

ADDRESSING THE PSYCHOLOGICAL ASPECTS OF INDOOR AIR QUALITY

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"The human being is the ultimate judge of indoor air quality, and the traditional hygienic/chemical method at this stage can be regarded as insufficient to define the quality of air as perceived by human beings."
(Iwashita, 1992, p.23)

INDOOR AIR QUALITY ISSUES

Good building ventilation creates comfortable and healthy indoor conditions. For thermal comfort ventilation, indoor spaces must receive a sufficient quantity of outdoor air that is warmed or cooled to satisfy human thermal comfort needs. Comfort ventilation is assessed by measuring occupant perceptions of indoor air quality, including their assessments of odors, thermal conditions, and the adequacy of ventilation. For health ventilation, indoor spaces must receive air that is free from hazardous chemical or microbiological contaminants. Here, indoor spaces must receive a sufficient quantity of outdoor air that has been filtered and cleaned to create acceptable indoor air quality conditions. Health ventilation is measured by comparing levels of indoor air pollutants against occupational health standards, which usually are expressed as threshold limit values (TLVs) or permissible exposure levels (PELs) for air pollutants.

Ventilation standards give outdoor air ventilation rates for indoor spaces which should satisfy comfort and health ventilation requirements and create acceptable indoor air quality. Standards should define acceptable indoor air quality and require that air is free from hazardous levels of contaminants and be judged as satisfactory by most occupants. In the U.S.A. the ventilation standard defines satisfactory indoor air quality as being air that is free from contaminants at hazardous concentrations and with which 80% of the building occupants are satisfied. Experiments show that 20% of people dissatisfied air quality corresponds to a steady state ventilation rate of about 12 cubic feet per minute per person air quality or to a carbon dioxide concentration of 995 ppm for a non-smoking space (Iwashita, 1992), which agrees well with the U.S. ASHRAE's criterion of 1000 ppm of carbon dioxide for acceptable air quality. However, even in buildings where ventilation system performance meets the current ASHRAE standard one in five occupants may be complaining about climate conditions.

Several types of indoor air quality (IAQ) problems can arise in buildings: complaints about IAQ; reports of the sick building syndrome (SBS); toxic reactions from acute or chronic exposures to contaminated air; and building-related illnesses (BRIs). Toxic reactions from acute or chronic toxic exposures can be verified by measuring concentrations of indoor air contaminants. Episodes of BRI can be diagnosed because sufferers develop measurable physiological changes and show clinical signs, such as a high temperature. Symptoms of BRIs usually are similar to those of other acute respiratory diseases and they persist when the person is away from the building, only being alleviated when the illness is treated or has run its course. BRIs often indicate indoor air which is contaminated by microorganisms, and again is objectively measurable. In both types of complaints remedial action involves treating affected workers and removing or controlling contaminant sources (Bardana, Montanaro and O'Hollaren, 1988). In buildings where the air is shown to be contaminated, however, not all occupants will develop problems because various non-environmental factors affect individual susceptibilities.

Complaints of poor IAQ and reports of SBS usually are more perplexing to diagnose because results of IAQ studies of buildings often fail to find highly contaminated air, and in these cases simply increasing the ventilation rate may not resolve IAQ complaints. The reasons for this lie in the research findings that

show that IAQ complaints and SBS are influenced by various non-environmental variables, such as personal, occupational, and psychological factors, which are thought to affect individual sensitivities and susceptibilities to IAQ problems (Hedge, Erickson, and Rubin, 1992, 1995, 1996). Understanding the role which these various non-environmental variables can play invariably helps to resolve IAQ problems.

PERCEIVED INDOOR AIR QUALITY

Perception of indoor air quality depends on various sensory processes. For example, irritating air pollutants arriving at the mucus membranes are detected by the receptors for the general chemical sense, and the resulting sensations of eye, nose, and throat irritation are indicators of poor indoor air quality. Odors detected by the olfactory nasal mucosa also can signal poor air quality.

However, sensitivity to irritants and judgements of odor usually are the outcomes of relative and not absolute perceptual processes. The perception of odors or irritants depends on the intensity of stimulation of the sensory receptors relative to background activity in the nervous system, called the signal/noise ratio. Sometimes the sensory system will fail to detect a pollutant. Indeed there are many hazardous air pollutants that we cannot detect, such as carbon monoxide and radon gases. Sometimes our sensory systems can cause us to imagine that we are being or have been exposed to a hazardous pollutant, when this is not the case, and people can show psychogenic illness. Psychogenic illnesses can arise because the sensitivity to irritation and odors is not fixed but varies between people and changes over time and with beliefs about the potential hazard. For example, to a person who likes a particular fragrance, a high concentration of that fragrance may be desirable, while for another person who dislikes the same fragrance the same exposure may be highly unpleasant. Also, for the same person, the perceived intensity of an odor which is being emitted at a constant rate also varies with time because of sensory adaptation processes, and consequently odor judgements made immediately upon entering a room are more intense than odor judgements made 30 minutes later. Immediate odor judgements have been suggested as a metric for determining perceived indoor air quality in buildings (European Concerted Action, 1992). It is not clear whether this approach is sufficient because judgements of what are desirable and undesirable odors are influenced by personal preferences and beliefs.

Unpleasant odors do not necessarily indicate hazardous indoor air and the absence of odors does not necessarily signify healthy air because many pollutants, like carbon monoxide, carbon dioxide, and airborne microorganisms have no odor. Field research also shows that thermal comfort variables, such as air temperature and air movement, affect perceptions of stale and stagnant air. Experiments show that judgements of acceptability correlate better with the percentage of dissatisfied people than judgements of odor intensity. Acceptability ratings change with air temperature (from 68 deg F to 79 deg F - about 20 deg C to 26 deg C), and the higher the air temperature the lower the acceptability of perceived air quality (Iwashita, 1992).

THE SICK BUILDING SYNDROME

Cases of the SBS typically report vague symptoms which cannot be objectively measured, and sufferers usually show no clinical signs of illness. SBS symptoms include headache, lethargy, eye, nose and throat irritation, breathing problems, and skin irritation (World Health Organization, 1983). SBS symptoms are linked to building occupancy because they get better on leaving the building. IAQ surveys of sick buildings often fail to find pollution problems, even though complaints are chronic and symptom prevalence among occupants is high with up to 80% of workers reporting at least one symptom (Wilson and Hedge, 1987). In newly constructed or recently remodelled spaces, reports of SBS can be acute and temporary, typically dissipating within 6 months. Many of these symptoms are thought to stem from acute exposure to volatile organic compounds (VOCs) emitted from new building materials, paints, furniture, and finishes, although research evidence for this remains inconclusive. In permanently "sick" buildings, a high symptom prevalence can persist for several years and exposure to VOCs emissions from new materials cannot explain symptoms. Moreover, concentrations of indoor air pollutants

invariably are low. Never the less, poor IAQ is suspected as the cause of symptoms because these are alleviated when sufferers are away from the building.

Buildings with a high prevalence of SBS cases are labelled "sick" buildings, although there is no standardized method for gauging symptom prevalence and no agreement on the criteria which can discriminate between "sick" and "healthy" buildings. Regrettably, there is no consensus on the number, pattern, severity, or frequency of symptoms which define an SBS case, on how to measure symptoms, over what time period, or even what symptoms should be measured. There is also no agreement on the criteria for classifying a building as "sick".

Investigations of IAQ and the SBS usually use unstandardized, self-administered questionnaires to gauge the prevalence of symptoms and IAQ complaints. Many of these questionnaires are biased, ambiguous, badly scaled, and poorly designed. Self-reports of symptoms and complaints are subjective judgements which can be influenced by a diverse range of psychological factors, such as recall and response scale biases. Recall bias occurs because we have an imperfect memory of events, such as how often IAQ problems have occurred or symptoms have been experienced in the past. Recall bias is influenced by differences in questionnaire design, such as whether question responses involve checking a list of named IAQ problems and SBS symptoms, or are open-ended questions. Research on prescribed drug use shows that recall is significantly higher when patients are given specific drug names rather than being asked to name the drugs being taken, even though all patients were on similar medication regimes (Mitchell et al., 1986). In IAQ studies some questionnaires have used open-ended questions, for example, the NIOSH questionnaire used in health hazard investigations, while others have listed specific problems. Poorly designed response scales can cause response scale bias. Categorical scales with labels such as "always", "often", "sometimes" or "rarely" are ambiguous labels and can be interpreted differently by different respondents and investigators. Likewise, symptom labels such as "shortness of breath" convey different meanings to people, some interpret this as meaning slow, labored breathing, while others interpret this as rapid, shallow breathing (Pennebaker, 1982).

Questionnaires usually collect data on workers' perceptions of environmental conditions and health over extended periods of time, such as one month, 3 months, 1 year, whereas measures of environmental conditions seldom are taken over such extensive periods. Moreover, such measurements normally are not taken for each individual location in a building. Thus, it is perhaps not surprising that little association between self-reported symptoms and measured IAQ has been found.

OTHER PSYCHOSOCIAL INFLUENCES ON IAQ COMPLAINTS AND THE SBS

Because we cannot directly sense many indoor air quality hazards, such as airborne bacteria, or colorless, odorless and toxic gases, we rely on beliefs and imagination to help us to anticipate and avoid invisible hazards. These same belief and imagination processes also change how we interpret internal bodily sensations. Belief and imagination processes work to influence what we create or choose as hypotheses to explain what we believe to be happening in the environment and inside our bodies. Once we believe that the air we are breathing contains a colorless, odorless, yet noxious pollutant which causes eye irritation, we will selectively attend to eye sensations for confirmation of exposure, and unconsciously we even may behave to create this information, by rubbing our eyes more frequently than normal thereby increasing irritation sensations. Such behaviors are, for example, quite common. If a person thinks about how itchy his/her nose is, they will eventually scratch it. If a person thinks about mites and fleas crawling over their body, they will eventually experience sensations of itchy skin and want to scratch. At musical concerts audience members are more likely to feel the urge to cough when they hear others coughing. At comedy shows audience members are more likely to start laughing when they hear others laughing. These contagion effects are very powerful. Studies of medical students have shown that 70% of freshman students believe they have developed the symptoms of diseases being studied (Pennebaker, 1982). Similar processes influence all perception, including a worker's perception of indoor climate conditions.

SBS symptoms also are percepts affected by the same cognitive processes which influence all other aspects of perception (Pennebaker, 1982). Reports of nasal congestion depend on whether people are told to focus their attention on nasal congestion, which increases reports of nasal stuffiness, or to focus attention on free breathing, which decreases reports of nasal congestion under precisely the same environmental conditions (Pennebaker and Skelton, 1981). Building occupants frequently cannot accurately identify what is causing symptoms which they are experiencing. Symptoms like headache, for example, can be caused by poor IAQ, inadequate lighting, pressure of work, noisy work conditions, and so on. Building occupants therefore must rely on personal beliefs about what is causing the sensations which they are experiencing. Sometimes the imagination of some building occupants can create a climate of panic hysteria that results in a major incident in which the building may even be evacuated because of a suspected IAQ problem.

Mass psychogenic illness

Mass psychogenic illness (MPI), or mass hysteria, refers to "the collective occurrence of a set of physical symptoms and related beliefs among two or more individuals in the absence of any identifiable pathogen" (Colligan and Murphy, 1982). Social psychological processes of contagion, where complaints and symptoms spread from person to person, and convergence, where groups of people develop similar symptoms at about the same time, underlie MPI. Environmental events, like an unpleasant odor, can trigger contagion and convergence processes, and occupants who cannot readily identify what has triggered their symptoms often attribute these to any visible environmental changes, such as installation of a new carpet, or invisible agents, such as a "mystery bugs". MPI symptoms include headache, nausea, weakness, dizziness, sleepiness, hyperventilation, fainting, and vomiting, and occasionally skin disorders and burning sensations in the throat and eyes (Colligan and Murphy, 1982; Olkinuora, 1984; Boxer, 1985, 1990).

MPI reactions probably arise from the interaction of pre-existing poor physical environment conditions (poor ventilation, poor lighting, excessive noise), stressful work conditions (tedious work, poor organizational climate, poor labor-management relations), disposition differences among individuals (gender differences, differences in anxiety levels), with the occurrence of a triggering event (bad odor), followed by inappropriate management response to the perceived threat. Studies of MPI typically find a similar sequence of events leading to the incident.

Environmental illness

People diagnosed as suffering from multiple chemical sensitivity or environmental illness are thought to be extremely susceptible to environmental agents. However, this susceptibility also can be influenced by psychological factors. Research suggests that for many sufferers the symptoms which they report are comparable to those of one or more commonly recognized psychiatric disorders, such as mood disorders, affective disorders, and anxiety disorders (Black, Rathe, and Goldstein, 1990).

Influences of Environmental Stress

Apart from finding that IAQ complaints and the SBS are significantly more prevalent in the air-conditioned than naturally ventilated offices (Hedge, 1984; Robertson et al., 1985; Burge et al., 1987; Hedge et al., 1989; Mendell & Smith, 1990; Zweers et al., 1992; Mendell, 1993), there has been comparatively little research linking these problems to actual exposures to indoor air pollutants. Studies have found that environmental stress plays a significant role in the occurrence of problems. The extent to which physical environment stressors create strain and adverse health effects depends on the characteristics of exposed individuals and their ability to cope with these stressors (Hedge, 1989). IAQ complaints and SBS symptom reports often arise from the effects of diverse environmental and non-environmental factors which stress the body and, depending on individual coping abilities, these can increase the personal strain which is experienced. This personal strain in turn can alter a person's sensitivity to environmental irritants or possibly even directly cause some of the SBS symptoms.

Research on office workers has shown that although workers usually believe their symptoms were caused by prevailing environmental conditions, typically there is no correlation between these conditions, such as daily variations in temperature and humidity, and their reports of SBS symptoms, such as dry nose/nasal congestion complaints. However, SBS symptoms are often correlated with stress levels (Morris and Hawkins, 1987). Occupational factors (job level, hours of computer use, job stress, job satisfaction, handling of carbonless copy paper, photocopying), psychological factors (perceptions of control, perceptions of ambient conditions, perceptions of comfort), personal factors (gender), and organizational factors (public sector versus private sector buildings), influence the prevalence of SBS symptoms among office workers (Hedge, 1988; Hedge et al., 1989; Skov et al., 1989). In a study of almost 4,500 office workers in air-conditioned office buildings perceived indoor quality, computer use, gender, job satisfaction, and job stress have been shown to significantly influence the number of SBS symptoms reported by workers (Hedge, Erickson and Rubin, 1992, 1995, 1996).

CONCLUSIONS

Research shows that IAQ problems and reports of the SBS generally are not caused simply by exposure to poor IAQ, but rather they occur because of the combined effects of various physical environment and non-environmental factors. IAQ complaints and the SBS are the outcome of complex processes, initiated by a set of stressful multiple risks which create personal strain.

Most studies of IAQ complaints and the SBS have found that there is good evidence that personal, psychological, and occupational variables also affect reports of IAQ complaints and health symptoms. Brooks and Davis (1992) summarize 3 sets of factors that appear to be common to most indoor air quality problems: the presence of point sources of pollution, the presence of a susceptible population, and inadequate ventilation. By studying and addressing all 3 sets of factors satisfactory climate conditions and healthful indoor air quality can be created in any building.

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