



## Special Report: NIOSH Testimony to the U.S. Department of Labor on Indoor Air Quality

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# NIOSH Testimony to the U.S. Department of Labor on Indoor Air Quality

Linda Rosenstock, NIOSH Director

## Introduction

I am Linda Rosenstock, Director of the National Institute for Occupational Safety and Health (NIOSH). With me today are senior staff from NIOSH. NIOSH is pleased to have this opportunity to testify in support of the Occupational Safety and Health Administration (OSHA) notice of proposed rulemaking on an occupational safety and health standard for indoor air quality.

NIOSH supports the OSHA determination that employees working in indoor work environments face a significant risk of material impairment to their health or functional capacity due to poor indoor air quality, and that compliance with the provisions proposed in this notice will substantially reduce that risk. NIOSH believes that the epidemiologic literature indicates that environmental tobacco smoke (ETS) is a cause of lung cancer and possibly a cause of heart disease as well. The more than 1500 indoor air health hazard evaluations (HHEs) that NIOSH has completed since the early 1970s provide substantial evidence of the extent and the persistence of indoor environmental health problems within the United States. NIOSH strongly supports OSHA in initiating regulatory action to reduce adverse health effects associated with the indoor environment.

It is NIOSH's opinion that the proposed standard to protect worker health in nonindustrial workplaces reflects the best available knowledge from building-related research. ETS is unnecessary in the work environment, and involuntary exposures should not be allowed. It is appropriate that, with the exception of ETS, OSHA has chosen not to establish contaminant-specific standards at this time, but rather to prevent environmental conditions that lead to poor indoor air quality.

## Overview of ETS Health Effects

NIOSH supports the OSHA proposal to control ETS in the workplace. OSHA would require employers, in workplaces

where smoking is not prohibited, to establish designated smoking areas that are enclosed and exhausted under negative pressure to the outside. This provision is consistent with the NIOSH Current Intelligence Bulletin (CIB) on ETS in the workplace, published in 1991.<sup>(1)</sup> In addition to recognizing that ETS is a carcinogen both in and outside of the workplace, NIOSH recommends that "...the best method for controlling worker exposure to ETS is to eliminate tobacco use from the workplace and to implement a smoking cessation program. As an interim measure until tobacco use can be completely eliminated, employers should protect nonsmokers from ETS by isolating smokers."

In our report entitled "Environmental Tobacco Smoke in the Workplace, Lung Cancer and Other Health Effects," NIOSH reviewed reports of the surgeon general on the health effects of tobacco smoke, epidemiologic studies of nonsmokers exposed to ETS, and comparisons of the chemical composition of ETS with that of mainstream smoke. Based on this published information, NIOSH concluded that the overall increase in risk that nonsmokers face for lung cancer as a result of smokers was about 30 percent, and that heart disease might also be associated with ETS. NIOSH therefore recommended that ETS exposures should be reduced to the lowest feasible concentration.

In December 1992, the U.S. Environmental Protection Agency (EPA) essentially concurred with the NIOSH position and published "Respiratory Health Effects of Passive Smoking: Lung Cancer and Other Disorders."<sup>(2)</sup> Using a total weight of evidence analysis, EPA concluded that ETS is a group A (known human) carcinogen in adults, responsible for approximately 3000 lung cancer deaths annually in U.S. nonsmokers. It is also causally associated with noncancer respiratory diseases and disorders in exposed children.

Regarding cardiovascular disease, in

1992 the American Heart Association (AHA) reviewed existing data and concluded that "the risk of death due to heart disease is increased by about 30% among those exposed to ETS at home and could be much higher in those exposed at the workplace, where higher levels of ETS may be present." The AHA went on to quote estimates of 35,000 to 40,000 heart disease deaths annually, while acknowledging the uncertainties in such estimates due to the difficulty of conducting adequate long-term epidemiologic studies.

In what follows, I proceed to discuss in more detail the association between ETS and lung cancer and heart disease, including highlights of a few more recent epidemiologic studies.

## Heart Disease

The NIOSH CIB summarized reports on ETS published in 1986 by the surgeon general and the National Research Council (NRC). Both were based on essentially the same set of studies, and both found that the data were not sufficient to conclude that ETS exposure was responsible for causing cardiovascular disease in nonsmokers, although the NRC called the hypothesis "biologically plausible." The NIOSH CIB then reviewed the conclusions of another seven studies that had not been considered in those reports. These studies varied in size and statistical power, but each of them found an increased relative risk (ranging from 1.1 to 2.9) of cardiovascular disease for nonsmokers living with smokers. This increased risk was statistically significant for only two of these studies, and NIOSH concluded only that ETS exposure "possibly" poses a risk of heart disease for occupationally exposed workers. Heart disease mortality potentially imposes the major portion of the public health burden caused by ETS.

Since the NIOSH CIB, there have been two published reviews of the epidemiologic studies regarding ETS and heart disease. Steenland,<sup>(3)</sup> who reviewed nine epidemiologic studies and numer-

ous experimental studies to evaluate the association between ETS and heart disease, concluded that the evidence suggested a real association, and estimated approximately 35,000 to 40,000 excess ischemic heart disease deaths annually among never-smokers and long-term former smokers due to ETS. Wells<sup>(4)</sup> updated the epidemiology review and concluded that exposure to ETS increases the coronary death rate among U.S. never-smokers by 20 to 70 percent. He estimated from analysis of epidemiologic studies that in 1985, 62,000 ischemic heart disease deaths were associated with exposure to ETS.

The epidemiologic studies of heart disease and ETS exposure do not generally consider occupational exposures. There is one recent study from China<sup>(5)</sup> which shows a significantly increased risk of heart disease due to occupational exposures after adjusting for common risk factors, and also shows a positive dose-response relationship between exposure and risk of heart disease.

### Lung Cancer

The NIOSH CIB summarized reports on ETS published in 1986 by the surgeon general, the NRC, and two independent research teams.<sup>(6,7)</sup> All were based on essentially the same set of studies and all four of these reports found an approximately 1.3-fold increase in the risk of lung cancer for nonsmokers living with smokers. The NIOSH CIB then reviewed the conclusions of another eight studies that had not been considered in those earlier reports. These studies varied in size and statistical power, but each of them found an increased relative risk (ranging from 1.1 to 4.0) of death due to lung cancer for nonsmokers living with smokers. That increased risk was statistically significant in six of the eight studies. Based on the collective weight of evidence, NIOSH concluded that "ETS poses an increased risk of lung cancer . . . to occupationally exposed workers."

The evidence about lung cancer risk as a result of exposure to ETS continues to mount. In perhaps the strongest new study by Fontham *et al.*,<sup>(8)</sup> based on 653 female lung cancer cases, investigators found that both home and occupational exposures to ETS significantly increased the risk of lung cancer. Occupational exposure to ETS caused a 39 percent increase in risk, and there was a clear dose-

response relationship with more years of exposure.

Other lung cancer studies with data bearing on occupational exposure to ETS include a study by Keller and Howe,<sup>(9)</sup> who found a nearly twofold risk for lung cancer in nonsmoking females employed in eating and drinking establishments. Siegel<sup>(10)</sup> studied involuntary smoking in restaurants to determine relative exposures and whether this exposure contributed to an elevated lung cancer risk. He found ETS levels in restaurants and bars were as much as 6.1 times higher than in offices and 4.5 times higher than in residences. Siegel reviewed six studies of lung cancer risk in food service workers, controlling for active smoking, and found an excess lung cancer risk of approximately 50 percent (10 to 90%) compared with the general population. He concluded that this elevated lung cancer risk is in part attributable to ETS exposure in the workplace.

Recent NIOSH HHE data support the feasibility of the OSHA proposal to eliminate exposure to tobacco smoke in the workplace.<sup>(11)</sup> In the 104 office buildings investigated, 58 percent allowed no smoking at all in the space studied. Twenty percent restricted smoking to a smoking lounge, and in only one place studied was smoking allowed without any restriction.

Isolating workers can be accomplished, then, by permitting smoking in separately ventilated smoking areas with no recirculation of the exhaust air so that the smoke-contaminated air is vented directly to the outside. Furthermore, no nonsmoking employee should be required to enter the smoking area.

### Building-Related Illness and Sick Building Syndrome

#### Current Knowledge

It is clear from the scientific literature that known building-related illnesses (BRIs)—diseases such as Legionnaires' disease, humidifier fever, asthma, or carbon monoxide poisoning—are caused by exposures in buildings to infectious organisms, allergenic or toxic biologic materials, or toxic chemicals.<sup>(12)</sup> These exposures occur because of deficiencies in design, operation, or maintenance of building ventilation systems, structures, or interior surfaces. These illnesses can be serious and occasionally life threatening.

Sick building syndrome (SBS), which together with BRIs constitutes the universe of building-associated illnesses, is characterized by nonspecific symptoms and other less well-defined health problems often reported by building occupants. We know from a number of epidemiologic studies—one from the United States and at least eight from five other countries—that a substantial proportion of office workers even in so-called "normal" buildings report frequent symptoms that improve when they leave the building.<sup>(13,14)</sup> These same symptoms are reported even more often by workers in so-called "sick" or "complaint" buildings. When researchers have studied health effects that can be measured, such as dry eyes and dry skin, they have found these measurements to correlate significantly with the reported symptoms.<sup>(14)</sup> Furthermore, several studies have demonstrated that both reported symptoms and measured health effects have been improved after a variety of interventions which have been performed in office environments.

In indoor environments, there are few specific measured exposures that have been clearly identified as causing the persistent symptoms characteristic of SBS, such as irritated eyes, nose, or throat; headaches; breathing discomfort; fatigue; or irritated skin. There are a number of indoor environmental risk factors, however, that have been consistently associated with increased frequency of symptoms.<sup>(14)</sup> It may be that currently unmeasured exposures related to these risk factors are responsible for adverse health effects. Given our limited knowledge, the best way to prevent illness in buildings is to prevent certain risk-related conditions related to building design, operation, and maintenance.

In the United States, although building designs must meet applicable building codes, there have been effectively no legal standards or regulations pertaining to the operation or maintenance of buildings. For example, there are almost no standards pertaining to the amount of outdoor air ventilation that must be supplied, nor are there standards governing the maintenance or cleaning of the systems which provide the air. Unfortunately, evidence from NIOSH and elsewhere shows that ventilation systems and other components of buildings are often not properly operated and maintained.

**NIOSH Experience and Data**

I would now like to turn to NIOSH data that bear directly on the proposed rule-making. NIOSH has now conducted over 1500 HHEs in indoor environments, covering a wide variety of building designs and occupational settings, including office buildings, schools, and healthcare facilities. The number of indoor air HHE requests has increased nearly 2000 percent, from 9 in 1978 to 181 in 1992. Most of these requests were made because of persistent health complaints which did not respond to conventional industrial investigation approaches and could not be easily resolved. The record of these requests at NIOSH over the past 20 years documents the appearance of this problem in this country, its growth, and its persistence, as well as the consistency of its presentation among building occupants throughout the country.

In the specific report for each building, investigators identify any environmental deficiencies they think are related to the health complaints reported. NIOSH has published several summaries of the earlier environmental evaluations. Summaries published in 1984 and 1990 included only the one environmental deficiency from each investigation thought to be most important. Based on additional years of experience, NIOSH now recognizes that most problem buildings have multiple environmental deficiencies, and that the scientific data in virtually all instances are inadequate to establish causal connections between any one factor and the health effects reported.

In 1992, a nationally televised news program triggered more than 800 requests for indoor environmental evaluations. From these requests, NIOSH selected 160 buildings for field investigations, during which standardized data were collected. Although analyses of data from these investigations are still not complete, I would like to highlight a few of our findings with Figures 1 and 2.<sup>(11)</sup> The final report will be submitted to the OSHA docket early in the posthearing period. Figure 1 shows that environmental deficiencies were found commonly in the evaluated buildings: investigators recommended correction of multiple environmental deficiencies in all but 3 of the 104 office buildings evaluated in 1993. Figure 2 shows that many buildings failed to follow a high standard of practice specifically in the operation and maintenance of

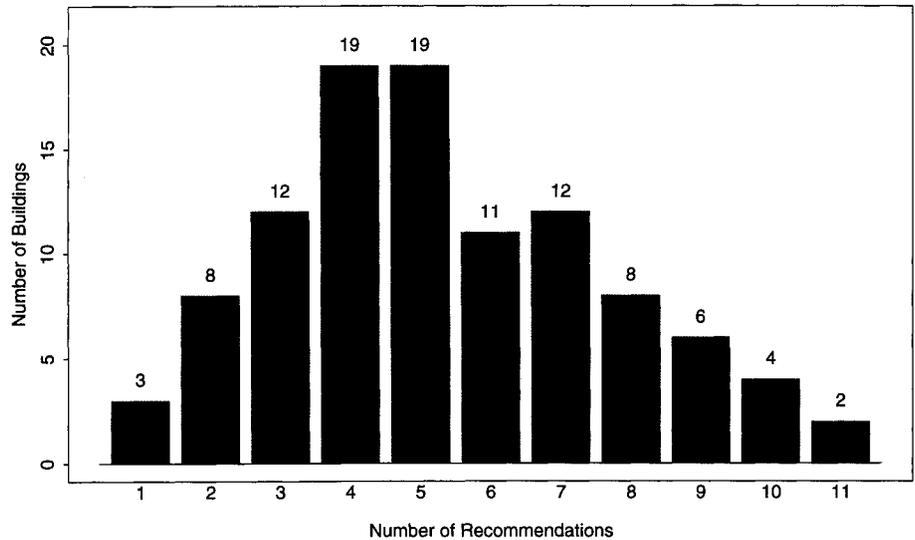


FIGURE 1. Distribution of the number of IEQ recommendations made among 104 office buildings (FY '93).

the heating, ventilation, and air-conditioning (HVAC) systems.

Overall, investigators found one or more evident deficiencies in the operation, design, or maintenance of ventilation systems on 93 of the 104 office buildings evaluated. These deficiencies included dirty air handler coils in 18 percent of the ventilation systems evaluated, dirty pans under coils in 35 percent of systems, and poor or no drainage from these pans in 20 percent of systems.<sup>(11)</sup>

There was a wide range in frequencies of symptoms assessed among workers in these buildings. We considered a frequent work-related symptom as one experienced in the building at least 1 to 3 days a week during the last 4 weeks, and which improved when away from the building. Figure 3 shows the average and

range of symptom frequencies in the office buildings we recently investigated.<sup>(11)</sup> To put these numbers into context, they can be compared to the occurrence of frequent work-related symptoms in a U.S. study which included both office buildings not known to have problems, and one building with a long problem history.<sup>(15)</sup> The NIOSH HHE buildings had average symptom frequencies between those of the non-problem buildings and those of the problem buildings. The highest symptom frequencies found in the recent NIOSH HHE data exceeded the frequencies in the problem California building.

Furthermore, preliminary analyses of the recent NIOSH HHE data have shown relationships between a number of assessments of HVAC maintenance quality

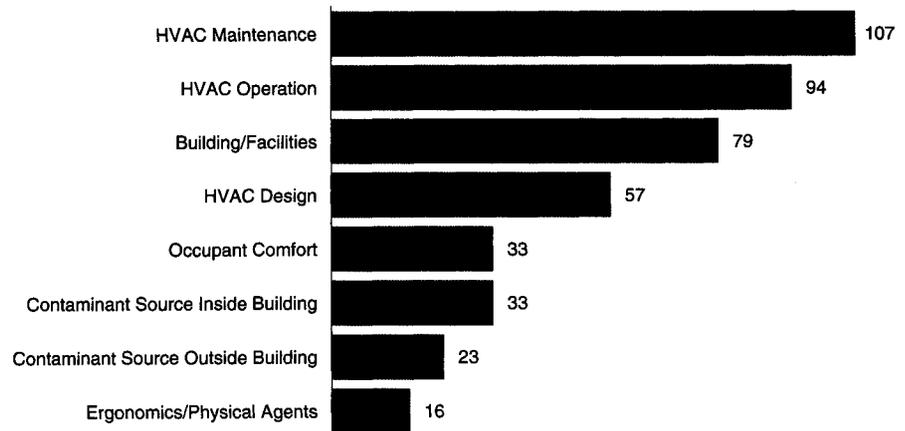


FIGURE 2. Number of IEQ problems by category among 104 office buildings (FY '93).

Symptoms	NIOSH 1993 HHEs		California Healthy Building Study	
	Average Symptom Prevalence (%)	Prevalence Range (%)	Air-Conditioned Buildings (excluding problem building)	Air-Conditioned Problem Building
Eye, Nose, or Throat Symptoms	36	0 - 71	37	67
Respiratory Symptoms	16	0 - 67	6	17
Headache	25	0 - 67	19	31
Skin Symptoms	9	0 - 40	9	22

FIGURE 3. Prevalence of frequent work-related symptoms within office buildings.

and symptom prevalence. For instance, lack of scheduled maintenance for HVAC systems was related to significant increases in respiratory symptoms, mucus membrane irritation, headache, and fatigue. NIOSH will submit further materials from these analyses in posthearing comments.

Although deficiencies in building ventilation systems are the most common problems found, it has been the experience of NIOSH investigators that other factors also contribute to the symptoms workers experience. These include air contaminants (chemical and biological agents); poor control of occupant comfort (temperature and humidity); physical stressors (noise and lighting); ergonomic stressors; and job-related psychosocial stressors. Thus, as we concluded in our response to the OSHA request for information on indoor air quality, the scope of the factors contributing to these health problems in buildings encompasses the "total indoor [work] environment," and is not limited to "poor air quality." However, because the scope of OSHA rulemaking is limited to air quality, our comments have been directed principally to this issue.

The overall scientific evidence demonstrates a number of important findings relevant to the importance of indoor air as a public health problem and supportive of the approach OSHA has undertaken:

1. Known BRIs, some of which are life threatening, occur in buildings and can often be attributed to specific deficiencies in design, operation, or maintenance of these buildings.
2. SBS, the mechanisms of which are not

yet well understood, occurs among workers in nonindustrial buildings around the world, and is, at least in part, environmentally related and preventable.

3. The health symptoms and complaints associated with SBS, some of which are measurable in objective terms, are also associated with deficiencies in design, operation, and maintenance of the buildings where these employees work.

**Specific NIOSH Comments on Rule**

NIOSH, in our earlier written comments on the proposed indoor air quality standard, suggested that OSHA consider ex-

panding the scope of the standard to include all work sites, including industrial. After further consideration of the scientific data, NIOSH now believes it is more justifiable to proceed as OSHA had proposed, namely, to target indoor air quality issues in nonindustrial environments only.

NIOSH supports OSHA's designation that levels of carbon dioxide above 800 parts per million (ppm) should trigger inspection of ventilation system operation. This level of carbon dioxide is an appropriate marker of potentially inadequate ventilation. Available research findings show a pattern of significantly higher symptom prevalence in association with ventilation rates below approximately 20 ft<sup>3</sup>/min per person.<sup>(14)</sup> At average occupant densities, this ventilation rate corresponds to approximately 800 ppm of carbon dioxide. Figure 4 shows data on this issue from a review of epidemiologic studies.<sup>(14)</sup>

The proposed rule requires that buildings be maintained and operated at original design specifications and that they provide the minimum outside air ventilation rate required by the applicable codes at the time the building was constructed or renovated. However, the codes that were in force at the time of construction or renovation may not provide adequate ventilation. For example, some older office buildings were built during a period when energy conservation measures required 5 ft<sup>3</sup>/min of out-

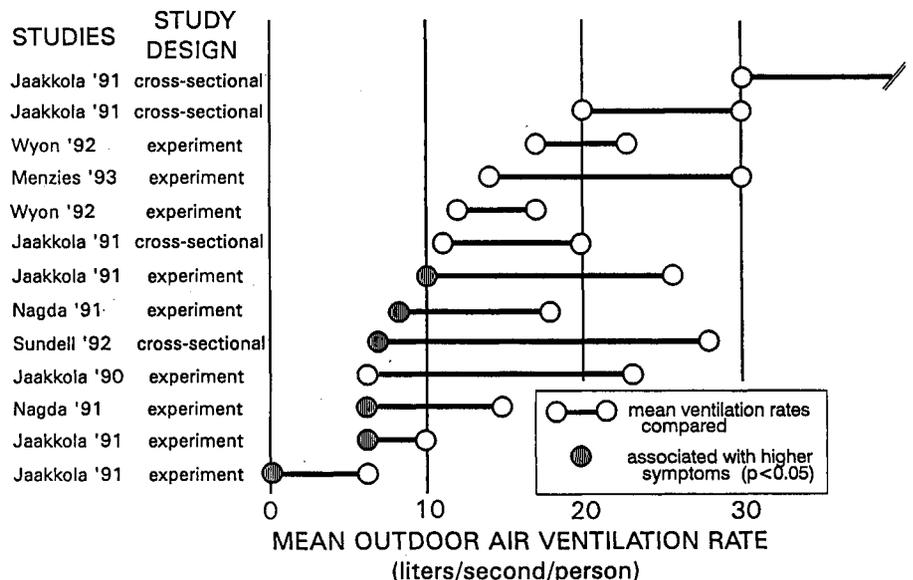


FIGURE 4. Outdoor air ventilation rates and work-related symptoms: Reported relationships summarized using estimated mean ventilation rates compared. (Adapted from Mendell 1993.)

side air per person. This is far below the current American Society of Heating, Refrigeration and Air Conditioning Engineers standard of 20 ft<sup>3</sup>/min per person. On the basis of the available data, NIOSH recommends that when technically feasible, a minimum of 20 ft<sup>3</sup>/min per person should be set as the triggering point.

I would now like to discuss in some detail the indoor air quality risk assessment used in the proposed rulemaking. In the preliminary risk assessment, OSHA relied on data from the 1992 National Health Interview Survey to estimate U.S. background rates for severe headaches and upper respiratory symptoms. Estimates of lifetime excess risk were developed using these background rates, compared with estimates of these symptoms associated with air-conditioned buildings from a study of California office buildings. These numbers were then expanded to the United States based on the proportion of buildings that are air conditioned.

NIOSH would like to suggest an alternative approach to this risk assessment. This approach would use data on work-related prevalence of symptoms in a minimally exposed population for background level. Workers in naturally ventilated buildings can serve as such a group, as they have been found in every study reported to have lower symptom prevalence than those in air-conditioned buildings. Such data in the United States are available from only one study, the California Healthy Building Study, begun in 1990 and first reported in 1993.<sup>(15)</sup> In this study, workers in air-conditioned buildings were found to have higher prevalence of a number of symptoms. Figure 5 shows data from this study.

A risk assessment could compare the symptom prevalence within the air-conditioned buildings with that in the naturally ventilated buildings. Symptoms of public health importance could be selected for inclusion in the risk assessment, which would allow consideration of symptoms in addition to headaches and upper respiratory ones that were addressed in the original risk assessment.

This approach assumes that naturally ventilated buildings in California are an appropriate source for baseline U.S. data, and that symptom differences between the two types of ventilation are valid and

PREVALENCE OF FREQUENT WORK-RELATED SYMPTOMS IN WORKERS BY VENTILATION TYPE		
Symptoms	Ventilation Type	
	Naturally Ventilated Buildings	Air-Conditioned Buildings (Excluding Problem Building)
	Prevalence (%)	Prevalence (%)
Eye Symptoms	14	20
Multiple Eye, Nose & Throat Symptoms	4	11
Respiratory Symptoms	2	6
Headache	13	19
Fatigue	16	22
Skin Symptoms	3	9

FIGURE 5. The California Healthy Building Study: A study of representative public office buildings in the San Francisco Bay Area, 1990.

provide relevant estimates for other buildings. Evidence for the internal validity of the study has been provided in the NIOSH comments submitted previously to the OSHA docket. Also, the consistency of findings from many other countries corroborates that these findings are generalizable. These are the best data available in the United States.

Preliminary analyses of the California data show that multiple work-related respiratory symptoms (such as chest tightness and difficulty breathing) are substantially increased in frequency in air-conditioned buildings. Workers with asthma are even more susceptible to these symptoms in air-conditioned buildings. NIOSH will submit further materials from these analyses in posthearing comments.

This risk assessment approach uses the presence of air-conditioning systems as a marker for potential poor operation and maintenance of building systems. To assess this assumption more critically, NIOSH is also examining the relationships between certain standards of ventilation system maintenance and reported symptoms in the California building data. Preliminary analyses show that poorer

standards of maintenance in the California air-conditioned buildings were in fact related to higher symptom prevalence. For example, lack of scheduled maintenance for HVAC systems in the air-conditioned study buildings was related to significant increases in respiratory symptoms, headache, and fatigue. NIOSH will provide these additional analyses to OSHA for posthearing comments.

### Conclusion

In conclusion, over 70 million American workers spend their time in indoor environments, normally considered to be clean and safe. Yet at times the NIOSH HHE program has been overwhelmed by requests to investigate complaints about buildings from workers who experience symptoms ranging from eye, nose, and throat irritation, headache, and breathing difficulty to life-threatening Legionnaires' disease. Although the specific exposures causing some of these conditions are elusive, NIOSH can often identify deficiencies in the design, operation, or maintenance of these buildings, which, when remedied, can improve the working environment. Tobacco smoke is one contaminant with clearly documented

health risks that is brought voluntarily into the workplace and is unnecessary to the work process. The best and least expensive method to eliminate exposure to tobacco smoke is to implement smoking cessation programs and prohibit smoking in the workplace. The second best method is to protect nonsmokers by establishing separately ventilated smoking areas as recommended in the NIOSH CIB and proposed in the OSHA rule.

Thank you for the opportunity to provide comments in support of this important standard. Additional comments and analyses will be submitted to OSHA in our posthearing comments. We will now answer any questions you may have.

Other NIOSH staff who contributed to the preparation of this testimony include: Richard W. Niemeier, PhD; Lawrence D. Reed; Richard W. Gorman; Michael S. Crandall; Mitchell Singal, MD; Mark J. Mendell, PhD; and Kyle Steenland, PhD. All are at NIOSH, 4676 Columbia Parkway, Cincinnati, Ohio 45226.

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**EDITORIAL NOTE:** Health effects associated with environmental tobacco smoke are a subject of considerable scientific debate. NIOSH testimony, presented at the U.S. Department of Labor hearings on indoor air quality, (29 CFR Parts 1910, 1915, 1926, 1928) represents a significant assessment of current epidemiological data on this issue. This document underwent NIOSH peer review and is published here in its entirety as a service to our readers.

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