CHAPTER 7

MEDICAL SURVEILLANCE

INTRODUCTION

Medical surveillance of personnel has become an intrinsic activity in any modern workplace. Various interrelated factors are responsible, including (a) extensive public awareness of health and safety risks, which is engendered by the explosion of telecommunication technology, (b) the increased exposure of corporations, corporate executives, and stockholders to potential liability regarding the exposure of both employees and the general public to workplace chemicals, (c) continually expansive regulatory requirements regarding employee health at all levels of government, (d) the rapid development of a global economy in which the protection of human health is rapidly becoming a basic precept of highly competitive marketing ploys, (e) trade union concerns for the health and well-being of members, and (f) corporate insurance underwriters.

While the nature and extent of medical surveillance in the workplace are variable with legal jurisdiction and type of industry, the broad dimensions of contemporary workplace medical surveillance are clearly established and pertain directly to any medical surveillance program established for emergency responders.

SURVEILLANCE OBJECTIVES AND CONCERNS

Typically, medical surveillance may be subdivided into four basic categories or types of surveillance: preemployment screening, periodic operational monitoring, episodic monitoring, and employment-termination examination.

Preemployment Screening

Preemployment screening generally encompasses three objectives:

- To determine the fitness of an employee to perform assigned work
- To identify any health conditions that might exacerbate the effects of work-related hazards
- To establish a baseline health profile that can be used to measure the effects of both short- and long-term exposure to work-related hazards

While each of these objectives is essential to the protection of workers, each is increasingly the subject of concern regarding a potential abasement of workers' rights—especially in light of the possible use of sophisticated clinical and genetic analyses to deny or otherwise restrict employment on the basis of potential health care costs likely to be borne by the employer.

It has also become clear that the increasingly widespread use over the last decade of the "temporary employee" (who is typically ineligible for health care and other work-related benefits) may reflect corporate intent to disclaim any long-term financial responsibility for worker health rather than simply to improve cost efficiency by reducing in-house staffs devoted to employee recruitment and training. There can be little doubt that the use of preemployment screening as a means of disenfranchising the employee-at-risk rather than as a means of protecting that employee will long continue to be the focus of legal, political, and social scrutiny and debate—especially with regard to emergency response personnel, a category that includes (a) first-responders, who may often be temporary employees or, if full-time employees, personnel whose primary exposure to hazards is defined by normal (i.e., nonemergency) workplace conditions, as well as (b) full-time emergency response personnel. In the latter case, the stringency of preemployment health standards (applied to "new hires") as compared to the stringency of post-employment health standards (applied to currently employed personnel) could well become of legal relevance in any legal proceeding based on purported bias in hiring practices.

Medical surveillance undertaken to determine fitness for work must be predicated on a precise understanding of the total range of health and safety hazards associated with individual work assignments (including both emergency-related and non-emergency-related tasks) as well as pertinent regulatory requirements (e.g., medical examination for use of respirator). While primarily defined by job requirements, fitness for work must also be determined on the basis of preexisting health conditions or limitations of the worker—a determination that may often be at odds with the desires of the worker and/or the employer. The employer is well advised that the willingness of a worker to undertake risks contrary to professional medical advice

generally does not necessarily abrogate the employer's responsibility for the health and safety of that worker. This fact underscores the importance of implementing a medical surveillance program that complies not only with the requirements of pertinent health and safety regulations but also with the constraints imposed by competent legal counsel.

In some instances, specific guidance is provided by regulatory authority or by professional organizations. For example, the standard promulgated by the National Fire Prevention Association (NFPA No. 1582: Standard on Medical Requirements for Fire Fighters) establishes medical requirements for both candidate as well as operational firefighters (*including age-dependent medical evaluations*) regarding:

- Vital signs
- Dermatological system
- Ears, eyes, nose, mouth, and throat
- Cardiovascular system
- Respiratory system
- Gastrointestinal system
- Genitourinary system
- Endocrine and metabolic systems
- Musculoskeletal system
- Neurological system
- Audiometric capacity
- Visual acuity and peripheral vision
- Pulmonary function
- Laboratory analyses
- Diagnostic imaging
- Electrocardiography

In addition to these requirements, various fire departments also use a range of tests to evaluate the physical fitness of candidate and engaged personnel, including (a) determination of body fat, (b) assessment of flexibility, (c) evaluation of aerobic power, and (d) assessment of physical strength.

Of critical importance in any medical surveillance program is the establishment of baseline health profiles of at-risk personnel. The comparison of these profiles with the results of subsequent surveillance is the basic means for detecting changes in health that may be related to routine and nonroutine exposures and stress. It is therefore essential that the medical examination performed in preemployment screening include those measurements of vital signs, vision and hearing measurements, lung function tests, and other clinical biochemical analyses that are directly relevant to work-related exposure and stress. The selection of specific tests and analyses and the type of data and information required must be made only with the professional advice of a competent medical authority who is provided with all

details regarding potential routine and emergency exposures. The medical surveillance program must, therefore, be understood to be specific to the emergency response service; no guideline can be provided for identifying specific tests and analyses to be included in a surveillance program that is universally appropriate throughout the emergency response community.

Periodic Operational Monitoring

The sole objective of periodic operational monitoring is the early detection of adverse health effects of routine exposure to hazardous agents and situations. As discussed above, periodic operational monitoring must be integrally linked with the baseline profiles established during preemployment screening. In the design of an operational monitoring program, particular attention should be given to the following issues:

1. Because of the wide diversity in types of hazardous agents and situations, the variable progression of different kinds of health impairments and conditions, and the range of work-related exposures, it is highly unlikely that a monitoring schedule appropriate for the early detection of one kind of health condition will be appropriate for the early detection of another kind. For example, depending upon specific work-related exposure, an annual schedule for blood testing to detect liver disease may not be appropriate for chest X-rays, which may in fact cause lung injury if used too frequently.

2. Differences noted between baseline profiles and subsequent operational monitoring do not necessarily indicate an actual disease or debilitation; even if a disease or debilitation is detected, it is not necessarily due to work-related exposure. All medical monitoring data and information are subject to normal variation; abnormal results that may indicate disease or debilitation may reflect home and recreational exposures as well as workplace exposures to hazardous agents; abnormal results may, in fact, not indicate any specific exposure but, rather, simply reflect overall systemic changes in body function.

For example, the alkaline phosphatase test is a very sensitive test that, simply because of its sensitivity, can give widely fluctuating results; it is therefore most often a rather nonspecific indicator of liver impairment. The less sensitive gamma glutamyl transpeptidase test is less influenced by extraneous factors, but elevations in this enzyme typically must be on the order of twice the normal amount to trigger clinical concern for liver damage.

The design of an operational monitoring program must therefore be undertaken with a clear understanding of statistical and other criteria of significance that medical professionals must use when interpreting monitoring results. It is strongly recommended that personnel included in a medical surveillance program be provided documentation regarding such criteria.

3. A properly designed medical surveillance program should include a detailed *action plan* that precisely describes steps to be taken whenever operational monitoring results in the detection of a medically significant condition, including follow-up medical examinations, tests, and treatments. The action plan should also provide for the implementation of a comprehensive review of response operations and procedures that may have contributed to the detected health impairment and which may be corrected.

Episodic Monitoring

Episodic medical monitoring includes any nonroutine medical monitoring or surveillance activity undertaken in response to a specific incident, condition, or circumstance, such as exposure to a specific chemical (e.g., styrene monomer), or responder complaints of unusual health symptoms (e.g., persistent headaches or nausea). While episodic monitoring is specifically addressed in particular U.S. regulations (e.g., 29 CFR 1910.1450 [Laboratory Standard], 29 CFR 1910.120 [Hazardous Waste Operations and Emergency Response]), it is appropriately included in any comprehensive medical surveillance program, regardless of regulatory jurisdiction.

Provisions for episodic medical monitoring must be predicated on several considerations:

1. While the episode that triggers nonroutine medical surveillance may often be described in terms of objective criteria, such as an uncontrolled exposure to a specific chemical, subjective criteria may alone be sufficient and even critical. Even in the absence of any objectively manifest evidence of exposure, the fact that personnel think they may have suffered a nonroutine exposure is sufficient cause for medical surveillance and consultation over and above that provided through regularly scheduled operational monitoring. While a safety officer may be apt—sometimes, with good reason—to consider an individual complaint the product of an overactive imagination or the purposeful contrivance of a "problem employee," safety officers are reminded that individual personnel may be particularly sensitive to a hazardous agent. Should a complaint be ignored simply because it is a singular complaint, it is possible that a real health threat will be ignored, with not only dire consequence to the individual, but also serious legal and financial ramifications for both the safety officer and the response service organization.

2. Whatever the cause or circumstance of the episode, medical authority must be provided with relevant data and information. In many instances, standard forms are used to provide medical professionals the appropriate information (Fig. 7.1). In all instances, it is necessary that

Global Emergency Response Services

Personnel Exposure Determination

Employee Identification

Name

Department

Reason for Implementing Determination of Exposure

- ☐ Monitoring Data
- ☐ Observed Spill or Release of Chemical
- ☐ Odor, Taste or Other Sensory Perception of Chemical
- ☐ Procedural/Operational Potential (e.g., open vessel; failure of ventilation)
- ☐ Signs or Symptoms of Chemical Exposure

Name(s) of Chemicals or Chemical Constituents and Relevant OSHA TLV

Chemical Name	OSHA TLV

Available Monitoring Data

Chemical Name	Date	Value/Unit

Description of Incident or Circumstance

Date

Signature of Safety Officer

FIGURE 7.1 Example of a form that provides an attending physician or other medical professional with critical information regarding personnel exposure to a hazardous agent.

preliminary liaison be established between the safety officer and medical personnel so that the latter have direct access to baseline information that may become relevant to any subsequent episode. Such baseline information should at a minimum include an inventory of relevant chemical agents that, for each listed chemical, identifies hazards, target organs, and routes of entry. It is

also recommended that combustion, water-reactive, and other by-products be identified for each chemical included in the inventory, along with the hazards and target organs associated with those by-products.

3. Episodic events that trigger medical surveillance include those predicated by the recognition of health symptoms. It is therefore essential that all personnel receive thorough training in the range of symptoms that may be associated with response-exposure to hazardous agents and understand the importance of reporting such symptoms to the safety officer. Symptoms (Table 7.1) associated with work-related exposure to hazardous agents typically cannot be differentiated from symptoms associated with non-work-related exposure or from various health conditions or infections totally unrelated to the work environment. However, the safety officer must understand that the only competent authority for determining the significance of any health symptom is the physician. It is the responsibility of the physician to evaluate symptoms and to determine the relevance of those symptoms to operational exposures; it is the responsibility of the safety officer (and the emergency service organization) to ensure that personnel who display health symptoms have immediate access to the physician.

4. As important as symptoms are for triggering medical consultation and surveillance, the limitations of symptoms must be recognized. For example, the health effects of exposure to many hazardous chemicals often require years and decades to develop. In such cases, there may be no readily recognized symptoms for extended periods of time, whereas in others, clear symptoms develop rapidly after exposure to the hazardous agent (Fig. 7.2). In compiling a list of symptoms requiring medical notification, the safety officer must therefore ensure consideration of the range of symptoms associated with both chronic and acute health effects. It is also necessary to identify which particular symptoms require immediate medical response.

The inherent limitations of symptomatology as a trigger to medical consultations mean that the safety officer must establish additional criteria for activating episodic medical monitoring. Examples of such criteria include (but are not limited to):

- Any failure or aberrant function in exposure control devices or procedures during an emergency response incident (e.g., respirator, decontamination procedure)
- An area-wide release of toxic fumes or particles, with the result of potential exposure of nonprotected emergency response personnel
- First-time operational experience with a specific chemical or other hazardous agent
- Notification through postincident review that personnel might have been exposed to hazardous agents not previously identified or recognized

TABLE 7.1 Common Symptoms That May Indicate Exposure to Hazardous Chemicals (Adapted from Materials Provided by Dr. Donald G. Erickson)

- Chest pain or discomfort
- Bluish lips or face; extreme paleness
- Persistent coughing or sneezing
- Breathing discomfort; rapid or strained breathing
- Palpitations or fluttering in chest
- Lightheadedness or dizziness; giddiness; fainting
- Headaches (especially persistent, recurrent or progressive)
- Itching or irritation of eye; watering of eye; sensitivity to light
- Visual impairment, including reduced vision, double vision and changes in perception of color
- Loss of physical coordination or dexterity; slurring of speech
- Unusual hair loss
- Bleeding of gums or nose
- Increased sensitivity to noise; changes in hearing acuity; ringing in ears
- Abnormal odor of breath
- Hoarseness
- Fever
- Abnormal sweating or dryness of skin
- Generalized aches and pains; muscle cramping; weakness of a particular muscle
- Prickly sensation in legs, arms, or face
- Prickly or numb sensation in tongue
- Nausea, vomiting, abdominal pain; burning sensation in throat or stomach
- Unusual thirst
- Problems in swallowing; change in taste sensation
- Loss of appetite
- Changes in color of urine
- Unusual skin rashes or swelling; acne-like skin lesions; blisters
- Changes in skin color
- Personality changes
- Abrupt or progressive behavioral changes, including changes in personal grooming; impairment of judgment; aggressiveness; irritability
- Nervousness or restlessness; tremors or shakes
- Lethargy or unusual sleepiness

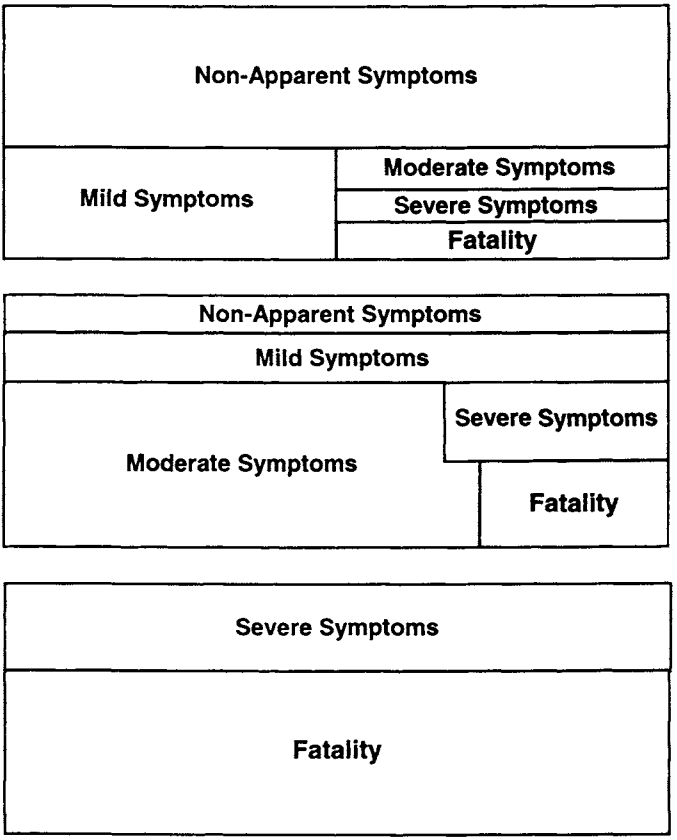

FIGURE 7.2 Distribution of clinical severity for three distinct types of infection. Other distributional patterns are possible, depending upon the specific infectious agent.

- Special conditions or circumstances encountered during emergency response operations that might have resulted in unforeseen exposures (e.g., temperature inversions, rain, discovery of purposely hidden hazardous wastes)

Termination Examination

The objective of the termination examination is to complete the total health profile of terminated personnel over the full period of employment. While specific requirements may be defined by pertinent regulations (e.g., in the United States, 29 CFR 1910.120) or, more commonly, by insurance

underwriters, the termination examination must be based on preemployment screening, operation, and episodic monitoring data and information available to date as well as on incident-related exposures or health symptoms experienced between the last medical examination and the termination examination.

In addition to taking specimens for the purpose of conducting final clinical or biochemical analyses (e.g., urinalysis, blood count, enzymes), it is possible that response organizations will increasingly request specimens to be warehoused for potential future analysis by as yet undeveloped or currently experimental methodologies. Such an approach, which is now rarely practiced, will most likely receive increased attention due to mutually reinforcing trends in rapidly expanding analytical technology and in work-related health and safety litigation.

LIAISON WITH MEDICAL AUTHORITY

The various types of information and data generated in the progress of medical consultation and examination may be described in somewhat different terms by different medical practitioners and measured by different methodologies. For example, a "physical examination" given by any physician typically varies greatly from one physician to another, especially with regard to the physician's focus on a person's overall health as opposed to a focus on heath in terms of work-related activity and risk. Whereas measurements of height and weight have some useful meaning with regard to a person's general health, there is generally little if any significant meaning to these parameters with regard to response-related activities. As to actual methodologies or procedures, preferred methods are not necessarily those that are most precise but, in some circumstances, may be those that can be performed most rapidly. Which tests to perform and which method to employ can only be decided by licensed medical authority—and these decisions must be made on a case-by-case basis.

The fact that decisions about the type of data and information required and the best means for obtaining that data and information are within the sole province of the physician does not mean that the safety officer has little or even no responsibility for the design of an effective and comprehensive medical surveillance program. On the contrary, no other responsibility of the safety officer is more demanding or requires more liaison and coordination with external medical authority. Of particular importance are the following considerations:

1. Most safety officers tend to assume that any licensed medical authority is suitable for the design and implementation of a medical surveillance program. This is definitely not the case—not for the industrial

workplace, and certainly not for emergency response personnel. Where possible, the selection of medical professionals should be based on (a) professional experience in occupational medicine, (b) direct professional access to medical and analytical specialists and services regarding laboratory analyses and the timely processing of medically relevant data, and (c) demonstrated experience in quality control management of all professional medical services.

2. Even when contracting with medical professionals who have extensive experience in occupational medical specialties, the safety officer must understand the importance of providing these professionals with comprehensive baseline data and information on work-related hazards. Such data and information include not only specific information (for example, about ambient concentrations of hazardous chemicals), but also all information regarding the potential health significance of those chemicals, such as the target organs of the chemicals themselves and of combustion or water-reactive byproducts. While the safety officer might assume that medical professionals have this information, they often do not—which, given the tens of thousands of different chemicals in daily commerce, is understandable. It is also useful for medical service personnel to become aware of specific correlations and/or recommendations regarding types of hazardous exposures, target organs, and standard medical monitoring practices (Table 7.2) which are increasingly available through such authorities as professional fire fighting services and organizations, HAZMAT specialists, and regulatory agencies. Redundancy of information cannot harm; oversight of information that is readily available can be disastrous!

3. Despite the fact that the selection of appropriate medical testing of personnel is the responsibility of the medical professional, it is necessary that the emergency service safety officer thoroughly understand the basis of selection, including (a) the range of different medical tests and procedures that can be performed, (b) alternative methods for performing the various tests and procedures, (c) interpretive criteria to be used in evaluating the significance of medical data and information, and (d) limits associated with the use of any medical data or information for the purpose of diagnosing potential health conditions. In this regard, the safety officer is well advised that, as with any contracted service affecting the health and safety of personnel, any potential liability that might result from incompetence or oversight is not necessarily restricted to the contractor, but might also accrue to the emergency response service itself. In short, it is always best to assume that the emergency service is ultimately responsible for accepting and implementing the professional recommendations of its medical service contractors, including the recommendations made by licensed medical practitioners.

4. Prior to committing to any professional medical surveillance service, the safety officer must ensure that medical surveillance reports will be presented in a format that provides for (a) ready comprehension of the sig-

TABLE 7.2 Target Organs and Medical Monitoring Associated with Selected Substances (Adapted from NIOSH, USCG, and EPA, 1985: Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities)

Substance	Target Organs	Medical Monitoring
Aromatic Hydrocarbons	Blood; Bone marrow; Central nervous system; Eyes; Liver; Respiratory System; Skin; Kidney	Occupational/general medical history emphasizing prior exposure to these or other toxic agents; Medical examination with focus on liver, kidney, nervous system, and skin; Complete blood count; Platelet count; Measurement of kidney and liver function
Asbestos	Lungs; Gastrointestinal system	History and physical examination focused on lungs and gastrointestinal system; Stool test for occult blood evaluation; High quality chest X-ray and pulmonary function test
Halogenated Aliphatic Hydrocarbons	Central nervous system; Kidney; Liver; Skin	Occupational/general medical history emphasizing prior exposure to these or other toxic agents; Medical examination with focus on liver, kidney, nervous system, and skin; Laboratory testing for liver and kidney function; carboxyhemoglobin where relevant
Heavy Metals	Blood; Skin Cardiopulmonary system; Kidney; Liver; Lung; Central nervous system; Gastrointestinal system	Occupational/general medical history emphasizing prior exposure to these or other toxic agents; Medical examination with focus on liver, kidney, nervous system, and skin; Complete blood count; Platelet count; Measurement of kidney and liver function
Herbicides	Kidney; Liver; Central nervous system; Skin	History and physical exam focused on the skin and nervous system; Measurement of liver and kidney function; Urinalysis
Organochlorine Insecticides	Kidney; Liver; Central nervous system	History and physical exam focused on the nervous system; Measurement of kidney and liver function; Complete blood count for exposure to chlorocyclohexanes
Organo-phosphate & Carbamate Insecticides	Central nervous system; Liver; Kidney	Physical exam focused on the nervous system; Red blood cell cholinesterase levels for recent exposure (plasma cholinesterase for acute exposures); Measurement of delayed neurotoxicity and other effects
Polychlorinated Biphenyls (PCBs)	Liver; Skin; Central nervous system (possibly); Respiratory system (possible)	Physical exam focused on the skin and liver; Serum PCB levels; Triglycerides and cholesterol; Measurement of liver function

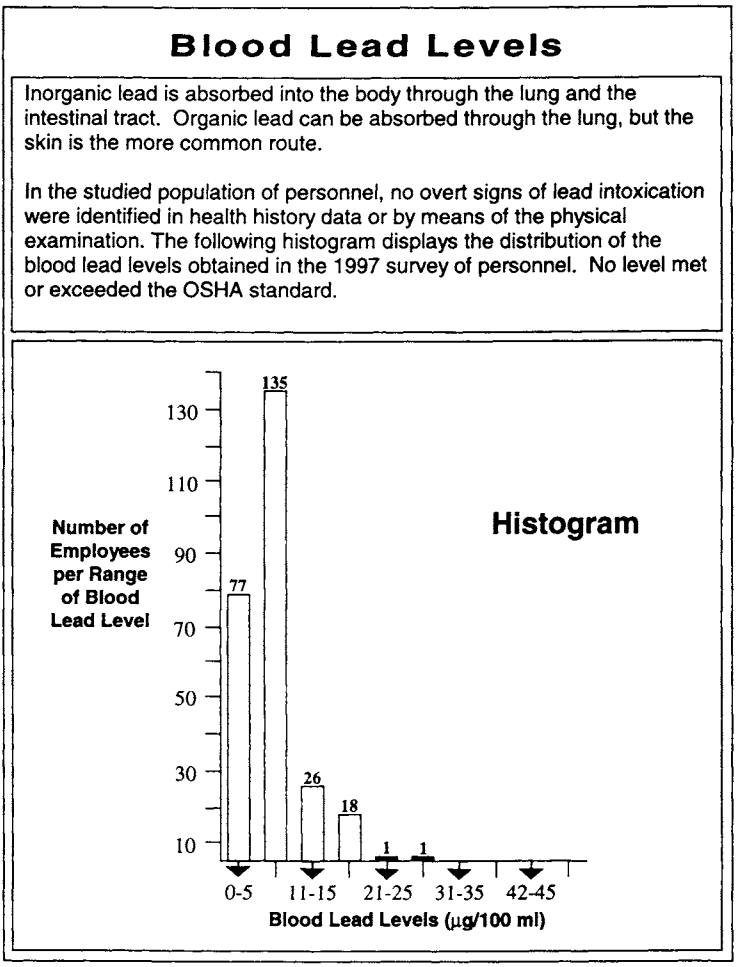

FIGURE 7.3 Example of a summary presentation of medical monitoring data regarding blood lead levels among personnel. Such a concise verbal and graphic presentation of medical surveillance data is necessary in order to ensure that nonmedically trained persons can understand the significance of detailed medical surveillance findings and the recommendations of physicians (adapted from materials provided by Environmental Medicine Resources, Inc.).

nificance of medical data and information by responsible emergency response service personnel, and (b) professional documentation regarding any potential need for follow-up action. Summaries of each type of health monitoring data should clearly highlight the significance of findings and present the basis for the interpretation of that significance (Fig. 7.3).

5. The processing and handling of any health-related information must be monitored assiduously to ensure confidentiality. The safety officer is strongly advised to examine in detail those control measures implemented by all relevant medical service personnel (including external examining physicians and medical-testing laboratory personnel) and, where necessary to demand additional safeguards.

Of particular importance is the need to ensure that physicians do not report any health information about personnel to emergency service personnel that does not directly relate to work-related conditions or fitness for assigned work. The reporting of medical monitoring results and the maintenance of medical records must be conducted in strict conformity with established rules governing confidentiality and should be closely coordinated with emergency service legal counsel, human resource personnel, and the legal counsel of medical contractors.

TYPES OF MEDICAL ANALYSIS

Overview of Standard Medical Tests

Medical service contractors that provide essential medical surveillance services to emergency response organizations (and, increasingly, emergency response services themselves) employ different categorical terms for describing analytical or diagnostic tests. Some of these categories are based on long-used terms that reflect medical specialties and/or health service management, such as hematology, clinical chemistry, and urinalysis (Table 7.3). Other categories are specific to the types of analyses available for diagnosing structural or functional aberrations of specific organs and tissues, such as the liver, kidneys, and blood-forming functions (Table 7.4).

However categorically described, individual analyses must be selected on the basis of a comprehensive assessment of the types of hazards actually encountered by emergency response personnel.

A detailed job (and task) analysis has long been recognized as the absolutely necessary first step in providing for the proper medical surveillance of emergency response personnel exposed to the smoke, toxic fumes and gases, and airborne particulates associated with fire fighting and the management of hazardous chemical wastes. Since the advent of AIDS and, certainly continuing with our on-going experience with emerging and re-emerging infectious diseases (Chapter 6), job analysis has also increasingly focused on how specific emergency response tasks can result in the exposure of response personnel to bloodborne pathogens and other biohazards. In the

TABLE 7.3 Types of Information Typically Generated in a Medical Surveillance Program for Emergency Response Personnel

Category	Analyses
Medical History	- Medical/surgical history - Allergy history - Family history - Body systems - Work-exposure history
Vital Signs	- Blood Pressure - Pulse
Respiration	- Respiratory rate - Pulmonary function
Vision	- Visual acuity - Depth perception - Color vision - Peripheral vision
Hearing	- Threshold value
Urinalysis	- Specific gravity - Albumin - Sugar - Blood - pH - Microscopic examination
Electrocardiogram	- Resting cardiogram - Stress Test
Radiology	- Chest X-Ray
Hematology	- White blood cell count - White cell differential count - Red blood cell count - Platelet count - Hemoglobin - Corpuscular volume - Corpuscular hemoglobin - Reticulocyte count
Clinical Chemistries	- Serum glutamic pyruvate transaminase - Total bilirubin - Alkaline phosphatase - Lactic dehydrogenase - Serum glutamic oxaloacetic transaminase - Gamma glutamyl transpeptidase - Blood urea nitrogen - Creatinine - Serum glucose - High density lipoprotein - Low density lipoprotein - Triglyceride - Sodium - Potassium - Chloride
Physical Fitness	- Body fat - Flexibility - Aerobic power - Muscular endurance - Muscular power - Muscular strength - Grip strength

same period, more and more attention has been given to the careful analysis of just how response personnel become subject to the extremely debilitating effects of both physical and psychological stress—two types of risk that have always been attendant to emergency response, but which demand closer scrutiny as *ergonomic* and *critical incident stress.*

TABLE 7.4 Relevance of Monitoring Tests and Analyses to Functional Health of Selected Organ and Tissue Systems(Adapted from NIOSH, USCG, and EPA, 1985: Occupational Safety and Health Guidance Manual for Hazardous Waste Activities)

Function	Test	Examples of Analyses
Liver:		
General	Blood Tests	Total protein; Albumin; Globulin; Total/direct bilirubin
Obstruction	Enzyme test	Alkaline phosphatase
Cell Injury	Enzyme tests	Gamma glutamyl transpeptidase; Lactic dehydrogenase; Serum glutamic-oxaloacetic transaminase; Serum glutamic-pyruvic transaminase
Kidney:		
General	Blood Tests	Blood urea nitrogen; Creatine; Uric acid
Multiple Systems & Organs:		
General	Urinalysis	Color; Appearance; Specific gravity; pH; Qualitative glucose; Protein; Bile; Acetone; Occult blood; Microscopic examination of centrifuged sediment
Blood-Forming Function:		
General	Blood Tests	Complete blood count with differential and platelet evaluation, including white cell count, red blood count, hemoglobin, hematocrit or packed cell volume, and desired erythrocyte indeces; Reticulocyte count may be appropriate if there is a likelihood of exposure to hemolytic chemicals

Ergonomic Stress

Clearly a still developing discipline, ergonomics deals with the causes and consequences of mechanical tensions in the musculoskeletal system, including those related to vibration, forceful exertion, awkward posture, repetitive and/or prolonged activity, localized bodily impact, and certain environmental conditions (e.g., heat, cold, noise). While ergonomics tends to focus on mechanical forces operating on muscles, nerves, bones, and tendons, ergonomics also extends into the emotional and other psychological correlates of musculoskeletal dysfunction.

Mechanical stress on muscles, nerves, tendons, and bones can lead to physical injury to joints (e.g., in hand, wrist, neck, back, elbow, shoulder, leg) and surrounding tissue. Most injuries experienced by fire fighters and EMTs are due to physical stress on the musculoskeletal system. Typically referred to as *cumulative trauma disorder* (CTD), such an injury may be relatively minor and last for a relatively brief period of time, with primary symptoms expressed as mild discomfort or ache. However, CTD may also become severe, resulting in acute pain, and may progress even to the point of complete disability.

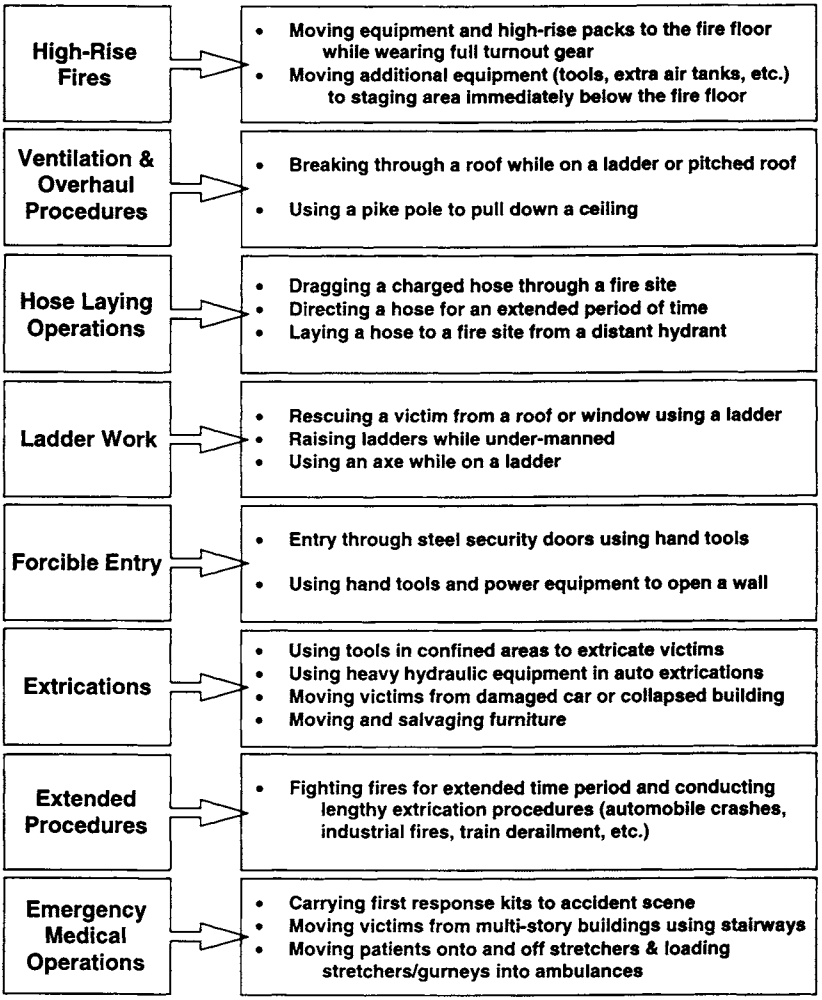

FIGURE 7.4 Typical fire fighting and emergency medical service activities involving ergonomic hazards (adapted from U.S. Fire Administration, 1996: Fire and Emergency Medical Services Ergonomics).

In formulating a comprehensive medical surveillance program for emergency responders, careful assessment of ergonomic risk factors must be undertaken in stepwise fashion:

1. Identification of specific actions and activities that may result in ergonomic stress, including not only those activities associated with on-site incident operations (Fig. 7.4), but also all activities related to (a) responding

to/and returning from the incident site, (b) postemergency clean-up, replacement and refurbishing, and (c) all other nonemergency operations

2. Identification of specific symptoms and syndromes to be associated with different types of ergonomic stress (Table 7.5), with particular emphasis on (a) target organs and (b) personnel risk factors (e.g., level or degree of response activity associated with ergonomic stress, age, physical condition)

3. Establishment of appropriate reporting procedures and personnel training program that promote timely notification of medical authority regarding personnel complaints and symptoms

Critical Incident Stress

All persons may be presumed to operate within a range of individual capacity to cope with events and circumstances that may vary from quite normal to extraordinary. Of course, just what is normal and what is extraordinary depends upon the individual—not necessarily as a conscious decision or perception, but simply as an experiential fact. When the individual experiences an incident that essentially overwhelms his or her capacity to cope, that incident may be described as being a *critical incident;* the consequence of a critical incident to the mental and physical well-being of the person who experiences it is known as *critical incident stress.*

Critical incident stress is a common phenomenon in extreme circumstances, such as circumstances involving mass death, co-worker suicide, injury, and death of children. While such circumstances are frequently encountered by emergency response personnel, the frequency of encounter certainly does not immunize response personnel against subsequent critical incident stress, nor does it alleviate the potential severity of critical incident stress due to many other circumstances of emergency response, including (and perhaps, especially) a prolonged and extremely hazardous rescue effort conducted without success.

Critical incident stress is not only a common but also a quite natural phenomenon that does not in itself indicate any pathological state. People react extraordinarily to extraordinary events, and that immediate distress experienced by any person involved in a horrifying incident typically does lessen with the passage of time. However, the actual rate of psychological recovery from "the extraordinary" to "the ordinary" is highly variable from person to person (Fig. 7.5), ranging from weeks to months. Unfortunately, there is always a small probability that an individual will not return to a state of fully functional normalcy—that the critical incident stress evolves into a persistent and profound state of *post-traumatic stress disorder* wherein the individual suffers substantial disability.

TABLE 7.5 Types of Cumulative Trauma Disorders (Adapted from U.S. Fire Administration, 1996: Fire and Emergency Medical Services Ergonomics)

Hand & Wrist	*Neck & Back*
• **Tendinitis:** Inflammation of a tendon	• **Tension neck syndrome:** Neck soreness, mostly related to static loading or tenseness of neck muscles
• **Synovitis:** Inflammation of a tendon sheath	• **Posture strain:** Chronic stretching or overuse of neck muscles or related soft tissue
• **Trigger finger:** Tendinitis of the finger, typically locking the tendon in its sheath causing a snapping, jerking movement	• **Degenerative disc disease:** Chronic degeneration, narrowing, and hardening of a spinal disc, typically with cracking of the disc surface
• **DeQuervain's disease:** Tendinitis of the thumb, typically affecting the base of the thumb	• **Herniated disc:** Rupturing or bulging out of a spinal disc
• **Ganglion cyst:** Synovitis of tendons of the back of the hand causing a bump under the skin	• **Mechanical back syndrome:** Degeneration of the spinal facet joints (parts of the vertebrae)
• **Digital neuritis:** Inflammation of the nerves in the fingers caused by repeated contact or continuous pressure	• **Ligament sprain:** Tearing or straining of a ligament (the fibrous connective tissue that helps support bones)
• **Carpal tunnel syndrome:** Compression of the median nerve as it passes through the carpal tunnel	• **Muscle strain:** Overstretching or overuse of a muscle

continues

By the nature of their work, emergency response personnel are at special risk with respect to critical incident stress and posttraumatic stress disorder. After all, each incident presents a wide range of both environmental and psychological sources of stress (Fig. 7.6), any one or combination of which may prove sufficient to overwhelm the individual's capacity to cope.

Signs and symptoms of both critical incident stress and impending posttraumatic stress disorder are recognized as being of the following types:

- Cognitive (pertaining to individual's state of awareness or capacity to make judgments)
- Emotional (pertaining to the nature of an individual's feelings)
- Behavioral (pertaining to objectively observed interactions of an individual with others and the environment)
- Physical (physical and physiological aspects of the body)

TABLE 7.5—*continued*

Elbow & Shoulder

- **Epicondylitis ("tennis elbow"):** Tendinitis of the elbow
- **Bursitis:** Inflammation of the bursa (small pockets of fluid in the shoulder and elbow that help tendons glide)
- **Radial tunnel syndrome:** Compression of the radial nerve in the forearm
- **Thoracic outlet syndrome:** Compression of nerves and blood vessels under the collar bone
- **Rotator cuff tendinitis:** Tendinitis in the shoulder

Legs

- **Subpatellar bursitis ("housemaid's knee"):** Inflammation of patellar bursa
- **Patellar synovitis ("water on the knee"):** Inflammation of the synovial tissues deep in the knee joint
- **Phlebitis:** Varicose veins and related blood vessel disorders (from constant standing)
- **Shin splints:** Microtears and infammation of muscle away from the shin bone
- **Plantar fascitis:** Inflammation of fascia (thick connective tissue) in the arch of the foot
- **Trochanteric bursitis:** Inflammation of the bursa at the hip (from constant standing or bearing heaving weight)

Signs and symptoms of critical incident stress in emergency response personnel (Fig. 7.7) should not be viewed as sufficient in and of themselves to initiate immediate intervention by medical authority. However, the emergency service safety officer should take due caution to observe the progress of such signs and symptoms over time. However, signs and symptoms typically associated with the impending development of posttraumatic stress syndrome (Fig. 7.8) must trigger immediate intervention by appropriate medical authority.

Of course, in any comprehensive medical surveillance program, proactive approaches to health maintenance must be given priority. With respect to the dangers of critical incident stress, careful attention must be given to the implementation of programs, procedures, and techniques that help personnel to reduce stress before that stress becomes a significant problem. Many programs have been developed and are readily available through private consultants, governmental agencies (e.g., U.S. Fire Administration), professional organizations, and community services. Such programs typically include several of the following types of stress reduction techniques:

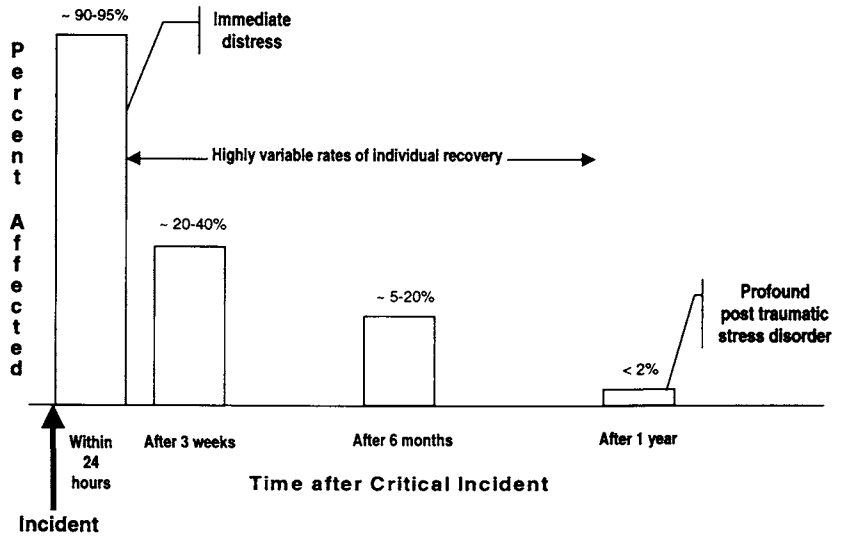

FIGURE 7.5 Typical pattern of development of critical incident stress over time (based on data and information provided by J. Mitchell and G. Bray, 1990: Emergency Services Stress. Englewood Cliffs: Prentice-Hall, Inc.).

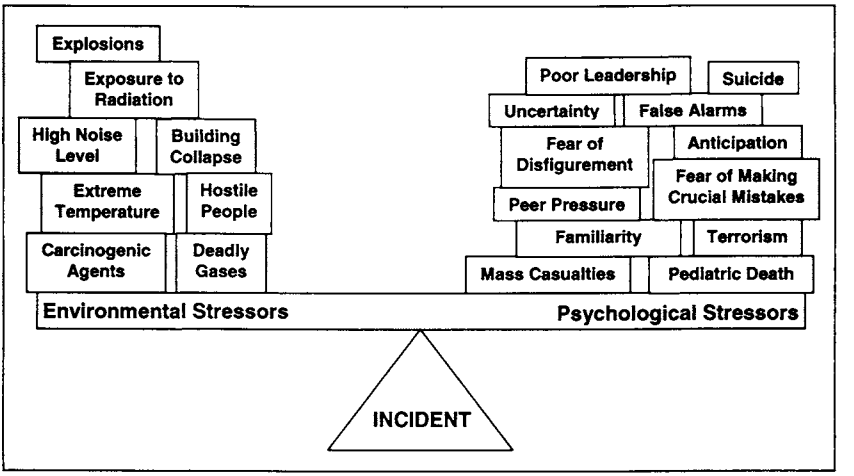

FIGURE 7.6 Environmental and psychological stressors that may result in the development of critical incident stress (based on information provided by U.S. Fire Administration, 1991: Stress Management: Model Program for Maintaining Firefighter Well-Being [FA-100]).

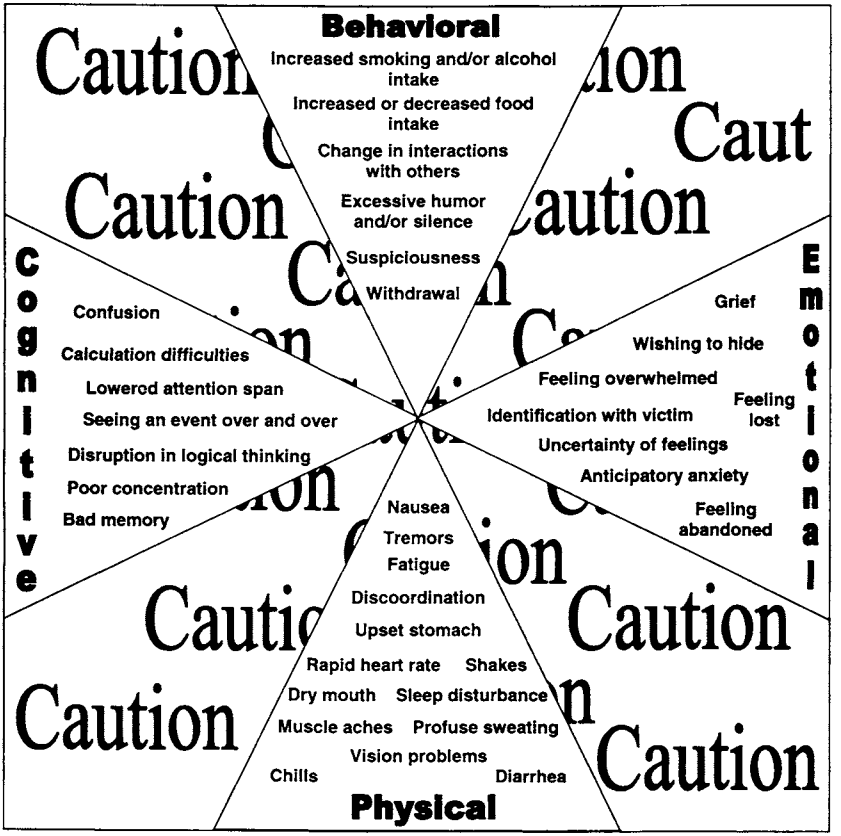

FIGURE 7.7 Behavioral, physical, cognitive, and emotional symptoms of critical incident stress that require cautionary monitoring (based on information provided by: (a) J. Mitchell and G. Bray, 1990: Emergency Services Stress. Englewood Cliffs: Prentice-Hall, Inc.; and (b) U.S. Fire Administration, 1991: Stress Management: Model Program for Maintaining Firefighter Well-Being [FA-100]).

- Centralized Relaxation (meditation, selective awareness, brain-wave biofeedback)
- Peripheral Relaxation (progressive muscle relaxation, yoga, breath control, biofeedback)
- Time management
- Cognitive reappraisal
- Aerobic physical exercise
- Diversionary techniques (e.g., vacation planning, hobbies, group activities)

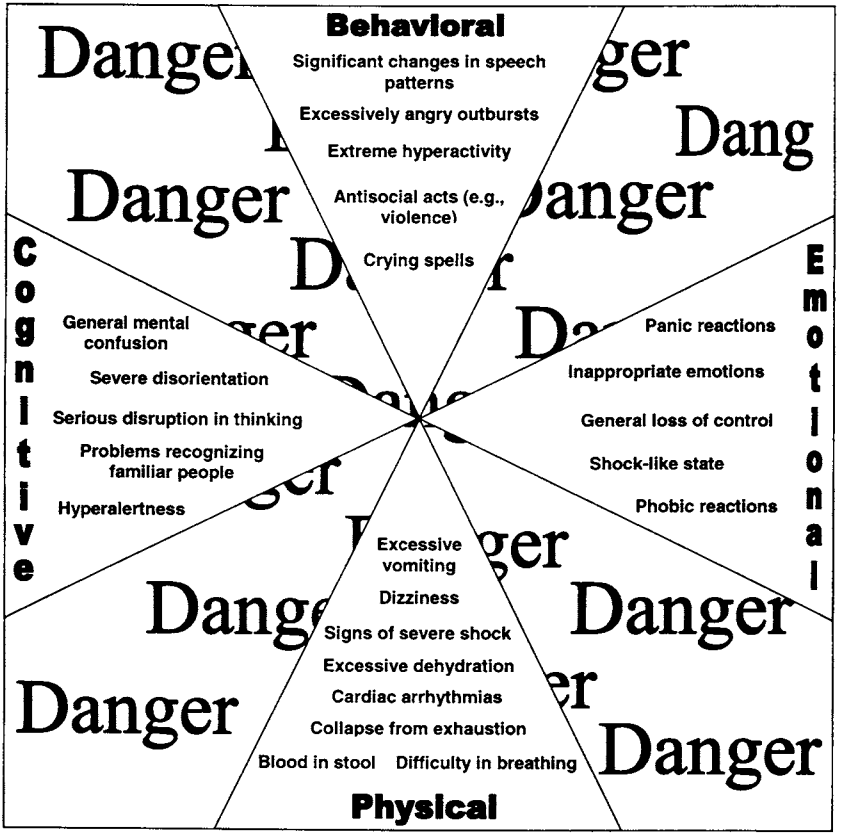

FIGURE 7.8 Behavioral, physical, cognitive, and emotional symptoms of critical incident stress that require immediate intervention (based on information provided by: (a) J. Mitchell and G. Bray, 1990: Emergency Services Stress. Englewood Cliffs: Prentice-Hall, Inc.; and (b) U.S. Fire Administration, 1991: Stress Management: Model Program for Maintaining Firefighter Well-Being [FA-100]).

A particularly important approach to stress management, which typically includes both proactive and reactive elements, is the development of a *critical incident stress debriefing* (CISD) team.

CISD teams are typically composed of at least one mental health professional and two or more members who may be drawn from emergency response personnel, other emergency support services (e.g., hospital administrator), local clergy, and other community services. Some CISD teams serve police, firefighters, and emergency response medical personnel in a multiagency and multijurisdictional setting; some operate within the context of a single organization. The basic functions of a CISD team generally are:

- To acquaint personnel with methods for recognizing and reducing both on- and off-the-job stress
- To train personnel in the use of specific techniques to reduce stress in emergency response situations
- To provide assistance to personnel who are experiencing stress
- To serve as a referral service for personnel who need additional support services

Another approach to stress management in emergency response services is the *member assistance program* (MAP), which is also sometimes referred to as the *employee assistance program* (EAP). An EAP or MAP is essentially a referral program (as opposed to a treatment program) designed to assist personnel with respect to personal problems (including drug and alcohol abuse) that can affect job performance. Fire service MAPs (addressed by NFPA 1500-1987) are sometimes used to promote the general health of personnel, including such activities as family orientation and education programs on weight control, stress reduction, and hypertension.

While the recent emergence of such programs as CISD teams and MAPs (EAPs) offers many alternative approaches to stress management, it must be emphasized that such programs typically require significant time and effort to design and implement. Given the very sensitive nature of the issues involved and the potential effect of such programs on mental and emotional health, no organization should undertake to develop either of these programs except with the professional advice of community medical authorities and/or professional organizations having direct experience in both their design and implementation.

Audiometric Testing

While audiometric testing is most often included in standard medical monitoring programs, there are many instances where this is not done; therefore, special attention must be given to this issue because it is particularly important in emergency response not simply as a matter of the responder's health, but also of his or her safety during incident operations.

In the United States, regulations include specific requirements regarding the certification of (a) persons performing audiometric testing, (b) testing devices and methodology, and (c) types and frequency of audiograms (29 CFR 1910.95(g)). While such requirements may vary from nation to nation, certain aspects of audiometric testing should be emphasized as being of universal concern:

1. The *baseline audiogram* is a hearing test conducted on an employee shortly following exposure to noise above the action level. As

TABLE 7.6 Noise Exposure Limits Promulgated by OSHA and Recommended by American Conference of Governmental Industrial Hygienists

	Duration (hours/day)	Sound Level (dB)
— ACGIH Standards —	16	80
	8	85
If these levels are exceeded, engineering controls will be used to reduce sound to acceptable levels or hearing protectors will be used	4	90
	2	95
	1	100
	1/2	105
	1/4	110
	1/8	115
— OSHA Standard —		
Whenever noise exposures equal or exceed an 8-hour time-weighted average (TWA) of 85 dBA, a continuing and effective hearing conservation program shall be instituted		

implied by the term "baseline," the objective of this audiogram is to define the normal hearing capacity of the employee in the absence of any work-related impairment. Subsequent audiograms can thereafter be compared with the baseline audiogram to detect work-related hearing impairment and, therefore, the need for appropriate revisions to response service policies and practices regarding hearing protection. Given the importance of the baseline audiogram, it is imperative that it be completed before work-related noise above action levels (Table 7.6) results in actual hearing impairment. Also because noise can cause short- as well as long-term hearing impairment (known, respectively, as *temporary threshold shifts* [TTS] and *permanent threshold shifts* [PTS]), it is necessary that the affected individual avoid or otherwise be protected from noise prior to examination for a baseline audiogram. In the United States, the standard requires that the baseline audiogram of an employee be established within 6 months (or, where mobile testing vans are utilized for the purpose, within 1 year) of the employee's first exposure at or above the action level and that the employee not be exposed to work-related noise for least 14 hours immediately preceding the test.

2. Subsequent audiograms should be obtained for affected employees over short enough time intervals to ensure the early detection of hearing impairment. In the United States, the standard rule is that audiograms for

employees be obtained at least annually. Longer intervals not only lead to an increased risk of permanent threshold shifts in specific individuals, but may also result in progressively expanding hearing risks to the emergency response team.

3. In comparing baseline and subsequent (at least annual) audiograms, the focus is on detecting an impairment of hearing. The action level for such a determination is what is called a *standard threshold shift* which, in the United States, is a change in hearing (relative to the baseline audiogram) of an average of 10 dB or more at 2000, 3000, and 4000 Hz in either ear. American OSHA regulations also provide for (but do not mandate) the standardized adjustment of annual audiograms for the aging process in making the determination of a standard threshold shift. The safety officer is advised that the decision as to whether or not to adjust annual audiograms for age should not be left to medical judgment alone because this decision has broad implications that go well beyond the professional purview of any attending physician, including:

A. Correcting an annual audiogram for aging is basically equivalent to lessening any observed difference between baseline and annual audiograms, and this, in turn, results in the removal of a possibly desirable safety margin. Of course, by not correcting for age, the safety officer may cause an age-related hearing loss to be falsely attributed to workplace exposure.
B. Even where there may be good reason to exercise this option, serious consideration should be given to the relevance of the database used to perform the age adjustment. For example, are the data (even if provided by regulatory authority) biased to particular national, cultural, or other social (including gender) groups? Is the database current? What is the extent of professional consensus regarding both the utility and the limitations of the database?

4. Where the comparison of an employee's baseline and annual audiogram reveals a standard threshold shift, it is the obligation of the employer to take immediate responsive action. The first action is, of course, informing (in writing) the affected person. The second action is implementing "appropriate" correction. Determining what constitutes appropriate corrective action is certainly highly problematic because it encompasses not only regulatory mandates, but other considerations well. Whether corrective action can be taken without continuing to place other responding team members at risk due to potential failure in communication with hearing-impaired personnel is certainly of major concern in any emergency response service.

If a standard threshold shift is attributed to or aggravated by the noise attendant to work-related noise, American OSHA regulations are clear about several required corrective actions, including:

- Other personnel who work under similar work-related conditions as those persons affected by a standard threshold shift and who *do not* use hearing protectors will be fitted with hearing protectors, trained in their use and care, and required to use them
- Other personnel who work in similar work-related conditions as those persons affected by a standard threshold shift and who *do* use hearing protectors will be refitted and retrained in the use of hearing protectors and, if necessary, provided with protectors offering greater noise attenuation
- The person affected by the work-related standard threshold shift will be referred to a clinical audiological evaluation or otological examination

PROGRAMMATIC REVIEW

Once implemented, a medical surveillance program must be viewed as an essential lifeline for emergency response personnel and should therefore be carefully monitored for effectiveness and efficiency. It is especially important that there be at least an annual review of the entire program, with particular care given to the following items:

1. A case-by-case review of any incident involving any aspect of the surveillance program, including episodic exposure to hazardous agents, medical monitoring data that required specific follow-up actions, and discernible trends in the frequency of episodic events or in monitoring data that may signify the need to review operational response procedures, the use of personal protective clothing and equipment, and personnel training requirements,
2. The need to include newly developed medical monitoring tests or to delete or modify other tests (e.g., frequency, methodology) in light of state-of-the-art developments in medical surveillance, changes in response service responsibilities and capabilities, or changes in regulatory requirements or applicable health and safety standards, and
3. Performance evaluation of medical service contractors, including attending physicians and analytical laboratories, with particular emphasis on (a) the timeliness, comprehensiveness, and clarity of written reports and recommendations, (b) adequacy of technical and scientific documentation, and (c) satisfaction of response personnel.

It is recommended that, during this annual programmatic review, contracted medical service personnel be requested to (a) present an oral review of findings to date regarding their own quality-control management studies, and (b) discuss their own recommendations regarding any potential changes in the surveillance program.