KEEPING BUILDINGS HEALTHY

How to Monitor and Prevent Indoor Environmental Problems

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US EPA and National Institute of Occupational Safety and Health. December 1991. *A Guide for Building Owners and Facility Mangers.* EPA/400/1-91 033.

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Chapter 3

Investigating Health Complaints

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PURPOSE

Though many books, chapters, and articles have been written about indoor air and health, they all lack a practical how-to quality. The purpose of this chapter is to provide a building manager with useful information to help assess the severity of complaints and devise an effective response strategy. To do so, those responsible for maintaining office spaces must understand some of the medical principles that underlie indoor air issues; these will be presented simply and practically. The ultimate purpose of this chapter is to keep those with financial responsibility for a building from doing too little or too much. Either can lead to disastrous financial consequences.

INTRODUCTION

Indoor air issues begin with health or comfort complaints. Someone in the office (or perhaps many people) complain to the office manager, supervisor, or building manager. The complaints may involve pure comfort allegations—too hot, too cold, too dry—or they may involve more-specific complaints—headaches, burning eyes and nose, red eyes, cough, fatigue, nosebleeds. On rare occasions complaints may be even more dramatic—for example, mass faintings. Since these complaints are first fielded by a medical layperson, that person has the un-

enviable responsibility of becoming a de facto medical triage officer. The initial task is to decide whether these complaints indicate a serious medical problem or whether they are readily managed by a nonmedical person.

Even more vexing is the dual nature of such complaints. On the one hand, complaints may be due to actual physical problems associated with the environment. Alternatively, they may be due to various psychological and/or emotional factors. Or they may be a combination of the two. The latter is no less concerning than the former and in fact is probably both more common and more serious to the integrity and financial risk of the organization and the building owners. Table 3–1 presents many of the potential causes of symptoms in building occupants. Note that symptoms people associate with the building may actually be related to the building, or they may not. Though people perceive that a building is associated with symptoms, those perceptions have varying degrees of accuracy. A good rule of thumb is that as time goes on, the accuracy of those perceptions diminishes. In other words, once a crisis has arisen and concerns are widespread, people will associate more and more symptoms with the building, whether or not those symptoms are actually related.

Secondly, Table 3–1 indicates that even symptoms that are accurately associated with the building may or may not have anything to do with indoor air quality (IAQ). The rush to judgment that "the air is bad" has only a random

Table 3–1. Causes of symptoms in building occupants: IAQ related, IAQ unrelated, and building unrelated.

IAQ	Non-IAQ
Building related	
Stagnant air	Thermal
Humidity	Lighting/Noise/Ergonomics
Odor	Psychosocial
Irritant	Political
Allergen	
Pathogen	
Building unrelated	
Environmental and home allergens	
Medications	
Underlying disorders	
Unrelated events (i.e., cancer and miscarriages)	

chance of being correct, without a complete investigation of the medical issues and proper correlation with environmental findings (Baker, 1989; Gots, 1993; Lees-Haley, 1993).

THE MANY CAUSES OF SYMPTOMS: DIFFERENTIAL DIAGNOSIS

The essence of medical practice is the differential diagnosis. By this we mean that a constellation of symptoms leads to a number of considerations about possible causes. This in turn leads to a series of diagnostic tests to rule in or rule out any of the potential causes.

For example, if you complain to a physician about a headache, the physician will get a more detailed history from you and arrive at a preliminary differential diagnosis. That differential diagnosis may include a brain tumor, eyestrain, a cervical strain, a migraine, a sinus infection, stress, or many other conditions, any of which can cause headaches. Appropriate tests follow to rule out the most serious causes, such as a tumor. The process of evaluating workers with complaints is no different. Each symptom has many possible causes that can be ruled in or out only through a careful history, physical examination, and proper testing targeted to the differential diagnosis.

Unfortunately, indoor air complaints are only rarely evaluated in this fashion. Frequently, the first person involved is a heating, ventilation, and air-conditioning (HVAC) engineer, a maintenance person, or an environmental consultant. Thus, the decision that the problem is related to air is often made at the moment the complaint is initiated. That is a bit like sending everyone with a headache to a neurosurgeon to explore the brain for a tumor. Since many worker complaints have nothing to do with indoor air, many of these investigations assume, incorrectly, that poor air quality is responsible. Although building management must recognize this potential for error, cost and practicality demand that the simplest, most cost-effective approach be followed. This means that every symptom an office worker reports cannot support a full medical evaluation. Therefore, it is incumbent upon consultants and building engineers to know when to bring in medical help and when not to.

Symptoms in workers are often called *health effects*. This term is inappropriate when introduced too early, because it makes the unsupported assumption that a symptom is the "effect" of something in the environment, when that remains to be proven. It also assumes that every complaint has something to do with health. Discomfort is not the same as ill health. A person may find a room too cold or too hot, hence uncomfortable. Or someone may have a minor symptom such as a transient headache or fatigue. Absent an underlying physical disorder, none of these situations can be said to imply an adverse health effect. Symptoms that workers may associate with the workplace are often quite varied in nature, having little to do with one another or with a common cause. Figure 3.1 illustrates the chaotic and diverse nature of symptoms or disorders that may be reported by office workers and that workers may relate to the workplace.

In the case of symptom complaints associated with office buildings, the differential diagnosis is complicated by a multidimensional consideration: the need to determine a diagnosis for the worker as well as for the building's condition and ultimately, to integrate the two. Not only are we trying to learn whether the headache is due to eyestrain or a brain tumor, we are also trying to determine whether environmental and/or psychosocial factors are contributory. Such a differential diagnosis is also complicated by multidisciplinary considerations. The person who diagnoses causes of headaches is not generally the one who decides whether the HVAC system is working properly, nor should he be.

Matching the Symptoms with the Possible Causes

Most health complaints begin with one or more workers who decide that the office is creating health problems. At the outset, they have made their own diagnosis and have determined the cause. As often as not, this attribution is incorrect, and it is important for the investigator to understand this.

However, it is equally important to realize that once a belief is firmly in place, it may be hard to dislodge, and indelicate attempts to do so may create resentment and distrust. In other words, you had better have good data as well as a caring manner when discussing with workers potential causes for their problems, which may differ from what they have come to believe.

Figure 3.1. Symptoms and disorders commonly related to the office environment by workers: A chaotic mixture

Headache
Rash
Itchy eyes and throat
Nosebleeds
Fatigue
Miscarriages
Asthma
Fainting
Cancer
Trouble concentrating

In other situations, there may be many causal attributions—each affected worker may have a unique explanation as to what is responsible for his or her symptoms. Quite often, these causal attributions change with time—either the workers develop new ideas or data provide leads to new understandings, or both.

Often, the first management person notified accepts uncritically the proposition that the symptoms and disorders are related to the indoor air, if that is what the concerned workers believe. While it may be appropriate to respond that way—to accept attributions from workers and occupants—it is equally important to keep an open mind and be aware of the many possible causes. In general, the broader the range of manifestations or symptoms, the less likely it is that the building is responsible for all of them. Among the complaints may be some that *are* connected to the environment. But others may be unrelated, only thought to be associated with the workplace. Lumping varied symptoms together as "health effects" and attributing them to bad air can be overly simplistic and fraught with error. Table 3–2 demonstrates this point by delineating some of the diagnostic considerations that could be connected to a given symptom absent any additional information.

This table illustrates several things. First, many of these symptoms and disorders do not share common possible causes. Second, in some instances the indoor environment has no known connection to the disorders. Third, all of the disorders and symptoms have multiple possible causes, many of which are unrelated to the office. For those that may be office-related, many are unrelated to IAQ. The important message here is that symptoms and disorders are not necessarily IAQ health effects just because someone has decided that they are. A thorough exploration of cause requires a differential diagnosis, a physical examination, and appropriate testing of the patient before even a possible link can be made. After that is completed and potential environmental causes are identified, environmental testing may or may not find the factors that could explain an individual's symptoms. Although the best explanation for symptoms requires a comprehensive set of evaluations, that is neither practical nor necessary in every instance. We will see in subsequent sections how to triage and how to limit and focus investigations (Abend, 1995; International Society of Indoor Air Quality and Climate [ISIAQ], 1996; United States Environmental Protection Agency [USEPA], National Institute of Occupational Safety and Health [NIOSH], 1991).

Effective Triage

Symptom complaints are often minor and may respond to simple adjustments in airflow from the HVAC system or small changes in temperature and/or humidity. These are obviously simpler solutions than bringing medical and engineering

Table 3–2. Possible causes of symptoms and disorders often attributed to IAQ.

Symptom or disorder	Common causes	Office-related possible causes	IAQ possible causes
Headache	• Stress • Eyestrain • Sinusitis • Migraine • Neck strain	• Stress • Eyestrain • Psychosocial	• Rarely chemicals
Rash	• Insect bite • Eczema • Contact dermatitis • Other skin disorders	• Neurodermatitis (stress-related)	• Fiberglass
Itchy eyes	• Contact lens problems • Allergies • Infection	• Eyestrain	• Low humidity • Mold • Chemicals • Dust • Fiberglass
Nosebleeds	• Allergies • Infections • Trauma		• Low humidity
Fatigue	• Many serious diseases • Depression • Sleep deprivation • Chronic fatigue syndrome	• Boredom • Job dissatisfaction • Overwork	• Possible (rarely volatile chemicals)
Miscarriages	• Idiopathic • Various factors Genetic Structural Infection Metabolic Etc.	• None known	• None known
Asthma	• Allergies Cat Dog Dust at home Pollens Etc. • Exercise induced • Cold air		• Allergies Dust Mold • Rarely irritant chemicals
Cancer	• Smoking • Heredity	• None known	• None known
Trouble concentrating	• Many serious diseases • Depression • Sleep deprivation • Chronic fatigue syndrome	• Boredom • Job dissatisfaction • Overwork	• Possibly (rarely) volatile chemicals
Fainting	• Blood Pressure Abnormalities • Heart disease • Anxiety	• Anxiety	• Major chemical intoxication (i.e., carbon monoxide)

(continued)

Table 3–2. Continued

consultants into every office in which workers have complaints. The challenge is for the first consultant on the scene (often the building maintenance staff) to do an effective triage or initial assessment: that is, to determine when a problem is trivial or serious and to recognize and respond quickly to any escalation. The key qualities needed in such a person to serve these functions well are common sense, an understanding manner, and sufficient awareness of the possible underlying causes of complaints. Independent assessments by outside consultants are generally not required in the majority of complaint situations. Nevertheless, consultants can serve as a sounding board or provide independent confirmation of an in-house assessment. Should a situation deteriorate, however, ready access to the appropriate consultants can be critical.

Because situations are so varied, there are no absolute triage rules that can be applied universally. However, several important clues and rules of thumb can help guide appropriate action.

Triage considerations are twofold. The first aspect might be called the *who* question. Who should do the investigation and work at resolving the problem? The second is the *what* question. What needs to be done to address concerns and resolve the problem?

One rule is that the development of indoor environmental complaints over time is unpredictable. What starts as a seemingly minor problem can become a nightmare, or what begins with explosive outbursts can fizzle. Second, building managers and owners can get into trouble by either doing too little or doing too much. Failing to recognize the potential severity of a problem, minimizing people's concerns, and responding too tentatively may increase anger, distress, symptoms, and financial risk. Conversely, overreacting at the first notice of a complaint can produce data that have no meaning or unleash frightening hazardous materials (HAZMAT) responses, both of which lead to heightened anxiety, expensive remediation, and psychologically induced illnesses.

Because of the risks just described, one thing should be clear. Whoever is entrusted with the preliminary evaluation of these complaints needs to understand the risks, have good common sense, and be an effective communicator. The management of perceived indoor air issues is half a technical function and half public relations. If these traits can be found in someone in the building-maintenance department, then that individual may be the appropriate initial contact. If on the other hand the building-maintenance department has no such individual, then the owners and managers would be well served to involve a consultant immediately. In either case, the need to have an IAQ plan in place *before* problems arise cannot be overstated.

Decisions about how to proceed with an investigation and what level of investigation to undertake are determined by a number of factors. The levels of investigation will be discussed in the next section. The relevant factors include the severity and nature of symptoms, lost work time, attributions made by employees, the number of people complaining, how long the problem has been going on, what has been done to address the problems thus far, whether consultants have been involved, and the quality of the landlord-tenant relationship.

Severity and Nature of Symptoms

The very first question that must be asked and answered is, "How sick are people?" Obviously, there is a difference between loss of consciousness or hospitalization for Legionnaires' disease and complaints of headaches. The first two may require evacuation of the building and primary attention to health needs. The second generally permits a more measured and systematic response. Severity of health complaints is, therefore, an initial triage question. If complaints consist of only minor symptoms, it may be possible to manage the problem locally and without medical intervention. If symptoms are more dramatic, and/or if workers have gone to hospitals or have seen physicians about them, the building manager must include appropriate medical help in the consulting team (ISIAQ, 1996; Hodgson, 1995).

This triage consideration is clear: severe symptoms demand appropriate referral. Ironically, however, the expected corollary—severe symptoms equal a serious environmental problem—is less often true. There is far less correlation than one might think between apparent severity of symptoms and long-term health allegations, litigation, and financial risk to the building owners. Numerous cases of mass faintings with emergency responses by HAZMAT, fire departments, and health departments have uncovered no evidence of environmental hazards (Bauer et al., 1992; Spitters et al., 1996). In many such cases, diagnoses of "mass psychogenic illness" have been made with minimal long-term cost to the facility (Alexander and Fedoruk, 1986; Brodsky, 1983; Hall and Johnson, 1989; Light and Tiffany, 1991).

On the other hand, many matters have produced catastrophic losses to building owners, architects, facility managers, ventilation and design engineers, and contractors that were heralded at first by seemingly trivial health complaints. In a matter that I investigated, several workers left a building complaining of headaches following interior renovation. Two years later, one of those workers settled a lawsuit for $400,000. Therefore, although one can offer triage advice, no rules can eliminate economic risks, even when health risks are not significant.

Lost Work Time

Lost work time is an important clue to the severity of the problem. If people believe that they are too ill to work, or if they are afraid to return to the building because they think it makes them sick, you are confronting a serious problem. You should also note if workers are restructuring their workday (e.g. leaving early) or restructuring their workstations to avoid what they perceive to be the problem. Since "the problem" may include actual health disorders and/or liability for lost productivity, lost work time and refusal to enter the building are measures of severity. One of the first questions to ask, therefore, is "Are people staying out of work?"

Attributions Made by Employees

If early complaints suggest that either the workers have *not* attributed symptoms to environmental factors or they have suggested an easily correctable change (e.g., too hot, too cold, or insufficient humidity), the situation may be manageable at the facility level.

On the other hand, if workers are using terms such as "sick building," "poisoning," or "toxic," this implies a potentially more difficult-to-manage situation. The more dangerous the building is in the eyes of the workers, the more complicated the resolution of the problem. The triage question is then "What do people think is wrong?"—a question that should also be asked of workers on an individual basis.

Number of People Complaining

Complaints from only one or two people may be more easily managed than a companywide problem. It is important to remember, however, that symptoms may herald an early health problem that can become more widespread and that symptoms can be contagious through the psychology of suggestion; one or two complaining workers can quickly spread their symptoms to others. Thus, it is important to respond in a caring and competent manner even when there is just a single complaint. The most intense response will be stimulated by situations with the most complainants.

Duration of Problem/Involvement of Other Consultants

A critical rule of thumb is that the longer the problem has existed, the more resistant it will be to correction. In addition, sometimes the building owner/manager is the last one called. The tenants have brought in their own consultants who have been unsuccessful in resolving the problem. Problems that are firmly entrenched generally require sophisticated and experienced problem solvers.

Quality of the Tenant-Management Relationship

Indoor-air allegations are a growing source of leverage in landlord-tenant disputes. It is not uncommon for leases to be broken based upon "bad air," and tenants have brought major lawsuits against landlords for such problems. In some cases tenants have trumped up "bad air" allegations in order to terminate a lease. I have personally investigated at least one such matter. Recognizing this, if you are a building owner or manager, the quality of your relationship with your tenant becomes an important triage issue. If the relationship is bad, or if indoor-air complaints follow a series of other problems, consider early expert consultation rather than simple fixes.

Investigation

The bottom line of any investigation is to make the workers feel more comfortable—to take their symptoms away. Sometimes this can be done without a complete understanding of the reasons that they have symptoms; a minor adjustment may satisfy people. At other times, the investigation of health complaints and their causes requires a systematic multistage process. In these instances, symptoms must be evaluated, the environment must be evaluated, and the two must be correlated as accurately as possible. While it is important to realize that an engineer cannot definitively determine the cause of someone's headache or other symptoms, some worker concerns may be appropriately addressed and solved by an engineer. Thus, if a worker feels that the air is too dry, a limited and focused evaluation of building humidity and correction where indicated is the most cost-effective and logical approach.

To simplify our organizational discussion, we may consider three levels of investigation. The level required will be dictated by the triage considerations identified in the preceding section.

Level 1

At its simplest, an indoor-air investigation involves an uncomplicated inspection and minimal corrections. When triage suggests a minor problem, then that is what should be addressed. It may be accomplished without sophisticated consultations or medical input. It may involve implementing an operations and maintenance plan; minor cleaning of the HVAC system; adjustments to airflow, temperature, or humidity; or any combination of these measures. For example, workers may express concern about localized mold growth. Cleaning the mold and adjusting the humidity may suffice.

Level 2

The second-level investigation requires more intensive analysis. Here there may be more health complaints, and triage may suggest a more serious problem. At this level appropriate consultants need to be engaged. These consultants must have the skills, knowledge, and expertise to solve complex problems involving engineering, industrial hygiene, and medicine—the three disciplines that are fundamental to office environments and health. At Level 2, a more intensive search for causes is in order and should include medical interviews, evaluations of occupational stressors, and facilities evaluation. Sampling for airborne contaminants is generally not performed unless indicated by point source evaluations; rather, general HVAC issues are evaluated and potential point sources of contaminants are reviewed (Persily, 1994; ISIAQ, 1996; Ventresca, 1995).

Level 3

The most intensive evaluation occurs at Level 3, where all of the expertise and evaluations noted previously are performed, but comprehensive environmental sampling and laboratory analysis may be required. A summary of the critical elements of this level of investigation are shown in Table 3–3.

A comprehensive discussion of these phases is beyond the scope of this chapter; some general descriptions are provided.

Complaint Evaluation

Complaint evaluation is the process of cataloguing the worker's symptoms and their attributed causes. But it also includes (as part of the differential diagnostic process) asking about other factors, including home environment, prior allergies, and job satisfaction. In general, widely distributed questionnaires, while commonly used, are not a good idea. Unless they are extremely well constructed (few are) and properly administered, they can provide leading questions and can make any building look sick (Gots, Gots, and Spencer, 1992; ISIAQ, 1996; Quinlan et al., 1989; Samimi, 1995). Brief interviews are strongly recommended. After reviewing complaint records, interview a representative number of complainants and noncomplainants. Additionally, occupants (complainants and noncomplainants) may be asked to maintain a diary of environmental conditions and their personal concerns. Complainants tend to keep more detailed diaries, and although this would be considered a bias in a formal scientific study, in a complaint investigation the diaries can be correlated with a daily log of building conditions. This may lead to further insight into occupant concerns. Having occupants maintain diaries also involves them in the investigation process.

Table 3–3. Phases of a comprehensive (Level 3) investigation.

1. Complaint evaluation
2. Clinical evaluation
3. Source evaluation
4. HVAC evaluation
5. Sampling (if necessary)
6. Causation analysis
7. Communication (this applies to levels 1 and 2 as well)

Clinical Evaluation

Clinical evaluation refers to the medical examination of the workers. At the simplest level this may mean looking at a red throat or a skin rash. At its more complex, it may include ordering blood or skin tests to evaluate allergies, chest X-rays, and pulmonary function tests.

Source Evaluation

Source evaluation refers to the process of examining potential sources of emissions or contamination. At times, the workers themselves will point to a perceived source—for example, recent painting or other renovation, copy-machine chemicals, new carpeting, and mold.

HVAC Evaluation

HVAC evaluation includes examination for dirt, dust, and biological contamination (e.g., mold growth); evaluation of the registers—location, cleanliness, balance, and so on; determination of the quality of airflow at specific locations; determination of the mix of outdoor and indoor air; and temperature and humidity evaluation (American Society of Heating, Refrigerating, and Air Conditioning Engineers [ASHRAE], 1989; ASHRAE, 1981; ISIAQ, 1996; Persily, 1994; Sheet Metal and Air Conditioning Contractors' National Association [SMACNA], 1995; Ventresca, 1995).

Sampling

Sampling follows the previously discussed evaluations. It must be targeted and specific and should be done only if two conditions are met: contaminants are suspected, and those contaminants would likely explain the symptoms. Random, extensive sampling should never be permitted. For example, sampling and analysis using gas chromatography (GC) and mass spectrophotometry (mass spec) can yield a list of 300 volatile organic chemicals at low parts per billion levels that have no medical relevance. This will inevitably increase the cost of evaluation and potentially create unnecessary distress.

Causation Analysis

Causation analysis in this case refers to the process of putting environmental data together with clinical data to reach cause-and-effect conclusions. Often this attempt is made by individuals with no relevant medical expertise who then draw incorrect conclusions. For example, an HVAC engineer may find poor airflow/air distribution in an area and conclude that it caused the reported symptoms. If symptoms include skin rashes, this conclusion is wrong, because airflow problems do not cause skin rashes. Or an industrial hygienist may find very low levels of a variety of volatile organic chemicals and conclude that they caused headaches, when they could not have done so. Or a small amount of visible mold may be blamed for respiratory complaints despite the fact that the sufferers were not allergic to that mold.

This process of causation analysis is the most sophisticated part of the investigation, for it goes beyond data collection and into differential diagnosis and clinical interpretation. Many engineers and industrial hygienists do this very poorly, but so too do many physicians who are unfamiliar with the health issues associated with office buildings. That is why a multidisciplinary team approach that includes consultants with indoor air expertise is so important.

Communication

Communication is listed last, but it is not the least of the phases. Rather, effective communication must be a continuous process. From the start, workers need to understand the investigation process itself. Throughout every phase of the procedure, the workers need to know that explanations are being sought and relief is on its way. This aspect of the investigative activity is extremely important, for it may determine how smoothly and inexpensively the situation is resolved. Occupants who are involved in and informed about the investigation are more willing to accept and more likely to understand investigative conclusions and recommendations. Disgruntled workers who feel sick and worried and who do not believe they are being heard or understood can quickly become a large group of plaintiffs.

Effective communicators need to be good listeners, but they also must have the expertise needed to gain and maintain credibility as well as the trust and respect of the workers. In other words, they must be honest and believable. This communication component may be the single most important part of the investigative process. If the facility-management team or the chosen consultants cannot communicate effectively, then someone who can should be brought in to fill this role.

Finally, an environmental evaluation may and often should proceed simultaneously with the medical evaluation. However, it must be recognized that such investigations often identify factors that have no causal relationship to symptoms. For example, an HVAC system may be found to be unbalanced, but that may not be the cause of people's headaches. Only when there is a careful interaction between medical evaluators and environmental investigators can such causal connections be accurately made. And only when results and activities are effectively communicated will problems be resolved with minimal adverse consequences for the organization.

Evaluating and Choosing Consultants

Popular concern about the quality of our indoor air has given rise to an explosion of "experts" and consultants, from engineers to duct cleaners to physicians, all ready to proclaim buildings and their occupants sick, to builders ready to charge thousands to millions of dollars to fix things. Entrepreneurship surrounding a new issue of public concern is neither new nor inappropriate. However, when it misrepresents health risks and states of health and produces runaway costs, it demands control. "The building is sick" has become the proclamation of purveyors of expensive, unnecessary services.

Any responsible party—building owners, managers, insurers—confronted with such complaints must exert great caution in selecting a consultant or environmental group to assess the problem. Quite frequently, these consultations and surveys produce more questions than answers and generate data that may appear meaningful but have no toxicological significance. Left uninterpreted, those data may both intensify worker anxieties and contribute to financial liability.

A significant impediment to the effective handling of such complaints arises because of the diversity of professionals involved in the relatively new area of indoor air quality. For example, environmental engineering firms may be prepared to measure substances in indoor air. Lacking toxicological or medical expertise, however, such firms may be ill equipped to interpret the potential public health effects of their findings. Even less frequently are they able to deal with the complaints of specific individuals within that working environment. Because they are neither effective communicators nor health professionals, they cannot respond effectively to the concerns of the workers. This may leave the employer or building manager with a set of data with no meaning, and with no plan of action. It is far easier to collect data than it is to interpret or act upon the information.

Because such investigations involve merging health information and analysis with environmental and engineering assessment, these investigations are of necessity multidisciplinary. Engineers and environmental specialists cannot evaluate health complaints. Medical specialists, without environmental expertise, cannot evaluate the environment. However, because complaints often begin with symptoms, a primary focus of the initial investigation must start with symptom evaluations. Thus, once the situation has demanded the acquisition of outside consultants, those consultants must have sufficient medical expertise to assess symptoms. This is important not only because this method is the most likely to succeed, but also because it minimizes liability. How would it appear to a jury if, after someone claimed that the building caused a serious illness, the building manager had responded by calling an engineer? Ultimately this medical expertise will include physicians, but at first it may be provided by nurses or industrial hygienists. A consulting firm that fails to involve these experts early and that has no readily available medical experts should be avoided.

Ask the environmental firm a few basic questions before hiring it to conduct an IAQ health investigation:

- Who in your organization has medical expertise?
- What physicians do you use?
- How do you define a sick building?
- What do you measure? For each chemical, fungus, mold, or bacterium that you measure, what numbers specifically indicate indoor air problems? What will you compare your numbers to for interpretation?
- How often do you identify indoor air problems and a correctable solution to them?
- What are the normal measured levels of contaminants that you will compare to my building?
- If measured levels of contaminants are in normal ranges, will you then tell me I do not have a sick building?
- Will you meet with the workers to discuss your findings and answer their questions about the health effects? Who will do this?
- Is it possible to satisfy all building occupants?

Those responsible for the quality of building-occupant health and safety must clearly recognize the difference between worker complaints and a proven air-quality problem. Of course you must investigate, but before doing so you must understand the significance of the intended investigation and must question the firm conducting the studies about the significance of potential findings and the expertise of those involved. A key means of assessing consultants' skills is to contact references whose problems the consultants have addressed and solved. Do not embark on a complex exploratory mission of this kind without such a background review.

Case Studies

Case 1

In 1992 air quality consultants forced immediate evacuation of a courthouse building in Florida, proclaiming that mold growth posed a cancer risk to occupants. Built in 1989, the building cost $11 million to construct. The renovation, overseen by those same consultants, cost $9.5 million. Litigation alleged personal injuries of the building occupants and sought to recover the cost of damaged property. It is true that there was mold. There is mold in all buildings in southern Florida. It is true that the building had some structural problems. It is not true that this posed an unusual or immediate threat to the employees as the consultants claimed; nor was it necessary to spend $9.5 million to rebuild this building when far more modest repairs and cleanup would have sufficed. This kind of irresponsible misuse of "expertise" can cost millions of dollars in inappropriate expenditures (as it did in this instance).

The lesson learned: when choosing consultants, it is important to find individuals who think responsibly and use good judgment and common sense to help their clients. Asking "what if" questions will help sort out those who have extreme views from those who are more rational. Getting references is essential. Also, beware of conflicts of interest. Investigators should not profit from remediation.

Case 2

In a school district in central Pennsylvania, an asbestos-abatement program included removal of asbestos floor tiles with a petroleum-based chemical solvent. Following this work, teachers and children noted "chemical" smells, sometimes quite intense, in certain classrooms. The school consulted an engineering firm, which measured levels of specific volatile organic chemicals, pronounced them safe because they were below occupational standards, and departed, leaving teachers and a by now frantic parents' group dissatisfied and more frightened than ever. The engineering group had identified and measured chemicals—but their basis for reassurance was a comparison with industrial settings. The teachers and parents thought this was hardly an apt model for an elementary-school environment.

As concerns mounted, so too did the range of symptoms. Headache, fatigue, and irritation were common. Other complaints included cough, increased frequency of colds, asthma, ear infections, upset stomachs, vomiting, diarrhea, and rashes.

By the time this author got involved, intense emotions had gripped this community, resulting in polarization. The school board was seen as uncaring and accused of covering up a potentially deadly situation. Teachers had mobilized in open revolt, as had parents' groups. Local newspapers and television stations had run stories emphasizing the hazards, the unknowns, the possibilities, and the children's fears. Attorneys were now beginning to enter the scene, offering to represent aggrieved parents in lawsuits on behalf of their children.

As we attempted to sort out the scientific issues from the perceptions, it quickly became clear that doing so was essential but not sufficient. If this situation was to be resolved, the issues as well as the perceptions had to be dealt with. Several facts were apparent. First, some classrooms had a persistent smell of petroleum distillates. Second, there were no carcinogens of concern. Third, measured levels of chemicals were quite low—above the odor threshold, but vastly lower than thresholds of toxic levels either for exposed workers or for young children. Fourth, it was possible that levels of some hydrocarbons were at times sufficiently high to produce some irritant symptoms. It was also quite clear that parents and teachers associated odors with toxicity and that they were absolutely convinced that the school was dangerous.

The best scientific explanation for the symptoms and complaints involved a combination of emotional response to odors, some irritant effects in sensitive individuals, and symptom magnification due to a perceived chemical threat. In other words, the teachers, students, and parents were primed emotionally to associate any and all symptoms and illnesses with that school environment.

Reassuring the parents and teachers that they were not being poisoned was an incomplete solution. Because the odors were so central to the symptoms and the perceptions, they had to be eliminated or at least reduced substantially. Ultimately, the resolution involved a combination of odor reduction and an intense educational effort. It was simply insufficient to compare the levels present with permissible occupational limits. Parents had to be taught basic principles of toxicology: how we know that these levels of chemicals are not going to harm their children, why odor had little to do with toxicity, and how and why symptoms have a variety of explanations. In the end, solving such problems involves addressing both the scientific aspects and the perceptions of toxicity.

This case illustrates two critical points. First, even though the cause of the problem was quite straightforward—more so than usual—critical errors were made. Measurements were performed for substances that were known to be present, since they are components of the petroleum distillate at issue, but that have no known health implications at the very low levels measured. This highlights a key axiom: do not measure things that you are not prepared to talk about. A long list of identified chemicals can be frightening, even when experts realize that the levels are low. Second, the consultants misjudged both the levels of concern and the parental distress occasioned by children at risk. They failed to deal with those concerns directly, and they had no knowledge of children's health issues. This only heightened anxiety and frustration among the parents.

Case 3

Fifteen employees of an accounting firm in Los Angeles sued the developer of the building in which they worked, claiming a variety of building-related ailments. For these injuries they demanded $10 million, but they settled out of court for several million dollars. It was determined that the employees smelled a chemical used to seal the ducts. There were no health risks and no health effects, though the workers claimed otherwise and several physicians supported them.

The problem began as many do, during a major renovation. One compound used in an adjacent office suite was a duct sealant that gave off a variety of strong-smelling volatile chemicals. At the levels involved, no significant or serious health effects were possible, but irritant responses were plausible. It must be remembered that chemical fears run high; thus smells generate intense emotional as well as physical responses. People feel sick because they think they have been poisoned, and they may ascribe all of their ill health (whatever the actual cause) to those same smells. In this case, the chemicals from the sealant probably produced some level of irritation and discomfort. This prompted a call to the local Environmental Protection Agency (EPA) office, which dispatched investigators who arrived fully outfitted in protective equipment and wearing respirators. That frightening scene converted worry into panic and further convinced the employees that they had been poisoned. After all, why else would environmental officials be wearing respirators? The actual reason was that the investigators simply did not know what was present and were taking no chances. They took numerous measurements; no harmful levels of any chemicals were found. But the employees never returned, and they filed lawsuits.

This case illustrates several things. First, and most important, smells lead to problems. It is very important, particularly in these days of heightened awareness and concerns, that renovation be carried out in ways that minimize the potential for exposure. Painting, for example, may be reserved for the weekends and should end early enough for sufficient dilution ventilation to take place before occupants return. When painting must take place while adjacent areas are occupied, measures to minimize exposures to occupants (while providing adequate dilution ventilation to maintain worker protection for the painters) may include the following: exhausting air to the outside using a portable fan while creating negative pressure; sealing all supplies and returns with plastic; modifying the HVAC system to service rooms where the painting will be done; and instituting an effective housekeeping program to control dust (SMACNA, 1995).

Second, psychological factors commonly contribute to associations people make between the workplace and their health. If they believe they have been poisoned, they will feel sick, and it may be impossible to dispel that perception. Also, the belief that one was poisoned is grist for lawsuits. Most of the cases arising from indoor air claims have at their foundation the claimant's abiding belief that the building caused an illness. And, more often than not, that belief exceeds the reality. In this case, overreaction by environmental-engineering teams, at the behest of the building manager, contributed to an atmosphere of fear and to permanent health complaints.

Summary

Confronting indoor air health complaints can be a daunting experience, even for experienced experts, let alone for a novice building manager or engineer. The purpose of this chapter was to provide a basic understanding of the causes of health complaints and the approaches to resolving them. Essential messages to derive from this discussion include understanding the severity of the situation to decide when sophisticated help is needed; knowing what to expect of consultants and how to evaluate them; recognizing the critical importance of both psychological and physical factors; and understanding why common sense, excellent communication skills, and the ability to react appropriately—neither overreacting nor unreacting—are the keys to a successful resolution.

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Chapter 4

Indoor Air and Health: Clear-Cut, Equivocal, and Unlikely

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Introduction

This chapter addresses the medical and causal links between common symptoms and the phenomenon of indoor air quality (IAQ) concerns. From a medical perspective, several of the health effects people often claim are related to indoor air are not legitimately causal; nor do these effects follow the patterns of clinical diagnosis used in medicine for many years. The author recognizes that well-intentioned and sincere advocates for other views do exist, but this chapter reflects on the findings of medical research papers and the author's own clinical experiences.

The central dilemma in IAQ cases is the differentiation that needs to be drawn between actual diagnosis of clinical illness and the physical complaints that are due to perceived environmental threats. The distinctions between the two are often elusive. IAQ complaints tend to expand beyond the ability of medicine to identify a particular physical cause.

Epidemiologists who track the occurrence of illness have added considerably to medicine's understanding of indoor air illness issues. Although between 500 and 5,000 buildings have been studied for these concerns, relatively few of these investigations have led to clear conclusions that could be implemented into effective corrective action (Stolwijk, 1990). A study by an expert team from Johns Hopkins University's School of Public Health found that identical symptoms were reported from two comparable buildings, one of which had been identified as a "sick" building by some occupants while the other had not. The only difference was that the "sick" building had generated a lot of responses from the occupants. These responses were common complaints such as headaches, but their frequency of attribution to the building was a distinction from the normal rate (Corn, 1991).

Several factors have coalesced in the study of the confusing phenomenon of indoor health effects:

1. More effects can be measured than can be explained. The detectable presence of chemicals and biological contaminants has become more evident as analytical tools have dramatically improved in recent years. Yet the tools have improved faster than our ability to use them in making scientifically defensible risk-management decisions. Some detectable contaminants are relevant to medical evaluations; some are not.

2. Because common symptoms of everyday life such as headaches, fatigue, and nose and eye irritation are the symptoms most likely to be alleged in IAQ concerns, diagnosing the physical problem is simple, but discovering its cause is not. In the patient's mind, the particular building is the culprit. Medical evaluation is made more difficult by such a perception.

3. Solutions to medical related symptoms tend to be diluted according to the number of different disciplines from which the problem solvers are drawn. As these cases have involved toxicology, industrial hygiene, engineering, architecture, public health and manufacturing chemistry issues, the likelihood that solutions will come piecemeal or in divergent directions is much worse than if one "big picture" solution were available. Medical personnel will need to coordinate their work with the efforts made by advisors from other fields.

4. Beliefs outpace data; perceptions become reality. Fear of the effect of a building expands, even if the data to support that belief does not exist or has been actively rebutted by measurements.

Indoor Air's Scientific Debate

The medical community relies on research findings and retrospective evaluations of data. In some buildings, a harmful effect existed and caused illness or death. The classic example is the bacterial contaminant that spread via the ventilation system of the Philadelphia hotel where American Legion members were attending a conference. The spread of the *Legionella* bacteria was a well-studied effect from a clear culprit. The 182 persons who became ill and the 29 who died were in fact affected by a hazardous building.

The debate over building materials and their effects on occupant health gained momentum during the late 1970s, when urea-formaldehyde foam insulation (UFFI) was being challenged. UFFI was eventually banned by the federal Consumer Product Safety Commission after a congressional inquiry into its risks. The UFFI situation led some members of the public to fear that a tightly sealed building posed excessive chemical exposure risks, although medicine has never conclusively drawn a correlation between the symptoms alleged from residents of homes using UFFI and the causal links of those symptoms.

From the standpoint of medical diagnosis, studies may be made more difficult by the variety of symptoms alleged and causes suggested. In some cases, the first investigator retained as a consultant believes that indoor air is the culprit, and this results in conclusions that the investigator may have been predisposed to discover. Faced with nonspecific complaints and many potential causes, the clinical physician finds that the sheer range of potential causes impedes the ability to do scientific investigation.

Three studies illustrate the difficulties the medical investigator encounters (see a more complete discussion in chapter 3). A Florida courthouse, built in 1989 for $11 million, was evacuated after worker complaints in 1992, and a $9.5 million reconstruction was initiated. The building had structural problems and mold. The decision to evacuate and spend heavily for rebuilding was criticized as an inappropriate response since no immediate or unusual threat existed. Less-drastic repairs and cleanup costs would have sufficed. One lesson learned here is that consultants should not be involved with both evaluation and the more profitable task of remediation, as the consultants were in this case. Another is that checking references and potential conflicts of interest must be part of the evaluation of any consultant.

In a second case, chemical smells were reported inside a school where a petroleum-based chemical solvent was being used to remove asbestos tile. This author became involved after the initial consultant declared the conditions safe because the airborne levels were below occupational-exposure guidelines. Medical complaints increased as parents' concerns mounted; children's symptoms included cough, increased frequency of colds, asthma, ear infections, upset stomachs, vomiting, diarrhea, and rashes.

The lesson was that for this situation to be resolved, perceptions had to be dealt with and treated. Medical advisors must keep in mind that solving odor-related complaints involves *both* the scientific assessment and the perceptions of toxicity. In a school setting, parents felt anxiety and frustration when children's health issues were not directly addressed. Also, measurement should not be done for chemicals for which there is no known health implication; "do not measure things you are not prepared to deal with!" The lay audience may be frightened by a long list of chemicals identified in workplace air, even when experts assure them that levels are low.

A third case is also worth consideration by building managers. A Los Angeles building was undergoing a major renovation. After complaints and litigation, 15 employees of a tenant settled for several millions of dollars in damages.

Odors from a chemical sealant used during renovation volatilized from an adjacent office suite into an accounting firm's offices. Levels of the chemical produced irritation, but no significant or serious health effect was likely. A call to the government for investigation led to an unexpectedly frightening response: government employees who did not know what was present and did not want to risk exposure arrived wearing full respirator-assisted protective gear. The sight of the suited investigators apparently led the employees to fear that serious health risks must exist. Numerous measurements were taken, but no harmful chemical levels were detected. In this case, the government workers' self-protective measures in the face of an unknown airborne vapor were understandable, but the reaction they produced among workers—the increase of fear and alarm—was also understandable.

Some preventive-health lessons from the million-dollar Los Angeles settlements are that renovation of indoor spaces must be undertaken in a way that minimizes the potential for exposure. In areas being painted, for instance, measures such as sealing air supply and return ducts with plastic, temporary heating, venting, and air-conditioning (HVAC) modifications, and exhaust fans to produce negative pressure will reduce the likelihood of odors that generate complaints. Another lesson is that people associate their workplace with safe conditions; if those perceptions change, the responsible officials should recognize and deal with the psychological factors involved. In the Los Angeles building, the arrival of air-sampling investigators in full protective gear with respirators contributed to an atmosphere of fear that generated health complaints.

Terminology

The study of indoor air–related disorders is sufficiently new and heterogeneous that the terminology is unclear. "Sick building," "tight building," and "building-related disease" are used interchangeably. Now a new term, *building-related occupant complaint syndrome* (BROCS), has been coined, adding further confusion to this field. Most commonly, the scientific literature places several building-associated conditions into separate categories. These include building-related diseases, tight building or sick building syndrome, and building-associated symptoms. Perhaps BROCS will soon incorporate the latter two expressions.

More recently, new terms describing alleged chronic health effects have arisen. These include multiple chemical sensitivities, toxic encephalopathy, reactive airway dysfunction syndrome (RADS), and occupational asthma.

Building-Related Diseases

Building-related diseases are disorders, ranging from mild to severe, due to specific, identifiable contaminants of indoor air. For a classification of building-related disease to be designated, clear and convincing evidence must exist that something in the building is causal; preferably, the agent should be known. Moreover, the disease or end point of the disorder must generally be quite clear-cut, not merely a set of nonspecific complaints. It may be death or serious respiratory infection, as was the case with Legionnaires' disease. It may be an epidemic of influenza passing through a workforce. It may be an occupational asthma proven by immunological studies of the patient and correlated with cultures of the causative organism, perhaps found in the building's ventilation system.

Legionnaires' disease is an example of a medically determined linkage between death or injury and the defective system in a particular building. There a specific bacterium was causal. Certain other organisms, commonly fungi, molds, and thermophilic bacteria, that contaminate heating and air-conditioning systems produce a variety of complaints and disorders—generally mild hay fever types of allergies, but at times more serious conditions such as asthma or hypersensitivity pneumonia.

Other common infectious diseases, like colds and influenza, may be spread by ventilation systems. In a study comparing Army recruits living in "leaky" barracks to those living in "tight," more energy-efficient barracks, the latter group had a higher frequency of colds (Brundage et al., 1988). When a large percentage of the workforce becomes ill from such infections, building-related diseases can be suspected, although it may be difficult to find a specific contributor in the building environment itself.

It is certainly reasonable to assume that confined spaces with poor outside ventilation would be an environment conducive to the transmittal of respiratory viruses. How and whether that translates to illness in more open and far larger office buildings is, however, not established by medical evidence.

Sick (or Tight) Building Syndrome

The term *sick building syndrome*, or *tight building syndrome*, has been applied to situations in which workers have many and varied symptoms. The sheer range of potential causes of those symptoms makes the term misleading. Hodgson and Cain argued that this term should be abandoned (Cain and Cometto-Muñiz, 1995; Hodgson, 1995a; Hodgson, 1995b). I agree, because the term leads to a false sense that groups of people in offices with symptoms have those symptoms because of some problem with the indoor air quality. However, since the term is so common, I will use it in this chapter.

The term sick building syndrome indicates that people in a workplace either are not feeling well or have health complaints, but it does not explain why. It implies that a significant percentage of building occupants complain of a variety of building-associated symptoms such as eye and mucous membrane irritation, headaches, fatigue, and sinus congestion. Furthermore, it requires a substantial attack rate (involvement by 20 percent or more of building occupants), a temporal relationship to the building, and improvement with specific corrective measures.

This term also implies that problems with indoor air, generally related to poor air exchange in energy-efficient buildings, have been identified. Unlike building-related disease, with sick building syndrome a specific agent such as bacteria or molds is rarely found. It suggests a building-related cause whether or not such a cause exists. People's symptoms may be due to a specific contaminant, but they also might arise from workers' stress or from poor ventilation in an area—what used to be called "stuffy air."

Today, in our body- and health-conscious society, people closely monitor their physical sensations and symptoms; thus symptoms that are merely the result of stuffy air become designated "sick building syndrome." It has been argued, with some merit, that energy-efficient buildings constructed after the early 1970s have sealed internal environments, permitting a variety of contaminants to linger and accumulate when formerly they would have migrated to the outdoors.

While it is clearly true that modern buildings are more tightly sealed, it is not clearly true that indoor air today is worse than it used to be. For example, in this country there are vastly fewer smokers now than in 1965. Conference rooms in office buildings during that era were filled with cigarette and cigar smoke (hence the expression "smoke-filled rooms"). In retrospect, what could be more disturbing to occupants than the hundreds of irritating chemicals emitted by tobacco smoke? That indoor air environment was much more contaminated with secondary tobacco smoke than today's indoor air, whereas today unseen and often unsmelled chemicals are the focus of intense concern. The contrast bears consideration.

Medical Investigation of Causation

Because sick building syndrome is associated with nonspecific symptoms and is dependent on subjective individual questionnaires for its identification, its causes—air contamination or psychological factors—cannot easily be distinguished. Other investigators have commented on this (Colligan, 1981). Moreover, as reporting of indoor air problems has become more frequent, there will be increases in psychological influences and reporting biases. The only way to approach some semblance of true scientific investigation is through controlled, blinded studies in which air constituents are varied, unbeknownst to building occupants, and a symptomatology is subsequently reassessed. The few instances in which this was attempted found mixed results regarding the relationship between air-exchange rates and contaminant levels and symptoms (Baldwin and Farant, 1990; Collett et al., 1991; Farant et al., 1990; Farant et al., 1992; Menzies et al., 1990; Menzies et al., 1993; Nagda et al., 1991; Palonen and Seppanen, 1990).

Whether today's sick building syndrome truly represents a defined syndrome is, for all of these reasons, not fully established. The prevalence of complaints alone does not prove that the cause is poor air quality. Complaints could be due to a high pollen count outdoors, a common viral illness, a dissatisfied workforce, reporting bias, or other factors. Only an intense, scientifically controlled investigation might distinguish among these alternatives. Moreover, symptoms do not establish the cause. They typically vary in nature from person to person and are sufficiently nonspecific (having many possible causes) to render uncertain a common causal attribution.

Building-Associated Symptoms

The term *building-associated symptoms* is the softest group of building-related conditions or complaints. Here, occupants of a building complain of various symptoms, which they associate with the building. Intensive investigation is unable to elucidate a specific common cause, or the possible cause is too speculative. Much of what has been termed sick building syndrome is probably better called building-associated symptoms.

Factors in the Workplace that Can Produce Symptoms

Because we are dealing with an eclectic group of symptoms and disorders, their causes are multifaceted, ranging from purely emotional factors to infectious viruses and bacteria. Clearly, as perceptions of bad indoor air increase, emotional factors grow in importance. It becomes increasingly difficult to sort out the real culprits and to separate symptoms due to perceptions from those due to bona fide contaminants. Following is a brief discussion of some of the specific ambient factors in indoor air that may affect levels of comfort and contribute to symptom complaints. We have already discussed factors such as bacteria, which may cause serious diseases, and have considered psychological factors that may cause or intensify complaints.

Ventilation and Related Factors

When researchers seek a cause of sick building syndrome, they most often study the type and quality of building ventilation. But when we read the studies, we see a lot of doubt and little conclusive evidence about whether ventilation alone can explain most cases. The studies vary. The National Institute of Occupational Safety and Health (NIOSH) has reported that ventilation problems existed in at least 53 percent of buildings investigated for indoor air complaints (Wallingford and Carpenter, 1986). That, of course, does not mean these problems caused the complaints.

One frequently cited epidemiological study concludes that air-conditioned buildings consistently show more symptoms than naturally ventilated buildings. Beyond this, no specific cause, such as the use of humidifiers or the presence of formaldehyde or other chemicals, could be identified (Finnegan, Pickering, and Burge, 1984).

Another study concluded specifically that buildings with ventilation from local or central induction fan coil units had more symptoms than buildings with all-air ventilation systems, which in turn had more symptoms than naturally or mechanically ventilated buildings. According to this study, microbiological contamination from chillers, ductwork, or humidifiers (secondary to the ventilation system) can result in some of the worst symptoms, probably by an allergic or endotoxin-related mechanism (Burge et al., 1987).

Another investigator measured a number of environmental characteristics, including thermal parameters (dry-bulb temperature, relative humidity, air speed, and radiant temperature), volatile organic compounds, respirable suspended particulates, lighting and noise intensity, and carbon monoxide and carbon dioxide levels. It was found that certain specific causes stood out; these turned out to be lighting and volatile organic compounds; layers of clothing and crowding were also related to increased symptoms (Hodgson et al., 1991).

The much-quoted Danish study of 4,369 workers in 14 town halls (Skov and Valbjorn, 1987) found no single etiology for sick building syndrome symptoms. Temperature and humidity, carbon dioxide and formaldehyde levels, static electricity, dust, microorganisms, volatile organic compounds (VOCs), and lighting were among the variables studied. Interestingly, the results did not corroborate earlier findings that a higher symptom prevalence exists in mechanically ventilated buildings than in naturally ventilated ones (Robertson et al., 1985).

Other studies done in this country concluded that, even if a single etiology is unknown or there are multiple compounding variables, the type and adequacy of ventilation has more bearing on indoor air quality than any other factor. The specific mechanism by which building ventilation leads to symptoms is unknown; it may be that reduced ventilation directly affects changes in comfort, or it may cause the buildup of chemical pollutants (Letz, 1990). The most likely connection is simply that poorly ventilated air is stuffier and has more odors than well-ventilated air; all this contributes to discomfort and, therefore, to symptoms.

Temperature and Humidity

Temperature and humidity are important comfort factors. Low humidity contributes to dry mucous membranes, which in turn can make the nose and throat feel scratchy, lead to nosebleeds, make throat and nasal membranes more susceptible to chemical and other irritants, and contribute to susceptibility to viral infections. High humidity can also create health risks, contributing to the growth of biological agents such as fungi.

Temperature affects comfort, and discomfort leads to symptoms. Unfortunately, finding the "right" temperature is difficult because some workers will judge a building too hot while others will find it too cold. Air temperature within the building is easy to maintain automatically by means of a thermostat, though an individual's personal comfort also depends on body metabolism and clothing weight. In older buildings, windows and doors can be opened and closed to adjust airflow. Sealed buildings in which windows cannot be opened have less flexibility, so the air-conditioning should be checked to be sure that it is working properly with suitable exchange rates, a balanced delivery system, and no obstructions in front of vents. Unfortunately, many offices are partitioned in ways that interfere with the original design of the airflow and location of the thermostat control; this future flexibility should be kept in mind during the design and construction of new buildings.

Biological Contaminants

Biological contaminants (also called bioaerosols) have received a great deal of attention of late as potential causes of indoor health complaints and disorders. The biological agents at issue are molds (fungi) and bacteria. While it is true that fungi and bacteria can cause certain diseases and symptoms under some circumstances, it is also true that we live in a world full of biological agents, including fungi and bacteria. The areas most contaminated with mold are dense woods, which are not usually considered threatening.

While some of the concern about mold is justified, in many cases the degree of concern seems to outstrip the actual health threats. Worries about potential, but unproven, health effects have led to extraordinarily expensive remediation of buildings. This attempt to eradicate all mold is both an overreaction and a contributor to the popular misperception that all mold is dangerous.

In allergic individuals, high levels of fungi can produce allergic responses such as hay fever or asthma. It is unusual for indoor airborne levels to be high enough to cause such reactions. However, in a heavily mold-contaminated office, it is possible for such responses to develop. Other sources have spent volumes to describe the detailed examination of such responses (Burge, 1995; Cox and Wathes, 1995; Federal-Provincial Committee on Environmental and Occupational Health, 1995). Sometimes these fungi are among the responsible factors in indoor air-related complaints and sick building syndrome, but those occasions are relatively unusual—less than 5 percent, according to NIOSH (Melius et al., 1984).

More-serious fungal and bacterial illnesses, such as hypersensitivity pneumonitis, have also been associated with bioaerosols. For the most part, our experience with such disorders comes from specific occupational exposures that are massive compared with office building exposures. Farmers, silo workers, and mushroom workers are among the susceptible populations.

Relatively few instances of these more-serious lung disorders have been associated with contaminated office buildings. For example, humidifier fever is a true building-related illness caused by biological organisms such as molds and fungi that are traced to standing water in ventilation ductwork and ambient temperature humidification equipment. Its symptoms are wheezing, fluid collection in the lungs, and recurrent fever, which characterize hypersensitivity pneumonitis. Humidifier fever is a respiratory disease that occurs only in sensitive individuals, and it is generally relieved when the affected person leaves the environment. Again, however, such outbreaks are exceedingly rare in the office environment, but they do need to be recognized and managed promptly if they occur.

Recently it has been claimed that certain toxin-producing fungi (particularly *Stachybotrys atra* and various species of *Aspergillus*) when found in an office pose a serious threat (Johanning, Morey, and Jarvis, 1993; Johanning and Yang, 1995; Sorenson, 1990). Although much expensive remediation has resulted from this perception, there is little evidence that the threat is real. True, these agents can cause serious disease) following massive exposures. But there is, to date, no scientific evidence that amounts found on surfaces in offices can give rise to levels that produce harm. Moreover, there is little reason to believe that they can.

It is important to keep in mind that mold on walls is not the same as mold or spores in the air. For the most part, hazardous exposures arise from direct contact with or inhalation of the agents or their spores. Although surface contamination can lead to airborne contamination, the actual quantitative relationship is at best indirect.

Odors

Odors, particularly those that are unfamiliar and are viewed as noxious or "chemical," invoke a wide range of emotional responses (Cometto-Muñiz and Cain, 1993; Knasko, 1993; Cone and Shusterman, 1991; Schiet and Cain, 1990; Shusterman, 1992; Shusterman et al., 1991). Think of responses to the smell of dead flesh. People faint, vomit, and develop palpitations and many other symptoms with such exposures. It is not that the putrefying flesh gives off toxic chemicals, but that it arouses a psychological effect.

Today, chemical smells arouse psychological effects because they are perceived to represent a hazard. Whether or not they actually do is a highly chemical-specific matter. Many completely odorless chemicals (e.g., carbon monoxide) can be quite toxic, whereas other highly odoriferous ones (e.g., mercaptans) are only minimally so. In building-related symptom complexes, however, odors can be extremely and increasingly important.

Odors are probably among the most important causes of health complaints in the indoor environment. Symptom-provoking odors often accompany remodeling or renovation projects; workers smell the chemicals associated with these activities and associate them with risk or danger. The result is symptomatic sick workers.

Emotional Causes and Mass Psychogenic or Sociogenic Illness

The increased awareness of chemicals in the environment and media attention on indoor air issues have bred a greater tendency for psychological factors to aggravate, and even cause, outbreaks of illness in the workplace. Psychosocial issues outside the workplace and stresses within it may result in some of the symptoms, such as headache or lethargy. The use of the term sick building syndrome is an emotionally charged issue already. Research is needed to develop scientific criteria for distinguishing between illness arising from psychological factors and symptoms resulting from exposure to indoor air pollution or toxic substances (Letz, 1990).

Many incidents of epidemic anxiety and mass hysteria have also been reported. These incidents sometimes begin with a remediable indoor air problem; at other times they can be traced not to a building problem but to "problem" individuals. In one acute epidemic, several hundred employees in a state office building in Missouri complained of headache, mucosal irritation, fatigue, odd taste, and dizziness. Extensive investigation revealed no toxic substances or direct cause of the illness. One interesting finding was that the employees who complained of illness were more likely to have perceived unusual odors and inadequate airflow. In any event, investigators concluded that a state of epidemic anxiety was triggered by negative factors in the environment, including poor air quality (i.e., crowding, blocked vents, smoking, high temperatures). Reports of illness from coworkers, arrival of emergency vehicles, and evacuation of the building probably led to the escalation of the event (Donnell et al., 1989).

In another similar incident, operators in a telephone-company building reacted to what they reported was a strange odor with symptoms of headache, nausea, throat irritation, and even respiratory distress. The incident dragged out over an entire month, with evacuations and inspections by California Occupational Safety and Health Administration (OSHA) officials, the local fire department, and the county hazardous materials–management team. No evidence of toxic fumes, gases, chemical leaks, or spills could be found, and all of the people taken to hospitals were found to be asymptomatic, with normal laboratory results. The investigation then turned to one individual who in fact had spread the epidemic as he moved from one part of the building to another with reports of noxious odors that he interpreted as petroleum distillate poisoning. Here, too, the hysteria escalated as emergency vehicles arrived on the scene and workers witnessed fellow employees in respiratory distress (Alexander and Fedoruk, 1986).

Often, investigations do not reveal a specific causal agent, even with careful monitoring of air contaminants. But because symptoms often disappear with improvements in ventilation or when individuals leave the building, it is difficult to know whether there is a physiological basis for the illness or whether it is a case of mass hysteria or epidemic psychogenic illness.

Products of Combustion, Including Tobacco Smoke

Combustion products are sometimes implicated in building-related illnesses, particularly in cases of respiratory effects. These products consist primarily of carbon monoxide (CO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). Sources of these compounds are tobacco smoking, gas ranges, pilot lights, unvented kerosene space heaters, wood and coal stoves, fireplaces, and vehicle emission exhaust.

The contaminant that probably has received the most publicity is environmental tobacco smoke (ETS), also called passive tobacco smoke (PTS), which refers to its effects on nonsmokers. Exposures from passive smoke are mainly sidestream. Though sidestream smoke may have higher concentrations of some toxic and carcinogenic substances than mainstream (active) smoke, it is diluted by room air.

The most consistent and conclusive findings have shown that for children, and particularly for children of parents who smoke, PTS increases the occurrence of respiratory illness and chronic respiratory symptoms such as bronchitis, pneumonia, and coughing (Samet, Marbury, and Spengler, 1987a and 1987b). The health effects of PTS on respiratory symptoms and infection in adults have not been as well studied, and the subject remains controversial. Studies of the association between passive smoking and lung cancer in adults are also inconclusive; case-control and cohort studies do not uniformly indicate increased cancer risk. However, the International Agency for Research on Cancer of the World Health Organization (WHO), the National Research Council, and the United States Surgeon General have all concluded that involuntary smoking is a respiratory carcinogen (Samet, Marbury, and Spengler, 1987a).

Less evidence exists for adverse health effects of some of the other chemical compounds listed here, like sulfur dioxide, partly because they occur infrequently in the indoor occupational environment. For example, though the effects of acute carbon monoxide poisoning by asphyxiation are known, health effects at low levels, and particularly those resulting from chronic exposure, are less well documented. Nitrogen dioxide occurs during combustion of gas during cooking and is emitted from burning pilot lights; exposure is usually residential. The magnitude of respiratory illness resulting from exposure to NO_2 is usually small (Samet, Marbury, and Spengler, 1987a).

Automobile exhaust makes people feel ill because of odors, carbon monoxide, and irritants. At times, building complaints occur where air-intake systems are near or in garages or carports, permitting exhaust fumes to enter the building.

Formaldehyde, VOCs, and Other Chemicals

Medical evaluation of some air complaints is difficult because physicians cannot correlate worker symptoms with the measured levels of chemicals detected in the workplace air. The science of measurement has become very sophisticated, enabling us to detect indoor air contaminants at extremely low levels. Investigators conducting such measurements find hundreds of chemicals around us at all times at these levels. Residential air, building air, outdoor air, air worldwide contains such materials. According to a 1989 report by WHO's Committee on Indoor Air Quality, ". . . the indoor organic air pollutants as reported from several large surveys are similar in the distribution of concentrations in residential environments in several industrialized countries" (WHO, 1989). That study discussed 73 chemicals commonly found in indoor air worldwide.

Thus it is quite easy to identify substances in indoor air. And these substances' complex and frightening organic chemical names (e.g., hexane, formaldehyde, benzene, trichloroethylene, 1,1,1-trichloroethane, methylethylketone) raise concerns in both those who believe that a building is causing their illness and those who are ultimately responsible for the building. Health effects of chemicals at these low levels, however, are often nonexistent or unknown.

For example, a common indoor air complaint is irritation of the nose and eyes. The WHO document previously mentioned noted, "Organic compounds do produce mucosal irritation and other morbidity, though usually at orders of magnitude above the measured concentrations noted indoors." Indoor air concentrations of identified substances are often thousands of times lower than those known to produce health effects. OSHA frequently permits workers in industries that use or manufacture those chemicals exposure to levels one hundred to many thousands of times higher than those found in buildings with no established untoward health effects.

Critics of this disparity point to differences in job requirements, such as intense cognitive functions needed in offices, and differences due to such things as "healthy worker effects" in which industries weed out sensitive workers. Though these and other arguments may be valid, there is little proof that they are.

To some extent, these arguments become rationalizations for people zealously committed to the belief that indoor air in modern buildings is uniformly bad and is producing significant health problems. Thus, frequently levels of chemicals in buildings in which worker complaints have occurred are no higher than customary background levels found in homes, shopping malls, and neighborhood restaurants. Invariably they are vastly lower than permissible exposure levels in manufacturing facilities. This leaves investigators with data that identifies chemicals but cannot correlate those levels of chemicals with the workers' symptoms.

Numerous chemical compounds may contribute to indoor air pollution. These include formaldehyde, asbestos, radon, carbon monoxide, and a category of complex mixtures of VOCs that are typically found in new buildings. Certain questions arise regarding these chemicals and their role in indoor air quality. We need to know in any given instance (a) whether the chemical (or chemicals) is (are) a proven cause of the illness; (b) whether the levels at which the chemicals exist in the environment are known to cause the illness or symptoms; and (c) what scientific methods have been used to measure the chemical levels, document symptoms, and prove causality.

Formaldehyde was used in UFFI until that product was banned; it also has numerous sources in the home and office—particleboard, paper products, floor coverings, and carpet backings are among the sources, albeit in very small amounts. Reported levels of formaldehyde in office buildings have ranged from 0.01 to 0.30 parts per million (ppm), all well below the OSHA standard of 0.75 ppm. Levels that have been measured in buildings with no complaints were typically less than 0.1 ppm, and reports of irritation of the eyes and upper respiratory tract have occurred at levels above 0.1 ppm. The disparity between the OSHA standard and levels of reported complaints should be noted. Formaldehyde has been associated with respiratory and neurobehavioral effects (at lower levels than OSHA permits), but this has not been proven. Published studies have been biased with regard to subject selection and data collection; further investigation is needed (Letz, 1990).

VOCs form a category made up of many different compounds that have been identified in indoor air. As the technology for chemical analysis improves, we have an increasing ability to identify trace amounts of these compounds. In a large-scale series of NIOSH investigations, 350 VOCs were identified in concentrations greater than 0.001 ppm. This does not mean that they exist in greater amounts than they did five years ago, or that exposure is greater, or that there is more danger from them, but simply that our techniques for detecting them are better. In all cases, the measured levels of VOCs were within a factor of 100 of OSHA's permissible exposure levels. Measured levels of VOCs were almost always well below the no-effect levels for acute symptoms in humans (Letz, 1990).

With VOCs, as with other chemicals that may affect IAQ, conflicting or incomplete scientific evidence of toxicity at low levels makes medical evaluation more difficult. One study, for example, found that a small sample of healthy individuals, when exposed for a short time to VOCs, experienced subjective symptoms such as headache and general discomfort but did not show any decreased performance on behavioral tests (Otto et al., 1992).

To the contrary, two other studies found that subjects exposed to organic solvents showed both cognitive deficits and psychological disturbances (similar to posttraumatic stress disorder) on standardized tests. But nowhere in the studies is information given on the levels and intensity of exposure—information we need to compare the levels to those of the same chemicals in indoor air. These studies, then, should not be used as the basis for concluding that low-level VOCs cause neuropsychological disturbance (Molhave, 1992; Molhave, Bach, and Pedersén, 1986; Morrow et al., 1989; Morrow et al., 1990).

Chronic Illnesses Alleged to Be Caused by Environmental Factors in Office Buildings

Four potential long-term or chronic illnesses have been blamed on indoor air. Most of these allegations arise in the context of claims of injuries from the workplace. In almost all cases (with a rare exception to be discussed later), these illnesses do not actually occur from office exposures; yet the claims allege otherwise.

One reason that such claims are made is that sick building disorders and building-associated symptoms are self-limited, relatively mild problems that do not create long-term dysfunction or disability. This lack of medical significance does not support the claims of medical damage that are sometimes made in a lawsuit.

Multiple Chemical Sensitivities or Idiopathic Environmental Intolerances

A certain percentage of individuals claim that they are permanently sensitive to all chemicals, and hence disabled, as a result of exposure to something in the workplace. Paints, carpeting, pesticides, copy-machine toner, carbonless copy paper, and standard cleaning chemicals are among the materials that have been blamed by those who view themselves as permanent victims. The claimants are often supported in their belief by a variety of medical practitioners who are equally strong in their beliefs (U.S. EPA, 1996; Gots, 1995). There is, however, no standard or recognized clinical definition for this condition, and no tests, studies, or other objective or reproducible criteria exist with which to make the diagnosis.

In 1985 Dr. Mark Cullen, a professor of occupational medicine at Yale University, named this condition *multiple chemical sensitivities* (MCS) (Cullen, 1987). More recently, a panel of experts convened by a committee of the International Programme on Chemical Safety (IPCS) of WHO and the German Federation of Health and of the Environment met in Berlin, Germany, and renamed this phenomenon *idiopathic environmental intolerances* (IEI) (IPCS, 1996).

Dr. Cullen presented seven criteria for the diagnosis, which included an extremely intense and acute chemical exposure. As practitioners have now promoted or questioned this diagnosis and/or its true cause, many of Cullen's criteria have been overlooked. They are significant and should be applied in any medical evaluation of this type of complaint.

Let us trace the development of a typical MCS/IEI diagnosis. First, the patient tells the physician that chemical exposures make him or her feel sick. Because low levels of chemicals are part of our world and unavoidable, the physician pronounces the individual "sensitive or allergic to the world." These patients have been studied. They do not have allergies. They do not have immune system disorders (despite some claims to the contrary). They have no specific physical abnormalities. Some have serious psychiatric disorders such as depression. Most have the psychiatric condition known as somatization, and many have been influenced by their doctors, who have convinced them, or at least have supported their belief, that they are sensitive to chemicals (Black, 1996).

Because there have been no scientific findings and no logical scientific explanation exists for MCS as a toxic disorder, most major medical and scientific bodies agree that MCS/IEI has not been shown to have a physical basis and is at least as or more likely to have a psychological origin. Such organizations have included the American Medical Association (AMA), the American Academy of Allergy and Immunology (AAAI), the California Medical Association, the American College of Physicians (ACP), the American College of Occupational and Environmental Medicine (ACOEM), the International Society of Regulatory Toxicology and Pharmacology, and a committee of WHO (AAAI, 1986; ACOEM, 1993; ACP, 1989; California Medical Association Scientific Task Force on Clinical Ecology, 1986; AMA, 1992; IPCS, 1996).

MCS might be defined as a phenomenon in which a person develops many symptoms resulting from perceived exposures to low levels of chemicals. There is no question that there are such people. The question, therefore, is not "Does MCS exist?", but "What is MCS?" In almost all instances, a conditioned response can explain the symptoms, just as a person can feel the pain upon walking into the dentist's office or experience distress from the smells of a hospital or an overflowing sewer. These are normal human emotional responses, not toxic effects (Shusterman, 1992; Gots, 1996 [In press]).

Notwithstanding the lack of medical consensus that IEI or MCS is a physical disease, it is a legally significant phenomenon. Many people alleging this disorder have obtained workers' compensation payments or have won judgments against employers and/or building owners.

Toxic Encephalopathy

An individual sometimes claims (usually in the context of a sick building lawsuit) that he or she developed toxic encephalopathy—brain damage—as a result of exposure to chemicals in the workplace. Such an occurrence is scientifically highly unlikely and probably does not occur, but it is worthwhile to understand the basis for this type of claim.

When inhaled at high levels, certain organic solvents may alter brain function acutely or possibly permanently. The best-known examples are, of course, general anesthetics that are used intentionally to alter consciousness and temporarily impair brain function. Chronic alterations of brain function have been categorically shown to occur in individuals who are exposed to exceedingly high levels of certain organic solvents for long periods. For example, glue sniffers who inhale 20,000 to 30,000 ppm of toluene day in and day out for many years eventually develop anatomical alterations in their brains. These abnormalities are identifiable on MRI scans and correlate with neurocognitive dysfunction manifested through neuropsychological testing. This is the classic case of the so-called *psycho-organic syndrome* or *solvent encephalopathy*.

At the lower end of the exposure scale, many studies have examined painters, printers, and others who have been occupationally exposed over long periods to moderately high levels of solvents (although far less than glue sniffers have been). Many of those studies identified subtle neurocognitive alterations identifiable through neuropsychological testing (Hänninen et al., 1976; Hooisma et al., 1993; Olson, 1982; Orbaek et al., 1987). Other studies, however, found conflicting data and did not make such identifications (Bleecker et al., 1991; Cherry et al., 1985; Colvin et al., 1993; Edling et al., 1993). Moreover, all of those studies in which changes were identified involved high exposures over prolonged working lifetimes. No generally accepted and recognized scientific evidence exists for the proposition that low-level or short-term exposures can produce chronic or permanent brain damage.

The reader should be cautious about extrapolations. People who claim that exposures in an office building cause such injuries are extrapolating inappropriately from these high-dose, long-term exposures to chemicals, with a pattern of dosing quite dissimilar to that found in office building exposures. Basic understanding of toxicology tells us that such extrapolations are inappropriate.

Reactive Airways Dysfunction Syndrome and Asthma

RADS and asthma are disorders of the lower airways that make it difficult to move air in and out. Typically, RADS is a disorder caused by exposure to high levels of highly irritating chemicals, such as may occur after a chlorine gas release (Bernstein and Bernstein, 1989; Boulet, 1988; Brooks, Weiss, and Bernstein, 1985a and 1985b). Some have claimed that RADS was caused by irritant substances in indoor air that occurred following such activities as renovation or the installation of new carpeting. There is no convincing evidence that this is true, and such claims arise primarily in the context of litigation. For the most part, levels of irritants from such exposures are far too low to produce RADS.

Asthma differs from RADS in that it is related primarily to environmental allergens as opposed to irritants. Individuals with asthma may be sensitive to agents found indoors, including dust, dust mites (which live in dust), cockroaches, fungi, and mold. Asthmatics are also more sensitive to odors and irritants than nonasthmatics and may experience some discomfort if these are found in the indoor environment. What is not likely true (but has been claimed in the context of building-related lawsuits) is that a person's asthma can be made permanently worse as a result of exposures that produce discomfort or transient exacerbation. Once the building-related exposures cease, the individual is generally no different from before (Chan-Yeung, 1995; Chan-Yeung and Malo, 1995).

Summary

Although health issues that relate to the office environment do exist, it seems that complaints far exceed identifiable environmental causes. This is because building-associated symptoms may or may not have anything to do with indoor air. They may be related to other environmental factors such as lighting, ergonomics, and noise; to psychosocial factors such as job satisfaction, stress, and perceptions of hazards; or to non-work-related factors such as other diseases (i.e., allergies) and home stresses.

Of course, some environmental factors can produce symptoms, such as poor ventilation, odors, infectious agents, molds and fungal spores, and some volatile chemicals. It is important to take complaints seriously and investigate appropriately. It is equally important not to overreact or spend vast sums of money for unnecessary testing or remediation.

The following eight items summarize the information presented in this chapter. Appendix H presents other information for ease of reference.

1. Health issues are most critical when they pose an imminent danger to health or life. Fortunately, such situations in commercial, nonmanufacturing settings are extremely rare. An example is a gas leak that threatens an explosion or asphyxiation. Crises of that magnitude involving bioaerosols have occurred only a couple of times in the history of this country; the outbreak of Legionnaires' disease is the best-known such incident.

2. The psychological aspects of health complaints are as important as the physical ones. In fact, they lead to more litigation and are far more expensive.

3. Building owners can minimize financial risk by being aware of the psychology of indoor health complaints. For example, they can prevent chemical odors from becoming a concern by renovating during periods when people are not in the area.

4. Most health complaints made by people in commercial and public buildings cannot be readily connected to specific environmental problems or findings unless the complaints coincide with painting or other renovations. Invariably, environmental issues can be identified, but only infrequently can they be linked to health effects.

Thus, three questions must be asked:

a. Are there identified environmental problems that need to be corrected?
b. Are people suffering medical problems from building-related factors?
c. Does the level of psychological distress threaten the building and its occupants?

5. For those health complaints that can be related to indoor air problems, the overwhelming majority (99% or more) are minor and pose no serious threat, either short-term or permanent, to individuals. Thus, they can usually be investigated systematically and carefully without undue alarm.

6. Immediate evacuation is *not* usually necessary because of exposure to biological airborne carcinogens (mycotoxins). Such a contention of imminent health risk has no scientific basis and is inappropriately alarming.

7. There is no epidemiological support for or general acceptance of the belief that indoor environmental contaminants in commercial or public nonmanufacturing settings can cause cancer or miscarriages.

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