus	Rubella
Rabies virus	Rabies
Cytomegalovirus	Pneumonia and retinitis,
Influenza virus	Influenza (flu)
Rhinovirus	Mild respiratory tract infections
Parvovirus B19	Erythema infectiosum, chronic anemia, and fetal death
Enteroviruses	Respiratory tract and/or gastrointestinal infections
Rotavirus	Gastroenteritis
Mycobacterium Tuberculosis	Tuberculosis
Bordetella pertussis	Pertussis
Corynebacterium diphtheriae	Diphtheriae

engineering controls that should be used to prevent the pathogen from spreading to other hospital areas (e.g., keeping the air pressure in the isolation room lower than the air pressure outside the room in cases of tuberculosis).

5.2.2 Hospital Wide Infection Control Procedures

These include measures such as using universal precautions (UP), which require healthcare workers to treat blood and certain blood-contaminated body fluids of every patient as potentially infected with a bloodborne pathogen (e.g., the use of personal protective equipment in situations in which there is a likelihood of exposure to blood). There should also be a written exposure control plan in accordance with Occupational Exposure to Bloodborne Pathogens Standard (29 CFR 1910.1030). Other control procedures used are listed in Figure 5-1.

5.2.3 Employee Health Programs

According to the CDC's Guideline for Infection Control in Hospital Personnel,[12] the basic elements of infection control that should be incorporated into an employee health program are listed in Figure 5-2.

5.2.4 Medical Surveillance

Medical surveillance of healthcare workers is the systematic collection and evaluation of employee health data for the purpose of diagnosing specific incidents of illness and of

1.	A "no recapping needles" policy.
2.	Sharps disposal units in all patient rooms.
3.	A standard system of infection control methods and techniques, such as guidelines for handwashing, the use of gloves and other forms of PPE, and the proper handling of infectious laboratory specimens.
4.	A system for promptly reporting exposure incidents to the proper inspection control administrators.
5.	Training and educational programs on nosocomial infections procedures, and isolation precautions.
6.	An established body of work restrictions for infectious personnel.

Figure 5-1 Hospital Wide Infection Control Procedures. (CDC, 1990)

1.	Preemployment placement evaluations.
2.	Personnel health and safety education.
3.	An employee immunization program.
4.	Protocol for surveillance and management of job related illnesses and exposures to infectious diseases.
5.	Preplacement medical screening and periodic health status evaluation of personnel.
6.	Medical treatment, and follow up examinations after exposure to certain pathogens.
7.	Recommendations for work restrictions or work exclusion for ill employees who might be infectious.
8.	Counseling services for personnel regarding infection risks related to employment or special conditions (e.g., counseling pregnant women about potential health hazards to their fetuses).
9.	Maintenance of employee health records.

Figure 5-2 Employee Health Program. (CDC, 1990)

identifying occupational infection trends that indicate an adverse health effect from exposure to a hazard in the workplace. Medical surveillance data can be used to formulate strategies for reducing exposure to the threat.

Surveillance data from follow-up employee health examination can monitor the effectiveness of exposure-control efforts. Medical surveillance can also identify healthcare workers who are not immune to certain diseases, and, thus, at risk of infection if exposed to them. The technique also recommends special measures to protect these persons from infection (e.g., immunization injection, offering relocation to another position, if possible).

The validity and usefulness of medical surveillance in an ICP, depends on how successful the individual healthcare facility is in handling the concerns of its employees about the consequences of reporting certain types of infections.

Therefore, medical surveillance is vital part of a hospital ICP because it acts to catch illness early, to reduce the severity of individual cases of illness, and to prevent disease from spreading to other workers and patients.

5.3 Bloodborne Pathogens

While healthcare facilities are allowed some freedom as to which features to include in their ICPs, the OSHA's Occupational Exposure to Bloodborne Pathogens Standard, 29 CFR 1910.1030,[102] mandates some elements to be present in the program.

HIV and HBV are the two most widely known which are transmitted through occupational exposure to blood and other body fluids. Other diseases referenced by OSHA in the standard and thus covered by the bloodborne pathogen standard include hepatitis C, arboviral infections, babesiosis, brucellosis, Creutzfeldt-Jakob disease, human T-lymphotropic virus type I, leptospirosis, malaria, relapsing fever, syphilis, and viral hemorrhagic fever. These diseases are seen with varying frequency in hospitals and present far less risk to healthcare workers than HIV or HBV.

HBV, HIV and other pathogens may be present in various common places in the healthcare environment:

- Body fluids such as saliva, semen, vaginal secretions, cerebrospinal fluid, synovial fluid, pleural fluid, peritoneal fluid, pericardial fluid, amniotic fluid, and any other body fluids visibly contaminated with blood.
- Saliva and blood contacted during dental procedures.
- Unfixed tissue or organs other than intact skin from living or dead humans.
- Cell, tissue or organ cultures that contain HIV or HBV.
- Blood, organs and tissues from experimental animals infected with HIV or HBV.

Bloodborne pathogens may enter the body and infect through variety of means including:

- An accidental injury by a sharp (e.g., needles, scalpels, broken glass, exposed ends of dental wires) object contaminated with infectious material.

- Open cuts, skin abrasions, dermatitis and acne, as well as the mucous membranes of the mouth, eyes or nose.
- Indirect transmission, such as touching a contaminated object or surface and transferring the infectious material to your mouth, eyes, nose or open skin.
- Contaminated environmental surfaces are a major mode of HBV spread in certain settings, particularly hemodialysis units. HBV can survive on environmental surfaces dried and at room temperatures for up to one week or greater. Surfaces and objects can be heavily contaminated by substances, such as serum or plasma, without visible signs.

Appendix D contains the primary categories of control measures to be taken to reduce the risk of exposure as detailed by OSHA's Occupational Exposure to Bloodborne Pathogens Standard (29 CFR 1910.1030).[102]

5.3.1 Modes and Risk of Transmission

Although the potential for HBV transmission is greater than for HIV in the workplace setting, the modes of transmission for these two viruses are similar. Both have been transmitted in occupational settings by percutaneous inoculation or contact with an open wound, nonintact skin (e.g., chapped, abraded, weeping, or dermatitis), or mucous membranes to blood, blood-contaminated body fluids, or concentrated virus. Blood is the single most important source of HIV and HBV in the workplace setting. Therefore, protective measures against HIV and HBV for workers should focus primarily on preventing these types of exposures to blood as well as delivery of HBV vaccination.

The risk of hepatitis B infection following a parenteral exposure to blood (i.e., needle stick or cut) is directly proportional to the probability that the blood contains hepatitis B surface antigen (HBsAg), the immunity status of recipient, and the efficiency of transmission. Of those persons who have not had prior hepatitis B vaccinations or postexposure prophylaxis, 6%-30% who experience a needle-stick exposure from an HBsAg positive individual will become infected.

The risk of infection for HIV following one needle-stick exposure to blood from a patient known to be infected with HIV is approximately 0.3%-0.4%. This rate of transmission is considerably lower than that for HBV, probably as a result of the significantly lower concentrations of virus in the blood of HIV infected persons. Though inadequately quantified, the risk from exposure of nonintact skin or mucous membranes is likely to be far less than that from percutaneous inoculation.

5.3.2 HBV

Among healthcare workers, the number of new HBV infections ranges from 6,000 to 12,000 per year. Infection occurs primarily in young adults, of whom 6% to 10% become chronic carriers; also 250 healthcare workers die each year from the effects of HBV. Healthcare workers who frequently contact blood, for example, pathologists, phlebotomists (persons who draw blood), surgeons, and emergency room personnel are at greatest risk. Emergency medical workers have an increased risk for hepatitis B infections. The degree of risk correlates with the frequency and extent of blood exposure during the conduct of work activities.

Occupational transmission of HBV can occur in a number of different ways. Needlestick transmission is probably the most important route. Transmission through contamination of mucous membranes is also possible. Mouth pipetting in the laboratory setting can lead to HBV transmission. "Splash conjunctivitis," blood splashed into the eye, can occur in the surgical environment and may result in the transmission of HBV.

The incubation period for hepatitis B ranges from 45 to 160 days, with an average of 120 days. It is an especially insidious disease because the majority of infected people remain permanently asymptomatic. Yet even without symptoms, infected people can transmit HBV through close contact because it is found in blood, saliva, and semen.

Because it is present in blood, HBV is transmitted through needlesticks. HBV is more resistant to inactivation than HIV and can remain active in dried blood for at least a week at room temperature on environmental surfaces such as counter tops and door knobs.

5.3.2.1 Diseases Resulting from HBV

Fulminant hepatitis. This massive and fatal infection destroys a significant portion of the liver.

Acute hepatitis. Within two to six months, infected people can develop acute hepatitis, which causes liver damage and is associated with abdominal pain, nausea, jaundice, and other symptoms. About half of all infected people will develop acute disease.

Chronic hepatitis. While almost all people recover completely from acute hepatitis, some become chronically infected. Some chronic carriers experience no deficiencies from the disease. Others suffer from chronic persistent hepatitis, which is characterized by fatigue in mild cases and by cirrhosis of the liver in serious cases.

Hepatocellular carcinoma. This is a liver cancer, the most serious outcome of chronic hepatitis.

5.3.2.2 Vaccination for HBV

A safe and effective vaccine to prevent hepatitis B has been available since 1982. Vaccination has been recommended for healthcare workers regularly exposed to blood and other body fluids potentially contaminated with HBV.

The vaccine stimulate active immunity against HBV infection and provide over 90% protection against hepatitis B for up to seven or more years following vaccination. Hepatitis B vaccines are also 70-88% effective when given within one week after HBV exposure.

Hepatitis B immune globulin (HBIG), a preparation of immunoglobulin with high levels of antibodies for HBV (anti-HBs), provides temporary passive protection following exposure to HBV. Concommitant treatment with hepatitis B vaccine and HBIG is over 90% effective in preventing hepatitis B following an exposure.

5.3.3 HIV

The occupational transmission of HIV is probably the most feared nosocomial infection of healthcare workers. Accidental needlestick transmission has been responsible for the majority of documented cases of occupationally acquired HIV infection. Rare cases are also believed to be transmitted through nonintact skin or possible mucous membrane exposure (Gerbert et al., 1988).

An effective vaccine for HIV is not yet available and is not anticipated in the near future. Therefore, the prevention of occupational transmission of HIV must depend on preventing exposure of workers to HIV. This entails measures to preclude needlestick injuries and the use of appropriate barrier precautions that also prevent the occupational transmission of other viruses in blood or other body fluids.

5.4 The Risk and Prevention of Needlestick Injuries

According to the CDC, needlestick injuries account for 80% of reported occupational HIV exposures, which can lead to

AIDS. Although the fear of contracting AIDS has overshadowed the concern about acquiring the HBV through an accidental needlestick, the risk of acquiring HBV is much greater. However, the risk of dying from AIDS is much greater than of HBV.

Accidental needlesticks occur frequently. As one physician noted, "Rarely a day goes by in any large hospital where a needlestick incident is not reported" (Roberts, 1987). Physicians, nurses, clinical laboratory technicians, pharmacy personnel, housekeeping staff, waste handlers, and all other healthcare workers who may be exposed to patients' blood or body fluids are at risk.

5.4.1 Sources of Risk

A number of clinical procedures and housekeeping activities carry an increased risk of needlestick injuries, including (1) disposing of or recapping used needles, (2) drawing blood, (3) administering parenteral medications, and (4) collecting linens and trash.

In one study of 316 reported needlesticks disposing of needles accounted for 24% of injuries; recapping needles, 12%; administering parenteral medications, 21%; drawing blood, 17%; and collecting linens and trash, 16% (McCormick and Maki, 1981).

In another study of 286 reported needlesticks, drawing blood constituted the highest risk, 21%; followed by recapping or corking needles, 18%; handling trash, 16%; and giving injections or infusions, 15%. Interestingly, injuries from needles poking out of overfilled needle disposal containers, which are designed to protect workers from accidental sticks, constituted only 8.5% of the total injuries (Neuberger et al., 1984).

5.4.2 Methods of Prevention

First and foremost, those healthcare workers at high or moderate risk should receive the hepatitis B vaccine, all healthcare workers should follow universal precautions, and healthcare workers who sustain needlestick injuries should report them in accordance with hospital policies and procedures.

Several methods for reducing the incidence of needlestick injuries are available. These include: (1) increased education and training of all hospital personnel who come into contact with used (potentially contaminated) needles, (2) a proposed OSHA ban on traditional recapping by the two-handed technique, (3) appropriate use of needle and syringe disposal containers, and (4) the use of needlestick prevention devices.

5.4.2.1 Education and Training

Properly educating employees about the importance of the following universal precautions is essential in minimizing needlestick occurrences using approved disposal methods, including recommended impervious disposal containers; prompt emptying of disposal containers before they overflow; and using preventive devices.

Educational efforts should be directed toward physicians, nursing personnel, clinical laboratory technicians, and the housekeeping staff. Special efforts should be made to educate part-time personnel on all three shifts, as well as personnel with less than one year's experience, because these groups appear to be at greater risk for needlesticks (Neuberger et al., 1984). Educating healthcare workers about the importance of receiving the hepatitis B vaccine is also important.

An effective educational program to prevent needlestick injuries should:

- Explain the hazards and risks associated with bloodborne pathogens.
- Stress policies on needle use and disposal.
- Describe the steps for reporting and following up on a needlestick injury, should one occur.
- Provide the necessary training on any specific needlestick prevention devices used.

5.4.2.2 The Needle Recapping

In its latest proposal recommendations on prevention of HIV transmission in healthcare settings, OSHA states: "Needles shall not be recapped (by the traditional two-handed technique), purposely bent or broken by hand, removed from disposable syringes, or otherwise manipulated by hand.

Resheathing instruments, self-sheathing needles, or forceps shall be used to prevent recapping needles by hand"[14].

Numerous studies show recapping to be the cause of a significant portion of all needlestick injuries (Edmond et al., 1988). According to a recent study performed at four large teaching hospitals, the percentage of injuries resulting from needle recapping was greater than 25%, and exceeded 50% in four instances (Becker et al., 1990).

The reasons for recapping were listed as inadequate knowledge (i.e., the misperception that recapping is a way to avoid needlesticks), concerns about personal risk, forgetfulness, and being too busy to follow universal precautions.

Problems with recapping underscore the need for proper training. In one study, the rate of needle recapping used with venipuncture and for percutaneous medication injections fell from 61% to 16%. In this one year period, an educational program was developed that showed encouraging results for the reported rate of needle recapping to employees (Ribner and Ribner, 1990). In addition to such preventive measures as thorough education and training and the use of preventive devices, proper disposal techniques must be used.

5.4.2.3 Sharps Disposal

Needle disposal systems must be properly labeled and stand out as infectious waste disposal containers. Some disposal systems are visually attractive and may be confused as a noninfectious unit (e.g., a towel dispenser).

In addition to ensuring that the system is easy to use and that containers are sturdy, it is important that the disposal container be located in all patients' rooms and other areas where needles are used and that a maintenance schedule that precludes overfilling be established. Staff responsible for replacing containers should be clearly identified (e.g., nursing, housekeeping), and a mechanism for recognizing, reporting, and correcting any container hazards that may arise should be in place.

5.4.2.4 Preventive Devices

Some of the devices currently being used based on their intended purposes for needlestick prevention are as follows:

- Needleless medication/vaccine injectors
- Prefilled medication system
- IV starters with catheters
- IV medication connectors
- Blood collection systems
- Disposable syringes
- Needle guards
- Needle recapping devices

These devices should be reviewed and assessed for their ease of use and effectiveness in preventing needlestick injuries in various applications before relying on them to reduce the needlestick risk.

5.5 Tuberculosis

5.5.1 Introduction

Tuberculosis (TB) is an airborne bacillus from which health care workers are at risk. Until recently, TB was no longer considered a serious health concern, but it again poses a major threat. Furthermore, multidrug-resistant (MDR) strains of TB have emerged, strains that do not respond to the usual course of drug therapy. Serious outbreaks of MDR-TB have occurred recently at health care facilities in several major cities, endangering the health of patients and workers alike.

5.5.2 Infection and Transmission

Mycobacterium tuberculosis can infect many parts of the body. However, it is generally thought of as an infection of the lungs transmitted from person to person through airborne particles known as droplet nuclei. These droplet nuclei are exhaled when a person with pulmonary or laryngeal tuberculosis sneezes, coughs, speaks, or sings. Although rare, infection can be caused by direct contact with tuberculosis-infected blood and inanimate objects (e.g., bed linens, chairs, sinks) that can harbor infectious organisms.

Infectious droplet nuclei of M. tuberculosis are approximately one to five micrometer (microns) is size, which are so small that normal air currents can keep them airborne long enough to spread through a room or building.

Infection occurs when a susceptible person inhales the droplets and the bacilli begin to grow in the small airways or alveoli of the lungs.

5.5.3 Healthcare Workers at Risk

Healthcare workers who are at the greatest risk of exposure to tuberculosis include:

- patient care workers who are in direct personal contact with infectious patients;
- workers who perform high-risk procedures, such as bronchoscopy, endotracheal intubation, suctioning with mechanical ventilation, open abscess irrigation, and autopsies;
- workers who are present at or assist in procedures involving sputum induction and aerosol treatments (e.g., pentamidine therapy); and
- workers in areas where patients with tuberculosis are provided care before diagnosis (e.g., clinic waiting rooms, emergency rooms) or in areas where diagnostic or treatment procedures that induce coughing are performed.

5.5.4 Prevention and Control

As a reflection of this urgency, the Centers for Disease Control and Prevevention (CDC) has recommended the following approaches to prevent tuberculosis in healthcare facilities:

- Early identification and treatment of persons with tuberculosis infection and active tuberculosis.

- Application of source control methods to prevent the spread of infectious droplet nuclei into the general air circulation.
- Reduction in the concentration of infected droplet nuclei in air.
- Decontamination: cleaning, disinfecting, and sterilizing.
- Surveillance of healthcare personnel for active tuberculosis and inactive tubercular infections.

The first guidelines are aimed at preventing the generation of droplet nuclei in patients with active TB. Identification of patients with active disease is accomplished by means of clinical assessment, selected diagnostic testing, skin testing, and laboratory identification of M. Tuberculosis. Patients with suspected or diagnosed TB should be isolated promptly to prevent spread of disease and placed on appropriate anti-TB therapy to cure them and decrease their infectivity. Patients without symptoms of TB but with increased risk for developing TB should be screened by skin testing. Patients with a history of a positive skin test, recent conversion to skin-test positive, or documented recent exposure to an individual with TB should be evaluated and considered for preventive therapy.

The second set of recommendations encompasses source-control methods for the capture of droplet nuclei on emission from the infectious patient. One class of devices for this purpose includes disposable particulate respirators and face masks worn by patients. Since these devices cannot be worn constantly by patients, their use is generally limited to special situations, such as patient transport within the hospital or between facilities. Another method, local exhaust ventilation, is limited to small enclosures such as rooms or booths used for sputum induction and administration of aerosolized medications. Ensuring that patients capture respiratory droplets with paper tissues while coughing and sneezing is a simple but effective method for minimizing the spread of droplet nuclei. However, the hand must be in the right place at the right time, which requires interest and cooperation from the patient. The old maxim "cover your coughs" is desirable, but usually inadequate.

The third set of methods is intended to reduce microbial contamination of ambient air on a large scale and involves considerable planning and cost. Properly designed ventilation systems include negative air pressure in areas where patients with active TB reside, dilution of contaminated air by fresh air exchange, and removal of contaminated air directly to the outside. An alternative approach recirculates ambient air through high-efficiency particulate air (HEPA) filters to remove minute particles (0.3 microns) which should theoretically remove airborne mycobacteria. The efficacy of ultraviolet irradiation for reducing contamination of air by mycobacteria, although controversial, is recommended as a supplemental method based both on theory and experimental findings.

Use of face masks and particulate respirators by personnel in proximity to infectious patients is also recommended with the caution that not all face masks offer a tight seal and are able to filter out particles in the critical range of 1 to 5 microns.

The recommendations also consider the need for decontamination of objects and surfaces in healthcare facilities. Only implements that penetrate skin and mucosal surfaces of patients need be sterilized. For implements that do not penetrate yet come into close contact with mucosal surfaces, such as laryngoscopes, sterilization is preferred but thorough chemical disinfection and mechanical cleaning is usually sufficient. Objects that only touch intact skin should be cleaned with detergent.

The CDC also recommends that each health care organization have a comprehensive program for preventing transmission of TB in the workplace. These programs should include active surveillance of personnel for infection with M. Tuberculosis as determined by skin test. Skin testing at the time of employment and subsequent periodic and postexposure testing of skin-test-negative personnel is recommended.

Clinical and radiographic evaluation of personnel who were skin-test negative but recently converted to skin-test positive is recommended. These individuals should be considered for preventive therapy and periodically evaluated for active TB. Since personnel with active TB are a source for transmission of the disease to patients and other personnel, they should only return to work after receiving appropriate therapy and found to be noninfectious.

5.5.4.1 Respiratory Protection

In most cases, respiratory protection from hazards is preferred only when engineering controls are unfeasible or inadequate. However, in the case of tuberculosis, local engineering controls, such as enclosures or hoods, are not feasible. Therefore, respirators provide the best protection.

Room ventilation and UV lights, no matter how efficient, do not ensure that room air breathed by personnel is free of infectious droplet nuclei.

Placing a barrier between the worker and bacilli is more effective than relying on the chance that the bacilli will be killed by environmental controls on their path from the TB patient to the healthcare worker.

There are two types of respirators available: reusable cartridge and disposable. The most important consideration with either type is the filter. The hospitals must provide respirators with high-efficiency particulate air (HEPA) filters. For National Institute for Occupational Safety and Health (NIOSH) certification, a HEPA filter must prove to be 99.97% effective for particles as small as 0.3 microns in diameter, which put them well within the droplet nuclei range of one to five microns. Non-HEPA particulate respirators, commonly called "dust and mist" respirators, are effective for particles down to approximately two microns. Because TB bacilli are approximately 0.4 to 0.6 micron in diameter and because droplet nuclei vary from one to five microns, HEPA filtration is the best protection available. Anything less would constitute an unacceptable risk for healthcare workers.

The choice between disposable and reusable respirators is clouded by cost and performance variables. Disposable HEPA respirators are fairly expensive. They would quickly add up to a significant investment if only one per day were provided to each worker exposed to patients with active TB. Disposable respirators are also almost impossible to fit test for leaks whereas reusable cartridge respirators can be fit tested.

If reusable respirators are chosen, each worker should be provided with his or her own respirator, which should not be used by anyone else. Each wearer must be fit tested and trained in respirator use and maintenance according to the Occupational Safety and Health Administration's Respiratory Protection Standard, 29 CFR 1910.134.[101] In addition, individuals who wear respirators must be medically cleared to do so in accordance with 29 CFR 1910.134. In the long run, reusable respirators might prove to be more expensive because cartridges should be replaced daily.

5.5.4.2 Engineering Controls

5.5.4.2.1 Hospital Ventilation System

Several important components of ventilation system design that assist in TB infection control should be considered.

Negatively pressurized isolation rooms. Negative pressurization should be provided in isolation rooms where persons known to carry, or suspected of carrying active TB are housed.

Positively pressurized rooms. Positive pressurization should be provided in isolation rooms where AIDS patients and other immunocompromised patients are housed to protect these patients from both identified and unidentified active TB carriers.

For both types of isolation rooms (negatively and positively pressurized), isolation room doors and alcove doors must be kept closed if room pressurization is to be effective in controlling the transportation of TB bacteria into or out of the isolation rooms.

Waiting areas. High air exchange rates and negative pressurization should be provided in hospital spaces where immunocompromised persons and persons with active TB might unknowingly be held in close proximity. These spaces commonly include laboratories, radiology, emergency rooms, and respiratory therapy waiting areas.

Procedure rooms. Negative pressurization and high air exchange rates should be provided in rooms where bronchoscopy, administration of aerosolized pentamidine, sputum induction, or other procedures inducing coughing or otherwise causing the release of large quantities of pulmonary fluids are conducted.

5.5.4.2.2 Additional Controls

Successful construction and maintenance of standard ventilation systems can assist in effective TB infection control. However, standard ventilation systems are not the only tool for controlling the movement of airborne TB bacteria in hospitals. Other tools are available to complement and, in some instances, replace standard ventilation systems.

High-Efficiency Particulate Air (HEPA) filters. For waiting or holding areas, HEPA filters can be used to clean and recycle air rather than exhausting the air outdoors. HEPA filters should not be used for recycling air from negatively pressurized isolation rooms or from procedure rooms. Also, because of high initial air-pressure drop and rapid loading, HEPA filters are best applied at the central fan system, not on system branches.

Germicidal ultraviolet lamps. UV lamps are used in surface mounted fixtures on the upper walls and/or ceilings of occupied spaces in high risk areas to kill airborne TB bacteria. UV lamps are also used inside ducts to disinfect the air before the air discharge outdoors or recirculate indoors. The CDC recommends that UV lamps be applied as a supplement to ventilation systems.

<u>Control booths</u>. Control booths are available for administering aerosolized pentamidine and for conducting sputum induction and related procedures to patients alone in these booths. Control booths provide efficient local capture of airborne contaminants. These control booths typically exhaust air directly outdoors or filter and recycle the air through HEPA filters. Control booths provide a greater degree of protection to health care workers administering high-risk procedures than do procedure rooms equipped with engineered ventilation and/or UV lamps because the health care workers do not enter these booths.

5.5.5 OSHA Develops Pilot TB Control Guidelines

The Occupational Safety and Health Administration (OSHA) has developed a pilot program designed to protect health care workers from exposure to TB. This program is currently effective in OSHA Region II, which includes New York, New Jersey, Puerto Rico, and Virgin Islands. The OSHA Region II guidelines cover employee training, skin testing, appropriate isolation techniques, patient transport requirements, record keeping, warning signs and labels.

In the face of recent outbreaks of TB, including a multi-drug resistant strain of the disease at hospitals in Atlanta, Miami, New York City and New Jersey, OSHA has issued agency wide enforcement policy guidance on workplace exposure to the bacteria. Five healthcare workers have died from TB, 16 have developed active multi-drug-resistant TB, and at least several hundred workplace originated cases have occurred nationwide, according to the OSHA's enforcement guidelines for occupational exposure to tuberculosis.[77]

OSHA's guidance, modeled after the CDC 1990 guidelines for preventing TB transmission in healthcare settings, is effective immediately including respiratory requirements. The guidance remains in effect until OSHA issues a more formal compliance directive based on CDC's revision of its guidelines, which is expected in late 1994.

5.5.5.1 OSHA's TB Control Methods

OSHA describes the following examples of feasible and useful abatement methods. The failure to use any of these methods is likely to result in the continued existence of a serious hazard and may, therefore, allow citation.

Medical screening. All employees in the facilities covered must be offered the Mantoux skin test free of charge and at a convenient time and place.

Work removal. When an employee is found to have current pulmonary or laryngeal TB, he or she should be excluded from work until adequate treatment is instituted, the cough resolved, and a physician certifies that the person is no longer infectious.

Training and education. Employees should be thoroughly trained regarding the hazards and control of tuberculosis. At a minimum, the following subjects should be discussed:

- Cause and transmission of TB;

- Definition of "infectious";
- Distinction between TB disease and TB infection;
- Purpose and interpretation of TB skin testing;
- Signs and symptoms of TB;
- Reporting and purpose of preventive therapy;
- Risk factors for TB disease development;
- Origin and prognosis of MDR-TB;
- Purpose of surveillance, and the recommended follow-up;
- Treatment of TB; and
- Site-specific protocols.

Training for employees should also include, if applicable,

- Purpose, proper selection, fit, use, and limitations of personal protective equipment;
- Engineering controls in use in the employee's work area; and
- The critical role directly observed therapy plays in preventing the emergence of multidrug-resistant strains of TB.

This training should be given to all employees in covered facilities upon initial employment and should be repeated annually thereafter.

Respiratory isolation. All covered facilities providing health care services to confirmed, infectious TB patients must keep these patients in pulmonary isolation rooms. The pulmonary isolation room must be under negative pressure and its air must be exhausted to the outside away from intake vents, and people. If venting directly to the outside is not possible, the air must be exhausted through properly designed, installed, and maintained high-efficiency particulate air (HEPA) filters.

Warning signs should be posted outside the room, stating "pulmonary isolation," "special respiratory isolation," or "AFB (acid-fast bacilli) isolation." The signs should also state what special precautions are required.

Transport of TB patients. Whenever an infectious TB patient is to be transported, the patient should be evaluated to determine if it is medically feasible for the patient to be fitted with an appropriate respirator. If feasible, the employee doing the transporting should ask the patient to wear a particulate respirator during the entire movement period. The employee transporting the patient should wear a dust, mist, and fume (DMF) respirator.

OSHA also supports the CDC's recommendation that employees wear DMF respirators or any more effective respiratory protection certified by NIOSH during certain high-risk situations, such as administration of aerosolized pentamidine. The use respirators is emphasized as a last resort, and would require respirator training under 29 CFR 1910.134.

5.5.6 Summary

Exposure to TB in hospital settings can be a serious health risk to health care workers, patients, and even visitors. To help control the threat of exposure, the hospital should ensure that proper ventilation is installed and maintained, especially in certain high risk areas. In addition, other tools such as HEPA filters, UV lamps, and control booths should be considered. Other elements of an effective TB infection control program must include the following:

- Early identification and treatment of persons with TB infections and persons with active TB;
- Staff training and education; and
- Use of particulate respirators.

The primary goal is protection of all patients and workers from transmission of tuberculosis. A general strategy for attaining this goal is provided in Figure 5.3.

Education should be provided for health care workers and patients regarding the risks of TB and its mode of transmission.
Current CDC recommendations should be implemented in full.
Environmental and engineering controls should be in place in all health care settings, including outpatient areas. There should be active dialogue between infection control practitioners and hospital engineers to ensure that these controls are effective.
Aerosolized Pentamidine treatments should be performed in designated treatment center equipped with adequate protection against fresh aerosolized secretions. Patients receiving these treatments should be screened before treatments are initiated. Screening should include a medical history, Mantoux skin test, and/or chest x-ray.
Tuberculin skin tests should be given to all new health care employees and to those whose tests have previously been negative or who cannot document a previous positive reaction. Employees in high-risk areas should be tested at least every six months.
Basic infection control should be practiced by all members of the health care team. Workers should strictly adhere to and remain aware that it is the undiagnosed patient who puts employees at risk.

Figure 5.3 A Strategy for Preventing TB Transmission. (JCAHO, 1993)

CHAPTER 6

PHARMACEUTICAL HAZARDS

6.1 Aerosol Pentamidine

6.1.1 Introduction and Risk

Pentamidine is a drug administered in aerosol form to acquired immune deficiency syndrome (AIDS) patients as prophylaxis against Pneumocystis Carinii Pneumonia (PCP), the leading cause of death for such patients.

Pentamidine was originally developed to fight PCP through intravenous (IV) administration and is still administered intravenously to patients with active PCP. Aerosol pentamidine is administered through a nebulizer, a device which produces an inhalable spray. When patients receiving the medication remove the nebulizer from their mouths to cough, the drug becomes airborne because the nebulizer continues producing aerosols.

From an occupational standpoint, pentamidine presents a twofold risk. First, the drug itself is a respiratory irritant, and exposure to it may have potential, long term consequences. Second, evidence compiled by CDC and other sources indicates that working in pentamidine therapy areas presents a high risk of exposure to infectious respiratory pathogens, especially Mycobacterium tuberculosis.

Montgomery et al., (1990) attempted to evaluate occupational exposure levels. This study indicated an average exposure dose which was very small compared to that received by the patients. Yet there is fear of teratogenic and mutagenic effects because pentamidine has a long tissue half life.

The CDC, in 1989, reported or an investigation which suggested that pentamidine administration was the circumstance that led to positive tuberculin skin tests in thirty healthcare workers at a Florida clinic. The risks to healthcare personnel should therefore, not be underestimated.

Thus, it is not surprising, that the CDC concluded: "Health care workers and patients may be at risk for exposure to TB in settings where cough inducing procedures, such as aerosolized administration of medications, sputum induction, and bronchoscopy, are performed on patents with TB. Before beginning aerosolized pentamidine therapy, patents should be evaluated for the presence of potentially infectious TB with a chest radiography and sputum smears. Any patient suspected of having potentially infectious TB should be started on anti-TB therapy before starting aerosolized pentamidine treatment" (CDC, 1989).

6.1.2 Symptoms

Despite evidence of only small concentrations, the continued reports from healthcare employees of irritation symptoms occurring during or after administration of aerosol pentamidine must be examined carefully. Some of the symptoms of exposure to aerosol pentamidine include:

- moderate to severe chest tightness;
- wheezing, coughing, sneezing, and burning eyes;
- shortness of breath with exertion;
- mild to moderate eye, nose, and throat irritation;
- increased mucous discharge and stuffy nose;
- fatigue, headaches, and lightheadedness; and
- a bitter metallic taste.

One exposed employee was hospitalized on two occasions with severe, acute asthmatic bronchitis (Cal/OSHA, 1990).

6.1.3 Engineering Controls

It is good practice to give engineering controls priority over personal protective equipment. Hospitals must employ engineering controls for administering aerosol pentamidine to prevent exposure to the drug and to help reduce the risk of TB infection.

6.1.3.1 Isolation Booths

The best pentamidine control technology is the exhausted isolation booth, which contains aerosols and filters exhausted air through a high-efficiency particulated air (HEPA) filter. Some booths may also contain ultraviolet (UV) light for disinfecting exhaust air. However, it is also a good idea to rely on respirators for additional protection against TB infection.

The hospital must require the following minimum requirements for its isolation booths:

- The booth should have no bare wood. Pentamidine administration generates a relatively large amount of moisture, which can quickly rot bare wood.
- The booth should have a HEPA filter in its exhaust air train.
- UV disinfection lamps may be used to supplement HEPA filtration. UV lamps should be shielded to protect the patient from harmful radiation.
- Fully enclosed booths must contain a fresh air intake port.
- In fully enclosed booths, the exhaust air fan should be of sufficient size to provide at least ten air changes per hour for the size of the enclosure.
- A fully enclosed booth should have an access port through which respiratory therapists and nurses can aid patients without having to enter the booth.
- A fully enclosed booth should have a transparent panel through which the patient is visible at all times.
- The booth should be comfortable for the patient.
- The booth should be easy to clean and disinfect. The sides and floor should be washable.

6.1.3.2 Automatic Cutoff Switches

Automatic cutoff switches are not an alternative to isolation booths. However, they can provide a convenient way to reduce air concentrations and conserve medication. Some hospitals may already have installed patient controlled thumb switches. However, patients complain that cutting off the nebulizer increases the time of treatment because they need to wait for nebulizer pressure to build up again. A better way may be the installation of pressure switches in the nebulizer mouthpieces to deactivate the pump automatically on removal from the patient's mouth.

6.1.4 Guidelines for Protecting Workers

Two states, Massachusetts and California, have taken the lead in establishing guidelines for protecting workers from administration of aerosol pentamidine. Unlike most other guidelines, Cal/OSHA's are enforceable by citation and fine. Based on the inspection of several facilities where healthcare workers reported exposure effects, Cal/OSHA cited for the following reasons:

- Inadequate room ventilation;
- Side by side patient chairs (up to eight);
- Aerosolized pentamidine mist being released from mouthpieces when removed due to coughing attack;
- The necessity for close patient observation requiring close patient-healthcare worker proximity during treatment;
- No healthcare worker eye protection, respirators, or other personal protection items available; and
- Inadequate preemployment and periodic medical screening of healthcare workers.

These are various factors which must be evaluated carefully in order to reduce exposure of aerosol pentamidine. In the absence of guidelines, and until CDC and/or OSHA guidelines are released, hospitals would be prudent to follow steps outlined in Figure 6.1.

6.2 Antineoplastic Drugs

6.2.1 Introduction

Antineoplastic drugs have been used in chemotherapy treatment for many years. They act to inhibit the proliferation of malignant cells by disrupting the cancer cell cycle and killing actively growing cells, while causing as little harm as possible to normal body cells. The toxic characteristics of these drugs, which allow them to be effective in destroying malignant cells, are the very characteristics that pose a risk for those handling or exposed to antineoplastic agents. But for the thousands of healthcare workers (physicians, nurses, and housekeepers) who must have regular contact with antineoplastic drugs, handling these drugs poses a potential health risk.

6.2.2 Potential Risk

The degree of risk to healthcare workers handling chemotherapeutic agents results from a combination of the drug's toxicity and the extent to which workers are exposed to it while carrying out their responsibilities. Other

1. Ensure that Cal/OSHA and/or Massachusetts guidelines are reviewed by the infection control committee, pharmacy, and respiratory therapy department.
2. Ensure that the respiratory therapy department adopts policies and procedures for the safe use of aerosol pentamidine.
3. Ensure adequate staff education on the safe use and administration of aerosol pentamidine.
4. Immediately implement a TB screening program for all PCP patients, including those already undergoing pentamidine therapy. There is simply no reason to delay testing.
5. Treat and resolve all TB problems before administering aerosol pentamidine.
6. Make sure that all isolation booths meet the minimum requirements.

Figure 6.1 Steps for Reducing Exposure to Aerosol Pentamidine (Cal/OSHA, 1990)

factors may include: genetic susceptibility, dietary and smoking habits, and the route of exposure (usually through inhalation of drug dusts or droplets, absorption through the skin, or ingestion through contact with contaminated food or cigarettes).

Little is known about the potential health hazards of chronic exposure to antineoplastic drugs, but Selevan et al. (1985) observed a statistically significant association between fetal loss and the occupational exposure of nurses to these drugs. Selevan found that initial trimester exposure to antineoplastic drugs was significantly more common among those nurses who experienced fetal loss or who gave birth to malformed infants than among those who delivered normal infants.

Sotaniemi et al., (1983) documented liver damage in three oncology nurses who had handled antineoplastic drugs for a number of years. Among pharmacists and nurses who prepare and administer antineoplastic agents, positive urinary mutagenicity, an indication of possible genetic damage, was found to increase with the period of exposure, with mutagenic activity falling significantly when they stopped handling the drugs (Rogers and Emmett 1987).

While there are conflicting and inconclusive studies regarding the cumulative risks inherent in chronic exposure to antineoplastic drugs, direct contact with these drugs can cause local allergic and toxic reactions. Many agents are potent chemicals that can injure the skin, eyes, and mucous membranes. Nurses handling antineoplastic drugs have reported various symptoms and complaints, including light headedness, dizziness, nausea, headache, skin and mucous membrane reactions, hair loss, cough, and possible allergic reactions (Crudi 1980). Roger and Emmett, (1987) reported coinciding symptoms of exposure to direct contact with antineoplastic drugs.

6.2.3 Reducing Occupational Exposure

From the time the drug is first shipped to the healthcare facility, through admixing, administration to patients, and disposal, it is important to minimize the possibility of accidental exposure.

Both the Occupational Safety and Health Administration (OSHA) and the American Society of Hospital Pharmacists (ASHP) have issued guidelines detailing what they consider to be appropriate work practices and personal protective apparel needed to protect healthcare workers from unnecessary exposures to antineoplastic drugs. These guidelines address drug preparation, drug administration, waste disposal, spills, medical surveillance, storage and transport, training, and information dissemination. These guidelines are summarized in Appendix F, and may be used as part of the management plan.

The OSHA guidelines for personnel dealing with[78] Cytotoxic (antineoplastic) drugs, points out two elements which are essential to ensure proper workplace practices:

- Education and training of all staff involved in handling any aspect of Cytotoxic drugs.
- A properly designed and maintained biological safety cabinet.

6.2.3.1 Education and Training

All employees who come in contact with antineoplastic drugs and contaminated drug waste should know the potential risks of exposure to these drugs, as well as the procedures they should follow in order to protect themselves. Before assuming responsibilities that include handling antineoplastic drugs, all employees should learn proper handling and disposal techniques to minimize their risk of exposure.

6.2.3.2 Biological Safety Cabinets (BSCs)

Dust and droplets of antineoplastic agents can be released into the environment when needles are withdrawn from drug vials, during drug transfers using syringes and needles or filter straws, during the breaking open of ampules, and during the expulsion of air from a drug filled syringe. Therefore, antineoplastic drugs should be prepared only in a Class II vertical laminar-flow containment hood, also called BSCs, preferably vented to the outside.

The Class II BSCs should be certified upon installation and then checked every six months or any time the cabinet is moved or repaired. During certification, all BSCs should be tested for the integrity of the HEPA filters, velocity of the work access airflow and supply airflow, airflow smoke patterns, and integrity of external surfaces of the cabinet and filter housings.

The BSC should be cleaned daily with a 70% alcohol solution and decontaminated weekly, whenever spills occur, or when the cabinet requires servicing or recertification. Decontamination should include surface cleaning with agents having a pH approximating that of soap, followed by a thorough rinsing. Removable work trays should be taken out and cleaned within the containment area. The back of the work tray and the sump below should be included in the cleaning process. Decontamination should be done from top (area of lesser contamination) to bottom (area of greater contamination).

6.2.4 Summary

Minimizing risk to healthcare workers requires that those who prepare, store, administer, and dispose of antineoplastic drugs are fully informed of all potential dangers and instructed in the proper techniques and work practices to follow. Protective garments, proper aseptic technique, appropriate engineering controls, and comprehensive staff training are all essential.

In addition, all employees should have a pre-placement physical examination, which should take note of any risk factors in the worker's history. The examination should emphasize the skin, the liver, and the reproductive, and nervous systems. Although the actual risks involved in handling antineoplastic drugs are yet to be fully substantiated, there is reason to believe that the risk of potential hazards can be reduced by following appropriate safety procedures.

CHAPTER 7

CHEMICAL HAZARDS

7.1 Introduction

Chemicals may exert either acute or chronic effects on workers. The effects depend on:

- the extent (concentration and duration) of exposure,
- the route of exposure (skin, inhalation, ingestion, eyes), and
- the physical (vapor pressure, boiling point, melting point, etc.) and chemical (the reactivity of a substance with other chemical) properties of the substance.

The effects may also be influenced by the presence of other chemicals (synergistic effects), by workers' personal habits (use of tobacco, alcohol, or drugs), or by the physiological or psychological state of the worker.

Some of the substances which may pose a hazard to healthcare workers include: ethylene oxide, freon, aldehydes (formaldehyde, glutaraldehyde), germicides (chloramine, ethyl alcohol, isopropyl alcohol, phenolic compounds, etc.), metals (copper, silver, mercury, etc.), resins and adhesives (epoxy resins, methyl methacrylate, etc.), acids and bases (sodium hydroxide, sulfuric acid, etc.), soaps and detergents, and solvents (acetone, toluene, xylene, etc.).

7.1.1 Regulations

OSHA's standard Occupational Exposure to Hazardous Chemicals in Laboratories (29 CFR 1910.1450) covers all laboratories that use hazardous chemicals.[106]

In a hospital setting, this covers all clinical, pathology, and anatomy laboratories and all affiliated research laboratories. The way for a hospital to achieve the goals of this standard will be determined on an individual basis through the formulation and implementation of a Chemical Hygiene Plan (CHP). The CHP should include the necessary work practices, procedures and policies to ensure that employees are protected from all potentially hazardous chemicals used in their work areas.

Among other requirements, the standard provides for employee training and information, medical consultation and examinations, hazard identification, respirator use and recordkeeping. To the extent possible, the standard allows a large measure of flexibility in compliance methods. The laboratory standard has several requirements which are detailed in Appendix E.

The Chemical Hygiene Plan needs to be tailored to specific laboratory procedures. Differences between laboratories may include: the chemicals and equipment being used, sophistication of facilities, hours of operation, types of personnel protective clothing, and decontamination or waste disposal procedures. Therefore, no one Chemical Hygiene Plan will be appropriate for all laboratories.

Remember, it must be customized to fit particular laboratory needs, eliminating elements not pertinent to the laboratory, and adding elements to address procedures that are unique to the operation of that particular laboratory.

7.2 Ethylene Oxide

Ethylene oxide (EtO) is an extremely effective sterilizing agent because it destroys microorganisms and spores without damaging most materials.

Hospitals routinely use EtO for sterilization of heat and moisture sensitive medical equipment, and no suitable substitute is currently available. The gas will readily diffuse and penetrate many materials, allowing for the effective sterilization of prepackaged, preassembled items.

Workers in central supply, surgical services, patient care, and other working areas where EtO sterilized materials are used are at risk of potential exposure. A typical source of ethylene oxide exposure in a hospital environment is through the operation of sterilizing equipment.

Ethylene oxide is regulated by OSHA as a carcinogen (29 CFR 1910.1047). Ethylene oxide is typically supplied to hospitals in compressed gas cylinders that contain 88% freon and 12% ethylene oxide, or in single dose cartridges of 100% ethylene oxide.

7.2.1 Potential Health Effects

Exposure to ethylene oxide occurs primarily through inhalation, but exposure of moist skin to the vapors can also cause irritation. EtO causes blisters on the skin, the eyes, and respiratory tract. Residual EtO, found after sterilization, has been associated with several skin problems: hand irritation from rubber gloves, facial irritation from anesthesia masks, wound reactions from prepackaged dressings, and severe dermatitis from surgical gowns and drapes. Prolonged skin contact will cause burns.

Skin and eye contact with liquid EtO or airborne vapors is the most common form of acute exposure; it may be caused by leaks or accidents occurring during cylinder changing. Even brief contact with a 40% to 80% solution of EtO can lead to second degree burns. Other effects include sensitization, frostbite, and edema. Although the eyes are less sensitive to EtO than skin, eye contact can cause burns and corneal damage.

Early symptoms of acute exposure to EtO include irritation of the eyes, nose, throat, and respiratory system; vomiting; nausea; headache; and a strange taste. These symptoms occur in most individuals when EtO concentrations reach approximately 200 ppm (Reish, 1991). At levels above 1,000 ppm, coughing, lung irritation, breathing difficulties, and chest pain occur. Short inhalation exposures to high levels of EtO have resulted in bronchitis, pulmonary edema, and emphysema; degenerative changes in the lungs, liver, and kidneys; nervous system depression; and incoordination and weakness (ATSDR, 1990). Hospital personnel exposed to EtO during pregnancy have been found to a higher frequency of spontaneous abortion compared with a control group (ATSDR, 1990).

7.2.2 Sources of Exposure

Although infrequent, the most likely sources of large accidental, emissions of EtO releases include:

- Leaks or failures in the supply cartridges or cylinders.
- Overpressurization of the sterilizer.
- Leaks that develop in the sterilizer door gasket.

The routine emission sources probably account for most of the EtO released into breathing spaces which include:

1. Antisiphon air gap. This depends on the ventilation control at the drain air gap, and may be the most significant routine source of EtO emission to workplace air.
2. Fugitive emission. Residual EtO may remain in the sterilizer chamber after completion of the sterilization cycle. It can be released when the sterilizer door is opened, exposing workers to brief but relatively high concentrations.
3. Transfer. Residual EtO is gradually released when workers transfer loads from a sterilization chamber to an aerator.

4. Opening the door. The greatest source of actual exposure is opening the sterilizer door after sterilization is completed. Even when all other sources of exposure are eliminated, opening the sterilizer door and removing the sterile items still presents significant risks.

The two most common low level exposures to EtO that have been identified are, opening an aerator door and cleaning a interior of the sterilizer chamber. The sterilizer may contain residual EtO even after the load is removed, especially since the door is closed after each use. Chamber cleaning often requires the worker to reach back surfaces, and if cleaning is done soon after a sterilization cycle, exposure may occur.

7.2.3 Standards and Recommendations

Unless good engineering controls and good work practices are followed, workers may encounter relatively high concentrations of ethylene oxide within brief periods. Exposure to EtO has been determined to present carcinogenic, mutagenic, reproductive, neurologic, and respiratory hazards to workers. In response to increased awareness of the adverse effects of EtO exposure, OSHA has established a Permissible Exposure Limit (PEL) of one part per million (PPM) as an eight hour time weighted average (TWA) and short term exposure limit (Excursion Limit) of five ppm time weighted over 15 minutes. OSHA requires that medical facilities implement control measures to minimize employee exposure and that healthcare staff understand the hazards associated with EtO and follow proper work practices to minimize exposure.

7.2.4 Exposure Control Methods

The first step in the development of an EtO control plan is to conduct initial exposure monitoring to determine if there is an exposure problem and, if so, its relative severity. If there is a problem, hospitals must institute corrective actions. For example, facility engineering should evaluate current sterilizer design and ventilation characteristics, and central services should evaluate work practices, emergency plans and procedures. The facility plan must also contain schedules for leak inspection, and the use of respiratory protection where engineering controls are not feasible.

Correct work practices can significantly decrease EtO exposure. All employees working with EtO should be instructed in proper procedures for all aspects of EtO sterilization processes, including gas cylinder changing, the sterilization cycle, and sterilized item handling. Rotating workers to achieve exposure control is not a proper work practice.

Respirators must be supplied for maintenance and repair work and for emergencies, and a Respiratory Protection program in accordance with 29 CFR 1910.134 must be instituted. If there is a risk of eye and skin contact with EtO, the employer must institute Eye and Face Protection program in accorance with 29 CFR 1910.133. Eye protection must be vapor proof for those potentially exposed to EtO release from sterilizers, and splash proof for those changing cylinders or performing maintenance.

7.3 Freon

Freon includes a number of gaseous, colorless chloroflurocarbons. Those most commonly used in hospitals are Freon 12 (dichlorodifluoromethane), Freon 11 (fluorotrichloromethane), and Freon 22 (chlorodifluoromethane).

Workers may encounter Freon hazards in the pathology laboratory where it is used to prepare frozen tissue sections, and in central supply department where it is used in combination with ethylene oxide for sterilization.

7.3.1 Potential Health Effects

Exposure to Freon may cause eye and skin irritation or sensitization. A high concentration of Freon may cause severe depression of the central nervous system, weakness, dizziness, convulsions, and irregular heartbeat (ACGIH, 1986). In one hospital study, four pathology residents experienced heart palpitations severe enough to prompt electrocardiograms. This incident appeared to be associated with the preparation of frozen sections in which a Freon 22 based aerosol solution was used (Speizer et al, 1975).

7.3.2 Exposure Control Methods

Local exhaust ventilation hoods should be installed to carry Freon vapors away from laboratory workers. Ventilation controls that protect workers adequately from ethylene oxide during sterilizing procedures will also protect them from Freon.

Goggles, aprons, and protective gloves should be provided to workers exposed to large amounts of Freon. Because Freon lacks adequate warning properties, only approved atmosphere supplying respirators should be used. Hand contact should be minimized because of the possibility of sensitization. Workers should be warned against touching their eyes with contaminated hands or gloves for the same reason.

A cardiovascular history should be obtained from each worker exposed to Freon because exposure may pose a greater risk to those with cardiovascular problems. Eyes, skin, and cardiac symptoms, should be monitored periodically for exposed workers.

7.4 Formaldehyde

Formaldehyde is a highly reactive chemical that has found widespread medical applications. Formaldehyde is used for cold sterilization of some instruments, but it is highly recommended that its use as general disinfectant be limited. It may be encountered in clinical laboratories as a tissue preservative, and in central supply, and dialysis units as a sterilant.

In addition, it may also be encountered in autopsy rooms, anatomy rooms, housekeeping, and patient care areas. Solutions of formaldehyde are used as a tissue fixative in sample preparations and as a disinfectant in dialysis units, labor and delivery and operating suites, and isolation areas. They are also incorporated into many plastic resin systems that have direct and indirect healthcare applications (for example, orthopedic casting materials and paper laminates).

Formaldehyde is often combined with methanol and water to produce formalin. Formalin is used to disinfect morgues, laboratories, operating rooms, surgical instruments, and hemodialysis equipment.

Formaldehyde may also pose a risk to workers because it has a few therapeutic uses, including a treatment of warts, diseased dental pulp, poison ivy rash, and fungal skin diseases.

7.4.1 Potential Health Effects

Formaldehyde has a wide range of health effects, depending on the pathway of exposure. Its solubility and high reactivity give it the potential for affecting different body systems.

The skin hazards associated with exposure to formaldehyde include both primary irritation dermatitis and allergic dermatitis. Irritant dermatitis occurs as the result of direct injury to the skin on contact with formalin and exposure to gaseous formaldehyde. Employees who handle embalming fluids or other concentrated solutions of formaldehyde frequently show evidence of skin diseases. Contact can produce redness and thickening of the affected area. There may be blistering and severe dryness accompanied by burning or itching.

Allergic contact dermatitis is a delayed elicitation of an immunologic response to low concentrations of chemicals. Agothos, (1982) reported allergic dermatitis from exposure to formaldehyde in nurses, dentists, technicians, and hospital cleaning personnel. Formaldehyde related allergic contact dermatitis has also been reported in five nurses handling thermometers that were immersed in solutions of 10% formaldehyde (NIOSH, 1976).

The high aqueous solubility of formaldehyde makes the compound irritating to the eyes. Exposure to airborne formaldehyde levels as low as one ppm commonly produces eye irritation. It has been reported that some people exhibit eye irritation at concentrations as low as 0.01 ppm (NRC, 1981). Formalin solutions splashed in the eyes may cause severe injury and corneal damage.

Hendrick et at., (1982) reported that two nurses working in a renal dialysis unit developed asthmatic symptoms associated with their work with formaldehyde. The symptoms were completely resolved for the nurse who spent some time without further exposure to formaldehyde, but other nurse, who had prolonged exposure, continued to have symptoms. Charney, (1990) also reported exposure to formaldehyde vapor to be associated with occupational asthma in hospitals and other occupational environments.

7.4.2 Sources of Exposure

NIOSH has estimated that one third of all workers exposed to formaldehyde are employed in the medical and health services. In addition to medical personnel, the use of formaldehyde as a disinfectant in hospitals provides exposure for cleaning staff, aides, orderlies, and attendants.

Operating room physicians, nurses, and technicians are exposed during transfer of tissue from patient to formalin before dispatch to pathology. Formaldehyde residuals from the disinfection of operating rooms are another source of exposure. Physicians and laboratory technicians in pathology, histology, and gross anatomy laboratories, where formalin is used as a tissue fixative during sample preparation, may be exposed to formaldehyde vapor during gross description and tissue sectioning. Technicians are further exposed during preparation of formaldehyde solutions and servicing and loading of sectioning instruments, as are autopsy assistants who transfer organs to formalin for storage or further sectioning.

The staff in hemodialysis units may be exposed to formaldehyde solutions used to disinfect surfaces and internal machine components. Other staff members in microbiology laboratories can be exposed because some older methods for the isolation of parasites employ formaldehyde. Fortunately, these methods are becoming obsolete. Staff members in clinics where many physicians maintain a supply of formalin for immediate tissue preservation may also be exposed to this agent.

7.4.3 Standards and Recommendations

Both OSHA and the American Conference of Governmental Industrial Hygienist (ACGIH) consider formaldehyde to be a possible human carcinogen. Employers must take steps to minimize the risk of employee exposure to formaldehyde to protect worker health and to comply with OSHA regulations (29 CFR 1910.1048). The Permissible Exposure Limit (PEL) is 0.75 ppm TWA over eight hours. The Short Term Exposure Limit (STEL) is two ppm time weighted over 15 minutes. The OSHA standard calls for: monitoring, safe work practices and engineering controls, respiratory protection, hygiene protection, housekeeping and emergency plans, medical surveillance, medical removal protection, hazard communication, employee training program, and thorough record keeping.

7.4.4 Exposure Control Methods

Phenol may be substituted for formaldehyde in some cases, and dilute bleach solutions can be used to disinfect the exteriors of dialyzers. Other cold sterilants such as glutaraldehyde are also available. These substitutes should be used with caution because they may have their own negative health effects.

It is recommended that formaldehyde management plan should be instituted and include the following points:

- Identification of all employees at risk in hospitals is a necessary first step.
- Initial exposure levels should be determined for all jobs that involve formaldehyde. Pre-employment baseline data should be recorded for the respiratory tract, liver, and skin condition for any worker who will be exposed to formaldehyde.
- Monitoring should be conducted annually at a minimum.
- Multiple exposure to other irritants must be taken into account at the same time as formaldehyde.
- Formaldehyde substances should be stored in closed containers.
- Pathology, anatomy, and histology laboratories should be fitted with local exhaust ventilation designed to pull air away from workers' breathing zones. Hoods or slot-type exhausts should be routinely tested and maintained.
- Goggles, face shields, aprons, NIOSH certified positive pressure air supplied respirators, and boots should be provided in situations where formaldehyde spills and splashed are likely.
- Hospital should train all staff who work with formaldehyde of the attendant hazards and procedures to overcome them.

7.5 Glutaraldehyde

Glutaraldehyde is used as a wet sterilant in the disinfection of delicate instruments, such as endoscopy equipment, dialysis instruments, surgical instruments, dental instruments, and thermometers, and as a fixative in the laboratory and in embalming materials.

It is a colorless, crystalline solid that is soluble in water and organic solvents. It is available most commonly as a nonflammable 50% or 2% aqueous solution. It is also found in surface disinfectants widely used by hospital staff, in developer used for x-ray film processing, and in tissue fixative for histologic examination by electron microscopy.

7.5.1 Potential Health Effects

Glutaraldehyde is an irritant of the skin and the mucous membranes. It has been implicated as a cause of contact dermatitis, asthma, and rhinitis (inflammation of a nasal mucosa) in endoscopy unit personnel. It also causes eye, throat, and respiratory tract irritation and reduced lung function. At high levels of exposure, it has been shown to produce liver toxicity (Wiggins et al., 1989).

General symptoms that have been reported by hospital personnel exposed to glutaraldehyde include burning eyes, headaches, rhinitis, skin sensitization, chest tightness, asthma-like symptoms, throat and lung irritation, flu-like symptoms, and hives (Charney, 1990).

Another study of an endoscopy unit found that 88% of the staff reported symptoms related to glutaraldehyde exposure (Jachuck et al., 1989). In one hospital's study of 13 employees with allergic contact dermatitis due to glutaraldehyde, the disease persisted for more than six months in ten of the subjects and forced five of the workers to leave their jobs (Nethercott et al., 1988). Another concern in cases of glutaraldehyde allergy is the possibility of cross reactions to formaldehyde.

7.5.2 Sources of Exposure

Nurses and doctors who perform cold sterilization in dialysis, endoscopy, and intensive care units and in emergency and operating rooms are subject to exposure. Also exposed are research technicians, pharmacy personnel, x-ray processing technicians, housekeeping staff, and electron microscopists. Dentists and their assistants are frequently exposed to cold sterilizing solutions containing glutaraldehyde.

In healthcare facilities, glutaraldehyde has often been handled in open containers without the benefit of local exhaust ventilation. The normal soaking time in activated glutaraldehyde solutions for disinfection is ten minutes, during which the buffered solution usually sits in an open one-liter container. Employees may also be exposed to high levels of glutaraldehyde vapor during manual cleaning of instruments, when instruments soaking in solutions are retrieved with unprotected hands, during mixing and activating of solutions, or when activated glutaraldehyde solutions are left standing in open containers.

A study conducted by NIOSH showed that the routine use of glutaraldehyde solutions in a hospital setting produced levels as high as 0.4 ppm by volume in air in both personal breathing zones and ambient air; the irritational response level is 0.3 ppm (Wiggings et al., 1989).

7.5.3 Standards and Recommendations

OSHA has determined that glutaraldehyde presents a significant risk of health impairment from short term exposure to airborne concentrations of 0.3 ppm or above, and has established a ceiling limit of 0.2 ppm. A ceiling limit is not a time-weighted average as is the PEL, but a maximum allowable level at any time.

7.5.4 Exposure Control Methods

Substitution of another, safer material for glutaraldehyde, while certainly the optimum solution, is not always practical.

Most substitutes are, unfortunately, less effective disinfecting or sterilizing agents. Until a safer, effective material is found, exposure to glutaraldehyde should be reduced through engineering and work practice controls.

Since general dilution ventilation is not adequate to prevent glutaraldehyde exposures, the solutions should be kept under a fume hood or otherwise provided with local exhaust ventilation. Areas using glutaraldehyde should be kept under negative pressure to avoid migration of vapors.

Workers should avoid breathing vapors. They should also be provided with and required to use splash-proof goggles, and protective clothing, including heavy neoprene, or nitrile gloves to handle glutaraldehyde solutions. Eyewash stations and quick-drench showers in usage area should also be provided.

7.6 Phenol

Phenol, also known as carbolic acid or hydroxybenzene is used in hospital disinfectants and cleaning solutions. These solutions are generally used to control a wide range of bacteria, but they are not effective against spores.

7.6.1 Potential Health Effects

Phenol is widely used on floors, glassware, and instruments. It is caustic and toxic by inhalation and ingestion. Phenol is readily absorbed through the skin and the gastrointestinal and respiratory mucosa. It is also readily absorbed into the blood.

Phenol can cause fatal respiratory failure following acute intoxication. The effects may also include local tissue irritation and necrosis, severe burns of the eyes and skin, irregular pulse, darkened urine, convulsions, coma, liver and kidney damage, collapse, and death (NIOSH, 1976d).

7.6.2 Recommendations and Control Methods

The current OSHA PEL for exposure to phenol is five ppm as an eight hour TWA. Phenol volatilizes from cleaning and disinfecting solutions, but if effective safety measures are adopted and employees are instructed in the proper handling of the compound, the risks of phenol intoxication can be minimized. Safety measure to be adopted should include, at a minimum, the following:

- Perform personnel monitoring for employees regularly exposed.
- Train employees handling phenol containing materials about the phenol's potential danger and proper handling procedures.
- Provide adequate ventilation.
- Provide readily accessible quick-drench showers for decontamination in the case of accidental skin contact.
- Provide PPE, such as gloves, and eye shields.
- Dispose of phenol in accordance with regulations.

7.7 Mercury

Elemental mercury and mercury compounds can be found in various circumstances throughout the healthcare facility. Elemental mercury is used in instruments such as mercury bulb thermometers and sphygmomanometers, some types of esophageal dilators, and dental amalgams. Clinical laboratory technicians are among the most highly affected workers at risk of exposure.

7.7.1 Potential Health Effects

Elemental mercury vapor and mercury compounds are extremely dangerous poisons and among the most toxic substances found in healthcare facilities. Exposure to high levels can cause acute poisoning or even death.

A short term exposure to high levels of mercury vapor can cause corrosive bronchitis and pneumonitis, and breathing the vapors chronically can produce severe and irreversible damage to the central nervous system (Goyer, 1986).

7.7.2 Sources of Exposure

Elemental mercury is an often unrecognized health risk to hospital workers. Colorless and, in most forms, odorless, elemental mercury vapor can be inhaled in toxic concentrations for long periods of time without producing any clinical signs or symptoms of poisoning. Workers also risk exposing members of their families to high levels of mercury by bringing home clothing and shoes that have been contaminated in the workplace (Hudson et at., 1987).

The use of instruments that contain mercury does not usually involve direct exposure to the metal unless an instrument, such as a thermometer, breaks and the metal is spilled onto a floor or counter top. Although this is the single largest source of exposure for mercury, exposure at this level is usually infrequent and incidental.

Exposure to mercury in the hospital is usually the result of an accidental spill. The two procedures during which such exposures usually occur are:

- repair of broken sphygmomanometers in central supply or maintenance, and
- sterilization and centrifugation of thermometers in central supply.

7.7.3 Recommendations and Control Methods

It is imperative that policies and procedures dealing with mercury exposure be established and followed to ensure that mercury related problems can be identified and effectively handled to minimize the risk of exposure to personnel.

Emergency engineering procedures for handling mercury contamination should include safe procedures for cleanup as well as for respirator selection. Exhaust systems should be designed and maintained to prevent the accumulation or recirculation of mercury vapor into adjacent work areas.

If proper spill handling procedures are quickly and efficiently followed with appropriate PPE, virtually all of the mercury from breakage of instruments containing mercury can be picked up permitting very little, if any, of the metal to vaporize and become a potential health concern.

Although the ultimate responsibility for meeting allowable exposure limits and creating protocols for the safe use, cleanup, and disposal of mercury lies with healthcare administrators, the success of safety procedures and programs is in the hands of the individual healthcare workers. Every hospital employee must carefully follow proper precautions and safety measures when handling mercury or mercury containing devices to ensure that mercury exposure does not pose an occupational health risk anywhere in the hospital.

7.8 Methyl Methacrylate

Methyl methacrylate is an acrylic cement-like substance commonly used by orthopedic surgeons and nurses in operating rooms to secure surgical prostheses to bone (as in total hip replacement). This compound is also used by dentists and dental laboratory technicians. The components, a liquid and a powder, are mixed immediately before use.

7.8.1 Potential Health effects

At concentrations in excess of 400 ppm, methyl methacrylate affects the central nervous system. It is an eye, skin, and mucous membrane irritant at or above 170 to 250 ppm.

7.8.2 Recommendations and Control Methods

The OSHA PEL, as well as the ACGIH TLV, for methyl methacrylate is 100 ppm as an eight hour TWA.

A local exhaust hood should be used to conduct exhaust fumes away from the area in which methyl methacrylate is mixed. A tent hood may be used unless mixing can be done in a separately ventilated area. Workers should wear PPE and avoid touching contaminated hands or gloves to their eyes or mouths.

Double gloving with rubber glove is recommended. However, where feasible, avoiding exposure through the development of "no-touch" methods offers the best prevention.

One study recommended a three-layered PVP glove 0.07 mm thick consisting of an outer layer of polyethylene, an intermediate layer of ethylene vinyl alcohol copolymer, and an inner layer of polyethylene for healthcare employees handling methyl methacrylate. These gloves were found to be impervious to methyl methacrylate for 20 minutes. Viton-butyl rubber gloves 0.27 mm thick were impervious for 15 minutes, and ordinary surgical rubber gloves were penetrated in less than one minute (Darre et at., 1987).

7.9 Solvents

Solvents refers to a large number of chemicals in medical laboratories. Laboratories workers are at risk from exposure to these chemicals, particularly xylene, which is commonly used as a solvent in tissue processing and slide-staining procedures in histology and pathology laboratories and in oil-immersion microscopy. Maintenance personnel and housekeepers may also encounter solvents in their work.

7.9.1 Potential Health Effects

Solvents can cause irritant contact dermatitis by defatting the skin, and can cause folliculitis by diffusion into the hair follicles. Most solvents can be absorbed through the skin or by inhalation. They act as central nervous system depressants, causing headaches, dizziness, weakness, and nausea. Solvents may also irritate eyes, skin, and the upper respiratory tract. Prolonged contact may result in defatting and dehydration of the skin which can lead to dermatitis.

Long term exposure to some solvents has been associated with cancer, adverse reproductive effects, cardiovascular problems, and damage to the liver, kidneys, central nervous system, and hematopoietic system (NIOSH, 1777a).

Acute exposure to low concentration of xylene vapor can irritate the eyes, nose, and throat. Higher concentrations (100 to 200 ppm) of xylene vapor produce dizziness, drowsiness, dyspnea (difficult breathing), and fatigue. Concentrations above 200 ppm have been reported to cause anorexia, nausea, vomiting, and abdominal pain (HISIS, 1986).

7.9.2 Recommendations and Control Methods

It is highly recommended that specific solvents, such as xylene, toluene, and acetone not be used, unless absolutely necessary. If they must be used, material safety data sheet (MSDS) should be consulted for information such as the appropriate PEL, and STEL for xylene as adopted by OSHA (100 ppm and 150 ppm respectively), and ten minute TWA ceiling limit recommended by NIOSH (200 ppm).

The following control methods may be used in order to minimize exposure to solvents, particularly xylene:

- Wear latex gloves, goggles, and xylene resistant laboratory coat or apron.
- Perform operations away from the general laboratory work area.
- Work under laboratory exhaust hood.
- Store quantities of more than two liters in safety storage cabinet.
- Dump xylene solutions used in special stains and tissue processing down the drains with running cold water.
- Replace portable fume hood charcoal filters periodically.
- Turn portable fume hood fans on even if they are noisy.
- Wear protective gloves.
- Train technicians in proper usage, cleaning, and storage techniques for the respirators provided to them during xylene solution dumping.

CHAPTER 8

WASTE ANESTHETIC GASES

8.1 Introduction

Waste anesthetic gas (WAG) is gas that escapes from the anesthesia system, which consists of the patient, anesthesia equipment, and other breathing apparatus (e.g., ventilators, carbon dioxide absorber) and that enters either a gas scavenging unit or the atmosphere. Long-term exposure to anesthetic gases is believed to increase the risk of a variety of general health problems, such as liver disease and certain types of kidney disorders. Recent studies of healthcare workers have correlated chronic exposure to WAG with high rates of spontaneous abortions (miscarriages) and congenital abnormalities in the offspring of operating room (OR) workers and dental assistants. Exposures may occur in operating rooms, labor, delivery, and recovery rooms, dental offices, emergency rooms, and outpatient clinics.

8.2 Commonly Used Anesthetic Agents

At the present time, nitrous oxide, halothane, enflurane, and isoflurane are the most common anesthetic agents in use in hospitals. Methoxyflurane once in general use, is now used primarily in veterinary procedures. Rarely is anesthesia produced by the use of a single agent; however the combination of agents used may vary considerably. The agents selected depends upon the type of surgery, the condition of the patient, and the training and preferences of the anesthesiologist.

Nitrous oxide is commonly used in dentistry, as well as general surgery, to induce loss of the ability to feel pain. Nitrous oxide is used as an adjuvant in anesthesia; that is, when used with 70% nitrous oxide and oxygen, the concentration of other anesthetic agents, such as the halogenated anesthetics (halothane, enflurane, isoflurane, methoxyflurane), can be greatly reduced. Nitrous oxide can cause hypoxia (oxygen deprivation) if used at concentration high enough to induce anesthesia (above 80%).

Halothane is a potent halogenated organic anesthetic. Halothane, like all halogenated anesthetics, is liquid at room temperature. The vaporizers vaporize the liquid anesthetic and send it into the breathing hoses. Halothane is usually administered in low concentrations, typically 0.3% of the total anesthetic gas. Halothane can induce arrhythmias in patients with heart disease, and it occasionally causes liver damage.

Enflurane, another halogenated anesthetic, is also administered in low concentrations (1.5% to 3% of the total gas) to maintain anesthesia. Enflurane causes a lower incidence of cardiac arrhythmias and liver damage than does halothane, but can induce seizures in patients with a history of seizure disorders.

Isoflurane is more potent than enflurane. Use of isoflurane causes a smooth and rapid induction of, and emergence from, general anesthesia. Isoflurane does not cause cardiac arrhythmias, and is not toxic to the kidneys or liver. However, respiratory depression and hypotension (low blood pressure) can result from isoflurane usage (Marshall and Longnecker, 1990).

Methoxyflurane is a clear, colorless, with a sweet, and fruity odor. It is the strongest of the anesthetics used for inhalation currently available. The use of methoxyflurane is restricted to certain special situations because it is highly toxic to the kidneys.

8.3 Potential Health Effects

The most serious adverse health effects allegedly caused by chronic, low-level exposure to WAG are fetal injury and spontaneous abortions.

Edling, (1980) has shown a positive correlation between long-term exposure to nitrous oxide and halothane and an increased incidence of miscarriages and congenital malformations among female anesthetists, among OR nurses, and among women who do not themselves work in the healthcare field, but whose husbands are anesthetists.

Rowland et al., (1992) indicated a decrease in fertility among female dental assistants exposed to high (unscavenged) levels of nitrous oxide. Short-term exposure to trace levels of waste anesthetic gases have been shown to cause headache, nausea, irritability, and fatigue in OR personnel (Kole, 1990). Chronic exposure to WAG has been implicated as the cause in several cases of liver disease, kidney function impairment, and immunosuppression in OR personnel (Edling, 1980). Other reports indicate that neurological disorders, such as impaired cognition, loss of dexterity, peripheral neuropathy, and various sensorimotor disturbances may be associated with long-term occupational exposure to WAG (Edling, 1980).

Liver function abnormalities have been observed in humans exposed to inhalation anesthetics, while experimental studies have revealed changes in microsomal enzyme-system activity caused by inhalation of a variety of anesthetics (Franco et al., 1992).

Eger, (1991) concluded that the risk of fetal injury from occupational exposure to anesthetic gases was so low as to be considered nonexistent. The study of pregnancies of anesthesiology and operating room nurses did not show an increase in the rate of spontaneous abortions or congenital abnormalities.

No studies have demonstrated a link between occupational exposure to the commonly used anesthetic gases and any mutagenic effects or increases in the rate of cancerous tumors in OR or anesthesia personnel (Edling, 1980; NIOSH, 1987; Eger, 1991).

8.4 Sources of Exposure

High concentration of WAG are found in many hospital ORs and in dental clinics, even in those with scavenging systems and the turbulent airflow nonrecirculating ventilation systems required in most hospitals today.

WAG enters the OR air primarily because of leaks in the anesthesia equipment, leaks around the mask (especially in pediatric patients, patients with beards, or patients undergoing surgery near the oronasal region), and faulty work practices of the anesthesia team. A number of other factors are also strongly associated with exposure. These include the type of OR service, the number of procedures taking place in the OR, the age of the anesthetic equipment, and the effectiveness of the general ventilation system.

8.4.1 Anesthetic Equipment Leaks

With age, anesthetic equipment is bound to develop leaks. Leaks often occur at joints where hoses are attached to valves or machinery.

Air monitoring studies have shown that the highest concentrations of WAG are found between the anesthesia machine and the wall and along the perimeter of the patient drapes. WAG levels around the patients's mouth often exceeded 200 parts per million (ppm). High WAG concentrations in the breathing zone of anesthesia providers were two to four times the levels experienced by other OR personnel (Kole, 1990).

The most common WAG leak sites on the anesthesia equipment are hose connections to the anesthesia machine, disposable breathing circuits, valves, vaporizers (especially when refilled in the "on" position), and the scavenging system.

8.4.2 Anesthetic Techniques and Work Practices

Waste anesthetic gas levels in the operating room can be high even when all equipment and systems are maintained in proper working order. Moreover, WAG levels in a given OR vary from day to day because of changes in the condition and assembly of the anesthesia equipment, the effectiveness of the scavenging system, room ventilation rates, operating techniques of the users, the type of patient being anesthetized, and the type of surgery being performed. Certain types of faulty work practices can produce unusually high WAG levels.

Work practices that can cause WAG leakage include the following:

- failure to turn on the scavenging unit,
- improperly fitting the anesthesia mask to the patient's face and failing to secure the endotracheal tube to the face,
- turning on the nitrous oxide gas flow before placing the mask on the patient or before the trachea is intubated and the endotracheal tube is connected to the breathing circuit,

- removing the mask before stopping flow,
- making disconnections in the breathing system without regard to minimizing gas escaping into the room,
- spilling anesthetic liquid (when filling the vaporizer), and
- not flushing the system with 100% oxygen to remove residual gas before extubation or removal of the anesthesia face mask.

8.4.3 Patients

Patients exhale nitrous oxide, dissolved in the bloodstream during anesthetic administration, after being transferred to the recovery room. Levels of the gas in the breath decline rapidly, so the amount exhaled in the recovery room depends upon the time interval between stopping administration and bringing the patient into the room.

8.5 Recommendations for Exposure Levels

Although there are no mandatory standards for WAG exposure published by OSHA, NIOSH recommends exposure levels to nitrous oxide at a time-weighted average (TWA) concentration of 25 ppm during anesthetic administration, when nitrous oxide is the sole anesthetic agent.

NIOSH recommends that exposure to halogenated agents (halothane, enflurane, isoflurane, methoxyflurane) not exceed two ppm TWA during any one-hour period. NIOSH notes that, when nitrous oxide is kept to 25 ppm, levels of about

0.5 ppm of halogenated agents will generally result (NIOSH, 1977). These limits do not assure occupational safety. The limits are recommended because they are achievable with available technology. As technology improves, exposure limits to WAG may be better controlled to safer levels.

8.6 Exposure Control Methods

Because a "safe" occupational exposure concentration of WAG cannot be defined based upon existing data, it is strongly recommended that all reasonable efforts be made to keep exposure as low as possible. Medical and dental laboratories can take a variety of steps to reduce worker exposure to waste anesthetic gases, ranging from the inexpensive and simple - using tightly sealed threaded hose connections instead of slip-on ones - to the more costly and complex - installing a special waste gas venting system.

Anesthetic gases have so many sources of escaping into the air that, without a systematic, well-thought-out source-control program, WAG air levels can remain a constant problem despite attempts to reduce them. Such a program should consist of an efficient scavenging system, correct work practices, proper anesthesia equipment maintenance, leak testing, and medical surveillance.

8.6.1 Scavenging Systems

Even in a well-ventilated room, it is impossible to maintain WAG levels below NIOSH limits without adequate scavenging.

A scavenging unit collects excess gases from the anesthesia-breathing circuit system and vents them to a disposal system outside of the OR (e.g., the medical-surgical vacuum system, the heating, ventilating, and air-conditioning (HVAC) system). Scavenging systems are characterized by the way gases are removed from the anesthesia circuit. There are two basic types of systems.

1. **Vacuum** These devices use the dedicated vacuum system of the OR to remove waste gases. Vacuum scavenging systems use either a negative-pressure-relief valve or an open port to the atmosphere in the transfer tubing to prevent the vacuum's negative pressure from affecting the operating pressure in the anesthesia circuit. Some units may also have either positive-pressure relief valves or open ports to prevent positive-pressure buildup in the scavenging unit if the disposal tubing becomes blocked, if the vacuum flow to the scavenging system is inadequate, or if there is a sudden increase in gas flow out of the anesthesia machine.

2. **Exhaust** These devices vent waste gases into the HVAC system or into a dedicated exhaust system. Unlike vacuum system, these units do not need relief valves or ports to prevent negative pressure in the system. The pressure of the waste gas discharging from the anesthesia machine forces gas through the disposal tubing. High levels of WAG can result when the scavenging system has an inadequate vacuum supply or reservoir capacity, is not used, or is used by someone unfamiliar with its operation.

8.6.2 Work Practices

Operating room workers can protect themselves from excess exposure by properly connecting the scavenging equipment, turning the gas off when the breathing system is disconnected from the patient, and ensuring that all patients have properly fitting masks.

In addition to proper anesthetic techniques, Cohen, (1980) recommended emptying the patient's reservoir breathing bag (which contains anesthetic gases), into the operating room's gas scavenging system, and giving the patient either oxygen or air at a high flow rate after surgery to flush out as much anesthetic gas as possible. He also advised workers to avoid a patient's exhaled gases in the recovery area, perhaps by simply moving toward the head of the bed.

8.6.3 Preventive Equipment Maintenance and Leak Testing

Without proper maintenance and leak testing of the anesthesia machine and components of the breathing system, WAG air contamination will occur regardless of the presence of an effective scavenging system. Preventive maintenance on the machine and ventilators should be performed quarterly by a manufacturer's service representative or other qualified person. Breathing hoses, scavenging system tubing, all bags associated with the patient breathing circuit and scavenging system, and ventilators should be tested daily and replaced when necessary.

The anesthesia machine and patient breathing circuit tubing and hoses should be tested for anesthetic leaks as follows:

- before each use,
- whenever the carbon dioxide absorber is changed, and
- during routine maintenance on the machine and ventilators.

The components of the system should be leak tested. The items to be checked include: the flowmeter, vaporizers, breathing bag, ventilator/bag selector valve, inspiratory and expiratory check valves, carbon dioxide absorber, breathing circuit hoses, spirometer, oxygen analyzer, endotracheal tube or mask, and the scavenging unit itself.

8.6.4 HVAC System

The HVAC system must be properly designed and operated with an adequate number of air changes per hour; it must also have properly located intakes to ensure low levels of WAG. If the HVAC system is used for scavenging, it must be non-recirculating to avoid contaminating any work areas with anesthetic gas.

For adequate ventilation, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) recommends 25 air changes per hour for recirculating systems and 15 air changes for non-recirculating systems (ASHRAE, 1991).

8.6.5 Air Monitoring

NIOSH recommends area and personal air monitoring (air samples from the individual's breathing zone) under the following circumstances:

- at the outset of the WAG control program and annually thereafter,
- when new equipment is installed, and
- to investigate complaints from employees.

Only by measuring anesthetic gases present in the OR can waste gas control measures be assured to be effective. Some methods that are available include: gas analysis, infrared analysis, air sampling techniques, measurement of high pressure leaks, and measurement of total leakage. A routine and thorough program of leak testing along with equipment inspection and maintenance can serve to identify point sources of gas escaping from the anesthesia system and eliminate the need for frequent air monitoring.

8.7 Medical Surveillance

Operating room personnel who are exposed to anesthetic gases should receive regular (annual) medical examinations. Examinations should check for short-term WAG exposure effects such as headaches or nausea, as well as potential chronic effects (e.g., liver or kidney disease). Workers must be advised of the potentially adverse health effects of exposure to WAG, such as spontaneous abortions, congenital abnormalities in their children, and adverse effects to the liver, kidneys, and nervous system.

8.8 Training Programs

Workers involved with waste anesthetic gases must be trained to recognize, understand, monitor, and reduce the health and safety risks of exposure to these substances. Personal protective equipment (PPE) are not needed or recommended if an adequate control program is in place. However, PPE should be available for use in case of an emergency.

CHAPTER 9

RADIATION

9.1 Ionizing Radiation

9.1.1 Introduction

Ionizing radiation is used for a multitude of purposes in medicine, including diagnosing duodenal ulcers, pancreatic neoplasms, and pneumonia, as well as treating neoplasms such as cancer of the cervix. Scattered radiation is generated during many diagnostic radiological procedures. It is important to note that scattered radiation may have almost as much energy as the primary beam and therefore represents a safety hazard for health care personnel who remain in exposure rooms during X-ray procedures.

A number of healthcare workers are exposed to scattered radiation, including radiologists, X-ray technologists, nuclear medicine technologists, invasive cardiologists, operating room personnel, and neonatal care unit personnel.

9.1.2 Exposure Limits Standards and Recommendations

Limits on occupational exposure to ionizing radiation have long been established. The maximum permissible annual whole body dose is five roentgen equivalent man (rem). Roentgen equivalent man (rem) is the dosage of any ionizing radiation that will cause biological injury to human tissue equal to the injury caused by one roentgen (unit of measure for quantity of ionization produced by X-radiation or gamma radiation) of X-ray or gamma ray dosage. No more than three rem may be received during a 13-week period (NCRP, 1976). OSHA, 29 CFR 1910.96, sets a limit of three rem/quarter. A limit on the radiation exposure of a fetus of an occupationally exposed female employee has also been created. The limit is 0.5 rem for the entire gestation period (NCRP, 1977)

For additional information on standards and recommendations, refer to the OSHA standard for ionizing radiation that are intended to protect workers not covered by the Nuclear Regulatory Commission (NRC) in 10 CFR 20, refer to 29 CFR 1910.96.

Several other agencies such as the National Council on Radiation Protection and Measurements (NCRP) and the Federal Radiation Council (FRC) also have the authority to set and enforce standards and other measures to protect workers from radiation exposure, and the JCAHO requires that a professional health physicist be available on staff or as a consultant in any hospital with radiology equipment.

9.1.3 Potential Health Effects

Radiation produces acute effects as well as delayed injuries. The degree of radiation damage depends on which organs and tissues are radiated. In general, the effects of radiation exposure are cumulative. Occupational exposure to ionizing radiation is usually localized and can lead to a sign condition known as erythema or radiodermatitis. A very high dose of radiation can produce symptoms of cerebral edema within minutes and can cause death within 24 hours.

Ionizing radiation can cause gene mutation and chromosomal alteration. It can also delay or impair cell division and interfere with metabolic processes. Cells that normally divide rapidly (e.g., the blood forming tissues, skin, and gonads) are usually more severely affected than the slower dividing cells (e.g., the bones, endocrine glands, and nervous system).

Other effects that result from radiation include several types of cancers such as myelogenous leukemia, lung and kidney fibrosis, cataracts, aplastic anemia, sterility, radiodermatitis, and a shortened life span resulting from accelerated aging.

9.1.4 Sources and Hazard Location

Radiation exposure usually results from the scattering of X-ray beams caused by deflection or reflection from the main beam, or the emission of gamma rays by patients who are being treated with radionuclides or have therapeutic implants that emit gamma and beta radiation.

Several areas of occupational exposure to ionizing radiation deserve special attention.

Interventional radiology is a new, rapidly expanding subspecialty of diagnostic radiology. Interventional procedures such as percutaneous angioplasty require health care personnel to be in the fluoroscopy suite for extensive periods of time that are far longer than the fluoroscopy times used for other procedures, for example, an upper gastrointestinal series. Healthcare workers employed in interventional radiology can receive monthly doses in excess of annual limits (Brateman, 1989).

Dynamic CT scanning is still another new diagnostic modality. Contrast material is injected intravenously as the patient is being scanned. This results in exposure for personnel present in the CT room during the scan. A study by Kaczmarek et at., (1986) demonstrated that the the resulting radiation exposure for the radiologist is appreciable (9 to 15 mR per scan).

Nuclear medicine entails the injection of radioisotopes into the patient. The radioisotopes emit radiation that is detected by gamma cameras to form an image. The patient continues to emit radiation after the completion of the study. The dose rate of radiation emitted after injection with most radioisotopes is low. Personnel located ten centimeters away from a patient who has just completed an average bone scan would potentially receive 9.6 mrem/hr (Harding et al., 1985).

According to Harvard, (1989) ultrasonographers can be exposed to ionizing radiation emitted from patients who earlier in the day underwent nuclear medicine studies. It is not uncommon for patients to undergo nuclear and ultrasound studies in the same day. The ultrasonographer must be in close physical proximity to the patient for a period of 10 to 15 minutes to perform the ultrasound examination. Although the dose from one person would be small, the cumulative annual dose could be substantial, as high as 1.5 rem/yr.

Rueter, (1978) demonstrated that the mean radiation exposure of physicians during cardiac catheterization, as measured at the collar level, is approximately 10 to 15 milliroentgens (mR) per procedure. Physician radiation exposure during an upper gastrointestinal series, a far less complex procedure than cardiac catheterization, is in the range of one to two mR per procedure.

9.1.5 Exposure control Methods

Figure 9-1 includes general control measures taken to reduce occupational radiation exposure. However, the cornerstones of radiation protection are time, distance, and shielding.

Time, in this context, refers to the time that a healthcare worker is exposed to ionizing radiation. Holding other factors constant, reducing the fluoroscopy time for a given procedure reduces the dose to healthcare personnel present in the fluoroscopy room. Therefore, careful patient scheduling can reduce this radiation dose to personnel such as ultrasonographers.

• Symbols should be properly mark in all radiation sources and radiation areas.
• Enclose all radioactive materials, and maintain contamination control boundaries around all sources.
• Locate X-ray controls to prevent the unintentional energizing of the unit, and check all X-ray machines before each use to ensure that the secondary radiation cones and filters are in place.
• Keep X-ray room doors closed when in equipment in use.
• Equip treatment rooms with radiation monitors, door interlocks, and visual alarm systems.
• Check system calibration periodically in therapeutic radiology settings.
• Permit only trained personnel in the room and provide adequate warning to nearby workers when portable X-rays are about to be taken.
• Follow correct decontamination procedures when control methods fail.
• Wear lead aprons, gloves, and goggles in areas where direct field or scatter radiation levels are high.
• Check all protective equipment annually.
• Use a thyroid shield and leaded glasses for consistently elevated exposure (e.g., angioplasty).
• Prevent radiation exposure to pregnant workers.

Figure 9-1 General Control Measures for Radiation Exposure. (NIOSH, 1988)

The intensity of scattered radiation relative to the primary beam decreases with the square of the distance from the center of the beam on the patient's surface. It is crucial that healthcare workers such as ICU personnel be situated an adequate distance away from sources of scatter radiation.

Shielding refers to barriers that can block radiation. The use of shielding allows healthcare workers to get closer to the source of radiation with a similar level of protection. Lead-lined and concrete walls are examples of barriers. Leaded aprons play an integral role in protecting bone marrow, one of the organs most sensitive to radiation. The radiation dose to personnel can be measured by using dosimetry and also be reduced by the use of leaded glasses and thyroid shields.

9.2 Nonionizing Radiation

Nonionizing radiation does not have enough energy to ionize atoms, but it vibrates and rotates molecules, causing heating. Nonionizing radiation is classified by frequency, which is stated in Hertz (Hz). Nonionizing radiations is not as great a hazard in health care facilities, but it may exist. The following types of nonionizing radiation may be present: ultraviolet (UV), infrared (IR), radiofrequency (RF), ultrasound, and visible (e.g., lasers).

Shielding, enclosures, and personal protective equipment including eye protection may often be used to control the exposure to nonionizing radiation.

9.2.1 UV Radiation

UV radiation may be emitted from germicidal lamps, dermatology treatments, nursery incubators, and air filters. Exposure may result in the burning of exposed skin and serious eye effects.

There is no current OSHA standard for UV radiation exposure, but NIOSH has composed guidelines which include some recommendations for allowable exposure to UV light.

The best prevention approach for UV exposure is to provide a strong educational program and to issue protective glasses for all potentially exposed workers.

9.2.2 IR Radiation

Exposure to IR radiation in hospitals may occur during the use of heating or warming equipment in the kitchen and during procedures involving lasers or thermography.

The hazards associated with exposure to IR radiation are acute skin burns, increased vasodilation of the capillary beds, and increased pigmentation that may continue for some time. Continued exposure may also result in eye damage.

There are no OSHA or NIOSH recommendations for occupational exposure to IR radiation, but eye protection with proper filters may be provided to workers to limit exposure.

9.2.3 RF Radiation

Numerous applications exist for RF radiation. These applications include heating as in diathermy, cancer therapy, thawing of frozen organs for transplantations, sterilization of ampules, and enzyme inactivation in tissues. Microwave ovens, used to heat food, are an additional exposure source. This is an important consideration for dietary/kitchen workers.

RF radiation may produce some adverse biological effects from the heating of deep body tissues, thus potentially damaging cells. Neurological, behavioral, and immunological changes have also been associated with RF radiation.

For guidelines for occupational exposure to RF radiation, consult both the American National Standard Institute (ANSI), and the American Conference of Governmental Industrial Hygienists (ACGIH).

The OSHA guidelines for exposure to microwaves is ten milliwatts per square centimeter. Food and Drug Administration has set a limit of five milliwatts per square centimeter for leakage from microwave ovens during normal use.

Any area where RF radiation exposure exceeds permissible levels may be considered potentially hazardous. These areas should be clearly identified, and warning signs should be posted.

9.2.4 Ultrasound Radiation

The medical use of ultrasound includes therapeutic, surgical, and diagnostic procedures. Low frequency ultrasound radiation may produce local effects when a person touches parts of materials being processed by ultrasound. Exposure to powerful sources of ultrasound may result in damage to peripheral nervous and vascular structures at the points of contact. Airborne ultrasound vibration may produce effects on the central nervous system and on other systems and organs through the ear as well as extra auditory routes.

There are no OSHA standards or NIOSH recommendations for ultrasound, but the ACGIH has proposed some permissible exposure limits to exposure to airborne upper sonic and ultrasonic acoustic radiation which can be referenced. Most exposure to ultrasonic vibration can be reduced by the use of enclosures and shields.

9.2.5 Visible Radiation

Sources of visible radiation in health care facilities include incandescent and fluorescent lighting and lasers. Constant exposure to some forms of lighting may result in visual fatigue and headaches. Glare from visible radiation sources may be reduced by properly positioning equipment, filters, or shields, and providing routine rest periods which are also helpful for the eyes.

9.2.5.1 Lasers

Lasers (light amplification by stimulated emission of radiation) have found use in virtually every surgical specialty including microsurgery. Lasers have also been used for measuring immunoglobulins and other elements in the blood. The most common locations for lasers are in radiology department (where they are used to help align patients for radiographic treatment) and in surgical areas (where they have a wide variety of applications).

Misdirection of the beam due to disconnection of the articulated arm, or a break in the fiberoptic cable, or specular reflection of the beam from shiny surfaces could expose those nearby to hazardous laser energy. Lasers cause damage because they focus large amounts of light energy on to a small surface area. Lasers present a few special hazards including damage to vision from exposure to laser light, skin burns from laser beams, the risk of inhaling pathogens, chemicals, or particulates in smoke from burned tissue, the possibility of fires, and electrical shock.

Although OSHA has not yet regulated lasers, various organizations have issued standards and protocols for general and surgical laser safety. The regulations by the FDA on performance of lasers should be consulted when these devices are used. ANSI has also provided guidelines for the safe use of lasers, and ACGIH has published recommendations for occupational exposure to laser radiation which should be consulted.

9.2.5.1.1 Area Controls

Lasers should only be used in controlled areas. Entry into the laser area should be limited to essential personnel, who must don protective eye wear prior to a laser procedure. Windows located in the laser area must be covered with material that is nonreflective and prevents light energy of the wavelength being used from escaping.

Various signs (e.g., the standard laser hazard symbol) and signals should be employed to alert personnel that the laser is being used.

9.2.5.1.2 Eye Protection during Surgery

During microscopic and endoscopic laser surgery, automatic shutter systems place protective filters in the line of sight during laser operation. These shutters have, on occasion, failed, causing damage to the surgeon's eyes. Except when special protocols have been established for specific surgical procedures, laser delivery through microscope optics does not preclude the need for protective eye wear for the rest of the OR staff. Surgeons using an endoscope equipped with protective filters must wear a protective lens for their other eye.

9.2.5.1.3 Inspection and Maintenance

It is strongly recommended that personnel who inspect or service surgical lasers receive special training. Inspecting and maintaining lasers is a dangerous as well as a necessary process. A far greater degree of care is necessary than with many other devices. Serious personal injury from laser emissions and electric shock can result to service personnel or others present in the room during servicing if appropriate precautions and procedures are not followed. Daily operational maintenance is usually performed by the user, laser technician, or OR personnel. Daily, weekly, and pre-use inspections and maintenance procedures should all be strictly adhered to for safe usage.

9.2.5.1.4 Summary

Healthcare facilities should have in place a comprehensive laser safety program, knowledgeable staff, and a laser safety committee (LSC) to provide the necessary controls to protect personnel against harmful exposure to laser light. The program must embrace all OR personnel, researchers and technicians, as well as those responsible for maintenance and repair of lasers.

CHAPTER 10

STRESS

10.1 Stress and Job Performance

It is generally agreed that physical and emotional fitness contributes to effective mental effort. If a high level of stress is detrimental to health, it follows that excessive stress is also likely to have an adverse impact on job performance.

To date, a substantial amount of behavioral research has established an inverted U-shaped relationship between stress and ability to maintain high performance on the job. Individuals who experience extremely low levels of stress are characterized by a low level of job performance. In other words, when a person is not ambitious, has no incentive to perform a task, or has no hope of a favorable outcome (promotion, salary increase), the expenditure of effort appears pointless. Individuals with higher educational achievement may be over-qualified for the position they hold. They are thus "under-loaded", and often manifest apathy, boredom, and low morale.

As motivation and drive to achieve increase, the level of stress rises along with productivity and efficiency. The right amount of stress can lead to innovative ideas and constructive output. A person working at the optimum arousal level shows enthusiasm, high morale, mental clarity and good judgment. But when the demands and pressures of the job become unreasonable, performance again declines as stress drains the person's health, power, stamina, and perspective.

Signs of overload include: irritability, physical and mental fatigue, indeciveness, loss of objectivity, an increased tendency to make errors, memory lapses, and strained interpersonal relationships. These characteristics are most dangerous in hospitals where a high level of performance is required because of the nature of the job, i.e., patients' lives may be in jeopardy. Therefore, an optimal stress level is necessary to allow an individual to perform at his/her best.

10.2 Overview of Stress Related Hazards

Hospital work often may requires coping with some highly stressful situations. Hospital workers must deal with life-threatening injuries and illnesses complicated by overwork, understaffing, tight schedules, paperwork, intricate or malfunctioning equipment, complex hierarchies of authority and skills, dependent and demanding patients, and patient death. All of these factors directly contribute to increasing stress.

In addition, the increasing size and bureaucracy of many hospitals may depersonalize the environment and leave many workers feeling isolated, fatigued, angry, powerless, and frustrated. Failure to recognize and treat the sources of stress results in workers who suffer "burnout" (i.e., those who remain on the job but cease to function effectively). Workers are most likely to encounter severe stress in intensive care units, burn units, emergency rooms, and operating rooms.

In 1977, NIOSH investigators published a study of hospital admissions for mental health disorders among 130 major occupational categories. Of the 22 occupations with the highest admission rates for mental disorders, six were health care occupations (health technologists, practical nurses, clinical laboratory technicians, nurses' aides, health aides, registered nurses, and dental assistants (Colligan et at. 1977). Another study reported that the proportional mortality ratio (PMR) for suicide was elevated for male dentists, physicians, medical and dental technologists, and nurses.

Hoiberg, (1982) examined occupational stress and illness among white male enlisted Navy personnel and found that mess management specialists and hospital corpsmen were more frequently hospitalized for stress related illnesses than Navy personnel in other occupational groups. She reported that the following factors contributed to the stress experienced by mess management specialists and hospital corpsmen: low job status, less favorable job characteristics such as work load, and reponsibility for the well being of others, and less satisfactory work environment composed of high physical demands, occasionally high noise levels, high temperatures, and dangerous work.

Hoiberg, (1982) reinforces existing information on stress among nurses and other occupational groups involved in direct patient care. Her study also indicates that hospital food service work may be considered a high stress occupation as well.

One of the most stressful areas of the hospital is the intensive care unit (ICU). Several studies of ICU nurses indicate that the following factors also increase stress (Bailey et al. 1980; Gribbins and Marshall 1982) in this setting:

- Interpersonal conflicts (nurse-physician, nurse-nurse, and nurse-supervisor)
- Complex disease states, treatments, and equipment
- Staffing problems
- Nature of direct patient care (emergencies, attemps to prolong life, sudden death, and the deaths of special patients)
- Physical work environment (malfunctioning or noisy equipment, lack of space, and physical injury)
- Lack of rewards (pay, benefits, and advancement opportunities)

Gribbins and Marshall, (1982) also examined stress among nurses in the neonatal intensive care unit (NICU). Over several years of employment, nurses progressed through various stages of stress. Initially the nurses were concerned about their competence in the new job. Later they raised questions about the job itself (e.g., they questioned the quality of life for NICU survivors). Still later, they felt they had mastered the job and were indifferent because they did not receive enough positive rewards for their work. Those still in the unit after three years had developed a number of coping mechanisms such as humor and tolerance.

Koran et al., (1983) explored the problems of 37 health care workers in the burn unit of a 425 bed county general hospital to determine how their job stresses affected morale and patient care. Koran et al. described the following emotional stressors of these workers:

- The pain suffered by patients during dressing changes
- Uncooperative behavior, expressions of hostility and rejection by patients because of the necessity to inflict pain during debridement
- Unreasonable demands made by family members
- Dealing with psychiatric disorders that frequently precede or accompany severe burns
- Problems common to staff members of other ICU's, including:
    - Lifting of heavy patients
    - Exposure to mutilated bodies
    - Conflict with administrators over staffing and scheduling
    - Lack of emotional support from physicians
    - Concern about the inevitability of mistakes

10.3 Potential Effects

Stress has been associated with loss of appetite, ulcers, mental disorders, migraines, difficulty in sleeping, emotional instability, disruption of social and family life, and the increased use of cigarettes, alcohol, and drugs. It has also been associated with loss of self-confidence, withdrawal, and/or absenteeism. Stress can also affect worker attitudes and behavior; all of which lead to decrease levels of job performance and increase the occupational hazard associated with the stress. Some frequently reported consequences of stress among hospital workers are: difficulties in communicating with very ill patients, maintaining pleasant relations with co-workers, and judging the seriousness of a potential emergency.

10.4 Causes of Stress

Factors commonly mentioned as causes of stress by all categories of hospital workers are enumerated in Figure 10-1. Other important stress factors include: job specialization, discrimination, concerns about money, lack of autonomy, work schedules, ergonomic factors, and technological changes. These factors are briefly discussed below.

Increased job specialization has made it more difficult for workers to move in to higher positions in the hospital. Specialized jobs are stressful and involve a higher rate of occupational injuries such as back strain and dermatitis.

• Understaffing
• Role conflict and ambiguity
• Inadequate resources
• Working in unfamiliar areas
• Excessive noise
• Lack of administrative rewards
• Under-utilization of talents and abilities
• Rotating shift work
• Exposure of toxic substance
• Exposure of infectious patients
• Lack of control (influence, power) and participation in planning and decisionmaking.

Figure 10-1 Causes of Stress.
(Bailey 1980; Gribbins et al. 1982; Koran et al. 1983)

Despite recent trends to the contrary, women and minorities still tend to be clustered in lower-level hospital positions. Money matters are a significant source of stress for many hospital workers. Although hospital workers's wages have increased over the past decade, the difference between the higher and lower paying positions has also increased.

Frustration over the frequent lack of decision making power is a significant stressor. Nurses sometime may feel demeaned when their observations and recommendations for patient care are ignored or overruled.

The effects of stress can be worsened by shift work, especially rotating shift work. A NIOSH study of the effects of rotating shifts indicated that approximately 25% of the 1219 nurses in the study regularly worked rotating shifts. These nurses reported visiting clinics for medical problems significantly more often than those working regular shifts (NIOSH, 1978a).

More nurses on rotating shifts stated that they stayed away from work because of acute respiratory infections, upper and lower gastrointestinal symptoms, headaches, colds, and influenza. The nurses on rotating shifts also visited clinics more because of these complaints and others such as pharyngitis, gastritis, menstrual disorders, dermatitis, nervous symptoms, sprains and strains, contusions, and crushed body parts (NIOSH, 1978a).

Stress can also result from ergonomic factors such as poorly designed equipment, lighting, and the need to lift heavy patients.

Technological changes have also contributed increasingly to the stress of hospital workers. The introduction of Video Display Terminals at ward desks, the rapid change in medication protocols, and the development of new procedures and equipment may all frustrate staff to a certain degree when they are not given adequate training and time to incorporate these changes into their work patterns.

10.5 Methods for Coping with Stress

Some of the methods that have successfully reduced hospital worker stress and dissatisfaction include the following (Huckabay and Jagla, 1979; Bailey et al., 1980; Koran et al., 1983):

- Regular staff meetings and discussions to communicate feelings, gain support, and share innovative ideas
- Institution of stress management programs
- Readily available counseling
- Flexibility and innovation by supervisors to create alternative job arrangements
- Adequate training
- Reasonable shift schedules for house staff to allow adequate time for sleep each day
- Organized and efficient work functions and environment
- Recognition of and action on legitimate complaints

- Group therapy for staff with difficult professional problems such as dealing with cancer patients, chronic illness, and death
- Relaxation exercises and biofeedback to relieve symptoms of stress until the sources are identified and evaluated
- Frequent educational sessions to improve skills and confidence
- More flexibility and worker participation in scheduling
- More attention to ICU's, operating rooms, and emergency rooms.

These methods have proven to be effective and may also help any hospital in reducing worker stress levels in order to achieve the goal of improving their job performance.

CHAPTER 11

CONCLUSIONS

A well designed occupational safety and health program serves healthcare facilities by reducing the risks to employees and thereby providing a happier, safer, and more healthful workplace. It should be designed to achieve several goals:

1. To make the facility safe and healthful.
2. To fulfill those requirements specified by JCAHO.
3. To comply with all applicable federal, state, and local regulations.

JCAHO's objective is for hospitals to establish a systematic approach to safety management. This requires the facility to develop an effective safety management program, appoint a safety officer, establish a safety committee, and provide in house safety orientation and continuing education. To enhance communications and compliance, JCAHO requires that the safety committee be composed of representatives from administrative, clinical, and support services.

The safety officer's participation is also critical, because he or she is responsible for the development, implementation, and monitoring of the safety management program, understanding all applicable regulatory requirements, and informing administration of its obligations. The safety officer must be able to enforce policies and procedures, communicate effectively at all organizational levels, and gain the support of nursing, medical, and other staff.

The safety officer cannot handle the management of hazards without appropriate help from all hospital personnel - from top management, through department heads and supervisors, to technical and support personnel, and even volunteers.

Regulatory compliance is an added burden, but it is the current way of doing business. In order to fully comply with regulation, and provide a safe and healthful workplace, two management principles must be instituted: (1) put the responsibility for compliance in the hands of well trained professionals, and (2) take a proactive posture toward regulation.

Healthcare facilities should lead the way in occupational health and safety, and assume a proactive posture toward regulation by taking steps to reduce or control hazards before they are required to act. This can be achieved by the following program:

- Manage the workplace as if a risk-free environment is attainable.
- Encourage trust so that employees will approach members of the administration first about problems, rather than OSHA or other regulatory agencies.

- Help those persons responsible for hazardous materials, waste disposal, and employee health and safety to obtain background educations that will increase their understanding of the nature of regulation, and training in practical solutions to managing specific problems.
- Be proactive in the workplace by considering these points:
  - Along with mandatory monitoring for formaldehyde and EtO, conduct annual monitoring in laboratories, and operating rooms for exposure to solvents, mercury, and other potentially harmful chemicals.
  - Consider the installation of EtO emission control equipment.
  - Keep careful track of all hazardous substances coming into and going out of the facility, and make every effort to reduce the amount of hazardous substances used.
  - Offer hazard training to employees who routinely use cleaning and disinfecting products.
  - Train all employees with potential exposure to harmful substances; offer refresher courses at least every two years.
- Implement a program to enable the hospital to become an occupational health and safety resource for the community. The minimum hospital commitment should be to provide basic information about all applicable occupational hazards.

Overall, it is more cost-effective to try to prevent problems than to solve them after they occur. Therefore, the information and management plans contained in this thesis represent the tools that will help hospitals minimize the impact of regulations, remain in compliance, and most important of all, provide a safe and healthful workplace for all their employees.

APPENDIX A

CHECKLIST FOR DEVELOPING A HOSPITAL SAFETY AND HEALTH PROGRAM

The following checklist provides essential elements for developing a hospital safety and health program to identify and control occupational hazards as suggested by NIOSH (1988). However, personnel thoroughly trained in occupational safety and health are needed to design, implement, and manage such a program.

1. Administrative support

A. Form a safety and health committee.

B. Appoint a safety officer, employee health director, and other responsible personnel.

C. Allocate time for surveys and committee meetings.

D. Allocate funds to evaluate and monitor hazards, implement controls, and conduct health exams.

2. Hazard identification

A. Conduct periodic walk-through inspections.

B. Obtain material safety data sheets (MSDS's) and other information on potential hazards.

C. Maintain a log of hazardous chemicals and materials that are used or stored in each department.

3. **Hazard evaluation**

   A. Conduct saftey inspections and industrial hygiene monitoring of potential hazards and determine needs for hazard controls.

   B. Conduct medical evaluation.

   C. Select appropriate medical surveillance program.

4. **Training**

   A. Develop and begin a training program for workers, based on job responsibilities.

5. **Controls**

   A. Select appropriate control measures and implement controls and medical surveillance program as determined in hazard evaluation.

6. **Program review**

   A. Preview results of periodic safety inspections, industrial hygiene monitoring, and medical surveillance programs to find patterns of hazards, to measure the success of the safety and health program, and to determine the effectiveness of controls.

   B. Change the safety and health program as new materials or procedures are introduced or as new hazards are identified in the review process.

7. Recordkeeping

A. Maintain records of results for all surveys, evaluations, monitoring, corrective actions, and worker medical examinations.

B. Maintain these records in accordance with applicable local, state, and federal regulations.

APPENDIX B

JOB TASKS FOR JOB SAFETY ANALYSIS

These are some examples of job tasks in the hospital setting that are needed for the job safety analysis. They may not be complete, but will be the place to start the analysis. This will help the analyst to recognize hazards and potential accidents associated with each job task. The job tasks listed below may not be the only responsibilities the particular worker has. Therefore, the need to think about more tasks associated with the job should be stressed.

BIOMEDICAL ENGINEERING TECHNICIAN

1. Repairs electronic equipment.
2. Solders circuit boards.
3. Repairs equipment in operating room.
4. Works on Respirators.
5. Calibrates sphygmomanometers.
6. Cleans equipment to be repaired.

HOUSEKEEPING AID IN PATIENT CARE AREA

1. Empties trash.
2. Cleans restrooms.
3. Cleans and waxes floors.
4. Vacuums carpets and dusts furniture.

LABORATORY TECHNICIAN

1. Draws blood samples.
2. Prepares samples for analyses.
3. Performs manual chemical analyses.
4. Uses flame photometer.
5. Cleans glassware with acids.
6. Makes up solutions.

NUCLEAR MEDICINE TECHNICIAN

1. Gives patients radioactive doses.
2. Prepares solutions.
3. Uses diagnostic detection equipment.
4. Draws blood.

GROUNDS WORKER

1. Mows lawns.
2. Fertilizes lawns.
3. Sprays herbicides.
4. Uses chain saw.
5. Uses gas "weedeater".
6. Drives a tractor.

APPENDIX C

OCCUPATIONAL HAZARDS BY LOCATION AND/OR DEPARTMENT

This list contains some hazards in the hospital by location and/or department. By no means, is this list all inclusive.

Location and/or Department	Hazard
1. **Bio-medical**	Communicable diseases Mercury
2. **Brace shop**	Machine guarding Solvents, glues Plastic resins Catalysts Methacrylates Isocyanates Welding Flammable
3. **Central supply**	Needle punctures Communicable diseases Ethylene oxide Infection Broken equipment (cuts) Soaps, detergents Steam Flammable gases Lifting Heat stress Noise Burns Asbestos insulation Mercury Disinfectants, cleaners Solvents
4. **Dialysis units**	Infection High risk Hepatitis B Formaldehyde Chemical disinfectants Concentrated acids

Location and/or Department	Hazard
5. Dental service	Mercury Ethylene oxide Anesthetic gases Ionizing radiation Infection
6. Emergency department	High risk hepatitis B Security
7. Food service	Strains, sprains Cuts/infections Falls, contusions Wet floors Sharp equipment Noise Heat stress Machine guarding Burns Soaps, detergent Disinfectants Ammonia Chlorine Solvents Drain cleaners Oven cleaners Caustic solutions Pesticides Microwave ovens Steam lines Ovens Electrical hazards
8. Housekeeping	Soaps, detergents Cleaners Solvents Disinfectants Glutaraldehyde Infection Needle punctures Communicable diseases Chemical wastes Radioactive wastes Infectious wastes Electrical hazards Strains, sprains Climbing Slips, falls

Location and/or Department	Hazard
9. Laboratory	Infectious diseases Toxic chemicals Benzene Ethylene oxide Formaldehyde Mercury Oxidizers Concentrated acids Corrosives Cyanide Dyes Solvents Flammable agents Explosive agents Carcinogens Teratogens Mutagens Cryogenic hazards Chemical wastes Radioactive wastes Infectious wastes Radiation High risk Hepatitis B Dermatitis/Burns
10. Laundry	Wet floors Lifting Noise Heat Burns Infection Needle punctures Chemical wastes Radioactive wastes Soaps, detergents Solvents, bleaches
11. Maintenance and engineering	Electrical hazards Tools, machinery Heat and Cold stress Lifting; Falls Noise Compressed gases Welding fumes Asbestos Solvents Pesticides Ethylene oxide Freons Paints, adhesives

Location and/or Department	Hazard
12. Nuclear medicine	Radionuclides Infection X-irradiation
13. Obstetrics	Nitrous oxide (C section)
14. Occupational therapy	Tools and equipment Chemicals, paints
15. Office areas	Falls, contusions Video display terminals Indoor air quality Ergonomic/body mechanics Chemicals Ozone
16. Oncology	Patients with radioactive implants Antineoplastic drug
17. Operating room/Surgery	Anesthetics Antiseptics Methyl methacrylate Ethylene oxide waste Compresses gases Sterilizing gases Infection X-rays, fluoroscopy Nonionizing radiation Ultraviolet Electrical hazard Sharp instruments Strains, sprains
18. Pathology	Infectious diseases Formaldehyde Glutaraldehyde Flammable substances Freons Solvents Phenols Xylene
19. Patient care	Lifting Pushing, pulling Slips, falls Standing for long periods Infectious diseases Radiation Radioactive patients

Location and/or Department	Hazard
patient care continues....	
	Needle punctures Toxic substances Chemotherapeutic agents Electrical hazard
20. **Pharmacy**	Pharmaceuticals Antineoplastic agents Flammable liquids Mercury Slips, falls
21. **Physical therapy**	Strain, sprains Chemical burns Security
22. **Radiology**	Radiation Infectious diseases Lifting, strains/sprains Pushing, pulling, moving Electrical hazard Falls, contusions Nitrous oxide
23. **Respiratory therapy**	Communicable diseases Contaminated equipment Ethylene oxide Cold soaks Disinfectants Aldehydes Phenols Compressed gas

APPENDIX D

OCCUPATIONAL EXPOSURE TO BLOODBORNE PATHOGENS

OSHA, in an effort to avert the spread of hepatitis B virus (HBV), human immunodeficiency virus (HIV), and other bloodborne diseases in the workplace, has finalized rules aimed specifically at the work practices of healthcare employees.

These rules assume that all human blood and certain body fluids and tissues are potentially infectious for HBV, HIV, and other bloodborne pathogens. The rationale for this approach is that carriers of these diseases are not always identifiable, and contaminated materials are not always properly labeled. Thus, the exposed worker can be at great risk without warning.

OSHA's bloodborne pathogens standard, 29 CFR 1910.1030, which is based on CDC's concept of universal precautions, includes the following eight primary categories of control:

1. EXPOSURE CONTROL PROGRAM

In implementing the standard, the employers will first develop a written exposure control program that identifies (a) the tasks and work areas that are likely to present exposures to blood or other potentially infectious products and the employee positions that are involved (b) the schedule and method of implementation of all of the standard's components, and (c) the evaluation procedures that will be used following exposure incident.

2. TRAINING

Employees will be required to participate in employer-provided training, which is to be accomplished at the time of employment, and at least annually thereafter.

The training must include clinical and epidemiologic information about infectious diseases, modes of transmission, and means to reduce risks of exposure. It must designate specific procedures to be used in the work setting and specific policies to deal with exposures. Signs and labels, warning of the hazards of exposure, are also an important element of the communication process.

3. PRE-SCREENING/HBV VACCINATION

The employers must offer prescreening and HBV vaccine to those employees who are exposed to blood or other potentially infectious materials on average of one or more times per month. It must be offered to new employees within 10 days of employment. HBV vaccination is a means of achieving substantial reduction in the risk of infection for nonimmune employees.

4. POST-EXPOSURE EVALUATION AND TREATMENT

This step includes testing to determine whether there has been any transmission of infection, and follow-up treatment and counseling. In the case of exposure to HBV, follow-up treatment can prevent illness. Thus, procedures for reporting exposures are also an important part of the infection control program.

5. ENGINEERING CONTROLS

Engineering controls serve to reduce employee exposure by either removing the hazard or isolating the worker from exposure. These controls encompass process or equipment redesign (e.g., self-sheathing needles), process or equipment enclosure (e.g., biosafety cabinets), and employee isolation. In general, engineering controls act on the source of the hazard and eliminate or reduce employee exposure without reliance on the employee to take self protective action.

6. WORK PRACTICES

Work practice controls reduce the likelihood of exposure through alteration of the manner in which a task is performed. While work practice controls also act on the source of the hazard, the protection they provide is based upon employer and employee behavior rather than installation of a physical device.

7. PERSONAL PROTECTIVE EQUIPMENT

The use of personal protective equipment (gloves, masks, face shields, gowns, aprons, and emergency ventilation devices) is a direct line of defense for healthcare workers whose exposures may occur through contact with infected patients.

8. HOUSEKEEPING MEASURES

Since linens or waste products contaminated with blood or other potentially infectious products may present a risk of disease transmission, the proposed standard establishes handling procedures for housekeeping and laundry staff, and provides measures that will reduce contact with contaminated linens and waste by requiring clearly labeled, leakproof containers or bags.

Recognizing that the conditions of exposure to bloodborne pathogens are substantially different from those of exposure to other hazards, and the primary hazard sources involved, the combination of controls described above is best used to prevent exposure incidents.

APPENDIX E

REQUIREMENTS FOR LABORATORY STANDARD
(29 CFR 1910.1450)

The laboratory standard is a generalized procedure-based, rather than a specific substance-based, standard. Consequently, OSHA conducts inspections to see if the procedures drawn up in the Chemical Hygiene Plan (CHP) will actually prevent or minimize exposure.

There is less concern with the specific chemicals handled in the laboratory than with the procedures for handling all chemicals of a specific hazard.

1. EXPOSURE MONITORING

Employers must conduct exposure monitoring if there is a substance-specific standard that requires it, such as for ethylene oxide. Otherwise, there are no mandatory monitoring requirements. Employees must be notified of the results within 15 days of the receipt of those results.

2. CHEMICAL HYGIENE PLAN

The employer must develop a written chemical hygiene plan (CHP) capable of protecting employees from health hazards associated with hazardous chemicals by maintaining exposures at or below permissible exposure limits (PELs) and short term exposure limits (STELs).

The CHP pertains to exposure to hazardous substances. The control of physical laboratory hazards is not required as part of the CHP. The plan must contain:

1. Standard operating procedures relevant to safety and health for use of hazardous chemicals.
2. The criteria by which employers must implement control measures to reduce exposures, including:
   - Engineering controls
   - Personal protective equipment
   - Hygiene practices
3. Special precautions for extremely hazardous chemicals (such as carcinogens, reproductive hazards, acutely toxic substances), which include:
   - Establishment of special areas for hazardous chemical use
   - Use of containment devices
   - Decontamination procedures
4. Specific measures to ensure that fume hoods and other protective equipment are working properly
5. Provisions for employee information and training
6. Provisions for medical consultation and examination
7. Designation of personnel responsible for implementing the CHP

3. EMPLOYEE INFORMATION AND TRAINING

Employers must advise employees of chemical hazards at the time of initial assignment and whenever new exposure situations occur. Refresher training schedules must be determined by the employer and do not have to be conducted at specific intervals. Employees must be informed of or trained in:

- The contents of the laboratory standard
- The location and the availability of the CHP
- The PELs for OSHA regulated substances and recommended exposure limits for nonregulated substances
- The signs and symptoms associated with exposures to hazardous chemicals.
- The location and availability of known reference material, including Material Safety Data Sheets (MSDSs), on hazards, safe handling, storage, disposal of hazardous chemicals.
- Methods and observation that may be used to detect the presence or release of hazardous chemicals
- Physical and health hazards of chemicals
- Measures which may be taken by employees to protect themselves, including emergency procedures and personal protective equipment

4. MEDICAL CONSULTATION AND EXAMINATION

Employers must provide medical attention, including follow up examinations if the employee develops signs or symptoms of exposure to a chemical; spills, leaks, or explosions occur, or exposure monitoring reveals an exposure level above the action level or the PEL. The employer must obtain a written opinion from the examining physician.

5. HAZARD IDENTIFICATION

Employers must ensure that labels on incoming containers of hazardous chemicals are not removed or damaged. The employer is encouraged to follow good laboratory practices, such as by, identifying the contents of all containers. Employers must also maintain all MSDSs received with shipments of chemicals. In terms of application, there is a gray area between the laboratory standard and the hazard communication standard. However, OSHA states that if the CHP is acceptable, then laboratories will automatically be in compliance with the hazard communication standard.

6. USE OF RESPIRATORS

Employers must provide respirators at no cost to the employee. Respirators must be selected and used in accordance with 29 CFR 1910.134. Employees must be trained in their use and certified by physicians to wear them.

7. RECORDKEEPING

Employers must maintain for each employee an accurate record of any monitoring and medical examination. These records must be made available in accordance with 29 CFR 1910.20.

APPENDIX F

THE MANAGEMENT PLAN FOR ANTINEOPLASTIC DRUGS

This plan summarizes the guidelines suggested by OSHA regarding the proper work practices for personnel dealing with cytotoxic (antineoplastic) drugs.

EMPLOYEE TRAINING PROGRAM

All employees who may come into contact with antineoplastic drugs and contaminated drug waste should know the potential risks of exposure to the drugs, as well as the procedures they should follow to protect themselves. It is also recommended that periodic review courses are given. A log should be kept that indicates which employees have received appropriate training.

WARNING SIGNS AND LABELS

Posted Warning/Label	Location
"Antineoplastic drugs-Authorized personnel only!"	Pharmacy storage areas Drug preparation areas
Spill procedures	Pharmacy storage areas Drug preparation areas
List of drugs covered by antineoplastic drug policies	Pharmacy storage areas
"Chemotherapy-Handle with gloves-Dispose of properly!"	Syringes, IV bags, bottles
"Danger-Chemotherapy spill-Keep clear."	Spill area
"Do not use-Contaminated."	Contaminated BSCs

DRUG PREPARATION

Personal Protective Equipment (PPE)

- Powder-free, disposable latex gloves.
- Lint-free, low-permeability disposable gown with a closed front, long sleeves, and elastic or knit cuffs.
- In the absence of a BSC:
  - Full-face respirator with HEPA filter.
  - Available eyewash.

Biological Safety Cabinets (BSC)

- Prepare drugs only when the viewing window is in the proper position.
- Line the BSC with a disposable, plastic-backed paper liner.
- Keep the BSC blower on 24 hours a day, 7 days a week.

Drug Handling

- Needles.
  - If possible, prime IV sets within BSC.
- Ampules.
  - Tap down contents before opening.
  - Open with gauze wrapped around the ampule neck.
  - Inject diluent down the inside wall of the ampule, wetting all powder before agitating.
- Vials.
  - Vent through a filtered venting device.

   - Add diluent to vial by alternately injecting small amounts and allowing displaced air to escape into the syringe.
   - Wrap gauze around needles and vial tops when withdrawing the solution.
- Noninjecting dosage forms.
   - Do not use counting machines for tablets or capsules.
   - Compound drugs in a BSC.
- Transport.
   - Ready to administer drugs should be in sealable containers for transport to patient area.

DRUG ADMINISTRATION

Personal Protective Equipment

- Powder-free, disposable latex gloves.
- Lint-free, low permeability disposable gown with a closed front, long sleeves, and elastic or knit cuffs.

Drug Administration Kit

- PPE.
- Sterile gauze pads.
- Alcohol wipes.
- Disposable plastic backed absorbent liners.
- Puncture proof sharps containers.
- Four millimeter sealable plastic or wire tie bags, with warning labels.

- If additional preparation must be done in drug administration areas:
    - Respirator.
    - Splash proof goggles.
    - 32 ounce bottle of eyewash or water.
    - Face wash.

Work Practices

- Wash hands before and immediately after wearing gloves.
- Immediately change gloves or gowns that become contaminated.
- Place a plastic backed absorbent pad under tubing during administration to catch leakage.
- Use gauze in a plastic bag when priming IV sets or expelling air from syringes.
- Wipe syringes, IV bottles and bags, and pumps clean of any drug contamination using an alcohol wipe.
- Wear surgical latex gloves and disposable gowns when handling blood, vomitus, or excreta from patients who have been treated with antineoplastic drugs in the last 48 hours.
- Observe Universal Precautions when handling contaminated linen, in compliance with OSHA's bloodborne pathogens standard.

PERSONNEL CONTAMINATION

- Direct skin contact.
  - Wash affected area immediately with soap and water.
  - Seek medical attention immediately.

- Eye exposure.
  - Flood affected eye with water for at least five minutes.
  - Seek medical attention immediately.

- All acute exposures should be reported on incident forms and in the employee's medical record.

SPILLS

Spill Kit

A spill kit containing the following items must be available in all areas where antineoplastic drugs are prepared, administered, and transported.

- Industrial latex gloves and shoe covers.
- Low permeability, disposable protective garments.
- Chemical splash goggles for eye protection.
- Full face respirator.
- Absorbent, plastic backed sheets or spill pads.
- Two or more sealable, thick plastic disposable bags with warning labels and disposable towels.
- Puncture-resistant sharps containers for glass fragments.

Small Spills (Less than five milliliters or five grams)

- Wear PPE (gloves, gown, and eye protection).
- Wipe up liquids with absorbent gauze pads.
- Wipe up solids with wet absorbent gauze, or wet the spill and sweep it into a dustpan.
- Clean area three times with a detergent solution and clean rinse water.
- Place glass fragments in a sharps container.
- Place the sharps container and all materials used in cleanup into a plastic disposable bag.
- Clean goggles with an alcohol wipe after cleanup.

Large Spills (Greater than five milliliters or five grams)

- Evacuate area.
- Notify spill team.
- Don PPE (gloves, gown, and Full face respirator)
- Gently cover spill with absorbent sheets or spill control pads or pillows to limit the spread.
- Cover powders with damp clothes or towels.

Spills in BSC Hoods

- Follow the procedures outlined above.
- Decontaminate all interior hood surfaces.
- Change the HEPA filter if it is so full that adequate airflow can not be maintained. Have a pressure gauge on the filter to indicate the filter's load.

WASTE DISPOSAL

- U-listed drugs must be handled as hazardous waste.
- U-listed drugs may be divided into:
  - "Trace amount" waste: used syringes, IV bottles, gloves, gowns, used alcohol swabs, etc.
  - "Bulk contaminated" waste: containers of unused drugs, partially filled containers, etc.
- Environmental Protection Agency (EPA) does not require that trace amount waste be disposed of as hazardous waste but Bulk contaminated waste does.
- Sharps can be disposed of in puncture-resistant, leakproof sharps containers as biomedical waste.
- Autoclaving contaminated sharps is not effective treatment.

REFERENCES

1. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile for ethylene oxide. Washington, DC: Public Health Services, 1990.

2. Agothos, M. "Formaldehyde contact allergy." Contact Dermatitis. 1982; 8: 79-80.

3. American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the threshold limit values and biological exposure indices. Cincinnati, OH: ACGIH, 1989.

4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). 1987 ASHRAE handbook: Heating, ventilating, and air-conditioning systems and applications. Atlanta, GA: ASHRAE, 1987.

5. Anderson, L. "Major trends in nosocomial viral infections." American Journal of Medicine. 1991 Sep 16; 91: 107-111.

6. Armstrong, S. "Aerosol pentamidine: Medical facilities cited." Job Safety Health. 1990 Sep 4; 333: 2-3.

7. Bailey, J., S. Steffen, et al. "The stress audit: identifying the stressors of ICU nursing." Journal of Nursing Education. 1980; 19(6): 15-25.

8. Becker, M., N. Janz, et al. "Noncompliance with universal precautions policy: Why do physicians and nurses recap needles?" American Journal of Infection Control. 1990 Aug; 18(4): 232-9.

9. Brateman, L. "A plea for sensible film badge placement in diagnostic radiology." Health Physics. 1989; 56: 567-8.

10. California Department of Industrial Relations, Division of OSHA (Cal/OSHA). Guidelines to prevent employee exposure to aerosolized pentamidine. San Francisco: Cal/OSHA, Sept 24, 1990.

11. Centers for Disease Control and Prevention (CDC). Protection against viral hepatitis: Recommendations of the Immunization Practices Advisory Commitee (ACIP). Morbidity and Mortality Weekly Report. 1990 Feb 9; 39(RR-2).

REFERENCES
(Continued)

12. Centers for Disease Control and Prevention (CDC). Guidelines for infection control in hospital personnel. Infection Control. 1983 Jul-Aug; 4(4): 326-49.

13. _____. Guidelines for isolation precautions in hospitals. Infection Control. 1983 Jul-Aug; 4(4): 245-325.

14. _____. Guidelines for prevention of transmission of human immunodeficiency virus and hepatitis B virus to health-care and public-safety workers. Morbidity and Mortality Weekly Report. 1989 Jun 23; 38(5-6): 1-37.

15. _____. Nosocomial infection rates for interhospital comparison: Limitations and possible solutions. Infection control Hospital Epidemiology. 1991 Oct; 12(10): 609-21.

16. _____. Public health service statement on management of occupational exposure to human immunodeficiency virus, including considerations regarding zidovudine postexposure use. Morbidity and Mortality Weekly Report. 1990 Jan 26; 39(RR-1): 1-14.

17. _____. Tuberculosis morbidity in the United States: Final data. Morbidity and Mortality Weekly Report. 1991; 40(SS-3): 23-27.

18. _____. Nosocomial transmission of multidrug-resistant tuberculosis among HIV-infected persons - Florida and New York, 1988-1991. Morbidity and Mortality Weekly Report. 1991; 40(34): 585-591.

19. _____. Guidelines for preventing the transmission of tuberculosis in health-care settings, with special focus on HIV-related issues. Morbidity and Mortality Weekly Report. 1990; 39(RR-17): 1-29.

20. _____. A strategic plan for the elimination of tuberculosis in the United States. Morbidity and Mortality Weekly Report. 1989; 38(16): 269-272.

21. Charney, W. Control of formaldehyde exposure in hospitals. In: Charney W, Schirmer J, eds. Essentials of modern hospital safety. Chelsea, MI: Lewis Publishers, 1990.

**REFERENCES
(Continued)**

22. Clever, L. "Health hazards of hospital personnel." Western Journal of Medicine. 1981; 135(2): 162-5.

23. Cohen, S. "Skin disease in health care workers." Occupational Medicine. 1987; 2(3): 565-80.

24. Colligan, M., M. Smith, et at. "Occupational incidence rate of mental health disorders." Journal of Human Stress. 1977; 3(3): 34-9.

25. Cox, T. "Nursing personnel accidents and their causes in a Veterans Affairs hospital." Applied Occupational & Environmental Hygiene. 1993 Aug; 8(8): 703-7.

26. Darre, E., P. Vedel, et al. "Skin protection against methyl methacrylate." Orthopedic. 1987; 58: 236-8.

27. Edling, C. "Anesthetic gases as an occupational hazard - A review. Journal of Work Environment Health. 1980; 6: 85-93.

28. Edmond, M., R. Khakoo, et al. "Effect of bedside needle disposal units on needle recapping frequency and needlestick injury." Infection control Hospital Epidemiology. 1988 Mar; 9(3): 114-6.

29. Eger, E. "Fetal injury and abortion associated with occupational exposure to inhaled anesthetics." American Anesthetic Association Journal. 1991 Aug; 59(4): 309-12.

30. Falk, S., and N. Woods. "Hospital noise levels and potential health hazards." New England Journal of medicine. 1973; 289(15): 774-781.

31. Finch, R. "Time for action on hepatitis B immunization." British Medicine Journal. 1987; 294: 197-8.

32. Fisher, W. "Laser smoke in the operating room." Biomedical Technology Today. 1987 Nov-Dec; 1: 191-5.

33. Fowler, J. "Allergic contact dermatitis from glutaraldehyde exposure." Journal of Occupational Medicine. 1989; 31(10): 852-3.

REFERENCES
(Continued)

34. Franco, G., M. Lorena and S. Ghitton. "Occupational exposure of operating theater personnel to isoflurane and nitrous oxide." Applied Occupational & Environmental Hygiene. 1992 Oct; 7(10): 677-681.

35. Gerbert, B., B. Maguire et al. "Why fear persists: health care professionals and AIDS." Journal of American Medical Association. 1988; 260: 3481-3.

36. Gribbins R., and R. Marshall. "Stress and coping in the NICU staff nurse: practical implications for change." Critical Care Medicine. 1982; 10(12): 865-7.

37. Goosens, A., and C. Enderby. "Fundamentals of medical lasers." Gastrointestinal Endoscopy. 1984; 30(2): 74-6.

38. Gullo, S. "Safe handling of antineoplastic durgs: Translating the recommendations into practice." Nursing Forum. 1988; 15(5): 595-601.

39. Harber, P., E. Billet, et al. "Occupational low-back pain in hospital nurses." Journal of Occupational Medicine. 1985 July; 27(7): 518-524.

40. Harding, L., A. Mostafa, et al. "Dose rates from patients having nuclear medicine investigations." Nuclear Medicine. 1985; 6: 191-4.

41. Harvard, A. "The unseen hazards of ultrasound." British Journal of Radiology. 1989; 62: 295-6.

42. Hazard Evaluation System and Information Service (HESIS). Fact Sheet #7: Xylene. Berkeley, CA: State of California Department of Health Services and Department of Industrial Relations, 1986.

43. Hendrick, D., R. Rando, et al. "Formaldehyde asthma: challenge exposure levels and fate after five years." Journal of Occupational Medicine. 1982; 24(11): 893-7.

44. Henderson, D., B. Fahey, et al. "Risk of occupational transmission of human immunodeficiency virus type 1(HIV-1) associated with clinical exposures." Annals of Internal Medicine. 1990; 113: 740-6.

**REFERENCES
(Continued)**

45. Hoiberg, A. "Occupational stress and illness incidence." Journal of Occupational Medicine. 1982; 24(6): 445-451.

46. Huckabay, L., and B. Jagla. "Nurses' stress factors in the intensive care unit." Journal of Nursing Administration. 1979; 9: 21-6.

47. Hudson, P., R. Vogt, et al. "Elemental mercury exposure among children of thermometer plant workers." Pediatrics 1987; 79(6): 935-8.

48. Jachuck, S., C. Bound, et al. "Occupational hazard in hospital staff exposed to 2 per cent glutaraldehyde in an endoscopy unit." Journal of Occupational Medicine. 1989; 39(2): 69-71.

49. Jensen, R. "Back injuries among nursing personnel related to exposure." Applied Occupational & Environmental Hygiene. 1990 Jan; 5(1): 38-45.

50. Joint Commission on Accreditation of Healthcare Organizations (JCAHO). 1993 accreditation manual for hospitals. Vol. 1 Oakbrook Terrace, IL: JCAHO, 1993.

51. _____. Plant, Technology & Safety Management Series. Controlling occupational exposures to tuberculosis. Number 1, 1993 Series.

52. Kole, T. "Environmental and occupational hazards of the anesthesia workplace." American Anesthesia Association Journal. 1990 Oct; 58(5): 327-31.

53. Koran, L., R. Moos, et al. "Changing hospital work environment: an example of a burn unit." General Hospital psychiatry. 1983; 5: 7-13.

54. Lloyd, P., C. Torling, et al. The handling of patients: a guide for nurses. 2nd ed. 1987; United Kingdom: Back Pain Association and The Royal college of Nursing.

55. Massachusetts Department of Public Health. Guidelines to reduce the chance of airborne tuberculosis transmission from HIV-infected patients. Boston: Massachusetts Department of Public Health, June 15, 1989.

REFERENCES
(Continued)

56. McCormick, R., and D. Maki. "Epidemiology of needlestick injuries in hospital personnel." American Journal of Medicine. 1981; 70: 928-32.

57. Montgomery, A., K. Corkery, et al. "Occupational exposure to aerosolized pentamidine." Chest. 1990 Aug; 98(2): 386-8.

58. Moser, R. Effetive management of occupational and environmental health and safety programs: A practical guide. Boston: OEM Press, 1992.

59. National Council on Radiation Protection and Measurements (NCRP). Radiation protection for medical and allied personnel. Washington, DC: NCRP, Report 48: 1976.

60. _____. Review of radiation dose limit for embryo and fetus in occupationally exposed women. Washington, DC: NCRP, Report 53: 1977.

61. National Institute for Occupational Safety and Health (NIOSH). Guidelines for protecting the safety and health of health care workers. Washington, DC: NIOSH, 1988: DHHS Publication No. 88-119.

62. _____. Work practices guide for manual lifting. Cincinnati, OH: NIOSH, 1981b: DHHS Publication No. 81-122.

63. _____. Hospital occupational health and safety. Cincinnati, OH: NIOSH, 1977: DHEW Publication No. 77-141.

64. _____. Development and evaluation of methods for the elimination of waste anesthetic gases and vapors in hospitals. Cincinnati, OH: NIOSH, 1975: DHEW Publication No. 75-137.

65. _____. Criterial for a recommended standard for occupational exposure to waste anesthetic gases and vapors. Cincinnati, OH: NIOSH, 1977: DHEW Publication No. 77-140.

66. _____. Criteria for a recommended standard: Occupational exposure to formaldehyde. Cincinnati, OH: NIOSH, 1976; DHEW Publication No. 77-126.

REFERENCES
(Continued)

67. _____. Criteria for a recommended standard: Phenol. Cincinnati, OH: NIOSH, 1976d; Publication No. 76-196.

68. _____. Criteria for a recommended standard: occupational exposure to dioxane. Cincinnati, OH: NIOSH, 1977a; DHEW Publication No. 77-226.

69. _____. Health consequences of shift work. Cincinnati, OH: NIOSH, 1978a; DHEW Publication No. 78-154.

70. _____. Criteria for a recommended standard: occupational exposure to hot environments; revised criteria 1986. Cincinnati, OH: NIOSH, 1986a; DHHS Publication No. 86-113.

71. _____. Working with hot environments; revised 1986. Cincinnati, OH: NIOSH, 1986b; DHHS Publication No. 86-112.

72. _____. Recommended standard for occupational exposure to xylene. Cincinnati, OH: NIOSH, 1975; DHEW Publication No. 75-124.

73. National Research Council (NCR). Formaldehyde and other aldehydes. Washington, DC: National Academy of Sciences, 1981.

74. Nethercott, J., and D. Holness. "Occupational contact dermatitis due to glutaraldehyde in health care workers." Contact Dermatitis. 1988; 18: 193-6.

75. Neuberger, J., J. Harris, et al. "Incidence of needlestick injuries in hospital personnel: Implications for prevention." Americal Journal of Infection Control. 1984 Jun; 12(3): 171-6.

76. Omenn, G., and S. Morris. "Occupational hazards to health care workers." American Journal of Industrial Medicine. 1984; 6(2): 129-137.

77. Occupational Safety and Health Administration (OSHA). Enforcement Guidelines for Occupational Exposure to Tuberculosis. New York: OSHA Region II, 1992.

78. _____. Work practice guidelines for personnel dealing with cytotoxic (antineoplastic) drugs. Washington, DC: OSHA, January 1986; Instructional publication 8-1.1.

REFERENCES
(Continued)

79. Patterson, W., D. Craven, et al. "Occupational hazards to hospital personnel." Annals of Internal Medicine. 1985; 102(5): 658-80.

80. Pearson, M. "Nosocomial transmission of multidrug-resistant Mycobacterium tuberculosis. A risk to patients and heath care workers." Annals of Internal Medicine. 1992; 117(3): 191-196.

81. Price, L., W. Rutala, and G. Samsa. "Tuberculosis in hospital personnel." Infection Control. 1987 Mar; 8(3): 97-101.

82. Reich, A. Safe use of ethylene oxide in the hospital environment. In: Charney W, Schirmer J. eds. Essentials of modern hospital safety. Chelsea, MI: Lewis Publisher, 1990.

83. Ribner, B. "An effective educational program to reduce the frequency of needle recapping." Infection Control Hospital Epidemiology. 1990; 11(12): 635-8.

84. Rogers, B., and P. Travers. "Overview of work related hazards in nursing: Health and safety issues." Heart Lung. 1991 Sep; 20(5): 486-97.

85. Rogers, B. "Health hazards to personnel handling antineoplastic agents." Occupational Health. 1987 Sep; 2(3): 513-24.

86. Rowland, A., D. Baird, et al. "Reduced fertility among women employed as dental assistants exposed to high levels of nitrous oxide." New England Journal of Medicine. 1992 Oct; 327(14): 993-7.

87. Rueter, F. "Physician and patient exposure during cardiac catheterization." Circulation. 1978; 58: 134-9.

88. Selevan, S., M. Lindbohn, et al. "A study of occupational exposure to antineoplastic drugs and fetal loss in nurses." New England Journal of Medicine. 1985 Nov; 313(19): 1173-8.

89. Sorsa, M., K. Hemminki, and H. Vainio. "Occupational exposure to anticancer drugs - Potential and real hazards." Mutation Respiration. 1985; 154: 135-49.

REFERENCES
(Continued)

90. Speizer, F., D. Wegman, et al. "Palpitation rates associated with fluorocarbon exposure in a hospital setting." New England Journal of Medicine. 1975; 292(12): 624-6.

91. Valanis, B., W. Vollmer, et al. "Antineoplastic drug handling protection after OSHA guidelines." Journal of Occupational Medicine. 1992 Feb; 34(2): 149-55.

92. Wear J., and D. Simmons. Hospital Safety Manual. 2nd Ed. 1986. Scientific Enterprises, Inc., North Little Rock, AR.

93. Wiggins, P., S. McCurdy, and W. Zeidenberg. "Epistaxis due to glutaraldehyde exposure." Journal of Occupational Medicine. 1989; 31(10): 854-6.

94. Williams, W. "Guidelines for infection control in hospital personnel". Infection Control. 1983 Jul-Aug; 4(4): 326-49.

95. 29 CFR 1900-1910. Occupational Safety and Health Administration (OSHA). 1910.94. Ventilation. Washington, DC: Office of the Federal Register National Archieves and Records Administration, 1993.

96. _____. 1910.95. Occupational noise exposure. Washington, DC: Office of the Federal Register National Archieves and Records Administration, 1993.

97. _____. 1910.96. Ionizing radiation. Washington, DC: Office of the Federal Register National Archieves and Records Administration, 1993.

98. _____. 1910.97. Nonionizing radiation. Washington, DC: Office of the Federal Register National Archieves and Records Administration, 1993.

99. _____. 1910.105. Nitrous oxide. Washington, DC: Office of the Federal Register National Archieves and Records Administration, 1993.

100. _____. 1910.133. Eye and Face Protection. Washington, DC: Office of the Federal Register National Archieves and Records Administration, 1993.

**REFERENCES
(Continued)**

101. 29 CFR 1900-1910. Occupational Safety and Health Administration (OSHA). 1910.134. Respiratory protection. Washington, DC: Office of the Federal Register National Archives and Records Administration, 1993.

102. 29 CFR 1910.1000 TO END. Occupational Safety and Health Administration (OSHA). 1910.1030. Occupational exposure to bloodborne pathogens. Washington, DC: Office of the Federal Register National Archieves and Records Administration, 1993.

103. _____. 1910.1047. Ethylene oxide. Washington, DC: Office of the Federal Register National Archieves and Records Administration, 1993.

104. _____. 1910.1048. Formaldehyde. Washington, DC: Office of the Federal Register National Archieves and Records Administration, 1993.

105. _____. 1910.1200. Hazard communication. Washington DC: Office of the Federal Register National Archieves and Records Administration, 1993.

106. _____. 1910.1450. Occupational Exposure to Hazardous Chemicals in Laboratories. Washington DC: Office of the Federal Register National Archieves and Records Administration, 1993.